PROGRAMME & ABSTRACTS

INTERNATIONAL PALAEONTOLOGICAL CONGRESS

LONDON 2010

June 28 - July 3

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International Palaeontological Congress
London, June 28 – July 3, 2010

RSM - Royal School of Mines, Imperial College (**IMP**) **Flett** Lecture Theatre is in the Natural History Museum (**NHM**)
RGS – Royal Geographical Sociey **Pippard** Lecture Theatre, Sherfield Building, IMP

Lunch and Refreshments are in Queen's Tower Room (**QTR**), Sherfield Building and Rooms 301 C, D, E (RSM)
Bar available in the Queen's Tower Room each evening

Venue	Monday	Tues am	Tues pm	Wed am	Wed pm	Thursday	Fri am	Fri pm	Sat am	Sat pm
	QTR Registration 12:00-18:00 Reception 19:00	**RGS** Registration (am only) Plenary Symposium 09:00	**QTR** **Posters** 17:15 – 18:15 Bar 17:00 – 21:00 (each day)		**QTR** **Posters** 17:15 – 18:15 **RGS** Public Lecture 19:30	**QTR** **Posters** 17:15 – 18:15 **NHM** Reception and Dinner 19:00/19:30		**QTR** **Posters** 17:15 – 18:15		
Flett Lecture Theatre, NHM			**S15** Palaeozoic climate	**S1** Lyell Symposium – geological and fossil records and biodiversity			**S5** Palaeontological collections		**S27D** Open Symposium – arthropods and exceptional preservation	
1.31 RSM			**S23** Palaeontology of China	**S23** Palaeontology of China		**IPA General Assembly** 16:30	**S2** Macroevolution and the modern synthesis		**S21** Phylogenetic approaches to large-scale events	**S16** Rates of morphological evolution
1.47 RSM			**S12** Chemosynthetic Communities	**S20** Taphonomy of skeletons and soft tissues		**W2** (am) **W10** (pm)	**S22** Vertebrate dentitions	**S18** Teeth to Tibet	**S8** Great Ordovician Biodiversification event	
Pippard Lecture Theatre							**S4** Microfossils & the tree of life			
1.51 RSM			**S7** Brachiopods	**S9** Devonian bivalves		**W4** (am) **W7** (pm)	**S24** Life on land		**S27C** Open Symposium - Palaeobotany	
2.28 RSM			**S10** Geomicrobiology	**S19** Major transitions in the early evolution of life	**S27A** Open Symposium - Vertebrates	**W1**(am/pm)	**S14** Molecular Palaeontology		**S13** Biotic recovery after mass extinction events	
G20 RSM			**S17** Functional Morphology	**S3** Micropalaeontological record of global change		**W6** (am) **W9** (pm)	**S27B** Open Symposium – General palaeontology			
G41 RSM				**S6** Palaeontological data analysis		**W5** (am) **W2/W6**(pm)	**S26** Time-specific facies			
G20 RSM						**W6** (am) **W9** (pm)				
G38 RSM						**W3** (pm)				
G39 RSM						**W8**(am/pm)				

Programme

All sessions will be held in Imperial College and The Natural History Museum *except* for the morning of Tuesday 29th June and the public lecture on Wednesday evening 30th June which will be held at the Royal Geographical Society.

Tuesday 29th June

Ondaatje Theatre, Royal Geographical Society

09:00 **Welcome and opening remarks:**

Professor Richard Aldridge, President, The Palaeontological Association

Sir Keith O'Nions, Acting Rector, Imperial College

Professor Norman MacLeod, Keeper of Palaeontology, The Natural History Museum

Chair: Richard Aldridge

09:15 *Wolfgang Kiessling*
Evolutionary regulation of biodiversity in the oceans

09:45 *Emily Rayfield*
From rock to reality? multiple approaches to functional analysis in fossils

10.15 COFFEE/TEA

Chair: David Harper

10:45 *Gene Hunt*
The fossil record of microevolution

11:15 *Geoffrey Eglinton*
Biomolecular palaeobotany – molecular records of continental vegetation in the Quaternary

11:45 *Svante Pääbo*
A molecular perspective on human origins

12.15 LUNCH ***Queens Tower Rooms, Imperial College***

Lecture Theatre 1.51, Imperial College

S7- Origin, evolution and phylogeny of the Brachiopoda

Chairs: David Harper and Rong Jiayu

13.45 **Keynote -** *Lars E. Holmer, Christian B. Skovsted, Zhang Zhifei, Glenn A. Brock and Leonid E. Popov*
Brachiopod phylogeny in the Cambrian

14.15 *Michael G. Bassett, Leonid E. Popov and Lars E. Holmer*
Craniiformea and their position within crown group brachiopods

14.30 *Zhang Zhifei and Lars E. Holmer*
Soft-tissue preservation in the early Cambrian brachiopods from the Chengjiang fauna of China and its implications

14.45 *Glenn A. Brock, Christian B. Skovsted, Lars E. Holmer, Timothy P. Topper, James L. Valentine and John R. Paterson*
Bioherms and boundstones, crypts and channels - the palaeoenvironment of Early Cambrian stem group brachiopods from Southern Australia

15.00 *Robert A. Henderson and Alison L. Dann*
Adaptive limits: evolutionary constraints for linguliform brachiopods

15.15 COFFEE/TEA

15.45 *Ian G. Percival*
A brief history of trimerellide brachiopods, and the role of pentamerides and megalodont bivalves in their demise

16:00 *Leonid E. Popov, Michael G. Bassett and Lars E. Holmer*
Ontogeny of early Palaeozoic rhynchonelliform brachiopods and its application for understanding brachiopod phylogeny

16.15 *Chen Xiuqin*
Devonian spiriferids in South China: characters and evolution

16.30 *Mena Schemm-Gregory*
New implications for the life habit of *Cyrtina* (Brachiopoda, Lower Devonian)

16.45 *Lucia Angiolini, Michael Stephenson, Melanie Leng, Flavio Jadoul, Dave Millward, Anthony Aldridge, Julian Andrews, Simo Chenery and Gareth Williams*
Seasonal profiling in a Mississippian gigantoproductid shell of palaeoequatorial Britain

17.00 *Luliana Lazar, Marius Stoica, Dumitru Roban Relu and Michael R. Sandy*
Occurrence of the enigmatic brachiopod *Peregrinella* from hydrocarbon-seep suspect sites in the Sinaia Formation, latest Hauterivian, Eastern Carpathian Mountains, Romania

Lecture Theatre 2.28, Imperial College

S10 - Geomicrobiology at critical periods of Earth History

Chair: **Xie Shucheng**

13:45 **Keynote -** *Roger E. Summons, Christian Hallmann, Jacob R. Waldbauer and Laura Sherman*
The cloud paradigm: geostable molecules as proxies for surface oxygenation

14:15 *David J. Bottjer*
Microbial sedimentary structures at critical intervals in Earth history

14:30 *Frances Westall and Barbara Cavalazzi*
A morphological, mineralogical, geochemical, and isotopic study of a 3.3 Ga photosynthetic microbial mat from Barberton, South Africa

14:45 *Martin Brasier, Leila Battison, Sean McMahon and David Wacey*
Early life, the phosphorus cycle and the 1900 Ma gunflint chert

15:00 *Wang Hongmei, Zeng Cuiping, Liu Qianying, Liu Deng, Qiu Xuan and Gong Linfeng*
Bacterially induced calcium carbonate precipitation and its implication for microbialite formation

15:15 COFFEE/TEA

Chair: Roger Summons

15:45 *Elena Naimark and Elena Kompantseva*
Changes in Mg ratios of silicate minerals related to interactions with purple nonsulfur bacteria

16:00 *Jia Chengling, Huang Junhua, Enzo Farabegoli, Cristina M. Perri and Xie Shucheng*
Variations of algae and bacteria during the end-Permian biotic crisis in the Bulla section, Italy

16:15 *Luo Genming, Wu Wenjun, Kliti Grice, Wang Yongbiao, Yang Hao and Xie Shucheng*
Change in microbial ecosystems after the end-Permian mass extinction: evidence from biomarkers of microbialite in South China

16:30 *Kliti Grice, Birgit Nabbefeld, Richard Twitchett, Roger Summons, Lindsay Hays, Kenneth Williford, Jennifer Mcelwain, Pierre Le Metayer, Michael Böttcher and Arndt Schimmelmann*
Biomarker distributions and isotopic signals associated with the Permian/Triassic and Triassic/Jurassic mass extinction events: a global perspective

16:45 *Yang Huan, Ding Weihua, Wu Xia, Ma Xiufeng, He Gangqiang, Huang Junhua, Hu Chaoyong and Xie Shucheng*
The occurrence of archaeal and bacterial tetra-ether membrane lipids in stalagmites, dripping water and overlying soils in central China

17:00 *Qin Yangmin, Yang Xiangdong and Xie Shucheng*
Ecology of testate amoebae in lakes of Middle Yangtze Reaches and their potential as water quality indicators

Lecture Theatre 1.47, Imperial College

S12 - Chemosynthetic Communities: palaeoecology, systematics and evolutionary history

Chairs: Cris Little and Kathleen Campbell

13:45 **Keynote -** *Jörn Peckmann*
Molecular palaeontology of seep ecosystems

14:15 *Hans Arne Nakrem, Øyvind Hammer, Jørn H. Hurum and Crispin T.S. Little*
A hydrocarbon seep fauna from the uppermost Jurassic of Spitsbergen, Svalbard

14:30 *Michael Sandy, Jörn Peckmann and Steffen Kiel*
Fossil brachiopods from chemosynthesis-based environments: a review

14:44 *Robert Jenkins and Andrzej Kaim*
Caspiconchiid bivalves: widespread occurrences in Late Mesozoic cold-seeps

15:00 *Kathleen A. Campbell, Elizabeth A. Nesbitt and Julie V. Rowlan*
Tectonic controls on Pacific Rim seep distributions in time and space

15:15 COFFEE/TEA

15:45 *Kristian P. Saether, Crispin T.S. Little and Kathleen A. Campbell*
The fossil fauna of Miocene cold seep carbonates, North Island, New Zealand

16:00 *Takami Nobuhara*
Comparative taphonomy of vesicomyid and bathymodiolin bivalves from the Mid-Miocene methane-seep limestones in the Bessho Formation, central Japan

16.15 *Marco Taviani, L. Angeletti, A. Ceregato, C. Froglia and F. Trincardi*
Recently discovered chemosynthetic assemblages from a pockmark system in the Strait of Sicily and their bearing on composition, evolution and biogeography of the Mediterranean deep water cold seeps

16.30 *Kazutaka Amano*
Depth-related ecologic structure in fossil cold-seep and whale-fall communities in Japan

16.45 *Nicholas D. Higgs, Adrian G. Glover, Thomas G. Dahlgren and Crispin T.S. Little*
Identifying *Osedax* traces on fossil whale falls

17.00 *Danise Silvia, B. Cavalazzi, S. Dominici, S. Monechi, F. Westall, B. Schmitz and S. Guioli*
Evidence of microbial activity in a Miocene whale carcass from shallow water sediments (Voghera, Northern Italy)

Flett Lecture Theatre, NHM

S15 - Modelling the climate of Palaeozoic Earth

Chairs: Mark Williams and Jan Zalasiewicz

13:45 **Keynote** - *Jeffrey T. Kiehl and Christine A. Shields*
Simulating icehouse and greenhouse climates of the Palaeozoic

14:15 *Mark A. Woods, Philip R. Wilby, Melanie J. Leng, Adrian W.A. Rushton and Mark Williams*
A high resolution record of the Late Cambrian SPICE event on Avalonia: causes and affects

14:30 *Elise Nardin, Guillaume Le Hir, Emilie Beaulieu, Yves Goddéris and Yannick Donnadieu*
Links between climate, bioproductivity and biodiversification during the Early Palaeozoic

14:45 *Thijs R.A. Vandenbroucke, Howard A. Armstrong, Mark Williams, Florentin Paris, Jan A. Zalasiewicz, Koen Sabbe, Jaak Nõlvak and Thomas J .Challands*
Chitinozoan biotopes, climate belt contraction and Polar Front shift towards the Hirnantian (440 Ma) glaciation

15:00 *Howard Armstrong and Thijs R.A. Vandenbroucke*
Reconstructing Ordovician climate from the distribution of radiolarian cherts: was cooling the cause of the Great Ordovician Biodiversification?

15:15 COFFEE/TEA

Chairs: Howard Armstrong & Thijs Vandenbroucke

15:45 *Andrea M. Snelling, Melanie J. Leng, Jan A. Zalasiewicz, Christopher C. Kendrick and Alex A. Page*
Carbon isotope composition of graptolite periderm and whole-rock from the Aeronian (Silurian, Llandovery) in Wales and Scotland and its use in chemostratigraphy

16:00 *Vincent Lefebvre, Olivier Averbuch, Louis François, Thomas Servais, Laurent Riquier and Nicolas Tribovillard*
Climate and environmental changes at the Frasnian-Famennian boundary : A global carbon cycle modelling approach

16:15 *Carys E. Bennett, Mark Williams, Sarah J. Davies, Melanie J. Leng and David J. Siveter*
The Ostracod terrestrialisation event in the Mississippian

16:30 *Milo Barham, John Murray and Michael D. Williams*
The onset of the Carboniferous glaciation – stable isotope evidence from Ireland

16:45 *Michael H. Stephenson, Lucia Angiolini, Pedro Cózar, Flavio Jadoul, Melanie J. Leng and David Millward*
Northern England Serpukhovian (Early Namurian) farfield brachiopod and plant isotope responses to Southern Hemisphere glaciation

17:00 *Matthew E. Clapham*
Marine faunal constraints on temperature and ocean circulation changes in the Permian

S17 - Functional morphology at the intersection between biology and engineering

Chair: Phil Anderson

13:45 **Keynote -** *Peter W. Lucas and Paul Constantino*
The role of fracture mechanics for analysing dental function and adaptation

14:15 *Colin Palmer*
Engineering the flight of pterosaurs

14:30 *David W. Bapst*
Using sinking experiments to understand graptoloid function

14:45 *Jen A. Bright*
The role of cranial sutures in validated finite element models of the domestic pig

15:00 *Ivan Calandra, Ellen Schulz and Thomas M. Kaiser*
Dental functional morphology of hoofed mammals: insights from 3-D microtexture analysis

15:15 COFFEE/TEA

Chair: Colin Palmer

15:45 *Aude G.M. Caromel, Daniela N. Schmidt, Emily J. Rayfield and Jeremy C. Phillips*
A link between form and function in planktic foraminifera?

16:00 *David Casenove, Taichiro Goto and Jean Vannier*
Morphological adaptations to a pelagic lifestyle in Early Cambrian chaetognaths

16:15 *Alex G. Janevski and Tomasz K. Baumiller*
Functional morphology of swimming crinoids

16.30 *David Jones and Alistair Evans*
Functional morphology of the earliest vertebrate feeding structures

16.45 *Marc E.H. Jones, Neil Curtis, Susan E. Evans, Shi Junfen, Paul O'Higgins and Michael J. Fagan*
Modelling muscle structure and activity in vertebrate skulls: implications for the analysis of extinct taxa

17:00 *Philip S.L. Anderson*
Complex structure in early jaw systems: linkage kinematics of arthrodire placoderms

17:15 *Laurent Darras, Mark A. Purnell, Paul J.B. Hart and Ralph G.Turingan*
Investigating the diet of extant and fossil fishes through microtextural analysis of teeth

S23 - Recent discoveries and advances in the palaeontology of China

23a: Doushantuo, Chengjiang and Kaili

Chairs: Zhu Maoyan and Hou Xianguang

13:45 **Keynote -** *Xiao Shuhai, Yuan Chuanming, Zhou Xunlai and Jiang Ganqing*
Paleobiology of the Ediacaran Doushantuo Formation: current controversies on early animals and their environments

14:15 *Zhang Xingliang*
Appendiculate nature of the jaw apparatus of anomalocaridids: with a discussion on the origin of arthropod mouthparts

14:30 *Ma Xiaoya, Hou Xianguang, Richard Aldridge, David Siveter and Derek Siveter*
Evidence of possible parasitic worms from the Lower Cambrian Chengjiang Lagerstätte

14:45 *Cong Peiyun, Hou Xianguang, Li Yizhen and Yang Jie*
The segmentation of yunnanozoans

15:00 *Zhao Fangchen, Zhu Maoyan and Hu Shixue*
The community structure and composition of the Cambrian (series 2) Chengjiang fauna, SW China

15:15 COFFEE/TEA

15:45 *Liu Jianni, Ou Qiang, Shu Degan, Han Jian, Zhang Zhifei, Wan Xiaoqiao and Lei Qianping*
New insights into the lobopods from the Cambrian Chengjiang Lagerstätte

16:00 *Lin Jih-Pai, Zhao Yuanlong, Imran A. Rahman, Xiao Shuhai and Wang Yue*
Bioturbation and Burgess Shale-type preservation: case study of trace fossil-body fossil association from the Kaili Biota (Cambrian Series 3), Guizhou, China

16:15 *Javier Ortega-Hernández, Thomas H.P. Harvey, Lin Jih-Pai, Zhao Yuanlong and Nicholas J. Butterfield*
Exceptional carbonaceous microfossil from the middle Cambrian Kaili Formation, South China

23b: Extinctions, radiations and other bio-events: cases from China

Chairs: Wang Xiangdong and Liu Jianbo

16:30 *Shen Shuzhong and Wang Yue*
The end-Permian mass extinction: a single- or two-phase extinction?

17:00 *D.P.G. Bond, P.B. Wignall,Y.-D. Sun, X.-L. Lai., H.-S. Jiang and W. Wang*
Precise coincidence of mass extinction and volcanism in the middle Permian of China: microfossil and carbon isotope records from the Emeishan LIP

17:15 - 18:15 **POSTER SESSION**

Symposium 7 - Brachiopods

Giuseppe Buono
New implications of ensiform crura and chemosynthesis-based environments of the dimerelloidea (Brachiopoda)

Giuseppe Buono
Toarcian (late early Jurassic) Tethyan brachiopods: palaeobiogeography and response to relative sea level fluctuations

Giuseppe Buono, Luis-Felipe Opazo, Brett Metcalfe, Mena Schemm-Gregory and Richard J. Twitchett
Paleobiogeographical and paleoecological brachiopod trends during the Permian Triassic (P-Tr) and Triassic-Jurassic (Tr-J) mass extinctions events

Sarah Long, Martin Munt and Lindsay Percival
A diagnostic key to the recent brachiopods

Bernard Mottequin and Denise Brice
Plicathyridine brachiopods from the Frasnian (Upper Devonian) of the Middle East and Belgium

Alexis Rojas Briceño and Aaron O'Dea
Morphology and ecology of recent brachiopod assemblages from the Caribbean coast of Panama

Mena Schemm-Gregory
New implications for the life habit of *Cyrtina* (Brachiopoda, Lower Devonian)

James Zambito and Mena Schemm-Gregory
Revised taxonomy and interpretation of life position for the brachiopod genus *Ambocoelia* in the Middle and Upper Devonian Appalachian Basin of New York State

James Zambito and Mena Schemm-Gregory
A new species of *Ambocoelia* (Brachiopoda) from the Middle Devonian (*ensensis* zone) silica shale of Northwestern Ohio, USA

Symposium 10 - Geomicrobiology

Chen Lin, Wang Yongbiao, Xie Shucheng, Stephen Kershaw, Dong Man, Yang Hao, Liu Hao and Thomas J. Algeo
Molecular records of microbialites following the end-Permian mass extinction in Chongyang, Hubei Province, South China

Huang Xianyu and Xie Shucheng
Microbially-mediated diagenesis of plant triterpenoids in peatland

Liao Wei, Wang Yongbiao and Weng Zeting
Pyrite framboids in microbialites across the Permo-Triassic boundary: evidence for the presence of abundant sulfate reducing bacteria

Adam Moolna, Michaël Hermoso and Rosalind E.M. Rickaby
Relaxation of carbon concentrating mechanism physiology in the coccolithophore *Gephyrocapsa oceanica* with raised dissolved inorganic carbon levels

Ruan Xiaoyan, Gu Yansheng, Huang Junhua and Xie Shucheng
Molecular records for spatial and temporal variations of cyanobacterial blooms in response to lacustrine eutrophication in Central China

Symposium 12 - Chemosynthetic communities

S. Danise, S. Dominicim, T.G. Dahlgren and A.G. Glover
Chemosymbiotic mollusks from recent and fossil shallow water whale falls

Symposium 15 - Palaeozoic climates

Tatyana K. Dimitrova and Ellen Stolle
Tracking palynological species as climate indicators in the latest Permian of Bulgaria and NW Turkey

Mohibullah Mohibullah, Mark Williams, David J. Siveter, Jan A. Zalasiewicz, Tonu Meidla and Laura J. Tilley
Response of the Laurentian ostracod fauna to global climate change during the early Palaeozoic icehouse

Firuza A. Salimova, Natalya A. Meshchankina and Firdaus S. Karimova
The Ordovician-Silurian transition in the Zerafshan-Hissar region, South Tien Shan

Thijs R.A. Vandenbroucke, Mark Williams, Melanie Leng, Richard A. Fortey, Julian E. Andrews, Clare Torney, Alex A. Page, Howard A. Armstrong and Alan W. Owen
Drilling the eyes out of trilobites: first results from stable isotope analyses of Ordovician *Carolinites*

Symposium 17 - Functional morphology

Antonino Briguglio and Johann Hohenegger
Functional test morphology of larger benthic foraminifera: biometric quantification by x-ray microtomography

Josep Fortuny, Jordi Marcé-Nogué, Lluis Gil and Àngel Galobart
Biomechanical analysis in capitosaur (Amphibia: Temnospondyli) skulls

Juan P. Gailer, Ivan Calandra and Thomas M. Kaiser
Three-dimensional functional quantification of ruminant occlusal patterns – an approach using industrial metrology systems

Konomi Morimoto and Yutaro Suzuki
Experimental confirmation on center of buoyancy and gravity in *Nautilus*; relationship with statocyst position

B. Schoenemann and E.N.K. Clarkson
Modern functional principles in ancient eyes (eyes of phacopid trilobites)

Symposium 19 - Major transitions

Jorge Esteve, Frederick Sundberg, Samuel Zamora and Rodolfo Gozalo
New Alokistocaridae (Altiocculinae, Trilobita) from the Middle Cambrian of Spain

Thomas H.P. Harvey, Dong Xiping and Philip C.J. Donoghue
Are palaeoscolecids ancestral ecdysozoans?

Takafumi Mochizuki and Tatsuo Oji
Rapid diversification of ichnofossils in the earliest Cambrian

Nora Noffke
Biostabilization properties of microbial mats in sandy marine environments

Roger D.K. Thomas, Jakob Vinther and Kerry Matt
Structure and evolutionary implications of finely preserved chaetae associated with *Pelagiella*, a stem-group gastropod from the Kinzers formation (Early Cambrian) at Lancaster, Pennsylvania

Symposium 23 - Palaeontology of China

Cheng Yeming
A new species of *Ashicaulis* (Osmundaceae) from the Mesozoic of China and its implication for relationships amongst *Ashicaulis, Millerocaulis* and *Osmunda*

Han Jian, Zhang Zhifei, Liu Jianni and Shu Degan
New anatomical data on the selkirkiids from the Lower Cambrian of Chengjiang, South China

Hu Shixue, Zhang Qiyue, Zhou Changyong, Lv Tao, Xie Tao and Wen Wen
Anew exceptionally preserved biota from the Middle Triassic of SW China

Jiang Baoyu, Franz T. Fürsich, Sha Jingeng, Wang Bo and Niu Yazhuo
A caldera-lake origin for the famous early Cretaceous fossillagerstätten in Sihetun, Western Liaoning, NE China

Li Guoxiang, Michael Steiner and Zhu Maoyan
Cambrian *Mongolitubulus*-like sclerites: spines of different arthropod fossils

Liu Qi, Hu Shixue, Gong Yiming, Zhang Ze and Zeng Guangchun
Palaeozoic non-lithistid sponges from China: review and recent progress

Liu Yan and Zhang Zhaoqun
New material of *Chalicotherium brevirostris* (Perissodactyla, Chalicotheriidae) from the Tunggur Formation, Inner Mongolia

Majid Mirzaie Ataabadi and Spencer G. Lucas
First tetrapod tracks from the Carboniferous of China

Wang Qiang, Zhao Zikui, Wang Xiaolin, Zhang Shukang and Jiang Yangen
Revision of the oofamily dictyoolithid dinosaur eggs

Wang Yongdong
***In situ* spores of two dipteridaceous ferns from the Jurassic of China and their evolutionary implications**

Xu HongHe, Christopher M. Berry and Wang Yi
The Middle Devonian flora of Xinjiang, China: new evidence of diversity and palaeogeography

Zhang Lanlan, Chen Muhong, Xiang Rong, Zhang Jianlin and Liu Changjian
Distribution of polycystine radiolarians in the northern South China Sea in September 2005

Zhang Qiyue, Hu Shixue, Zhou Changyong, Lu Tao, Xie Tao and Wen Wen
Occurrence of horseshoe crab fossils from the Middle Triassic of SW China

Zhang Zhifei, Hu Shixue, L.E. Holmer and C.B Skovsted
New occurrence of soft-tissue preservation in Brachiopods from the Lower Cambrian Wulongqing Formation (series 2, stage 4) of Yunnan, Southern China

Zhu Maoyan and James G. Gehling
More ediacara-type fossils from the black shale of the upper Doushantuo Formation, Guizhou, China

Symposium 27B - General Palaeontology

Andrés S. Rigual-Hernández, María A. Bárcena, Francisco J. Sierro, José A. Flores, Iván Hernández-Almeida and Serge Heussner
Seasonal, interannual and geographical distribution of silicoflagellate fluxes in the Western Mediterranean

Wednesday, 30 June

Flett Lecture Theatre, NHM

S1 - The Lyell Symposium - Comparing the rock and fossil records: implications for biodiversity studies

Chair: Andrew Smith

09:00 **Keynote -** *Shanan E. Peters*
Macrostratigraphy and macroevolution in marine environments: testing the common-cause hypothesis

09:30 *Bjarte Hannisdal*
Inferring causal relationships between geological and fossil records

09:50 *Alistair J. McGowan, Paul M. Barrett, Jennifer Bow, Richard J. Butler, Guy J. Harrington and Phillip E. Jardine*
Disentangling signals of regional biodiversity change from geological and sampling biases

10:10 *Alexander M.Dunhill*
Using remote sensing and a GIS to quantify rock exposure area in the United Kingdom: implications for palaeodiversity studies

10:30 COFFEE/TEA

Chair: Paul Upchurch

11:00 **Keynote -** *James S. Crampton, Alan G. Beu, Roger A. Cooper and Michael Foote*
Diversity dynamics of endemic molluscs on a mobile margin: sorting the actual from the apparent

11:30 *Martin Zuschin, Mathias Harzhauser and Oleg Mandic*
Disentangling palaeodiversity signals from a biased sedimentary record: an example from the Lower to Middle Miocene of central Paratethys

11:50 *Lesley Cherns and Paul V. Wright*
Skeletal mineralogy and biodiversity of marine invertebrates

12:10 *Austin J.W. Hendy*
Just how good is the Cenozoic fossil record? Applications of environmental coverage, geographic range, and body size data to test spatial and temporal completeness

12:30 LUNCH

Chair: Matthew Wills

13:45 **Keynote -** *Michael J Benton*
The quality of the vertebrate fossil record and geological record

14:15 *Paul Upchurch and Philip D Mannion*
Geological and anthropic controls on the sampling of the terrestrial fossil record: a case study from the Dinosauria

14:35 *Patrick D. Wall, Linda C. Ivany and Bruce H. Wilkinson*
Impact of outcrop area on estimates of Phanerozoic terrestrial biodiversity trends

14:55 *Roger B.J. Benson and Richard J. Butler*
Mesozoic marine tetrapod diversity: temporal and ecological heterogeneity in sampling biases and insights into the 'common cause' hypothesis

15:15 COFFEE/TEA

Chair: Alistair McGowan

15:45 **Keynote -** *Anthony D. Barnosky, Marc A. Carrasco and Russell G. Graham*
Calibrating the 'sixth mass extinction' for mammals

16:15 *David Lazarus*
The deep-sea microfossil record: potential and current data quality

16:35 *Graeme T. Lloyd, Andrew B. Smith and Jeremy R. Young*
Comparing rock and fossil records in the deep sea

16:55 *Matthew A. Wills and Anne O'Connor*
What do cladistically implied ghost ranges tell us about the fossil record?

Lecture Theatre - G20, Imperial College

*S*3 - The micropalaeontological record of global change

Chair: Tom Dunkley Jones

09:00 **Keynote –** *Luc Beaufort, Nicolas Barbarin, Antoine Bouvet, Thibault de Garidel-Thoron, Fabienne Regoli, Noëlle Buchet, Yves Gally, Zhimin Jian, Liming Ye and André Droxler*
Changes of late Pleistocene nannoplankton calcification in response to ocean carbonate chemistry

09:30 *Michaël Hermoso, Fabrice Minoletti, Rosalind E.M. Rickaby, Stephen P. Hesselbo and Hugh C. Jenkyns*
Calcareous nannofossil "blackout" and seawater acidification prior to the Early Jurassic giant perturbations to the carbon cycle

09:45 *Daniela N. Schmidt, Andy J. Ridgwell, Simone A. Kasemann and Ellen Thomas*
Quantifying ocean acidification during the PETM

10:00 *Jorijntje Henderiks, Bjarte Hannisdal, Rosalind E.M. Rickaby, Lee Hsiang Liow, Trond Reitan and Tore Schweder*
Phytoplankton size: climatic adaptation and long-term evolution

10:15 Andy Ridgwell
The global change record of micropalaeontology

10:30 COFFEE/TEA

Chair: Taniel Danelian

11:00 *Luke Mander, Wolfram M. Kürschner and Jennifer C. McElwain*
Response of terrestrial vegetation to Triassic-Jurassic climate change in East Greenland

11:15 *Oliver Friedrich, Silke Voigt, Jochen Erbacher and Richard D. Norris*
Long- and short-term benthic foraminiferal response to ocean anoxia

11:30 *Samantha J. Gibbs and Paul R. Bown*
Background versus event-level biotic variability

11:45 *Rachel Jamieson*
The North Sea record of vegetation change during the Palaeocene/Eocene thermal maximum (PETM)

12:00 *Phillip E. Jardine and Guy J. Harrington*
How significant was the PETM for driving paratropical floral turnover in the early Palaeogene?

12:15 *Peter Stassen, Ellen Thomas and Robert P. Speijer*
Earliest Eocene environments along the New Jersey coastal plain (US)

12.15 LUNCH

Chair: Tom Dunkley Jones

13.45 *M. Vecoli and P.K. Strother*
Changing atmospheric CO_2 and the evolution of Palaeozoic phytoplankton: causes and consequences

14:00 *Aurélien Delabroye, Marco Vecoli, Axel Munnecke, André Desrochers, Michael Joachimski and Paul Copper*
Phytoplankton dynamics during perturbations across the Ordovician-Silurian transition of the low latitude carbonate platform from Laurentia (Anticosti Island, Canada)

14:15 *Mihaela C. Melinte-Dobrinescu and Marcos-Antonio Lamolda*
Calcareous nannofossil fluctuation in the Tethyan realm during the Oceanic Anoxic Event 2 (OAE2)

14:30 *Delphine Desmares and Danièle Grosheny*
Coeval microevolution of two Upper Cenomanian planktonic foraminifera genera in response to Oceanic Anoxic Event

14:45 *Valentina S. Vishnevskaya*
Some Jurassic and Cretaceous warm and cool greenhouse regimes based on radiolarians and ammonites

15:00 *M. Kucera*
Origin of modern planktonic foraminifera and their resilience to climate change

15:15 COFFEE/TEA

Chair: Taniel Danelian

15:45 *James R. Wheeley, Paul M. Smith and Ian Boomer*
Conodonts as palaeothermometers in ancient oceans: tests and limitations

16:00 *Živilė Žigaitė, Alberto Pérez-Huerta and Michalel M. Joachimski*
Palaeozoic vertebrate microfossils: stable isotope and elemental geochemistry in palaeoclimate studies

16:15 *Simon D'haenens, André Bornemann, Ursula Röhl and Robert P. Speijer*
Detection and characterization of Early Eocene hyperthermals using benthic foraminiferal associations and stable isotopes

16:30 *Daan Vanhove, Peter Stassen, Robert P. Speijer and Etienne Steurbaut*
Paleotemperature and seasonality during the Early Eocene climatic optimum (EECO): evidence from stable O and C isotope profiles of fish otoliths from Belgium

16:45 *Matthew J. Pound, Alan M. Haywood and Ulrich Salzmann*
Global vegetation and modelling Neogene climates

17:00 *Jennifer Pike*
Marine diatom response to the last deglaciation of Antarctica

S6 - Palaeontological Data Analysis

Chair: Norman MacLeod

09:00 *Carlos Martínez-Pérez, H. Botella and B. Cascales-Miñana*
Large-scale palaeontologial data analysis of the conodonts fossil history

09:15 *Marina L.Aguirre, Donato Mariano, Sebastián M. Richiano and Ester A. Farinati*
Molluscan palaeobiodiversity and palaeobiogeography: Pleistocene and Holocene interglacial assemblages from Bonaerensian and Patagonian littoral (SW Atlantic)

09:30 **Keynote -** *David D. Polly*
Quantitative approaches to geographic variation: environment, palaeophylogeography and ecometrics

10:00 *Alex G. Janevski*
A likelihood approach to detecting extinction selectivity

10:15 *Sylvain Gerber*
Developmental morphological disparity: a brief overview

10.30 COFFEE/TEA

11:00 *Borja Cascales-Miñana*
Discontinuities and disparity of the Palaeozoic plant fossil record: a global mutlivariate analysis

11:15 *Julien Louys, Carlo Meloro, Sarah Elton, Peter Ditchfield and Laura C.Bishop*
Quantitative approaches in palaeosynecology: correlating community structure with habits

11:30 *Ian J. Corfe, E. Harjunmaa, E. Seiffert, D. Boyer, L. Säila and J. Jernvall*
Quantitative developmental tinkering and soft-tissue 3D nano-ct scanning offer developmental insight into palaeontological phylogenetics

11:45 *Alexander Markov and Elena Naimark*
The Phanerozoic history of the latitudinal diversity gradient in the marine realm

12:00 *Pablo Turrero, Miguel Arbizu and Eva García-Vázquez*
The oldest palaeontologists: on using our ancestors as involuntary samplers for palaeontological studies

12:15 *Majid Mirzaie Ataabadi, Jussi T. Eronen, Liu Liping, Aleksis Karme and Mikael Fortelius*
A method for visualization of similarity/disparity analysis

12:30 LUNCH

13:45 *James W. Atwood, Colin D. Sumrall and Michael L. McKinney*
Discriminating blastoid species using 3D morphometrics

14:00 *Elina Hernesniemi, Kasimir Blomstedt and Mikael Fortelius*
Multi-view stereo 3D reconstruction of the lower molars of recent and north-western European Pleistocene rhinoceroses for the purpose of mesowear analysis

14:15 **Keynote -** *Philipp Mitteroecker*
Measuring modularity and morphological integration: examples from hominoid cranial morphology

14:45 *Luis Azevedo Rodrigues, Josep Daunis-I-Estadella, Gloria Mateu-Figueras and Santiago Thió-Henestrosa*
Limbs in compositional morphospaces: prior and new approaches

15:00 *Norman MacLeod*
Discrimination between three Pleistocene *Astarte* species (Bivalvia, Astartidae): taxonomic and morphometric implications

15:15 COFFEE/TEA

15:45 *Javier Echevarría*
Morphological change through time in *Pterotrigonia* (Trigonioida – Bivalvia) from Picún Leufú Formation (Lower Cretaceous, Neuquén Basin)

16:00 *Takao Ubukata*
A hypersherical theoretical morphospace for molluscan shell forms

16:15 *Marina L. Aguirre, SergioI Perez and Ester A. Farinati*
Morphometric analyses of *Mactra* Linné (Bivalvia) from the marine Quaternary of Argentina (southwestern Atlantic)

16:30 *Chloe L. Marquart and David B. Norman*
The bare bones of it: does morphometric analysis of osteological variation in the skulls of extant crocodilians give biologically congruent definitions of inter and intraspecific variation?

16:45 *Carlo Meloro*
What was on the carnivores' menu 2 million years ago? Multiple evidence from mandibular form

17:00 *Shawn B. Whiteman, Michael D. Carleton and Gene Hunt*
Wisdom teeth: a study of morphological variation of woodrat (Neotoma) molars using geometric morphometrics

Lecture Theatre 1.51, Imperial College

S9 - Devonian bioevents: timing, palaeoecological and evolutionary patterns

Chairs: Thomas Becker and José Valenzuela-Ríos

09:00 **Keynote –** *Sandra I. Kaiser*
The global Hangenberg crisis at the Devonian-Carboniferous boundary – a review of the 6th first order mass extinction

09:30 *Markus Aretz and Hans-Georg Herbig*
Post-Hangenberg biovents: an inventory of Mississippian bioevents

09.45 *Carlo Corradini, Sandra I. Kaiser, Maria Cristina Perri and Claudia Spalletta*
Conodont genus *Protognathodus* as a possible tool for recognizing the Devonian/ Carboniferous boundary

10:00 *Hanna Matyja, Krzysztof Malkowski, Katarzyna Sobien and Marzena Stempien-Salek*
Devonian – Carboniferous boundary in Poland: conodont and miospore successions and event stratigraphy

10:15 *John E.A. Marshall*
The Late Devonian and Early Carboniferous terrestrial climatic record

10.30 COFFEE/TEA

11:00 *Nilyufer Gibshman and Svetlana Nikolaeva*
Ammonoid and foraminiferal faunas from the Famennian of Western Kazakhstan: depth control distribution on a carbonate ramp

11:15 *Nadezhda G. Izokh*
Upper Devonian conodonts of West Siberia, Russia

11:30 *Svetlana Nikolaeva and Vladimir Pazukhin*
Ammonoids and conodonts from the Frasnian and Famennian of the western slope of the South Urals: stratigraphy and paleogeography

11:45 *Qi Feng, Yiming Gong and Robert Riding*
Frasnian-Famennian decline in calcified algae and cyanobacteria, South China

12:00 *Edouard Poty and Bernard Mottequin*
Sea-level changes, Kellwasser horizons and coral - brachiopod crises during the late Frasnian in the Namur-Dinant Basin (Belgium)

12:15 *Michael L. Tuite, Stephen A. Macko and Sarah R. de la Rue*
The ecology of upper Kellwasser productivity

12:30 LUNCH

Chairs: Thomas Becker and John Marshall

13:45 *Marina S. Afanasieva and Edward O. Amon*
Temporal and spatial distribution of radiolarians in the Devonian

14:00 *Marina S. Afanasieva, Svetlana Nikolaeva and Vera Konovalova*
Frasnian radiolarians and ammonoids in the Timan-Pechora Basin: an ecological dimension

14:15 *William T. Kirchgasser, Gordon C. Baird, Jeffrey D. Over, Carlton E. Brett and Thomas R. Becker*
Konzentrat Lägerstatte of the goniatite *Naplesites* marking a global transgresssion event (Upper Devonian, *Mesobeloceras* genozone) in the Rhinestreet Shale, western New York

14:30 *Thomas R. Becker, Sarah Z. Aboussalam, Sven Hartenfels and Ahmed El Hassani*
An update of Middle/Upper Devonian global events in southern Morocco

14:45 *Olga V. Artyushkova and Victor A. Maslov*
Conodonts imprints from volcanogenic-siliceous deposits – an important palaeontological base for biostratigraphical subdivisions in folded areas

15:00 *José I. Valenzuela-Ríos and Liao Jau-Chyn*
Conodont biofacies and palaeoenvironment: a case study for the Middle and Upper Devonian of the Spanish Central Pyrenees

15:15 COFFEE/TEA

15:45 *James Zambito, Carlton E. Brett and Gordon C. Baird*
Quantitative analysis of the Late Middle Devonian (Givetian) Taghanic biocrisis in the type area (New York State Appalachian Basin) and throughout North America

16:00 *Françoise P. Bigey*
Bryozoan diversity in the Devonian of France and bioevents

16:15 *Aleftina L. Jurina and Marina G. Raskatova*
Effect of the Kačak event (Middle Devonian) in the Central Barrandian area on the development of the highest plants

16.30 *Rainer Brocke, Stanislava Berkyová, Petr Budil, Oldrich Fatka, Jiří Frýda and Eberhard Schindler*
The early Middle Devonian Choteč Event in the Barrandian area (Czech Republic): new insight from a phytoplankton bloom

16.45 *C.Dojen, Sarah Z. Aboussalam and Thomas R. Becker*
Effects of Lower/Middle Devonian Events on ostracodes from Morocco

17:00 *José I. Valenzuela-Ríos and Carlos Martínez-Pérez*
Pyrenean conodonts as a relevant tool for evaluating the Pragian/Emsian (Lower Devonian) boundary concepts

Lecture Theatre 2.28, Imperial College

S19 - Major transitions in the early evolution of life

Chairs: Stefan Bengtson and Nora Noffke

09:00 **Keynote –** *Andrew H. Knoll*
The major transitions in evolution: a physiological perspective

09:30 *Martin D. Brasier, D. Wacey and M. Kilburn*
Critical testing of the earliest fossil record on Earth

09:45 *Emmanuelle J. Javaux, Craig P. Marshall and Andrey Bekker*
Large organic-walled microfossils in Mesoarchean shallow-marine siliciclastic deposits

10:00 *Nora Noffke*
Turbulent lifestyle: cyanobacteria on Earth's sandy beaches – today and 3 billion years ago

10:15 *Crispin T.S. Little, John F. Slack, Tor Grenne, Andrey Bekker and Olivier J. Rouxel*
Filamentous microfossils in 1.74 Ga jaspers from Arizona: implications for Proterozoic ocean Oxygenation

10:30 COFFEE/TEA

11:00 *Stefan Bengtson*
Origins of multicellularity

11:15 *Martin D. Brasier, J. Antcliffe, A. Liu and L. Menon*
Making sense of the earliest 'animal' fossils

11:30 *Adam C. Maloof, Catherine V. Rose, Claire C. Calmet, Robert Beach, Bradley M. Samuels, Douglas H. Erwin and Frederik J. Simons*
Probable animal body-fossils from pre-Marinoan limestones, South Australia

11:45 *John R. Paterson, Mary D. Droser and James G. Gehling*
Anchors aweigh: rheotactic behaviour in the Ediacaran organism *Parvancorina*

12:00 *Emily G. Mitchell*
Feeding strategy models of Ediacaran communities

12:15 *Kirk L. Domke, Frank A. Corsetti and David J. Bottjer*
Regional patterns in the alteration of *Cloudina* in western North America

12:30 LUNCH

13.45 *Liam G. Herringshaw, Richard H.T. Callow and D. McIlroy*
The trace fossil record of ecosystem engineering

14:00 *Bertrand Lefebvre, Oldrich Fatka, Elise Nardin, Fleur Noailles and Bruno David*
The Cambrian substrate revolution and its impact on the diversification of echinoderms

14:15 *Katherine N. Marenco and David J. Bottjer*
A bioturbation-induced ecological transition: Quantitative evidence from the Lower Cambrian of California and Nevada, USA

14:30 *Oldrich Fatka, Petr Budil, Michal Szabad, Václav Micka and Martin Valent*
***In situ* feeding trilobites and hyolithids: their responsibility for the Cambrian substrate revolution**

14:45 *Jean Vannier*
Direct evidence for animal feeding relationships in Cambrian marine ecosystem, exemplified by priapulid worms

15:00 *Jean-Bernard Caron, Simon Conway Morris and Shu Degan*
Tentaculate deuterostomes from the Cambrian of Canada and China

15:15 COFFEE/TEA

Lecture Theatre 1.47, Imperial College

S20 - Taphonomy of skeletons and soft tissues

Chair: Patrick Orr

09:00 **Keynote –** *Derek E.G. Briggs*
The limits of fossilization

09:30 *Rudolf A. Raff, Elizabeth C. Raff, David Nelson, Evelyn Toh, Lisa Pratt, Seth Young and David Bish*
Fossilization as a biological process: the role of microbiology in taphonomy

09:45 *John A. Cunningham, Philip C.J. Donoghue, Stefan Bengtson, Ceri-Wyn Thomas, Federica Marone and Marco Stampanoni*
Distinguishing biology from geology in the Ediacaran Doushantuo biota

10:00 *Aodhán D. Butler, Philip C.J Donoghue and John A. Cunningham*
New analytical approaches in experimental taphonomy: implications for the role of microbial activity

10:15 *Robert S. Sansom, Sarah E. Gabbott and Mark A. Purnell*
Morphological decay experiments applied to fossil data: unlocking the non-biomineralized vertebrate fossil record

10:30 COFFEE/TEA

Chair: Rudy Raff

11:00 *Ragna Redelstorff, Patrick J. Orr and Maria McNamara*
Die and rot: experimental taphonomy of tadpoles

11:15 *Maria E. McNamara and Patrick J. Orr*
Experimental degradation of mice and birds: implications for the fossil record

11:30 *Alexander G. Liu, Małgorzata Bednarz and Duncan McIlroy*
Decay on the Ediacaran seafloor; experimental testing of the effaced preservation taphonomic model

11:45 *David C. Fernández-Remolar and Andrew H. Knoll*
Preservation of the biological information under acidic conditions in the Río Tinto extreme environment

12:00 *Crispin T.S. Little*
Rapid fossilization processes at hydrothermal vents

12:15 *Daniel I. Hembree, Royal H. Mapes, Bart A. Rasor, Alycia L. Stigall, Claire Goiran and Bertrand Richer de Forges*
The taphonomy of modern *Nautilus* (Cephalopoda) in a nearshore, shallow water environment, Lifou (Loyalty Islands)

12.30 LUNCH

Chair: Mark Purnell

13.45 **Keynote -** *Susan M. Kidwell*
Conservation paleobiology – an emerging application of modern death assemblages and taphonomic analysis

14:15 *Sue Beardmore, Patrick J. Orr and Heinz Furrer*
Skeletal taphonomy of marine reptiles from the Middle Triassic of Monte San Giorgio, Switzerland

14:30 *Debarati Mukherjee and Sanghamitra Ray*
Taphonomy of a New Upper Triassic rhynchosaur (Reptilia; Archosauromorpha) accumulation from India

14:45 *James H. Nebelsick*
Resolving taxonomic resolution along taphonomic gradients: comparing macrofauna and carbonate microfacies

15:00 *E. Lukševičs, P.A. Beznosov, T.V. Majdl', P.E. Ahlberg and Ģ. Stinkulis*
Taphonomy of a Late Devonian vertebrate assemblage from Izhma River site, Sosnogorsk Formation, South Timan, Russia

15:15 COFFEE/TEA

Chair: Sarah Gabbott

15:45 *David A.T. Harper, Arne T. Nielsen, M. Paul Smith and Jakob Vinther*
Soft bodies from the Sirius Pass: combining a unique environment with an unusual taphonomic window in the Cambrian rocks of North Greenland

16:00 *David Riley, Sarah Gabbott, Mike Norry and David Siveter*
Taphonomy of the Herefordshire Lagerstätte

16:15 *Kate M. Trinajstic, Kliti Grice, Per E. Ahlberg, Sophie Sanchez and John A. Long*
Soft tissue preservation in Devonian vertebrate fossils from Western Australia

16:30 *Michael Steiner and Guoxiang Li*
Cambrian small shelly fossils and the taphonomic phosphatization window

16:45 *Joanne MacDonald, Andy Freer and Maggie Cusack*
Cementation of oysters to natural substrata by biogenic and diagenetic processes

17:00 *Clare Torney, Martin R. Lee, Alan W. Owen, Robert W. Martin and Paul R. Edwards*
Seeing through the diagenesis of schizochroal trilobite

S23 - Recent discoveries and advances in the palaeontology of China

23b: Extinctions, radiations and other bio-events: cases from China (cont'd from Tuesday)

Chairs: Wang Xiangdong and Liu Jianbo

09:00 *Wang Yue, Liu Yu, Katsumi Ueno, Zhang Yichun and Cao Changqun*
Progress on upper Permian boultoniid biostratigraphy: its evolutionary and palaeogeographic implications

09:15 *Liu Xinchun, Wang Wei, Chen Xiaozhen and Ye Facheng*
The Permo-Triassic boundary and microbialite in the northeast of Sichuan Province

09:30 *Liu Jianbo, Yoichi Ezaki, Natsuko Adachi and Zhan Renbin*
Spatial and temporal distributions of the early Ordovician reef systems in South China: geobiological process during the early stage of the great Ordovician biodiversification event

09:45 *Zhang Yuandong, Chen Xu and Zhang Ju*
Graptolite fauna and biostratigraphy of Ordovician Ningkuo and Hulo formations in SE China

10:00 *Wu Rongchang, Wang Zhihao and Svend Stouge*
Ordovician conodont diversification in the Lower Yangtze Valley

10:15 *Yan Kui, Thomas Servais and Li Jun*
Biodiversity patterns of Lower - Middle Ordovician marine microphytoplankton in South China: relation to the evolution of the marine invertebrates

10:30 COFFEE/TEA

23c: Vertebrate Palaeontology and Mesozoic bio-events

Chairs: Sha Jingeng and Zhang Zhaoqun

11:00 **Keynote -** *Xu Xing*
Recent advances in research on avian origins

11:30 *Wu Feixiang and Sun Yuanlin*
The diversity of saurichthyids from Middle Triassic (Anisian) of southwestern China

11:45 *Qu Qingming, Zhu Min and Li Ga*
Synchrotron radiation X-ray microtomography reveals the primitive histological architecture of osteichthyan scales

12:00 *Zhang Shukang and Wang Qiang*
A parataxonomic revision of the Cretaceous faveoloolithid eggs of China

12:15 *Xing Song, Wu Xiujie and Liu Wu*
Cusp size, crown outline shape, and occlusal grooves pattern of M^1s in Middle and Late Pleistocene hominins of China

12:30 LUNCH

23c: Vertebrate Palaeontology and Mesozoic bio-events (cont'd)

Chairs: Sha Jingeng and Zhang Zhaoqun

13:45 *Jingeng Sha*
Classification, stratigraphy, palaeoecology and palaeobiogeography of Trigonioidacea (non-marine Cretaceous Bivalvia)

14:00 *Wang Bo, Zhang Haichun and Fang Yan*
The evolution of the Palaeontinidae (Insecta: Cicadomorpha)

23d: Palaeobotany, palynology and Cenozoic fossils and bio-events in China

Chair: Sun Bainian

14:15 **Keynote -** *Wang Jun, H.W. Pfefferkorn, Zhang Yi and Zhuo Feng*
Early Permian vegetation preserved in volcanic air-fall tuff from Inner Mongolia: forest reconstruction, palaeoecology, and palaeobiogeography

14:45 *Wang Deming, Xu Honghe and Zhu Xiao*
A new fern-like plant with pinnules from the Upper Devonian of South China

15:00 *Meng Meicen and Wang Deming*
New insights and evolutionary significance of a strobilar lycopsid plant from the Upper Devonian of South China

15:15 COFFEE/TEA

15:45 *Liu Feng, Ouyang Huaicheng and Zhu Shu*
Late Carboniferous–Permian palynology and biostratigraphy of Baode in Shanxi Province, North China

16:00 *Wang Yongdong, Tian Ning, Jiang Zikun and Mei Shengwu*
Fossil ferns from the Early Jurassic in Western Hubei, China: biodiversity, reproductive structures and evolutionary implications

16:15 *Jiang Zikun, Wang Yongdong and Tian Ning*
Diversity and palaeoclimate of the floral assemblages form the Tiaojishan and Tuchengzi Formations of Jurassic in Western Liaoning, China

16:30 *Sun Bainian, Wu Jingyu, Xie Sanping, Yan Defei and Lin Zhicheng*
Pliocene angiosperm fossils from Tengchong in West Yunnan, China and their palaeoclimatic significance

16:45 *Gongle Shi, Zhiyan Zhou and Zhiming Xie*
A new cephalotaxus from the oligocene of Guangxi, South China

17:00 *Xiang Rong, Chen Muhong, Zhang Jianlin, Zhang Lanlan, Lu Jun and Liu Fang*
Distribution of living planktonic foraminifera in the spring Southern South China Sea

Lecture Theatre 2.28, Imperial College

S27A - Open Symposium - Vertebrate palaeontology

Chairs: Alain Blieck and Vincent Dupret

15:45 *Alain Blieck*
Palaeozoic vertebrate biodiversity and bioevents: a macroecological hypothesis

16:00 *Alice M. Clement*
Functional morphology of Devonian dipnoans: jaw mechanics and air-gulping behavior

16:15 *Chavalit Vidthayanon and Prateung Jintasakul*
A new Triassic brachyopoid amphibian (Temnospondyli: Brachyopoidea; Brachyopidae) from upper central Thailand

16:30 *David B. Norman and Chloe L. Marquart*
The taxonomic diversity of iguanodontian ornithopod dinosaurs in the Lower Cretaceous of NW Europe

16:45 *Qi Zhao and Michael J. Benton*
Diversity and fossil record of the ceratopsian dinosaurs

17:00 *Khizar Samiullah, Muhammad Akhtar, Abdul Ghaffar and Muhammad Akbar Khan*
***Giraffokeryx punjabiensis* (Aertiodactyla, Ruminatia, Giraffidae) from Lower Siwaliks (Chinji Formation) of Dhok Bun Ameer Khatoon, Pakistan**

17:15 - 18:15 **POSTER SESSION**

Symposium 3 - Micropalaeontological record

Jawad Afzal, Mark Williams, Melanie J. Leng and Richard J.Aldridge
Biotic responses of Late Paleocene-Early Eocene larger benthic foraminifera to the Paleocene-Eocene thermal maximum and India-Asia collision

Laia Alegret and Silvia Ortiz
Benthic foraminiferal record of the Late Paleocene and Early Eocene warming events in the Western Tethys

Laia Alegret and Ellen Thomas
Benthic foraminiferal turnover and carbon cycle perturbation across the Cretaceous-Paleogene boundary in the Pacific Ocean

A.M. Ballegeer, J.A. Flores and F.J. Sierro
"New" carbonate dissolution indexes based on the fragmentation of single coccolithophore species

Clara T. Bolton, Kira T. Lawrence, Samantha J. Gibbs and Paul A. Wilson
High- and low-latitude calcareous nannoplankton responses to an abrupt change in surface ocean conditions during the Late Pliocene

Marisa Borges, Paulo Fernandes, Zélia Pereira, James B. Riding
Jurassic palynostratigraphy of the Sagres region (Algarve Basin) and the Carrapateira outlier: preliminary results

Simone N. Brandão, Jenni Grossmann
Ostracoda (Crustacea) in the encyclopedia of life

Simone N. Brandão, Olinga Päplow
Biogeography and autoecology of Southern Ocean *Poseidonamicus* species (Crustacea, Ostracoda)

Şenol Çapkinoğlu
Middle-Upper Devonian and Lower Carboniferous conodonts from the Istanbul Zone, NW Turkey

Thomas B. Chalk, Helen L. Johnson, Rosalind E.M. Rickaby, Michaël Hermoso and Fabrice Minoletti
Changes in the thermocline depth through the last glacial maximum in the East Atlantic as revealed by the species-specific geochemistry of coccolithophores and foraminifera

Marie-Emilie Clémence, Silvia Gardin, Annachiara Bartolini, Guillaume Paris, Valérie Beaumont and Jean Guex
Bentho-planktonic evidence of End-Triassic sea-surface carbonate production decline in the Austrian Alps

Letizia Di Bella, Virgilio Frezza, M. Gabriella Carboni, Rita M. Pichezzi, Mariagrazia Rossi, Donatella Magri, Federico Di Rita, Gilberto Calderoni and Chiara D'Ambrogi
Paleoclimatic and paleoecological reconstruction of the Pleistocene-Holocene succession of the Tyrrhenian margin (central Italy): micropaleontological results from the Tiber deltaic area

Tom Dunkley Jones, Daniel J. Lunt, Daniela N. Schmidt, Cecily Chun, Mark Maslin, Andy Ridgwell and Paul J. Valdes
A review of the Paleocene-Eocene thermal maximum temperature anomaly

Kirsty M. Edgar, Samantha J. Gibbs, Phillip F. Sexton, Richard D. Norris and Paul A. Wilson
Planktonic foraminiferal response to the Middle Eocene climatic optimum

Andrea Fiorentino
Nannofossil assemblages as a tool to infer environmental conditions: an example from the Cenomanian-Turonian boundary OAE

Natalia V. Goreva
Evolution of conodonts of the Late Pennsylvanian in the Moscow syneclise (Russia)

Michael A. Kaminski, Silvia Ortiz and Paul R. Bown
The Eocene-Oligocene extinction of deep-water agglutinated foraminifera at ODP site 647, Southern Labrador Sea

Michael A. Kaminski and Claudia G. Cetean
A catalogue of agglutinated foraminiferal genera

Elena I. Kulagina
On the foraminiferal superfamily Lasiodiscoidea from the Late Mississippian of the South Urals

Jackie Lees, Paul Bown, Alvaro Jimenez Berrocoso, Ken MacLeod, Brian Huber, Stuart Robinson and The Tanzania Petroleum Development Corporation
Calcareous nannoplankton during Oceanic Anoxic event 2 (Cenomanian/Turonian boundary): exceptionally-preserved records from the Tanzania drilling project

Ilaria Mazzini, Natalia Hudackova, Eva Halasova, Marianna Kovacova, Peter Joniak, Ingeborg Soulie-Marche, Daniela Esu and Bora Rojay
Hyperhaline associations in the continental Late Miocene of the Çankiri Basin (Central Anatolia, Turkey): implications for palaeoenvironmental reconstructions

A. Mejía-Molina, J.A. Flores, F.J. Sierro and D. Rincón
Stratigraphic distribution of *Sphenolithus* in the Colombian Caribbean Sea from Late Eocene to Late Miocene

Brett Metcalfe, Gerald M. Ganssen and Frank J.C. Peeters
Quantifying the impact of anthropogenic carbon dioxide on planktic foraminifera

Sarah A. O'Dea, Samantha J. Gibbs, Paul A. Wilson and Kirsty M. Edgar
The Middle Eocene climatic optimum: turnover in calcareous nannofossil assemblages

Silvia Ortiz, Laia Alegret, Aitor Payros, Xabier Orue-Etxebarria, Estibaliz Apellaniz and Eustoquio Molina
Microfossil and isotopic data from the Gorrondatxe section, N Spain: new insights into the early Eocene climatic optimum

Silvia Ortiz and Michael A. Kaminski
Deep-sea benthic foraminiferal (elongate cylindrical) record across the Eocene-Oligocene transition at the Southern Labrador Sea (ODP hole 647a)

Johan Renaudie, Taniel Danelian, Simona Saint Martin, Laurence Le Callonnec and Nicolas Tribovillard
The diatom and silicoflagellate response to a Middle Eocene warming event recorded in the tropical Atlantic (Demerara Rise, ODP site 1260a)

I. Pérez-Rodríguez, J.A. Arz and I. Arenillas
Preliminary analysis of planktic foraminifera in the Middle Maastrichtian of the Zumaia Section (Spain)

Claudius Pirkenseer, Etienne Steurbaut, Chris King and Robert Speijer
Ypresian microfossils in the Corbières (Aude, France) continental margin record and the identification of an Early Eocene hyperthermal event

Andrea M. Snelling, Jennifer Pike, Melanie J. Leng and George E.A. Swann
Preparation and analysis of seasonally laminated diatom samples for oxygen isotope analysis from the Late Quaternary Antarctic margin

Emine Türk, Şenol Çapkinoğlu and İsmet Gedik
Planktonic foraminifera fauna and biostratigraphy of the Çeşmeler Member, Maçka-Trabzon, NE Turkey

Valentina S. Vishnevskaya
Radiolaria and sponge spicule evolution as reflection of ocean change

Qi Yuping, Wang Xiangdong, Barry C. Richards, John R. Groves, Katsumi Ueno and Wu Xianghe
Recent study of conodonts and foraminifers from the candidate GSSP of the Carboniferous Visean-Serpukhovian boundary in the Naqing (Nashui) section of South China

Menahem Weinbaum-Hefetz and Chaim Benjamini
Behaviour of nannofossil assemblages in chalk cycles, Lower Eocene of the Shefela region, Israel

Khand Yondon
Non-marine ostracods from the Cretaceous of Mongolia

Symposium 6 - Palaeontological data analysis

Azzurra Cillari
The teeth of *Elaphrosaurus* (Dinosauria, Theropoda): classification and misunderstanding

K.S. Collins, J.S. Crampton and M.J. Hannah
Preliminary stratocladistic study of *Spissatella* (Bivalvia, Crassatellidae)

W.A. Green and C. Jaramillo
Stratigraph: an open-source framework for analyzing stratigraphically distributed data

E.D. Humphries and Marc E.H. Jones
Landmark analysis of the lower jaw in *Sphenodon* (Reptilia: Diapsida: Rhynchocephalia) from Holocene assemblages

Jung Jikhan
Modan: a new comprehensive morphometric software package

Aleksis Karme, Alistair R. Evans and Mikael Fortelius
GISwear; 3D and GIS diet analysis method for bunodont omnivore groups Suina and Hominidae

Carlo Meloro, Sarah Elton, Joulien Louys, Peter Ditchfield and Laura Bishop
What to do with fragmentary fossils? an example based on a fossil dog from Olduvai bed ii

Helje Pärnaste
Biometry of the Ordovician trilobites *Krattaspis* and *Hadromeros*

Tae-yoon Park, Jikhan Jung and Duck K. Choi
Three-dimensional landmark analysis of two late Cambrian (Furongian) trilobites, *Asioptychaspis subglobosa* and *Quadraticephalus elongatus*

Symposium 9 - Devonian bioevents

Z. Sarah Aboussalam and R. Thomas Becker
Middle/Upper Devonian boundary conodont faunas from Giebringhausen (Rhenish Massif, Germany)

Reza Aharipour, Bruno Mistiaen and Emilie Pinte
Distribution of the genus *Thecostegites* (Tabulata) in Western Europe (France, Belgium) and South-Western Asia (Iran, Afghanistan)

Nikolay K. Bakharev
Middle and Upper Devonian ostracods from the Salair and Kuznetsk Basin, Russia

Julien Denayer and Edouard Poty
Unusual biological association event within the Late Frasnian crisis

Irina Evdokimova
Associations and diversity dynamics of Frasnian-Early Famennian ostracods in the central part of the East European platform, Russia

Mikołaj K. Zapalski and Benoît L.M. Hubert
Parasitism in Devonian stromatoporoids

Ulrich Jansen
Biohistory of Pridolian through Eifelian brachiopods

Aleksey I. Kim, Maya V. Erina, Irina A. Kim, Firuza A. Salimova, Natalya A. Meshchankina, Firdaus S. Karimova and U.D. Rahmonov
Early Devonian (Pragian-Emsian) biodiversity pattern in Zinzilban and Khodzha-Kurgan sections, Zerafshan Range, South Tien Shan

Rudy Lerosey-Aubril, Raimund Feist and Eberhard Schindler
Ecological and behavioural changes associated to the evolution of tagmosis in scutelluid trilobites

Ma Xueping and Zong Pu
Middle and Late Devonian brachiopod assemblages, sea level change, and paleogeography of Hunan, China

Olga T. Obut and Nadezhda G. Izokh
Upper Devonian radiolarians from the Zeravshan-Gissar mountanous area (Uzbekistan Republic)

Robert M. Owens, Irina A. Kim and Leonid E. Popov
Review of Early to Mid Devonian trilobite faunas of South Tien Shan, Uzbekistan

Vladimir N. Pazukhin and Elena I. Kulagina
Conodonts and foraminifers from the Devonian/Carboniferous boundary beds in the South Urals

Emilie Pinte and Bruno Mistiaen
What is the impact of the Taghanic event on tabulate corals of the Ardennes?

Symposium 20 - Taphonomy

Paul R. Bown, Tom Dunkley Jones, Jackie A. Lees and Jeremy R.Young
Preserving the smallest fossils – learning from exceptionally preserved calcareous nannofossils (coccolithophores) from Tanzania

Antonino Briguglio and Angela Forchielli
Transportability of larger benthic foraminifera

Antonino Briguglio and Johann Hohenegger
Biostratinomy in shallow water environments: how to tackle the larger benthic foraminifera depth distribution

Larisa Doguzhaeva, Royal Mapes, Stefan Bengtson, Herbert Summesberger and Guillermo Meléndez
Ink, soft tissues and non-mineralized skeletal structures in the fossil record of cephalopods

Angela Forchielli, Michael Steiner, Hu Shixue and Helmut Keupp,
Taphonomic pathways of the Early Cambrian Chengjiang Biota

Franz T. Fürsich, Winfried Werner, Graciela Delvene, Jose Carlos GarcÍa-Ramos and Carlos Aramburu
Shell concentrations record climatic cycles: the Upper Jurassic Tereñes Formation of Northern Spain

Yasuo Kondo, Keisuke Yano, Naoki Kikuchi and Takeshi Kozai
Importance of analyzing *in-situ* bivalves in the reconstruction of brackish-water benthic associations

Liisa Lang, Ivar Puura and Ethel Uibopuu
Phosphatized organic nanofibrils in Cambrian lingulate brachiopods

Maria E. McNamara, Patrick J. Orr, Stuart L. Kearns, Luis Alcalá, Pere Anadón and Enrique Peñalver-Mollá
A new integrated approach to taphonomic analysis of exceptionally preserved taxa

Ivar Puura, Liisa Lang, Ethel Uibopuu, Jüri Nemliher and Elga Mark-Kurik
Apatite varieties in living and fossil skeletons

René A. Shroat-Lewis, Colin D. Sumrall, Michael L. McKinney, David L. Meyer and Carlton E. Brett
Paleoecologic assessment of an Ordovician edrioasteroid encrusted obrution surface from the Upper Ordovician (Maysvillian) Bellevue Formation, Maysville, Kentucky

Akihiko Suzuki
Relationship between northward migration of modern warm-water mollusks and surface water warming in the northern Japan Sea

J. Vasiļkova, E. Lukševičs, I. Zupiņš, Ģ. Stinkulis and P.E. Ahlberg
Taphonomy of the Upper Devonian vertebrate bone beds at Langsēde Cliff, Latvia

Wang Bo, Zhang Haichun and Fang Yan
Comparative taphonomy of Palaeontinidae and Tettigarctidae (Insecta: Hemiptera) from the Middle Jurassic of Daohugou, China

Zhang Fucheng, Stuart L. Kearns, Patrick J. Orr, Michael J. Benton, Zhou Zhonghe, Maria E. McNamara, Diane Johnson, Xu Xing and Wang Xiaolin
The taphonomy of birds and dinosaurs from the Jehol Biota (Early Cretaceous) of China

Ivars Zupiņš
Taphonomical aspects of the Middle Devonian fossil assemblages at Lode clay quarry (Latvia)

Symposium 27A - Vertebrates

Adán Pérez-García, Xabier Murelaga, Fidel Torcida Fernández-Baldor and Pedro Huerta
High diversity of turtles in the Cretaceous of the Western Cameros Basin (Burgos, Spain)

Adán Pérez-García and Francisco Ortega
The more ancient Pleurosternid genus (Chelonii, Paracryptodira) recorded in Europe

PUBLIC LECTURE

18:30 Bar opens ***Royal Geographical Society***

19:30 *Sean B. Carroll*
Remarkable creatures: epic adventures in the search for the origins of species

20:30 Bar reopens for 1 hour

Thursday 1st July

Workshops

Lecture Room 2.28, Imperial College

W1 – Echinoderm origins and evolution

This workshop is for all interested in getting up to speed with recent advances in echinoderm palaeobiology and phylogeny. Echinoderms continue to be a focus for much innovative palaeobiological research, partially because they have been the subject of extensive phylogenetic work, and partially because their complex skeleton shows such a close relationship between structure and function. Recent advances in our understanding of this group include the use of large integrated databases for phylogenetic reconstruction, the use of new technologies, notable CT-scanning and 3-D reconstruction to derive a better understanding of functional morphology, and the study of disarticulated ossicles which has extended our understanding of the range and diversity of Cambrian forms.

Roots of the modern fauna

09:00 *William I. Ausich and Bradley Deline*
What is a crinoid?

09:30 *Andy S. Gale*
Evolution of the Asteroidea; where the gaps in knowledge lie

09:45 *Mike Reich*
Solving the palaeobiological puzzle of sea cucumbers and their relatives: problems and future research needs

10:00 *Thomas E. Guensburg*
Revolutionary new understanding of crinoid origins and early history; old questions addressed, new questions posed

10:15 *Andrew B.Smith, Kevin J. Peterson and Davide Pisani*
Why is it so hard to establish a molecular framework of echinoderm class relationships?

10:30 COFFEE/TEA

Tracing homologies in early Palaeozoic echinoderms

11:00 *James Sprinkle*
Phylogenetic patterns and controversies in the echinoderm subphylum Blastozoa

11:30 *Sergei Rozhnov*
Baltic Ordovician edrioblastoid morphology: imitation of crinoid arms, asteroid rays and rhombiferan pore system

11:45 *Colin D. Sumrall and Johnny A. Waters*
***Troosticrinus*, coronoids, and the origin of blastoids in light of universal elemental homology**

12:00 *Aaron W. Hunter*
Resolving asterozoan origins: towards a better working model for skeletal homologies and phylogeny for the Asteroidea and Ophiuroidea

12:15 *Elise Nardin and Bertrand Lefebvre*
Morphological diversity of the Cambrian echinoderms and its contribution to the understanding of the primitive echinoderms

12:30 LUNCH

The Cambrian Diversification: new perspectives

13:45 *Sébastien Clausen and Artem Kouchinsky*
The earliest record and palaeoenvironmental setting of Cambrian echinoderm diversification

14:00 *Samuel Zamora*
New fossil discoveries indicate a diverse Cambrian record of Spanish echinoderms

14:15 *Bertrand Lefebvre, Elise Nardin, Oldrich Fatka, Fleur Noailles and Seung-Bae Lee*
The Cambro-Ordovician diversification of echinoderms: a peri-Gondwanan perspective

New approaches to old questions

14:30 *Louis G. Zachos and James Sprinkle*
A computational model of growth in Palaeozoic echinoids

14:45 *Imran A. Rahman*
Novel imaging techniques for studying fossil echinoderms

Lecture Theatre 1.47, Imperial College

W2 – Annual Business Meeting of the International Sub-Commission on Devonian Stratigraphy

Meeting starts at 09:00

Lecture Theatre G38, Imperial College

W3 - Restoration of marine ecosystems following the Permian-Triassic mass extinction: lessons for the present

IGCP572 is concerned with improving our knowledge and understanding of marine ecosystem recovery after the end-Permian extinction event. Not only was this the most severe trauma to have affected marine ecosystems, but it occurred during a time of global warming and many of the associated environmental changes that apparently controlled ecosystem recovery are predicted to occur in the near future. Understanding how marine ecosystems recovered from near-total collapse during the Permian-Triassic interval should help frame predictions of what will happen in the near future. Topics to be covered include reviews of past field-trips and workshops, and discussions of future plans and key results. IGCP572 runs from 2008-2012, so this is a key mid-term meeting

Meeting starts at 13:45

Lecture Theatre 1.51 Imperial College

W4 – PaleoParks and the threat to our basic data

Fossil sites across the world are endangered by development, construction, collecting, and vandalism, even though many outstanding examples have been protected in World Heritage Sites, national parks, monuments and reserves, state and provincial parks, and local government and non-profit organizations, as well as by some private individuals. The International Palaeontological Association (IPA) established a PaleoParks Initiative to protect endangered sites and to catalogue and make public established parks of any nature that protect fossils in the ground; these are primary sources of scientific data, educational opportunities and recreational activities. Key places protecting 'living fossils' are also covered. (see 10 examples of PaleoParks in: Lipps and Granier 2009). IPA has 15 aims and goals (Lipps and Granier 2009) and a web site for documenting both established and proposed sites. The Workshop will consider these aims and goals and ways to improve the website. In addition to these, submitted papers will be presented on examples of new kinds of PaleoParks that protect a wider variety of fossils, including additional invertebrate sites and new microfossil and microbial sites or especially unique examples of fossils in the ground.

Meeting starts at 09:00

Jere H. Lipps
Paleoparks: the protection and conservation of paleontologic field sites worldwide

Dennis O. Terry Jr. and David E.Grandstaff
Geochemical fingerprinting of fossil vertebrates from the Paleogene White River group of Nebraska, South Dakota and Wyoming, USA: a tool to protect fossil resources on Federal l lands

Nora Noffke
A new geosite "Earth's oldest cynanobacteria" – White Umfolozi Inlier Geopark, South Africa

Pratueng Jintasakul and Jaroon Duangkrayom
Fossil record in Taru Tao Island and coastal areas, Satun Province, southern Thailand

Daniel Marty, Géraldine Paratte, Christel Lovis, Jean-Paul Billon-Bruyat, Wolfgang A. Hug and Céline Fuchs
Dinosaur tracksites unearthed by ten years of palaeontological excavations on Highway A16 (Jura Mountains, NW Switzerland): results, future research directions and implications for geoconservation

Xu Zhijun and Xu Xing
An introduction to the China Fossil Preservation Foundation (CFPF)

Lecture Room G41, Imperial College

W5 – Virtual palaeontology techniques

In recent years there have been rapid advances in three-dimensional imaging techniques, including laser-scanning, physical-optical tomography, neutron tomography, optical tomography, magnetic resonance imaging, x-ray tomography, holotomography and laminography. The increasing availability and quality of these data-capture techniques is rivalled by the increasing ease with which modern computers and software can reconstruct, view and manipulate the resulting datasets; the 'virtual fossils' thus created provide a new and powerful medium for working with palaeontological material. Details of data-capture, reconstruction techniques and the applications of virtual palaeontology will be presented and demonstrated in this workshop.

09:00 *Paul Tafforeau*
Keynote – X-ray synchrotron imaging: a revolution in palaeontology

09:30 *Ranate Matzke-Karasz, R.J. Smith, Radka Symonová, C. G. Miller and Paul Tafforeau*
Holotomography in exceptionally preserved Cretaceous ostracods

09:45 *John Cunningham, Philip C.J. Donoghue, Stefan Bengtson, Xiao Shuhai, Ceri-Wyn Thomas, Federica Marone and Marco Stampanoni*
Synchrotron x-ray tomographic microscopy as a tool to study early animal evolution

10:00 *Carsten Kamenz*
Depth of field – a limiting factor as an advantage for 3D

10:15 *Joachim Haug, Carolin Haug, Andreas Maas and Dieter Waloszek*
Using light microscopy for 3D imaging

10:30 COFFEE / **discussion and informal presentation session with commercial exhibitors**

11:00 *Richie L. Abel, Alex D. Ball and Lauren E. Howard*
Non-destructive imaging and analysis techniques for palaeontological samples

11:30 *Susanne Feist-Burkhardt*
Confocal laser scanning microscopy and spectroscopy of organic-walled microfossils: 3D-imaging, analysis and online presentation

11:45 *Margaret Collinson*
Virtual palaeobotany and taphonomy: applications for mesofossils

12:00 *Liam Herringshaw, Małgorzata Bednarz, Duncan McIlroy, and Christopher Boyd*
Tracing the traces: the ichnological applications of 3D visualization techniques

12:15 *Mark Sutton*
Other approaches to the acquisition of 3D morphological data

Lecture Room G20, Imperial College

W6 – How conodonts lived and ate: food processing functions of conodont elements

The workshop will consist of a series of presentations by participants followed by a break-out session where participants may view fossils and other evidence cited in the presentations. The focus of the workshop and break-out session will center around discussion and debate of macro-, meso-, micromorphological, and/or geochemical evidence of conodont ecology and food processing ability. In particular, we plan to engage the conodont community to provide evidence for and constraints on the food processing function(s) of conodont elements, and to bring evidence that supports their models for or against wear on conodont elements.

08:55 *Stephen A. Leslie*
Welcome

09:00 *Jerzy Dzik*
Vertebrate homologies and analogies in the conodont oral apparatus

09:25 *Carlos Martínez-Pérez, Philip C.J. Donoghue and Emily J. Rayfield*
Finite elements analysis of conodont element function

09:50 *Robert S. Nicoll and Stephen A. Leslie*
Variety in conodont element morphology and apparatus structure, Cambrian and Triassic, a reflection of different prey and feeding strategies

10:10 *Ismet Gedik*
Conodonts: were they (the first?) parasitic animals?

10:30 COFFEE/TEA and visit Posters

11:00 *Charles M. Henderson*
The evolution of gondolellid tooth morphology in relation to how they lived and ate

11:25 *Carlos Martínez-Pérez and Pablo Plasencia*
Functional approach to the Triassic conodont species *Pseudofurnishius murcianus* van den Boogaard

11:50 *Achim D. Herrmann, Kenneth G. MacLeod and Stephen A. Leslie*
Using conodont paleoecology and isotope geochemistry to assess if a volcanic mega-eruption caused global cooling during the late Ordivician

12:30 LUNCH

13:45 **Afternoon session - posters and open microscope session in *Lecture Room G41***

Michele Mazza, Manuel Rigo, Stefano Furin and Christoph Spötl
Possible influence of the δ13C variations on the Carnian/Norian conodonts diffusion

Manuel Rigo and Michael M. Joachimski
Late Triassic conodont lifestyle: constraints from oxygen isotopes of biogenic apatite

Manuel Rigo, Sara Callegaro, Massimo Chiaradia, Michael Orchard and Andrea Marzoli
Sr isotopic shift as a potential global geochemical marker for the base of the Rhaetian stage

Lecture Room 1.51, Imperial College

W7- Palaeobiology, palaeoecology and stratigraphy of graptolites

Graptolites have long been a prime biostratigraphic tool for subdivision and correlation of Early Palaeozoic strata. As examples of highly integrated and organized colonial zooplankton, too, their affinities and enigmatic biology have long been discussed. More recently, they have been used as proxies of ocean state and palaeoclimate. This workshop will focus on recent developments in graptolite research, with updates on both traditional research aspects and novel geological uses and interpretations.

Session starts at 13:45

Lecture Room G39, Imperial College

W8 - Chelicerate phylogeny

This workshop is for anyone interested in chelicerate evolution, with a focus on how fossils help inform the phylogeny. In the morning we'll have a series of short informal talks on the various groups (i.e. the chelicerate-stem, pycnogonids, xiphosurans, chasmataspidids, eurypterids, scorpions, spiders, and the various other arachnids). In the afternoon, we'll have round-table discussions on the competing phylogenetic hypotheses for the various groups, try to reach a consensus, before closing with a session on systematic revisions required for the Treatise, led by Paul Selden and Jason Dunlop.

Morning Session starts at 09:00

Afternoon Session starts at 13:45

Lecture Room G20, Imperial College

W9 - Origin and evolution of early vertebrate characters

13:45 **Keynote -** *Per E, Ahlberg, Kate M. Trinajstic, Sophie Sanchez, Paul Tafforeau, John A. Long and Kliti Grice*
New anatomical information of organ and muscle tissue in vertebrates from the Good Formation

Evolution of fins

14:15 *Henning Blom*
Anaspid affinity and the evolution of early vertebrate characters

Basal lungfish

14:30 *Barbro B Mellbin*
***Iowadipterus halli* revisited**

Early vertebrate cranial morphology

14:45 Gai *Zhikun, Philip C.J. Donoghue, Zhu Min, Philippe Janvier and Marco Stampanoni*
Cranial anatomy of 400 Ma jawless fish from China throws new light on precursors of jawed vertebrates

15:00 *Vincent Dupret, Sophie Sanchez, Daniel Goujet, Paul Tafforeau and Per E.Ahlberg*
The cranial anatomy of *Romundina stellina* Ørvig, 1975 (Vertebrata, Placodermi, Acanthothoraci) revealed by synchrotron scanning

15:15 COFFEE/TEA

15:45 *Kate Trinajstic, Zerina Johanson and John Long*
New information on the endocranium and visceral skeleton in Australian ptychtdonts

Early vertebrate reproduction

16:00 *Robert Carr*
The evolution of gnathostome reproductive strategies: placoderm egg cases

Early vertebrate phylogeny

16:15 *Michael Coates and Samuel P. Davis*
A new view of *Acanthodes* and the roots of modern gnathostomes

Early tetrapod relationships

16:30 *Marcello Ruta*
Patterns of morphological evolution in major groups of Palaeozoic Temnospondyli (Amphibia: Tetrapoda)

Nature of crown and stem groups

16:45 *Matt Friedman and Martin D. Brazeau*
Outgroups, characters and polarity: current challenges in inferring the interrelationships of early jawed vertebrates

Lecture Room 1.47, Imperial College

W10 - Palynology and the Palaeozoic earth system

The workshop will focus on how organic walled microfossils have contributed to our understanding of the Palaeozoic earth system.

Meeting starts at 13:45

Aurélien Delabroye, Marco Vecoli, Olle Hints and Thomas Servais
Hirnantian acritarchs from Anticosti, Canada (Laurentia) and Valga, Estonia (Baltica): biostratigraphic implications

Paweł Filipiak and Michał Zatoń
Animal and plant cuticles from the Lower Devonian of Poland

Monika Jachowicz-Zdanowska
New Middle Cambrian Axcritarchs from Upper Silesia, southern Poland

Irfan Jan and Michael Stephenson
Age and regional context of the Carboniferous-Permian glacigenic Tobra Formation (Salt Range, Pakistan)

Valentina N. Mantsurova
Terrigenous Devonian zonal miospore stratigraphy of the western part of the Pre-Caspian Depression and its frame (Russia)

John E. A. Marshall, Tim R. Astin, Olga P. Tel'nova
Spores, life, death and the Devonian Earth System

Ellen Stolle
Biostratigraphic correlation of Permian strata from SE Turkey and Australia – and palynological species as indicators for climate

Petra Tonarová
Polychaete jaws in Silurian of the Prague Basin (Czech Republic)

Lecture Room 1.31, Imperial College

16:30 - 17:15 **General Assembly, International Palaeontological Association**

17:15 - 18:15 **POSTER SESSION**

Symposium 27A - Vertebrates

Jennifer E. Anné, Allison R. Tumarkin-Deratzian, Dennis O. Terry Jr. and David Grandstaff
Geochemical properties of pathologic bone in extinct and extant archosaurs

Flavio Bellardini, Paolo Gandossi, Jorge O. Calvo and Juan D. Porfiri
New record of a Rebbachisauridae (Dinosauria, Sauropoda) from the Candeleros Formation (Albian-Cenomanian) of northern Patagonia, Argentina

Arnau Bolet and Susan E. Evans
New assemblages of Eocene squamates from Spain

Aurore Canoville, Daryl P. Domning, Ruggero D'Anastasio and Vivian de Buffrénil
How sea cows acquired their skeletal ballast: pachyostosis and osteosclerosis in the evolutionary history of sirenians

Jaroon Duangkrayom, Yoshikazu Noda, Pratueng Jintasakul and Yoichi Azuma
Sedimentary processes and palaeogeography at the dinosaur sites, Upper Khok Kruat Formation of Nakhon Ratchasima Province, NE Thailand

Mats E. Eriksson, Johan Lindgren, Karen Chin and Urban Månsby
Fossil faeces from the Upper Cretaceous of southern Sweden

Guillaume Guinot, Charlie J. Underwood, Henri Cappetta and David J. Ward
Review of sharks of the genus *Heterodontus* (Blainville, 1816) from the Late Cretaceous of the Anglo-Paris Basin

Christy A. Hipsley, Johannes Müller, Michael Wuttke, Jason J. Head, Robert R. Reisz, Nikolay Kardjilov and André Hilger
A burrowing, lacertid-like squamate from the Eocene of Messel, Germany, reveals amphisbaenian origins

Jozef Klembara
A new Discosauriscid (Seymouriamorpha) from the Lower Permian deposits of the Czech Republic

Majid Mirzaie Ataabadi and Borzu Asgari Pirbaluti
First report of *Equus* (Mammalia, Equidae) from the Pliocene of the Zagros Basin, Iran

Germán M. Gasparini, Martín Ubilla and Eduardo P. Tonni
The chacoan peccary, *Catagonus wagneri* (Mammalia, Tayassuidae) in the Late Pleistocene of northern Uruguay (South America)

Andrés Rinderknecht, Martín Ubilla and Enrique Bostelmann
The auditory region of the largest fossil rodents (Mammalia, Dinomyidae, Eumegamyinae)

Carlos E.V. Toledo, Paulo M. Brito, and Lúcio P. Machado
Morphometric analyses of recent and fossil tooth plates of the genus *Lepidosiren* (Lepidosirenidae, Dipnoi)

Carlos E.V. Toledo and M. Richter
Petalodontiform (Chondrichthyes: Holocephali) teeth from the Passa Dois group, Paraná Basin, Southeastern Brazil

Carlos E.V. Toledo, M. Richter, Luiz C. Weinschütz and Denise C. Bacci
New data about paleonisciformes (lower actinopterygians) from the Irati formation, Paraná Basin, Brazil

Martín Ubilla, Daniel Perea, Andrea Corona and Andrés Rinderknecht
Late Pleistocene continental mammal assemblages of Northern Uruguay (South America)

Symposium - 27B General palaeontology

Osman Abdelghany, Hasan Arman, Mohamed El Tokhi, Waheed Hashem and Ayman Al Saiy
Litho- and bio-facies of the Lower Oligocene rocks from the United Arab Emirates

Chris Andrew, Paddy Howe, Christopher R.C. Paul and Stephen K. Donovan
A hitchhikers' guide to the Liassic: epifaunal worm tubes on Lower Jurassic ammonites from Dorset

Zain Belaústegui and Jordi M. de Gibert
Miocene shallow marine trace fossils and bioturbation in the Camp de Tarragona Basin (NE Spain)

John B. Brenner
Systematic abiogenesis

Andrei Briceag, Mihaela C. Melinte-Dobrinescu and Marius Stoica
The record of the macrofaunas, microfaunas and nannofloras in the Holocene deposits of the Black Sea

Ricardo Cordeiro, A.M. de Frias Martins, Sergio Stefanni and Sérgio P. Ávila
Paleo- and neo-biogeographic relationships of the shallow-water marine gastropods of The Azores

Iván Cortijo, Mónica Martí Mus, Teodoro Palacios and Sören Jensen
***Cloudina* from the terminal Ediacaran of Spain**

A.C. da Silva, S. Kershaw and F. Boulvain
Stromatoporoid palaeoecology of the Frasnian (Upper Devonian) of Southern Belgium

Claudia del Río, Sergio Martínez and José María Orensanz
Tertiary roots in the recent molluscan faunas of the southwestern Atlantic Ocean

Sandrine Delculée
The Lithostrotionidae (rugose corals) from the Viséan of the Campine Basin (Belgium and The Netherlands) and their implications for palaeogeography

Rosa Domènech, Miguel Ángel Mancheño and Jordi Martinell
The recent Asian clam *Corbicula fluminalis* (Müller, 1774), also in the Mediterranean Pleistocene?

Andrej Ernst and Caroline Buttler
Lower Devonian (Emsian) cystoporate bryozoan fauna from northwestern Spain

Howard R. Feldman, Mena Schemm-Gregory, Mark A. Wilson and Elyssa B. Krivicich
Sclerobionts and bioerosion in a shallow marine equatorial Jurassic fauna: the Matmor Formation (Callovian) of southern Israel

Diego C. García-Bellido, Maria Eugenia Dies Álvarez, José Antonio Gámez Vintaned, Eladio Liñán and Rodolfo Gozalo
First report of *Crumillospongia* (Demospongea) from the Cambrian of Europe: *Crumillospongia* sp. nov. from Murero (Spain)

Ismet Gedik
How do evolution and natural selection function?

Austin J.W. Hendy, Gregory P. Dietl and Ursula E. Smith
Body size in space and time: exploring spatial size gradients in the western Atlantic and effects of the rise of the isthmus of Panama

Hans-Georg Herbig, Elke Minwegen and Sebastian Rautenberg
Facies relations of Moscovian and Kasimovian (Pennsylvanian) sponges from the Cantabrian Mountains, northern Spain

Hiromichi Hirano and Mitsuru Obayashi
Taxonomic revision of the Late Cretaceous ammonite *Polyptychoceras* Yabe, 1927, based on an ontogenetic study

Makiko Ishikawa, Nanako O. Ogawa, Naohiko Ohkouchi and Tomoki Kase
Stable carbon isotopic composition of marine naticid snails for dietary analysis

Rimma R. Khodjanyazova and Vladimir I. Davydov
Evolution of the Late Pennsylvanian lineage *Fusulina* – *Quasifusuliniodes* – *Quasifusulina* within the Moscovian – Kasimovian transition

Olga Kossovaya, Alain Izart, Krzysztof Malkowski and Daniel Vachard
Permian reefs of the East-European platform (crisis, biota, microfacies)

Luo Hui and Yang Hao
Lower and Middle Triassic foraminifera from Zunyi, Guizhou Province, China

Jordi Martinell, Rosa Domènech, Miguel Ángel Mancheño and Michal Kowalewski
***Oichnus* in Pleistocene *Melanopsis*: evidence for predation or parasitism**

Sergio Martínez, Alejandra Rojas and Mariano Verde
Mollusc fossil concentrations and Quaternary relative sea levels in Uruguay

Sergio Martínez, Claudia J. del Río and Rich Mooi
Temporal and geographical distribution of Tertiary South American sand dollars (Echinodermata: Echinoidea: Clypeasteroida)

Manchuk Nuramkhaan, Yusuke Katsurada, Kazuhiro Tsukada, Mitsuo Hoshino, Takeshi Saito, Tsuyoshi Tanaka, Toshio Nakamura and Hidekazu Yoshida
Radiolarians from gravels along the River Euphrates in Ar-Raqqa Prefecture, Syria

Damián Perez and Claudia del Río
Phylogeny of the neogene-recent genera *Ameghinomya* and *Protothaca* (Bivalvia: Chioninae) in southern South America

Johan Renaudie and David Lazarus
Macroevolutionary patterns in Antarctic Neogene radiolarians

Alejandra Rojas, Mariano Verde, Fabrizio Scarabino and Diego Urteaga
The first predation borehole on a fossil chiton plate (Late Pleistocene, Uruguay)

Jennifer A. Sawyer, Martin Zuschin, Stefano Dominici, Mathias Harzhauser and Oleg Mandic
Sieve-size effects on patterns of drilling predation in the Eocene and Miocene of Central Europe

Eiichi Setoyama, Jarosław Tyszka and Michael A. Kaminski
"Flysch-type" biofacies – how shallow are the deep-water agglutinated foraminifera (DWAF) in the Barents Sea during the Late Cretaceous?

Marika Steinová
Palaeotaxodont bivalves from the Darriwilian (Middle Ordovician) of Bohemia reclassified

Seyed Hamid Vaziri, Bahaedin Hamdi and Farideh Rangriz-Azarfam
Permian foraminifera and conodonts (Artinskian-Murgabian) from the Ruteh Formation in the Hiv Area, Central Alborz, North Iran

Wang Lin and Shi Xiaoying
Carbon and sulphur stable isotopes from the deep-water Doushantuo Formation suggest a stratified Ediacaran ocean in South China

Rowan J. Whittle, J. Alastair Crame, Katrin Linse, Jane E. Francis and Jon R. Ineson
The Cenozoic fossil record of Antarctica

CONFERENCE DINNER

The Natural History Museum

19:00 **Reception**

19:30 **Dinner**

Friday 2nd July

Lecture Theatre 1.31, Imperial College

S2 - Macroevolution and the modern synthesis

Chairs: Erin Saupe, Corinne Myers and Wesley Gapp

09:00 *I. Wesley Gapp, Francine R. Abe, Curtis R. Congreve, Corinne E. Myers and Erin E. Saupe*
Integrating macro and micro: bringing the Modern Synthesis into the 21st century

09:15 *Mirnada Paton*
Penny wise but pound foolish: the cost of excluding macroevolution from the Evolutionary Synthesis

09:30 *Niles Eldredge and Stefano Dominici*
Palaeontology and the dawn of evolutionary theory

09:45 *Warren Allmon*
Changing palaeontological concepts of species and their role(s) in 20th century macroevolutionary thought

10:00 *F. Bokma*
Estimating tempo and mode of evolution from neontological data

10:15 *Bruce Smith Lieberman*
Macroevolution: on the birth, death, and persistence of species

10:30 COFFEE/TEA

11:00 *Pascal Neige*
Adaptive radiations and the fossil record: a case study using Jurassic ammonites

11:15 *Francine R. Abe*
Abiotic factors in the speciation mechanisms behind evolutionary radiations

11:30 *Corinne E. Myers and Erin E. Saupe*
Testing the relevance of competition in a hierarchical framework

11:45 *Erin E. Saupe, Corinne E. Myers and Curtis R. Congreve*
Macroevolutionary implications for a microevolutionary technique: putting ecological niche modeling into a hierarchical perspective

12:00 *Alycia L. Stigall*
Using ecological niche modeling to evaluate niche stability in deep time: analyzing late Ordovician brachiopods of Eastern North America during across an invasion event

12:15 *Gregory P. Dietl*
Invitation to paleobiologists to dissect the dynamics of evolutionary stasis with an ecological lens

12:30 LUNCH

Chairs: Curtis Congreve and Francine Abe

13.45 **Keynote -** *Keith D. Bennett*
Fossils and molecules: macroevolution in the Quaternary

14:15 *David Jablonski*
Three modes of diversification: ecological context and hierarchical level as determinants of clade dynamics

14:30 *Curtis R. Congreve*
The great equalizer of evolutionary biology; mass extinctions as large-scale analogues of species turnover

14:45 *Paul Wignall*
Mass extinctions: background extinctions written large or different in kind?

15:00 *Adolf Seilacher*
Tiered patterns of Phanerozoic macroevolution

15:15 COFFEE/TEA

15:45 *Gunther Eble*
On the origin of spaces: development, macroevolution, and the placement of the diversity of biological spaces, both representationally and causally, in the emerging new structure of evolutionary theory

16:00 *Douglas H. Erwin*
Macroevolution is not one thing: three styles of 'macroevolutionary' change

16:15 *Gregory D. Edgecombe*
Evo-devo and the limits of the synthesis

16:30 *Paulyn Cartwright*
Major transitions in an early diverging animal lineage: synthesizing evidence from molecular phylogenetics, palaeontology and developmental biology

16:45 *Catherine Crônier*
Disparity and ontogeny: how the environment or developmental constraints influence morphological changes in Late Devonian phacopid trilobites

17:00 *Ricard S. Solé*
***In silico* evodevo: the multiple paths to evolutionary convergence**

17.15 *David Bruno and Rich Mooi*
Disorder in the *Hox* cluster as generator of modularity: a macroevolutionary view of echinoderms

Pippard Lecture Theatre, Sherfield Hall, Imperial College

S4 - Microfossil contributions to understanding the tree of life

Chairs: Paul Bown and Jeremy Young

09:00 Keynote – *Jan Pawlowski*
Deep phylogeny of eukaryotes: how important are microfossils in the genomic era?

09:30 Thomas H.G. Ezard, T. Aze, Paul N. Pearson and Andy Purvis
Key contributions of inter-group variation for macroevolutionary inference

09:45 *Jeremy R. Young, Paul R. Bown, Martine Couapel, Kyoko Hagino, Ian Probert and Colomban de Vargas*
Integrating molecular and palaeontological data on the evolution of coccolithophores

10:00 *Edwige Masure, Jean Dejax and Gaël De Ploëg*
Multi-staged dinoflagellates with gametes fusion in Cretaceous amber: Peridiniaceae evolution

10:15 *Dany Azar, Jean Dejax and Edwige Masure*
Palynological analysis of an amber-bearing clay and of this amber from the Lower Cretaceous of Lebanon

10:30 COFFEE/TEA

11:00 **Keynote –** *Ivan J. Sansom*
Lower Palaeozoic microvertebrates and macroevolution

11:30 *Duncan J.E. Murdock, Philip C. Donoghue, Stefan J. Bengtson and Marco Stampanoni*
The origin of the conodont skeleton

11:45 *Michele Mazza, Andrea Cau and Manuel Rigo*
Revision of the Carnian/Norian conodonts through the application of cladistic analysis

12:00 *Andrew J. Jeram*
The micropalaeontology of terrestrial arthropods – progress and prospects

12:15 *David J. Siveter, Derek E.G. Briggs, Derek J. Siveter and Mark D. Sutton*
Exceptionally preserved myodocope ostracods from the Herefordshire (Silurian) Lagerstätte: implications for the Palaeozoic ostracod record

12:30 LUNCH

Flett Lecture Theatre, NHM

S5 - The acquisition, curation and conservation of palaeontological collections

Chairs: Sarah Long and Matthew Parkes

09:00 *Michael P.A. Howe, David Williams, Ian Evans, Jonathan G. Larwood, Susan Martin, John N. Carney, Mark C. Dean, Louise F Neep, Paul J. Shepherd and Philip R. Wilby*
First impressions – casting the enigmatic Ediacarans of Charnwood Forest

09:15 *Jonathan G. Larwood, Richard Edmonds and Hannah C.Townley*
Closing the circle – conserving fossils at source

09:30 *Melissa Grey and Deborah M. Skilliter*
Collections management at the Joggins Fossil Cliffs UNESCO work heritage site: a new model?

09:45 *Lorraine Cornish*
Laser cleaning palaeontology specimens – treatment and ethical considerations

10:00 *Carolina R. Laurini, Martha Richter and Richie Abel*
Utilizing CT-scan technology to dissect rare Palaeozoic shark teeth

10:15 *Giles C. Miller and Chris Collins*
Management of micropalaeontological collections – science or tradition?

10:30 COFFEE/TEA

11:00 *Svetlana Nikolaeva*
Historical collections of Carboniferous ammonoids at The Natural History Museum: amateur collecting and professional expertise

11:15 *Paul D. Taylor and Di Clements*
Curation of complex palaeontological objects: cobbles encrusted by multiple individuals and species from the Japanese Pleistocene

11:30 *Ulrich Jansen*
The Hunsrueck slate and brachiopod collections of the Senckenberg Museum: new initiatives

11:45 *Petr Budil, P. Bokr, P. Čoupek and M. Steinová*
Gathering and presentation of the data from palaeontological collections: The case study of the Czech Geological Survey

12:00 *Olle Hints, Mare Isakar and Rutt Hints*
Palaeontological collections in Estonia: an example of development of national collection management software.

12:15 *Tiffany S. Adrain, Ann F. Budd and Jonathan M. Adrain*
The University of Iowa paleontology repository digitization project

12:30 *Tim McCormick*
Palaeosaurus: feeding the big beast

12:45 *Andrea Fiorentino*
Database of samples and paleontological analyses in the frame of the Italian CARG Project, geological cartography at the 1:50.000 scale

13:00 LUNCH

POSTERS

Anna García-Forner and Ana Márquez-Aliaga
Museum of Geology at the University of Valencia (Spain): general aspects

Alejandra Rojas
The palaeontological collection at Facultad de Ciencias, Montevideo, Uruguay: past, present and future

M. Consuelo Sendino and Paul D.Taylor
Charles Lyell's research on fossils from the Canary Islands

Paul P. Tinerella, Sam W. Heads and Michael D. Maehr
The fossil resins in the entomology collection of the Illinois Natural History Survey: overview and current work

Lecture Theatre 2.28, Imperial College

S14 - Molecular palaeobiology: molecular clocks, evolutionary rates and geological dates

Chair: Phil Donoghue

09:00 **Keynote -** *Bruce Runnegar*
Towards high-resolution timescales for paleobiology, geobiology and astrobiology

09:30 **Keynote** › *S.A. Bowring, D.H. Erwin, A.C. Maloof and D.J. Condon*
Geochronology and molecular clocks: calibrating Earth history and the origin of animals

10:00 **Keynote -** *Davide Pisani, Erik A. Sperling and Kevin J. Peterson*
A new molecular timescale of animal evolution: parameters tuning and palaeontological hypotheses testing

10:30 COFFEE/TEA

11:00 *Rachel C.M. Warnock, James E. Tarver, Alistair J. McGowan, Yang Ziheng, Philip C.J. Donoghue and Kevin J. Peterson*
Integrating molecular and palaeontological approaches to telling evolutionary time

11:15 *F.U. Battistuzzi, A. Filipski, S.B. Hedges, and S. Kumar*
Performance of relaxed clock methods in estimating evolutionary divergence times and their credibility intervals

11:30 *Ma Junye and Yang Qun*
Molecular dating suggests biomineralization of sponges in late Neoproterozoic

11:45 *Omar Rota-Stabelli, Allison C. Daley, Hervè Philippe and Davide Pisani*
Dating arthropod relationships using relaxed clock, soft constrains and diverse phylogenomic datasets

12:00 *Jakob Vinther, George Kampouris, Kevin J. Peterson, Thomas Near and Derek Briggs*
Multi placophorans, polyplacophorans, stem groups and crown groups: a molecular paleobiological perspective on early chiton evolution

12:15 *Andrea Waeschenbach, P.D. Taylor, J.S. Porter and D.T.J. Littlewood*
Interrelationships of major clades of Bryozoa: integrating molecular evidence with the fossil record

12:30 LUNCH

Chair: Davide Pisani

13:45 *Carl Simpson, Heike Mewis, Wolfgang Kiessling, Rosemarie C. Baron-Szabo, and Johannes Müller*
Extinction-driven diversification decline in reef corals during the last 200 million years

14:00 *Harald Schneider, Nadia Bystriakova and Wang Li*
Exploring the impact of Cenozoic climate fluctuations on the extant diversity of ferns

14:15 *Li Chun-xiang, Yang Qun, Ma Jun-ye and Lu Shu-gang*
Continental Asia or Malesian Archipelago: molecular dates to trace the origin of fern *Phymatopteris* (Polypodiaceae)

14:30 *Patrick Strutzenberger and Konrad Fiedler*
Molecular dating reveals a Mid to Late Miocene origin of present day neotropical species richness in a diverse genus of geometrid moths

14:45 *Steven M. Carr*
Ice-age phylogeographic genomics in Holarctic terrestrial & North Atlantic marine environments: case studies of four pre- and post-glacial population structures

15:00 *Sheng Guilian, Yi Jian, Wu Lianjuan, Lai Xulong and Chen Quanjia*
Phylogeographic pattern indicated by ancient DNA analyses of the Pleistocene spotted hyena (*Crocuta crocuta ultima*) from Northern China

15:15 COFFEE/TEA

15.45 *Kazuyoshi Endo, Isao Sarashina, Satoshi Chiba and Toshifumi Takao*
Phylogeny estimation based on fossil protein sequences: a case of extinct land snails from the Bonin Islands

16:00 *Stuart J. Longhorn*
Insights on the sensory capabilities of extinct lineages in a node-dated framework

S18 - From teeth to Tibet – new techniques and views on mammals and Cenozoic environmental change

Chair: Christine Janis and Jussi Eronen

13:45 *Polly P. David and A. Michelle Lawing*
Cats in the trees, snakes in the grass: ecometric variation in locomotion of terrestrial vertebrate carnivores

14:00 *Leah R.S Schwartz*
Palaeoecological interpretations of Australia's mid-Tertiary: new methods and tensions

14:15 *Philip J. Hopley, Lars Werdelin, Henrik J. Jensen, Randall R. Parrish and Mark Maslin*
Plio-Pleistocene climate change in Africa and modeling faunal response

14:30 *Catherine Badgley and John A. Finarelli*
Diversity dynamics of Miocene rodents in relation to tectonic and climatic history

14:45 *Blaire Van Valkenburgh and W.J. Ripple*
Carnivore tooth fracture and Pleistocene predator-prey dynamics

15:00 *Sarah C. Joomun, Jerry J. Hooker and Margaret E. Collinson*
Climate change versus competition as the cause of ungulate extinction at the Grande Coupure (Early Oligocene, Europe)

15:15 COFFEE/TEA

15:45 **Keynote -** *Adrian M. Lister*
Mammalian responses to environmental change: the Quaternary link between ancient and modern

16:15 *Jason J. Head*
Metabolic paleothermometry: climatic insights from the fossil record of reptiles

16:30 *Dennis O. Terry Jr. and David E. Grandstaff*
The non-marine Eocene-Oligocene climate transition of the northern Great Plains, USA: insights from rare earth element signatures of fossil bone

16:45 *Isaac Casanovas-Vilar, Israel García-Paredes, David M. Alba, Lars W. Van den Hoek Ostende and Salvador Moyà-Solà*
The European far west: Miocene mammal diversity dynamics in the Iberian Peninsula

17:00 *Christine M. Janis, Jussi T. Eronen, Majid Mirzaie Ataababi, Kai Puolamäki and Mikael Fortelius*
Patterns of hypsodonty in ungulates show that Neogene aridity in North America preceded that in Eurasia

17:15 *Jussi T. Eronen, Majid Mirzaie-Ataabadi, Aleksis Karme, Arne Micheels, Raymond L Bernor and Mikael Fortelius*
Rise and fall of the Pikermian chronofauna

Lecture Theatre 1.47, Imperial College

S22 - Mechanisms that guide evolutionary change for vertebrate dentitions: co-option of ancient patterns

Chair: Zerina Johanson and Moya Meredith Smith

09:00 **Keynote –** *Gareth J. Fraser and Todd J. Streelman*
Ancient gene networks and the evolution of the core tooth module from old to new jaws

09:30 *Moya M. Smith, Kate Trinajstic and Zerina Johanson*
Origin of teeth in placoderms, co-option of genetic regulation in a developmental model

09:45 *Martin Rücklin, Philip C.J. Donoghue, Zerina Johanson, Kate Trinajstic, Marone Federica and Marco Stampanoni*
The evolution and development of teeth and jaws before gnathostomes

10:00 *Andrew B. Heckert and Jonathan M. Mitchell*
Mesozoic microvertebrates as windows into tetrapod tooth evolution and development

10:15 *Victoria L. Herridge and Adrian L. Lister*
Ontogeny underpins the evolution of dwarf elephant molars

10:30 COFFEE/TEA

11:00 ***Keynote –*** *Mark Tummers*
Tinkering with root development and tooth diversity

11:30 *Živilė Žigaitė*
Evolution of vertebrate exoskeleton: Silurian thelodont biodiversity and tissue development

11:45 *Claire Derycke and D. Goujet*
Scheme of characters in chondrichthyans (teeth and scales)

12:00 *Plamen S. Andreev*
Convergence in dental histology between the Upper Triassic semionotiform *Sargodon tomicus* (Neopterygii) and a pycnodontid (Neopterygii: Pycnodontiformes) from the Upper Cretaceous

12:15 *Charlie J. Underwood and David Ward*
Chondrichthyan palaeoecology in a whale carcass rich environment in the Late Eocene of Egypt

12:30 LUNCH

Lecture Theatre 1.51, Imperial College

S24 - The origin of life on land and its geological consequences

Chair: Marco Vecoli

09:00 **Keynote -** *Nicholas J. Butterfield*
Multicellular plants in deep time: developmental constraints and coevolutionary motors

09:30 *Leila Battison and Martin D. Brasier*
Ecological adaptation of algal communities in billion-year-old lake basins

09:45 **Keynote -** *Charles H. Wellman*
The origin of land plants and its impact on the environment of planet Earth

10:15 *Paul K. Strother*
Character evolution and the origin of land plants

10:30 COFFEE/TEA

11:00 *Paul Kenrick*
Land plant origins: phylogenetic and temporal context

11:15 *Gaël Clément, Nicolas Rabet, Olivier Béthoux, Sylvain Charbonnier, Marco Vecoli, Sébastien Olive and Linda Lagebro*
Arthropod fauna of the Upper Devonian tetrapod-bearing locality of Strud, Belgium

11:30 *Alan Channing and Dianne Edwards*
A 400 million year history of silicon accumulating plants in geothermally influenced wetlands?

11:45 *Christopher M. Berry, William E. Stein and Peter Giesen*
New tales from the oldest forests

12:00 *Brigitte Meyer-Berthaud, Anaëlle Dambreville, Hervé Rey and Jean-François Barczi*
Numerical modeling of *Pseudosporochnus* (Cladoxylopsida), a tree of Middle Devonian age

12:15 *Cyrille Prestianni, Brigitte Meyer-Berthaud and Philippe Gerrienne*
The flora from Dechra-Aït-Abdallah (Morocco): a Lower to Middle Devonian transitional assemblage

12:30 LUNCH

Chair: Paul Kenrick

13:45 *Christine Strullu-Derrien, Paul P. Kenrick, Jean-Philippe Rioult and Désiré-Georges Strullu*
Fungi and fungal-like microorganisms in early terrestrial ecosystems

14:00 *Sophie Sanchez, Paul Tafforeau and Per E. Ahlberg*
Limb bone histology and architecture of *Eusthenopteron*: new lights on its life-history traits

14:15 *Per E. Ahlberg, Pavel Beznosov, Ervins Luksevics and Jennifer A. Clack*
A primitive Devonian tetrapod from the Lower Famennian of South Timan, Russia

Lecture Theatre G41, Imperial College

S26 - Time-specific facies: the colour and texture of biotic events

Chairs: Pat McLaughlin and Annalisa Ferreti

09:00 **Keynote** - *Eberhard Schindler*
Time-specific facies – meaning, application, potential

09:30 *Jin Jisuo, David A.T. Harper and Jan A. Rasmussen*
The Late Ordovician *Thalassinoides* ichnofacies along the palaeoequator of Laurentia

09:45 *Benjamin F. Dattilo, Patrick I. McLaughlin and Carlton E. Brett*
Facies and biotic events in the type Cincinnatian (Upper Ordovician): differentiating environmental from climatic-oceanographic signals

10:00 *Carlton E. Brett, Gordon C. Baird, Alex J. Bartholomew, Patrick McLaughlin, Eberhard Schindler and James Zambito*
Mid Paleozoic rhythmic trilobite-rich beds: a time-specific signature of obrutionary events and diagenetic rhythms

10:15 *Alexander J. Bartholomew and Carlton E. Brett*
Sequence stratigraphic interpretation of 'Thicketing Intervals' in the Middle Devonian of Eastern North America

10:30 COFFEE/TEA

Chairs: Carl Brett and Pat McLaughlin

11:00 *Johanna I.S. Mellgren, Mats E. Eriksson and Birger Schmitz*
Faunal changes and hi-res biostratigraphy through a colour-shifting limestone sequence: the unravelling of a Middle Ordovician eco-event in Baltoscandia

11:15 *Kathleen Histon*
The Silurian nautiloid faunas of the Cellon Section (Carnic Alps, Austria): colour variation related to events

11:30 *J. Javier Álvaro*
Colour and texture banding in a late Neoproterozoic, microbially variegated sabkha of the Taoudeni Basin, Adrar, Mauritania

11:45 *Annalisa Ferretti, Barbara Cavalazzi, Roberto Barbieri and Rossana Todesco*
The colour of the Silurian: just biopaintings?

12:00 *Mikael Calner and Oliver Lehnert*
Oolite distribution in space and time (ODSAT): a future global data base for calcareous oolites

12:15 *José I. Valenzuela-Ríos*
Colour change and global events, a hoax? A case study from the Lochkovian (Lower Devonian) in the Spanish Central Pyrenees

12:30 LUNCH

Chairs: Annalilsa Ferretti and Kathleen Histon

13:45 **Keynote -** *Anthony Hallam*
Black is the colour – not just a seasonal fashion

14:15 *Martin Zuschin, Michael Stachowitsch and Bettina Riedel*
Modern shelf anoxia and dead zones as analogues to ancient anoxic facies of epicontinental seas: from settings to processes

14:30 *Elisabetta Erba, Cinzia Bottini, Helmut J. Weissert and Christina E. Keller*
Surface-water acidification precedes deep-water carbonate dissolution and anoxia during Oceanic Anoxic Event 1a

14:45 *Patrick I. McLaughlin, Carlton E. Brett and Poul Emsbo*
A mid Silurian red-green to gray-black shale transition: a case study in time specific color facies

15:00 *Poul Emsbo, Axel Munnecke, George N. Breit, Alan E. Koenig, Patrick I. McLaughlin, Lennart Jeppsson and Philip L.Verplanck*
Geochemical record of marine anoxia during the Ireviken Event

15:15 COFFEE/TEA

Chairs: Kathleen Histon and Carl Brett

15:45 *Ian G. Percival*
Biotic characteristics of deep-water cherts in the Ordovician of eastern Australia, and their correlatives in Kazakhstan and Scotland

16:00 *Gordon C. Baird, James J. Zambito and C.E. Brett*
Lithologic signature of the Late Middle Devonian Taghanic bioevent in its type area: anomalous carbonate and chamosite accumulations in the Tully Formation Interval, New York State

16:15 *Eberhard Schindler and Manfred Gereke*
Tracking biological and sedimentological changes in event-related crisis intervals across facies borders – do they represent "Time-Specific Facies"? The Kellwasser Horizons and their equivalents near the Frasnian/Famennian boundary

Lecture Theatre G20, Imperial College

S27B - Open Symposium – General palaeontology

Chair: Martin Munt

09:00 *Julien Denayer*
Lower Carboniferous rugose corals from the Zonguldak Area (northwestern Turkey)

09:15 *Michael J. Vendrasco, Antonio G. Checa and Artem V. Kouchinsky*
Shell microstructure of the early clam *Pojetia* and the independent origin of nacre within the Mollusca

09:30 *Martin Munt and Graciela Delvene*
Palaeobiogegraphy of the trigonioidids of Europe

09:45 *Vojtěch Turek and Štěpán Manda*
Polymorphism in colour pattern in the Silurian nautiloid *Phragmoceras* Broderip, 1839

10:00 *Seyed Hamid Vaziri*
Late Ladinian to early Carnian ammonoids from the Ashin Formation in the Nakhlak Area, central Iran

10:15 *Kazuyoshi Moriya, Hiromichi Hirano, Tadamichi Oba, Kazushige Tanabe and Cyprian Kulicki*
Isotopic signatures for the habitat and growth of the Middle Jurassic ammonoid *Quenstedtoceras*

10:30 COFFEE/TEA

Chair: Lars Holmer

11:00 *Margaret M. Yacobucci*
Speciation during the Cenomanian radiation of ammonites in the Western Interior Seaway of North America

11:15 *C.B. Skovsted, L.E. Holmer, T.P. Topper and G.A. Brock*
Brachiopod affinity of the Lower Cambrian problematic bivalve *Apistoconcha*

11:30 *Rong Jiayu, Zhan Renbin and Huang Bing*
Origin and early evolution of spiriferid brachiopods

11:45 *Martin Aberhan, Wolfgang Kiessling and Sabine Nürnberg*
Is vision in Phanerozoic marine invertebrates associated with evolutionary success?

12:00 *Marcus M. Key Jr., Gregory A. Schumacher and Loren E. Babcock*
Palaeoecology of commensal episkeletozoans fouling *Flexicalymene* (Trilobita) from the late Ordovician Cincinnati Arch Region

12:15 *Michael J. Pratt*
Did Mark Twain discover America's most important fossil site?

12:30 LUNCH

Chair: Paul L. Smith

13:45 *Charles E. Mitchell, Michael J. Melchin, Chris B. Cameron and Jörg Maletz*
Phylogeny of the tube-bearing Hemichordata reveals that *Rhabdopleura* is an extant graptolite

14:00 *Seda Uzuncimen, Ugur K. Tekin, Yavuz Bedi and Elif Varol*
Late Triassic radiolarian biostratigraphy of the Kocali Complex, SE Turkey

14:15 *Ibrahim K. Ertekin, Nazire Özgen Erdem and Cemal Tunoğlu*
Middle Eocene Ostracoda and benthıc foramınıfera faunas from the Kazan Basın, central Anatolia, Turkey

14:30 *Colin D. Sumrall and Michael L. McKinney*
Heterochronic evolution of isophorid edrioasteroid ambulacra in the context of surface-volume constraints

14:45 *Stephen K. Donovan and David N. Lewis*
Upper Cretaceous *Echinocorys* Leske (Echinoidea) as a hard substrate in a modern shallow water environment

15:00 *Andrew H. Caruthers, Darren R. Gröcke and Paul L. Smith*
The Early Toarcian oceanic anoxic event in Western North America

15:15 COFFEE/TEA

Chair: Martin Zuschin

15:45 *Johann Hohenegger*
Gardeners and architects of glasshouses in the oceanic microcosm

16:00 *Stefano Dominici, Martin Zuschin and D. Merle*
Intertidal to shelf gradients across the Cenozoic

16:15 *Jennifer A. Sawyer and Martin Zuschin*
Spatial variation in drilling predation from intertidal, shallow sublittoral and shelf environments from the Early and Middle Miocene marine fossil record of the central Paratethys

16:30 *Patrícia Madeira, Sérgio P. Ávila , Ricardo Cordeiro and Ricardo P. Meireles*
Palaeobiogeographic challenges in the middle of the Atlantic – MPB working group

16:45 *Sérgio P. Ávila*
Why are oceanic islands' shores so devoid of life? A 5My story from The Azores (NE Atlantic)

17:00 *Jesper Hansen, Hanken Nils-Martin, Jesper K. Nielsen, Jan K. Nielsen and Elsebeth Thomsen*
Holocene *Mytilus* in the Barents Sea Region

17:15 *Ralf Kosma, Ulrich Joger, Alexander Mudroch, Kristian Remes and Ute Richter*
New dinosaur fossils from the Middle Jurassic Irhazer site of Northern Niger

17:15 - 18:15 **POSTER SESSION**

Symposium 2 - Macroevolution

Manabu Sakamoto, Graeme T. Lloyd and Michael J. Benton
Phylogenetically structured variance in felid bite force: the role of phylogeny in the evolution of biting performance

Akinori Takahashi and Yasuhiro Iba
Biogeographic change in inoceramid bivalves during the Mid-Cretaceous in the Northwest Pacific

Symposium 8 - Great Ordovician biodiversification event

Olle Hints and Jaak Nõlvak
Metazoan egg capsules from the Baltic Darriwilian (Middle Ordovician)

Sarah E. Stewart
Molluscs and shelly faunas from the Ordovician of Girvan and Southern Uplands of Scotland

Zbigniew Szczepanik and Wiesław Trela
Upper Ordovician acritarch assemblages from the Southern Holy Cross Mountains (Poland)

Martin Valent
Palaeogeographic distribution of Ordovician hyoliths

Graham A. Young, David M. Rudkin, Edward P. Dobrzanski, Sean P. Robson, Michael B. Cuggy and Deborah P. Thompson
Late Ordovician Lagerstätten in Manitoba, Canada: glimpses of soft-bodied diversity

Cheng Junfeng, Zhang Yuandong, Axel Munnecke and Zhou Chuanming
Carbon isotope development in the Ordovician of the Yangtze Gorges region (South China) and its implication for stratigraphic correlation and palaeoenvironmental change

Symposium 13 - Biotic recoveries

Heather Birch, Helen Coxall, Paul Pearson and Daniella Schmidt
Evolution of photosymbiosis and recovery of the carbon system after the End Cretaceous mass extinction

Rowan C. Martindale and David J. Bottjer
Palaeoecology of Upper Triassic reefs

Aaron O'Dea and Walton A. Green
Evolution of cupuladriid niche breadths during environmental change, habitat diversification and faunal turnover in the Caribbean

Luis-Felipe Opazo, Richard J. Twitchett, Andrew J. Jeram, Ian Enlander and Michael Simms
Using rank-abundance curves to evaluate the palaeoecological response of marine benthic communities to the Late Triassic mass extinction event

Laura K. Säilä
The interrelationships, paleobiogeography and the End-Permian extinction event survival rate of the parareptile clade Procolophonoidea

Ladislav Slavík
The effect of the Late Ludfordian Lau event on the conodont faunas from Bohemia

Wang Yongdong, Tian Ning and Zikun Jiang
Macrofloral response to the End-Triassic mass extinction event: evidence of plant diversity variation and turnover through the Triassic/Jurassic boundary in the Sichuan Basin, China

Bettina Riedel, Michael Stachowitsch and Martin Zuschin
An experimental approach to benthic community destruction and recovery from anoxia in the Northern Adriatic Sea

Symposium 16 - Rates of morphological evolution

Martin Hughes, Sylvain Gerber and Matthew A. Wills
Trends in morphological disparity through the Phanerozoic

Melanie J. Monroe and Folmer Bokma
Rates of speciation, extinction and phenotypic evolution in birds and mammals

Symposium 18 - Teeth to Tibet

Jussi T. Eronen, Majid Mirzaie-Ataabadi, Aleksis Karme, Arne Micheels, Raymond L. Bernor and Mikael Fortelius
The rise and fall of Pikermian chronofauna

M. Gameil, M. Al Anbaawy and A. Gebaily
Fossil whale skeletons of Wadi Al-Hitan, Fayoum Area: stratigraphy and paleoecologic significance

A. Michelle Lawing and P. David Polly
Testable paleophylogeographic models and species' response to climate change

Anneke Madern and Lars W. van den Hoek Ostende
Drift in Miocene mammalian hotspots

Juha J. Saarinen
Local body size patterns of large herbivorous land mammals in the Miocene of Eurasia

Leena Sukselainen
Pliopithecid biogeography and paleoecology: Asian localities

Symposium 21 - Phylogenetic processes

Lisa A. Cajsa and Isabel Sanmartín
Is there a Rand flora pattern? (and how do we answer that question?)

Joanna M. Wolfe
Arthropod tagmosis: inferred expression of developmental genes in extinct taxa

Symposium 24 - Origin of life on land

Maria-Fernanda Romero-Sarmiento, A. Riboulleau, M. Vecoli and G.J.M. Versteegh
Aliphatic and aromatic biomarkers from Carboniferous coal deposits at Dunbar (East Lothian, Scotland): palaeobotanical and palaeoenvironmental significance

Amalia Spina and Marco Vecoli
Palaeovegetational and palaeoclimatic trends across the Silurian-Devonian transition by palynological data from Southern Tunisia

Marco Vecoli, A. Delabroye, A. Spina and O. Hints
Cryptospore assemblages from the Hirnantian of Anticosti Island, Québec, Canada, and from Valga-10 borehole, Estonia : palaeophytogeographic and palaeoclimatic implications

Symposium 26 - Time-specific facies

Matthew W. Demski, Lori A. Stewart, Robert J. Elias, Graham A. Young, Godfrey S. Nowlan and Edward P. Dobrzanski
Hirnantian (Latest Ordovician) event in the centre of North America? Colour, carbon isotopic excursion and conodont turnover

Kathleen Histon
The varied colours of palaeozoic orthoconic nautiloid cephalopod accumulations

Andrea Tintori, Annalisa Ferretti and Alessandra Negri
Black and white colour in sediments: a Jurassic switch?

Symposium 27C - Palaeobotany

Alan R.T. Spencer and Mark D. Sutton
3D X-ray Microtomography reconstrutions: an important preliminary tool for palaeobotanists

Symposium 27D - Arthropods and exceptional preservation

Petr Budil, Oldřich Fatka and Brigitte Schoenemann
Exoskeletal structures in Ordovician trilobites of the Prague Basin (Czech Republic)

Petr Budil, Martin David, Oldřich Fatka and Michal Mergl
Trilobite associations of the Kraluv Dvur Formation (Czech Republic, Prague Basin)

Dai Tao and Zhang Xingliang
Ontogeny of the redlichiid trilobite *Metaredlichia cylindrica* Chang, 1953 from the Lower Cambrian of South China

Huang Jiandong, Liu Pingjuan and Ren Dong
Aquatic insect community succession and environmental changes in the Late Mesozoic of Northern China

Sören Jensen, Teodoro Palacios and Mónica Martí Mus
Revised age of trilobites from the Lower Cambrian Pusa Formation, Central Iberian Zone, Spain

Lucy M.E. McCobb, W. Douglas Boyce, Ian Knight and Svend Stouge
A bathyurid biofacies (trilobita) from the Lower Ordovician (Ibex, Tulean) Septembersø Formation, North-East Greenland

Ricardo P. Meireles, Ricardo Cordeiro, Patricia Madeira, António Frias Martins and Sérgio P. Ávila
New data on the Miocene marine ostracodes from The Azores

Saturday 3rd July

Lecture Theatre 1.47, Imperial College

S8 - Great Ordovician biodiversification event: causes and consequences

Chairs: David Harper and Thomas Servais

09:00 **Keynote –** *Alan W. Owen*
The Ordovician world

09:30 *Jonathan M. Adrain, Stephen R. Westrop, N.E.B. Karim and T.S.McAdams*
The Ordovician radiation of trilobites: the last "biomere" recovery

09:45 *Neo E.B. McAdams and Jonathan M. Adrain*
Beyond biostratigraphical correlation: *Carolinites*, calibrating the Whiterock trilobite fauna diversification, and phylogenetic tests of proposed ancestry

10:00 *Talia S. Karim and Jonathan M. Adrain*
Resolving Whiterock trilobite fauna "cryptogenesis" with developmental data: styginids are paedomorphic derivatives of leiostegiids

10:15 *Stephen R. Westrop, Lisa Amati, Jesse R. Carlucci, Carlton E. Brett and Matthew R. Saltzman*
Late Ordovician trilobite biofacies of eastern Laurentia: paleoecological patterns in the wake of the Ordovician radiation

10:30 COFFEE/TEA

11:00 *Oldřich Fatka and Petr Budil*
Edrioasteroids attached to *Selenopeltis* revisited

11:15 *Stephen K. Donovan, C. Giles Miller, Ivan J Sansom, Alan Heward and Jan Shreurs*
Gondwana to Baltica to Avalonia to Laurentia: *Iocrinus* Hall (Disparida), a globetrotting crinoid in the Ordovician

11:30 *Tõnu Meidla, Oive Tinn, José Maria Salas, Mark Williams, David Siveter, Thijs Vandenbroucke and Koen Sabbe*
Biogeography of Ordovician ostracods: palaeo-continental or climatic controls?

11:45 *Zhang Yuandong, Chen Xu, Dan Goldman, Zhang Ju, Cheng Junfeng and Song Yanyan*
Diversity and palaeobiogeographic patterns of Ordovician graptolites in distinct environments of South China

12:00 *Thomas Servais, David A.T Harper and Axel Munnecke*
Climate, sea-level, trophic chains: what happened in the Ordovician oceans?

12:15 *Nikolay V. Sennikov, Olga T. Obut and Elena V. Bukolova*
Ordovician graptolites and chitinozoans and their leading role in formation of complicated Palaeozoic pelagic biota structure

12:30 LUNCH

13:45 *Gladys Ortega, Guillermo L. Albanesi, Agustin Bejerman, Gustavo G. Voldman and Aldo L. Banchig*
Graptolite and conodont faunas from the Middle-Upper Ordovician Sierra de la Invernada formation, central Precordillera of San Juan, Argentina

14:00 *Peter Van Roy, Patrick J. Orr, Joseph P. Botting, Lucy A. Muir, Jakob Vinther, Bertrand Lefebvre, Khadija el Hariri and Derek E.G. Briggs*
An exceptionally preserved biota from the Early Ordovician of Morocco

14:15 *Mansoureh Ghobadi Pour, Irina A. Kim, Firuza A. Salimova, Alexei I. Kim, Leonid E. Popov and Maya V. Erina*
Mid to Late Ordovician biodiversity and biogeography patterns in 'east' peri-Gondwana from Iran to Central Asia

14:30 *Ian G. Percival*
Ordovician biodiversification trends in east Gondwana: comparsion between cratonic and island arc settings

14:45 *Guillermo L. Albanesi, Gladys Ortega, Fernando J. Zeballo and Fernanda E. Pacheco*
The Cambrian-Ordovician boundary in South America: high resolution biostratigraphy, global correlation and paleoenvironments

15:00 *Natsuko Adachi, Yoichi Ezaki and Liu Jianbo*
The oldest bryozoan (Early Ordovician) reefs were constructed by an unusual mode of bryozoan growth

15:15 COFFEE/TEA

15:45 *Yoichi Ezaki, Liu Jianbo and Natsuko Adachi*
Early Ordovician marine regime shift from Precambrian-type microbe-dominated to Phanerozoic-type Metazoa-dominated reefs: geobiological turning point

16:00 *Robert J. Elias, Lee Dong-Jin and Bae Boo-Young*
Did storms have a role in the great Ordovician biodiversification event? Evidence from corals in a Laurentian storm-swept epicontinental sea

16:15 *Dimitri Kaljo, Linda Hints, Olle Hints, Peep Männik, Tõnu Martma and Jaak Nõlvak*
Katian biodiversity – a prelude to the Hirnantian (Ordovician) mass extinction as seen from Baltic data

16:30 *Aurélien Delabroye, Aïcha Achab, Esther Asselin, Paul Copper, André Desrochers, Claude Farley, Jean-François Ghienne, Michael Joachimski, Alfredo Loi, Axel Munnecke, Florentin Paris and Marco Vecoli*
Toward a refined "Hirnantian Composite Stratigraphic Model" for Laurentia, Baltica and North Gondwana

16:45 *William B.N. Berry*
Role of oxygen in Hirnantian graptolite extinctions

Lecture Theatre 2.28, Imperial College

S13 Biotic recovery after mass extinction events

Chair: Richard Twitchett

09:00 **Keynote –** *Hugo Bucher*
The Early Triassic biotic recovery: new facts challenge old tales

09:30 *Sylvie Crasquin and Marie-Beatrice Fore*
Ostracods (Crustacea) and Permian–Triassic events: extinctions and recovery

09:45 *Marie-Béatrice Forel and Sylvie Crasquin*
Ostracods (Crustacea): witnesses of paleoenvironmental modifications associated with Permian-Triassic boundary events in the Paleo-Tethys Ocean

10:00 *Richard Hofmann, Michael Hautmann, Nicolas Goudemand, Martin Wasmer and Hugo Bucher*
Dynamic recovery patterns of benthic ecosystems in the aftermath of the End-Permian mass extinction

10:15 *Andrzej Kaim and Alexander Nützel*
Dead bellerophontids walking – the short Mesozoic history of the Bellerophontoidea (Gastropoda)

10:30 COFFEE/TEA

11:00 *Steve Kershaw, Sylvie Crasquin, Marie-Beatrice Forel, Carine Randon, Pierre-Yves Collin and Erdal Kosun*
Permian-Triassic boundary microbialites in southern Turkey: a high-resolution analysis

11:15 *Lai Xulong, Yang Bo and Jiang Haishui*
A newly discovered early Triassic chert at Gaimao section, Guzhou, Southwestern China

11:30 *Alexander Nützel and Andrzej Kaim*
Larval ecology in the aftermath of the End-Permian mass extinction: possible selectivity and implication for a possible productivity crisis

11:45 *Tatsuo Oji and Richard J. Twitchett*
A new Griesbachian crinoid: implications for palaeogeographic recovery patterns

12:00 *Pablo Plasencia and Ana Márquez-Aliaga*
Recovery of conodonts after the Permian extinction

12:15 *Tong Jinnan, Wang Chenggan and Xiong Xinqi*
Biotic radiation following the Early Triassic recovery in South China

12:30 LUNCH

13:45 *Richard J. Twitchett and Thomas J. Algeo*
High sedimentation rates in Early Triassic shelf settings: a control on post-Permian biotic recovery?

14:00 *J. Javier Álvaro, Samuel Zamora and Daniel Vizcaïno*
Aftermath of the mid Languedocian (mid Cambrian) regression in southwestern Europe

14:15 *André Desrochers, D.G.F. Long and Claude Farley*
Changes in the style of carbonate production in the tropics during the End-Ordovician glaciation

14:30 *Petr Štorch, Ladislav Slavík, Štěpán Manda and Jiří Frýda*
Late Ludlow *koslowskii* event in Bohemia: graptolite record combined with conodont, sedimentary and carbon isotope data

14:45 *Lauren C. Sallan*
Functional morphology and modular lags in radiation events: patterns from early actinopterygian morphospace

15:00 *Olga L. Kossovaya*
Event patterns of Pennsylvanian – Cisuralian rugose evolution

15:15 COFFEE/TEA

15:45 *Marie-Emilie Clemence, Annachiara Bartolini, Silvia Gardin, Guillaume Paris, Valerie Beaumont and Kevin N. Page*
Early Hettangian benthic-planktonic coupling at Doniford (SW England): Palaeoenvironmental implications for the aftermath of the end–Triassic crisis

16:00 *Peter M. Sheehan, John L. Isbell and David E. Fastovsky*
Post-K/Pg terrestrial and freshwater recovery in a physically devastated landscape

16:15 *Caroline E. Sogot, Elizabeth M. Harper and J. Alistair Crame*
Predatory activity towards *Rotularia* (Annelida) at the K-T mass extinction

16:30 Aaron O'Dea and Walton A. Green
Persistent niche conservatism curbs recovery after Caribbean extinctions

16:45 *Theodora Pados, K. Pretterebner, Lucy Schiemer, Bettina Riedel, Michael Stachowitsch and Martin Zuschin*
Quantifying short- and longer-term responses to marine anoxia: an actualistic approach

17:00 **Discussion**

Lecture Theatre 1.31, Imperial College

S16 - Rates of morphological evolution: size, shape and charatcter change in fossil lineages

Chairs: Stephen Brusatte and Graeme Lloyd

14:30 **Keynote** - *Peter J. Wagner*
Some possible directions for future tree-based studies of rates

15:00 *H.C.E. Larsson, T.A. Dececchi and L.B. Harrison*
Clocking morphology: estimating ancient divergence times and absolute rates of morphological evolution

15:15 COFFEE/TEA

15:45 *Steve C. Wang, Graeme T. Lloyd and Stephen L. Brusatte*
Testing for heterogeneity in rates of morphological evolution: discrete character change in the evolution of lungfish (Sarcopterygii; Dipnoi)

16:00 *Matt Friedman and Lauren C. Sallan*
Heads and tails, size and shape: contrasting patterns and modes of phenotypic diversification during the evolutionary radiation of acanthomorph teleosts

16:15 *Stephen L. Brusatte, Graeme T. Lloyd and Steve C. Wang*
Morphological evolution in Triassic archosaurs: rates of character change during an exemplary evolutionary radiation

16:30 *Chris Venditti, Andrew Meade and Mark Pagel*
The evolutionary sources of dinosaur body size evolution

16:45 *Thomas A. Dececchi and Hans C.E. Larsson*
Morphological rates of change in the theropod forelimb: patterns and implications

17:00 *John A. Finarelli*
Modeling evolutionary rates of mean and variance in body size for the Canidae (Mammalia)

Lecture Theatre 1.31, Imperial College

S21 - The wood from the trees: phylogenetic approaches to large-scale events in the history of life

Chair: Marcello Ruta

09:00 **Keynote** – *William L. Crepet and K.C. Nixon*
The mismeasure of a mystery: angiosperm origins and phylogenetics

09:30 *Ursula E. Smith*
Macroevolutionary patterns of the Turritellid gastropods (family Turritellidae) of New Zealand

09:45 *Andrew B. Smith, Andreas Kroh, Alexander Zeigler, Simon Coppard and Tim Littlewood*
Using multiple data sets to investigate echinoid phylogeny

10:00 *Michael Coates*
Wrong tree - right signal: deep branching events in actinopterygian phylogeny

10:15 *Johannes Müller*
Patterns and rates of diversification in amniote vertebrates

10:30 COFFEE/TEA

11:00 **Keynote -** *Andy Purvis, Lynsey McInnes, Thomas H.G. Ezard, Tracy Aze and Paul N. Pearson*
Phylogenies and the fossil record for understanding large-scale events in the history of life

11:30 *Matthew A. Wills and Ross C.P. Mounce*
How do fossils influence estimates of phylogeny?

11:45 *Peter J. Mayhew, Robert B. Davis and Sandra L. Baldauf*
Using phylogenies to understand global insect richness

12:00 *Alistair J. McGowan, G.J. Dyke and M.A. Bell*
Phylomorphospaces: informative mash-ups or pulping the trees?

12:15 *A. Goswami, G.V.R. Prasad, P. Upchurch, D. Boyer, E. Seiffert, O. Verma, E. Gheerbrant and J.J. Flynn*
The phylogenetic affinities of the enigmatic mammal *Deccanolestes* from the Late Cretaceous of India and implications for the origin of crown placental mammals

12:30 LUNCH

13:45 *Jennifer F. Hoyal Cuthill*
Homoplasy, character variability, and the size of the morphological state space: an increase in evolutionary flexibility through time and significant phylogenetic effects

14:00 *A.Z. Krug, D. Jablonski and A. Beu*
Phylogenetically structured extinction and the evolution of polar marine faunas

14:15 *Marcello Ruta*
Character exhaustion and evolutionary rates in temnospondyls

Lecture Theatre 1.51, Imperial College

S27C - Open Symposium – Palaeobotany

Chair: *Alan Channing*

09:00 *Oive Tinn, Tõnu Meidla and Leho Ainsaar*
Dasyclad alga *Cymopolla* from the Kalana Lagerstätte and its evolutionary significance

09:15 *Wan Zhenzhu*
Carbon isotopic composition and water-use efficiency of Early Devonian to Early Carboniferous land plants

09.30 *Olga A. Orlova and Aleftina L. Jurina*
The genus *Pseudobornia* (arthrophyte) from the Upper Devonian of Russia: morphology, anatomy and distribution

09:45 *Sarah C. King, Chris J. Cleal and Jason Hilton*
A Late Palaeozoic jigsaw puzzle: how and when did the wetland plant community template migrate?

10:00 *Anne-Laure Decombeix, Ignacio H. Escapa, Andrew B. Schwendemann, Rudolp Serbet, Edith L. Taylor and Thomas N. Taylor*
Diversity and ecology of Permian floras from Antarctica

10:15 *Cajsa Lisa Anderson and Alan Channing*
When new fossils make the difference

Flett Lecture Theatre, NHM

S27D - Open Symposium – Arthropods and Exceptional Preservation

Chair: David Siveter

09:00 *Jorge Esteve, Samuel Zamora and Nigel C. Hughes*
The Purujosa trilobite assemblage and enrolment strategies in Cambrian trilobites

09:15 *Stephen R. Westrop, Jennifer D. Eoff, Raina A. Waskiewicz Poole and Jonathan M. Adrain*
Stratigraphic bias in the expression of a Late Cambrian trilobite extinction, Laurentian North America

09.30 *Rudy Lerosey-Aubril and Kenneth J. McNamara*
The cephalic median organ of trilobites: a single throw or multiple throws of the evolutionary dice

09:45 *M.A Bell and S.J. Braddy*
Coping with gigantism in the trilobite Order Asaphida: patterns of body-size evolution across all most parsimonious trees

10:00 Petr *Budil, J. Collette and Š. Manda*
An occurrence of *Ceratiocaris papilio* Salter *in* Murchison, 1859 (Crustacea, Phyllocarida) in the lower Ludfordian (Silurian) of the Prague Basin (Czech Republic)

10:15 *Jordi M. de Gibert, A.A. Ekdale and F. Muñiz*
Bioglyphs in fossil crustacean burrows: reading the signatures of ancient tracemakers

10:30 COFFEE/TEA

Chair: Paul Selden

11:00 *Loren E. Babcock and Richard A. Robison*
Inferences about the feeding habits of three Cambrian arthropods based on fossilized alimentary tracts

11:15 *Thomas H.P. Harvey, Maria Velez and Nicholas J. Butterfield*
A new crustacean micro-Lagerstätte from the Middle Cambrian Earlie Formation of Saskatchewan, Canada

11:30 *Christopher Castellani, Brigitte Schoenemann, Joachim T. Haug, Andreas Maas and Dieter Waloszek*
Exceptionally well preserved isolated eyes from the Cambrian 'Orsten' faunal assemblages of Sweden

11:45 *Gian Luigi Pillola and Andrea Mancosu*
The intriguing Ordovician 'trilobite' *Taricoia arrusensis* (Arthropoda, Nektaspida, Naraoiidae) from Sardinia: new data and perspectives

12:00 *Michael B. Cuggy, David M. Rudkin and Graham A.Young*
A new Late Ordovician eurypterid from the William Lake Lagerstätte, Manitoba, Canada

12:15 *David M. Rudkin, Michael B. Cuggy, Graham A. Young and Debbie Thompson*
An Ordovician pycnogonid (sea spider) with preserved "head" segmentation

12:30 *Derek J. Siveter, Derek E.G. Briggs, David J. Siveter and Mark D. Sutton*
Further insights into arthropod soft part morphology: new discoveries from the Herefordshire (Silurian) Lagerstätte

12:45 LUNCH

Chair: Derek Siveter

13:45 *Russell J. Garwood, Jason A. Dunlop and Mark D Sutton*
X-ray microtomography of Carboniferous Harvestmen (Arachnida: Opiliones)

14:00 *Paul A. Selden, Rony Huys, Michael H. Stephenson and Alan P. Heward*
The antiquity of copepods: crustaceans from a pitch clast in Carboniferous glacial diamictite of Oman

14:15 *Carolin Haug, Joachim T. Haug, Andreas Maas and Dieter Waloszek*
Morphology, ontogeny and evolution of mantis shrimps (Stomatopoda, Crustacea) in the light of new Mesozoic fossils

14:30 *Sam W. Heads and Paul P. Tinerella*
An exceptionally preserved stem-group stick insect (Holophasmatodea: Susumaniidae) from the Jurassic of China and the early evolution of Phasmatodea

14:45 *Paul P. Tinerella and Sam W. Heads*
Water bugs (Insecta: Heteroptera) from the early Cretaceous of Brazil: ancient origins of the modern fauna

15:00 *Diego C. García-Bellido, John R. Paterson, Gregory D. Edgecombe, James B. Jago, James G. Gehling and Michael S.Y. Lee*
A vetulicolid-banffozoan intermediate from the Early Cambrian Emu Bay Shale Lagerstätte, South Australia

15:15 *Mark D. Sutton, Derek E.G Briggs, David J. Siveter and Derek J. Siveter*
A Silurian soft-bodied lophophorate

15:30 COFFEE/TEA

Abstracts

S27B - LITHO- AND BIOFACIES OF THE LOWER OLIGOCENE ROCKS FROM THE UNITED ARAB EMIRATES

Abdelghany, Osman, Arman, Hasan, El Tokhi, Mohamed, Hashem, Waheed, and Al Saiy, Ayman

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The city of Al-Ain is located in the eastern region of the Emirate of Abu Dhabi, United Arab Emirates, Arabian Peninsula, near the international border of Oman. Lower Oligocene limestone represents most of the foundation bedrock of this city and unconformably overlies Upper Eocene rocks of the Dammam Formation. An Early Oligocene diagnostic foraminiferal assemblage, coral heads, calcareous algae, bryozoa, molluscs and echinoids are described from marls and limestones of the Asmari Formation of the southeastern United Arab Emirates. Two 150 m stratigraphic sections through this formation were measured through nearly complete exposures on the flanks of Hafit Mountain, near Al-Ain city. The succession begins with a relatively deep-water (50-100 m) marl facies containing *Nummulites intermedius* and other small foraminifera. The marls are succeeded by packstones, lagoonal wackestones and reefal grainstone limestones, with *Nummulites intermedius* and *N. fichteli. Lepidocyclina undosa* is found only in the uppermost limestone sections. The limestones indicate progressive shallowing of the depositional environment to <30 m (or even as shallow as 5-10 m), recording the progradation of a high-energy reefal margin of a carbonate platform across a shelf. The vertical facies changes recorded in the Asmari Formation are consistent with a marine regression at the end of the Rupelian.

S2 - ABIOTIC FACTORS IN THE SPECIATION MECHANISMS BEHIND EVOLUTIONARY RADIATIONS

Abe, Francine R.

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At the core of every evolutionary radiation is the process of speciation. Following the tradition of studies of speciation, explanations for evolutionary radiations have presumed biotic mechanisms, specifically natural selection. Here, I use evolutionary radiations as an example of how we have failed to synthesize our understanding of the mechanisms behind speciation processes. Most speciation events are two-part processes involving an initial isolation event followed by divergence (e.g., natural selection, drift). By this characterization of speciation, the “adaptive” nature of a radiation is confined to the secondary process of divergence, specifically as a product of natural selection. An examination of the biogeography, phylogeny, and geographic context of an evolutionary radiation in the fossil record—the calmoniid trilobites of the Devonian-shows that abiotic factors likely yielded the same patterns as so-called “adaptive” radiations through a model of multiple allopatric speciation events. An area of high geographic complexity, e.g., multiple basins that can be isolated and joined with sea level changes—can be the setting for an exponential diversification rate. Ultimately, in an evolutionary radiation, allopatry caused by abiotic factors can be the primary cause, while subsequent divergence through natural selection yields the incredible diversity of taxa and form in a monophyletic clade. Understanding this framework of speciation, whereby initial isolation is a fundamental first step, not only elevates the importance of paleontological contributions, but also clarifies some of the barriers between ecological and macroevolutionary data.

W5 - NON-DESTRUCTIVE IMAGING AND ANALYSIS TECHNIQUES FOR PALAEONTOLOGICAL SAMPLES

Abel, Richie. L., Ball, Alex. D. and Howard, Lauren. E.

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The Natural History Museum, London, is home to a world class electron imaging and analysis laboratory called EMMA (Electron Microscopy and Mineral Analysis). Recent equipment purchases include a micro-CT scanner and nano-CT scanner. These instruments generate 2D x-ray images which are processed to produce 3D virtual volumes of the specimen. This allows the external and internal structure of a specimen to be visualised in 3D. Volumetric determinations and measurements of curved surfaces with complex topographies can be carried out using software such as MeshLab and VG StudioMax. Micro-CT techniques are ideally suited for samples which are extremely rare or delicate since they are non-destructive, high resolution and yield datasets which are very flexible in terms of end-use. 3D printing can be used to produce 3D models or replicas from the datasets. The EMMA laboratories also house four Scanning Electron Microscopes (SEM). SEM has a number of advantages over light microscopy. These include: higher resolution; insensitivity to reflective surfaces; better depth of field and integration with a range of high precision analytical techniques (e.g. X-ray spectroscopy). Disadvantages include the requirement to expose the sample to a vacuum and the inability of an SEM to see through transparent surfaces. Modern Variable Pressure SEMs do not need any sample preparation, beyond the basic requirements that the surface to be examined be dry and clean. As well as yielding 2D images, steroscopic techniques can be used to produce Digital Elevation Models (DEMs) which can be manipulated with software (e.g. Alicona MeX) for detailed metrological studies (measurements, volumetric determinations and quantitative examination of surface features including scratches, indentations etc). In this presentation we will discuss the various techniques employed and their application to palaeontological samples, including relevant examples.

S27B - IS VISION IN PHANEROZOIC MARINE INVERTEBRATES ASSOCIATED WITH EVOLUTIONARY SUCCESS?

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Image-forming eyes may have contributed to the evolutionary success of taxa in the geological past. We analysed, based on fossil occurrences in the Paleobiology Database, the diversity, evolutionary rates, stratigraphic ranges and relative abundances of 16800 Phanerozoic genera of marine invertebrates living on or above the shallow water sea-floor according to their visual capabilities. With all taxa included, a trend towards an increase of visual animals is lacking. Animals with well-developed vision are on average significantly shorter lived than those lacking eyes. In contrast, within-clade comparisons of groups with eyes versus those without eyes in trilobites, pectinoid bivalves and gastropods reveal increasing representations of the subgroup with eyes. High turbidity may have compromised the spread of clades with imaging eyes. This is illustrated by an increase of blind trilobites in the Late Devonian (a time of increased nutrient fluxes from the continent leading to higher turbidity) and by higher abundances of pectinoids in carbonate environments (i.e. those with clear, oligotrophic waters) versus more turbid, siliciclastic settings. Diversity dynamics and abundance patterns change markedly during times of mass extinction. A shift towards blind animals across the KT-boundary can be explained by a nutrient collapse, which selectively affected animals with eyes and active, and therefore starvation-prone, lifestyles. In contrast, a proportional increase of taxa with eyes across the Permian/Triassic-boundary is consistent with a scenario of hypercapnia, preferentially removing passive, blind groups with reduced tolerance against high levels of CO_2.

S9 - MIDDLE/UPPER DEVONIAN BOUNDARY CONODONT FAUNAS FROM GIEBRINGHAUSEN (RHENISH MASSIF, GERMANY)

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Conodonts from a now partly overgrown quarry near Giebringhausen played a prominent role when the original Givetian zonation was introduced. However, apart from a rough sketch, the details of this important locality were never published. Previous conodont illustrations suggest the presence of diverse faunas and new taxa. Over several years we re-sampled the section, which spans the top of the middle Givetian (Taghanic Crisis Interval) to the basal Frasnian (*rotundiloba soluta* Zone). Therefore, the new faunas can contribute significantly to the understanding of radiations and extinctions across the upper Givetian and through the multiphase global Frasnes Events. The lihofacies comprises an alternation of middle grey to dark, unfossiliferous Flinz shales and thick- to thin-bedded, turbiditic Flinz limestones. Black shales at the top of the Givetian and in the lower Frasnian base represent peaks of anoxic sedimentation. All upper Givetian conodont zones can be recognized, including separate *dengleri sagitta* and *dengleri dengleri* Subzones. As elsewhere, the *disparilis* Zone is notably thin whilst there is a thick turbidite sequence of the *norrisi* Zone, which suggests and end-Givetian phase of increased carbonate erosion in the source region at the southern margin of the Brilon reef. The conodont record is almost interrupted at the series boundary; turbidites of this interval carry very few or mostly ramiform elements. There are several new species of *Polygnathus* and *Schmidtognathus* and first records for Germany. Two hardly twisted forms related to *T. subsymmetricus* and *T. tedi* represent the phylogenetic transition between *Tortodus* and early ancyrognathids.

S8 - THE OLDEST BRYOZOAN (EARLY ORDOVICIAN) REEFS WERE CONSTRUCTED BY AN UNUSUAL MODE OF BRYOZOAN GROWTH

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The Bryozoa is an enigmatic phylum because in contrast to most other major metazoan phyla, bryozoans do not appear in the Cambrian fossil record. The Bryozoa first appeared in the Early Ordovician (late Tremadocian) and showed an increase in biodiversity during the Ordovician diversification. The oldest known bryozoans, from the Three Gorges area of Hubei Province, South China, built bryozoan (lithistid sponge–bryozoan) reefs. This study reports on the construction of these reefs, which were apparently dominated by bryozoans with an unusual mode of growth: they encrusted the lateral surfaces of lithistid sponges and preferentially grew downward and laterally. The sponges do not appear to have been important frame-builders, as they are made up of an organic collagenous network with spicules and would have been easily degraded via bacterial decay. In most cases, sponges are only found as micrite or peloid with spicules that are partly preserved via calcification, although they played an important role in providing attachment sites for bryozoans throughout reef growth. In contrast, once calcareous bryozoans acquired attachment sites on sponges, they became encrusted themselves one after another to produce rigid frameworks. This reef-building mechanism for the oldest bryozoans provides a new insight into the initial and subsequent development of bryozoan–related (metazoan) reefs.

S8 - THE ORDOVICIAN RADIATION OF TRILOBITES: THE LAST "BIOMERE" RECOVERY

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It has been demonstrated that trilobites, despite forming the bulk of the Cambrian Evolutionary Fauna, experienced rapid global diversification along with elements of the Palaeozoic Fauna during the Ordovician Radiation. Trilobite families with a pattern of mid-Ordovician radiation include all groups which survived the end-Ordovician mass extinction, and have been termed the Whiterock Fauna. The factors influencing the diversification of the Whiterock Fauna have remained opaque. Trilobites experienced three major cycles of "boom and bust" diversification and mass extinction during the Late Cambrian (termed "biomeres"). We demonstrate that this pattern continued well into the Ordovician with a further two episodes of radiation and severe extinction culminating in a fifth and final newly documented extinction event which terminates the Laurentian Stairsian Stage (mid-Tremadocian in global terms). Each of the prior extinction-bound intervals contains a striking record of morphological innovation and diversification, the products of which are largely unique to their respective interval. Entire monophyletic families and subfamilies arose, diversified, and were extinguished within each extinction-bounded period, and almost completely different sets of taxa characterize each. The events, despite ranking among the most proportionally severe extinctions of the Phanerozoic, were significant drivers of trilobite evolution. The Ordovician Radiation of the Whiterock Fauna may be best explained as an ongoing recovery in the wake of the final "biomere" extinction, which proceeded unchecked until the great end-Ordovician event. This implies that different factors may have governed the Ordovician Radiation of trilobites versus the groups comprising the Palaeozoic Fauna.

S5 - THE UNIVERSITY OF IOWA PALEONTOLOGY REPOSITORY DIGITIZATION PROJECT

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The University of Iowa Paleontology Repository is the fifth largest university fossil collection in the U.S., holding over 1 million specimens from all geologic ages, worldwide. A digitization project, funded by the National Science Foundation (DBI-0544235; $284,724), has made previously inaccessible collections available to researchers, including the Amoco Conodont Collection, the Paleozoic Coral Collection, the Neogene Coral Collection, the Trilobite Collection, the Amoco South Florida Collection, and the Micro-mammal Collection. Specimen data are captured using a Specify Biodiversity Collections Database and shared with the Paleontology Portal. Inventories of new, as yet uncatalogued, collections are available on the Paleontology Repository website (www.uiowa.edu/~geology/paleo), including the Crossman and Strimple Crinoid Collections. Ancillary materials have been digitized and made available, including 1,316 Amoco conodont locality folders and 7,000 field photographs (funded in part by a University of Iowa Innovations in Instructional Computing award). Along with specimen samples, cores, and maps, these photographs form the basis for the Tropical America Virtual Field School, an on-line teaching resource drawing on collections made during 30 years of fieldwork in South Florida and the Caribbean. Through the Digital Image Project, a database of specimen images is being developed, particularly useful for fragile specimens that cannot be loaned. Information for researchers is complemented with information for the public, using different methods of data access and presentation. The Fossils in My Back Yard website provides a user-friendly option for looking at the same specimen data without overwhelming the non-scientist.

S9 - FRASNIAN RADIOLARIANS AND AMMONOIDS IN THE TIMAN-PECHORA BASIN: AN ECOLOGICAL DIMENSION

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The evolutionary history of pelagic organisms in the Timan-Pechora Frasnian Basin was closely linked to global eustatic events combined with local volcanism and dynamic upwelling. We analyzed new and published data on ammonoid and radiolarian distributions from outcrops and wells in the Ust-Yarega, Domanik, and Lyaiol Formations, spanning five radiolarian and nine ammonoid zones, which we were able to correlate. In the early Frasnian, as the subsidence of the basin began, the diversity of radiolarians and ammonoids was low, with two dominating morphotypes in each of these pelagic groups (discoidal and spiculate radiolarians and compressed and thickly discoidal ammonoids, each representing major taxonomic clades), but then began to increase, although the basic shell morphologies remained. The peak of taxonomic diversity in both groups coincided with a major transgression in the Middle Domanik and with the peak of eutrophication, when an explosive diversification of radiolarians (129 species of 30 genera) profiting from a dramatic increase in silica caused an overproduction of nutrients combined with disrupted seawater circulation. Periodic fluctuations in the abundance of spiculate over spherical radiolarians suggest temperature fluctuations. The peak of radiolarian diversification coincided with the maximum transgression and radiation in regional ammonoid faunas of the *Ponticeras domanicense* and *Nordiceras timanicum* zones, suggesting an extensive occupation of the upper pelagic layers. During the regression episode just before the beginning of the Late Frasnian, the diversity of radiolarians and ammonoid decreased but then gradually recovered, probably due to immigration and reoccupation of the distal shelf in the recovering oligotrophic basin.

S9 - TEMPORAL AND SPATIAL DISTRIBUTION OF RADIOLARIANS IN THE DEVONIAN

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The distribution of Devonian radiolarians demonstrate the phenomenon of species invasion into new ecosystems as solitary population waves, which, possible only in phylogenetically younger taxa, shows a high activity of mobile genetic elements. These are capable of a hyperbolic growth of population size and rapidly fill new ecological niches. Four solitary population waves, and an expansion of radiolarians possessing two spheres and one spine, have been recognized. The first wave emerged in the early Emsian in Japan and attenuated in the Famennian of southern China. The second wave began in the middle Emsian of New South Wales and was accompanied by an explosive increase of new genera and species in the early Frasnian of Western Australia. The third wave began in the late Emsian of the Southern Urals and the dispersal of this morphotype followed a fan-shaped pattern: Prague Basin, Northern Mugodzhary, Rudny Altai, Volga-Ural and Timan-Pechora Basins, fading in the Famennian. The fourth wave began in the early Famennian of the Polar Urals and showed a centrifugal expansion of the geographical range of this morphotype. Famennian radiolarians of Euramerica show a high frequency of the main generic core of associations at the level of 39,0% – 63,4% and a clear pattern of migration of dominant taxa. This allowed the establishment of four major migration pathways of radiolarians in the Famennian: North-Western Stream (North America D Polar Urals), South Stream (North America D Pripyat Depression), Eastern Stream (Pripyat Depression D Polar Urals), and North-Eastern Stream (Polar Urals D Middle Urals).

S3 - BIOTIC RESPONSES OF LATE PALEOCENE-EARLY EOCENE LARGER BENTHIC FORAMINIFERA TO THE PALEOCENE-EOCENE THERMAL MAXIMUM AND INDIA-ASIA COLLISION

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The Paleocene-early Eocene carbonate successions of the Indus Basin in Pakistan formed on the north-western continental shelf margin of the Indian Plate in the east Tethys Ocean. The succession encompasses the interval of the Paleocene-Eocene Thermal Maximum (PETM) and the collision of India with Asia, and this is reflected in the evolution of shallow marine larger benthic foraminifera (LBF) and the carbonate platforms they inhabited. Stable isotope analysis of bulk carbonates through the P-E boundary interval identifies $\delta^{13}C_{carb}$ values for the Late Paleocene of +3.4‰ to +3.0‰, while values of +2.7‰ to +1.6‰ characterise the earliest Eocene. However, there is insufficient sampling resolution to identify the PETM $\delta^{13}C$ maximum negative excursion itself. During Late Paleocene times LBF assemblages in the Indus Basin were taxonomically close to those of west Tethys. However, this faunal continuity is lost at the P-E boundary and the earliest Eocene succession of the Indus Basin lacks typical west Tethys *Nummulites*, whilst *Alveolina* are rare: LBFs such as *Miscellanea* and *Ranikothalia* continue to dominate. The apparent absence of *Nummulites* from the earliest Eocene of Pakistan and rarity of *Alveolina* – elsewhere used as the prime marker for the base of the Eocene - may imply a geographical barrier between east and west Tethys faunas, perhaps caused by India-Asia collision.

S6 - MOLLUSCAN PALAEOBIODIVERSITY AND PALAEOBIOGEOGRAPHY: PLEISTOCENE AND HOLOCENE INTERGLACIAL ASSEMBLAGES FROM BONAERENSIAN AND PATAGONIAN LITTORAL (SW ATLANTIC)

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Quaternary littoral deposits along the SW Atlantic (Surinam, Brazil, Uruguay, Argentina) contain rich molluscan assemblages. In Argentina qualitative and quantitative variations are recorded between the Río de La Plata and Tierra del Fuego where several sea-level highstands (MIS11/9, 7, 5, 1) are characterized by abundant, exceptionally well preserved shell concentrations (mainly bivalve and gastropod benthic taxa). From a total of 197 taxa (112 gastropods, 85 bivalves; 1 escaphopod, 7 polyplacophors), 89% occur in the Holocene (20% gastropods and 25% bivalves are exclusive), 40% gastropods and 17% bivalves since the Pleistocene, and ca. 40% since the Late Miocene. Molluscs have modern counterparts in the Argentine and Magellanean zoogeographical provinces, determined by the extension and seasonal intensification of the cold Malvinas (Falkland) and warm Brazilian currents. Results from quantitative comparisons (cluster analysis, principal component analysis, parsimony analysis of endemism techniques applied to 35 localities) show that, during the Pleistocene (ca. 400 Ka) and the mid-Holocene (ca. 7 Ka), interglacials, taxonomic

composition and distribution discriminate Patagonian and Bonaerensian deposits. Extinctions (*Tegula atra, Ostrea tehuelcha*), latitudinal shifts (*Triphora, Urosalpinx rushi, Anachis avara, Thais haemastoma; Noetia bisulcata, Crassostrea rhizophorae, Anomalocardia brasiliana, Venericardia procera*) and changes in relative abundance for dominant individual taxa (i.e., *Littoridina, Nacella* spp., *Fissurella* spp; *Mactra* spp., *Brachidontes* spp., *Aulacomya atra, Protothaca antiqua, Mulinia edulis,Tagelus plebeius, Ensis macha*) suggest that salinity, SST and substrate nature are the main controlling factors, reinforcing the conclusion that these variations are biotic responses to environmental and rapid climate changes.

S6 - MORPHOMETRIC ANALYSES OF MACTRA Linné (BIVALVIA) FROM THE MARINE QUATERNARY OF ARGENTINA (SOUTHWESTERN ATLANTIC)

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Mactra is a common and distinctive bivalve in Pleistocene and Holocene marine sediments of Argentina. Along the Bonaerensian area, *M. isabelleana* is constant and abundant, exhibiting wide morphological variation. Scarcer modern records in the Argentine and Magellanean Malacological Provinces (SW Atlantic margin) include similar species originally described on shell shape, *i.e., petiti, isabelleana, patagonica, marplatensis, jane\iroensis.* Relative Warps analysis (*RW*) on coordinates of 16 landmarks and 25 semi-landmarks along the inner outline (digital images of the right valve) for 1,200 shells (fossil and modern) of different morphs (species) from 24 Bonaerensian sites (beach ridges, tidal flat, coastal lagoonal facies, beach) improve objective evaluations of intraspecific and interspecific variation of *Mactra* in this area. Shape similarity of morphs suggests that interspecific differences are not important and shell shape variation represents a sequence of decreasing umbonal inflation and increasing elongation (conditioning length of pallial sinus and elongation of hinge features) in a chain of transitional morphs. The modern variation of *Mactra* correlates with environmental parameters (mainly substrate nature and salinity, secondarily water energy and depth). Subtrigonal inflated shells (*isabelleana, petiti*) predominate in muddy substrates of quieter, shallow mixo-polyhaline waters; ovate-elongate, less convex shells (*marplatensis, janeiroensis, patagonica*) are typical of fine sands in poly-euhaline deeper waters, close to higher energetic open marine conditions. Therefore, we suggest that *M. isabelleana* is a polymorphic species, with ecomorphs potentially useful as palaeoenvironmental indicators during the last high sea-level stands up to present.

S9 - DISTRIBUTION OF THE GENUS *THECOSTEGITES* (TABULATA) IN WESTERN EUROPE (FRANCE, BELGIUM) AND SOUTH-WESTERN ASIA (IRAN, AFGHANISTAN)

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Thecostegites, with the most frequent species *T. bouchardi* (Michelin, 1846), is a typical auloporid Tabulata genus regarded as mostly characterizing the Frasnian pararecifal deposits from Western Europe (Boulonnais, Ardenne). It is usually considered as not frequent, moreover "very rare" (Webby, 1966) in the "Middle-Upper Devonian in west Somerset" or "occasionally present" (Coen-Aubert, 1980) in the Frasnian of Belgium. But it is relatively abundant in its *locus typicus*, the Boulonnais (Mistiaen, 1988; Mistiaen *et al.*, in press). The genus has been recently recognized in Iran in the Khoshyeilagh Formation, Middle to Late Devonian of the eastern Alborz Mountains (north-east Iran). In Iran, the genus was formerly only observed one time in the Chahriseh area (Esfahan Province, Central Iran). In the wider region, the genus was previously just signalled one time in the Central Mountains of Afghanistan, in not well dated beds. Samples from the different localities in the Boulonnais, Ardennes, and Afghanistan and from two places in Iran are analysed with a statistical approach. A biostratigraphical use of the species is also suggested and the ontogenetic development in relation with other support organisms is presented.

S24 - A PRIMITIVE DEVONIAN TETRAPOD FROM THE LOWER FAMENNIAN OF SOUTH TIMAN, RUSSIA

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The lower Famennian Sosnogorsk Formation outcropping along the Izhma River, Komi Republic, Russia, represents a coastal lagoon environment and contains a vertebrate fauna including *Bothriolepis*, *Holoptychius*, lungfishes, a new porolepiform, and an undescribed tetrapod. The tetrapod, first identified by A.O. Ivanov from jaw material housed in St. Petersburg, is now known from numerous bones collected during field seasons in 2008 and 2009. Most come from two compact clusters that appear to represent disarticulated heads of two individuals. In general it appears broadly comparable to previously known Famennian genera (excepting *Tulerpeton*). However, it has several autapomorphies and some surprisingly primitive features. Autapomorphies include a pterygoid and prearticular dentition composed of radiating rows of small teeth rather than denticle shagreen, and an angular orbit bounded anteriorly by a vertical buttress. Primitive features include a partly ornamented cleithrum, as well as *Elginerpeton*-like (but less elongated) coronoids with an elaborate dentition comprising a fang pair, a main tooth row and an uninterrupted row of maringal denticles. Most importantly, the skull table does not resemble those of known Devonian tetrapods but is remarkably similar to that of *Tiktaalik*; the braincase attachment suggests that a lateral commissure was present, implying that the hyomandibula had not yet been transformed into a stapes. No limb elements have been recovered, but the shoulder girdle is of tetrapod rather than elpistostegid type, suggesting that limbs were present. We tentatively place the new taxon on the internode between *Tiktaalik* and *Ventastega* as the most primitive tetrapod known from extensive remains.

W9 - NEW ANATOMICAL INFORMATION OF ORGAN AND MUSCLE TISSUE IN VERTERBATES FROM THE GOGO FORMATION

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The reliable reconstruction of soft tissues is a primary aim in palaeontology. In most instances this has had to rely on entirely indirect evidence such as comparative anatomy. Exceptionally preserved vertebrate fossils are known from a number of localities but with few exceptions these are flattened and provide only two dimensional outlines. The fossils, from the Gogo Formation in northern Western Australia preserve three-dimensional body musculature and in rare cases organs. Placoderms including the arthrodires *Incisoscutum ritchiei* and *Compagopiscis crouncheri* and the ptyctodont *Austroptyctodus gardineri* have recently been shown to have large amounts of their body musculature preserved *in situ*. The myomeres of the trunk and tail are arranged in a segmental pattern; however, two areas of specialized muscle development have also been identified along the ventral body wall. The discovery of specialized copulatory elements in arthrodires suggests that these muscles may have been used to lift and separate the clasper organs. An alternate hypothesis is that these muscles were locomotory. The rigid head and thoracic armour would have restricted placoderms to crangioform or thunniform modes of swimming. The unique arrangement of muscles in the posterior region of the trunk shield may have been important in anchoring the body to the dermal armour during propulsive waves. These discoveries provide the first direct evidence of tissue and organ structures in the fishes from the Gogo Formation.

S8 - THE CAMBRIAN-ORDOVICIAN BOUNDARY IN SOUTH AMERICA: HIGH RESOLUTION BIOSTRATIGRAPHY, GLOBAL CORRELATION AND PALEOENVIRONMENTS

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The base of the Ordovician System was formally established 120 years after Charles Lapworth in 1879 proposed this system to be inserted between the Cambrian and the Silurian in Great Britain. According to the GSSP in western Newfoundland, the FAD of the conodont *Iapetognathus fluctivagus* Nicoll *et al.* defines the Cambrian-Ordovician boundary. This species is recorded for the first time in South America in the Amarilla section in the Cajas Range, Cordillera Oriental of Jujuy, northwestern Argentina. High resolution biostratigraphy in other localities in the same basin, such as Alfarcito and Salto Alto, provides information regarding the homotaxial succession of key graptolite and trilobite species, in relation to conodont ranges. *Rhabdinopora f.* cf. *canadensis* (Lapworth) is recorded below the first appearance of *Anisograptus matanensis* Ruedemann, suggesting that the presence of the lowest Ordovician *R. f. parabola* Zone, as verified worldwide. The FAD of the trilobite *Jujuyaspis keideli* Kobayashi has up to now been considered as a proxy for the Cambrian-Ordovician boundary in the absence of key conodonts or graptolites. However, our recent studies demonstrate that *J. keideli* occurs from the lower *Cordylodus intermedius* Zone of late Cambrian age, up to the *Iapetognathus* Zone in the lowermost Ordovician. The new data allow for precise regional correlation with other Argentine basins, such as Famatina and Precordillera. A thorough analysis of the conodont faunas reveals the presence of different faunal provinces for these basins in relation to their respective palaeogeographic positions in the Iapetus Ocean and the Gondwanan margin of South America.

S3 - BENTHIC FORAMINIFERAL TURNOVER AND CARBON CYCLE PERTURBATION ACROSS THE CRETACEOUS-PALEOGENE BOUNDARY IN THE PACIFIC OCEAN

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Carbonate-secreting oceanic surface dwellers (calcareous nannoplankton, planktic foraminifers) suffered extreme extinction at the Cretaceous/Paleogene (K/Pg) boundary, coinciding with the collapse of the vertical (surface-bottom) gradient in carbonate carbon isotope values. Deep-sea benthic foraminifera show transient assemblage changes at the K/Pg boundary, but no significant extinction. In order to gain insight in paleo-environmental changes across the K/Pg boundary in the largest ocean, we analyzed benthic foraminifera from Pacific ODP Site 1210 (Shatsky Rise) and DSDP Hole 465 (Hess Rise). Benthic foraminiferal assemblages at these sites present strong evidence for stressed environmental conditions and a high food supply to the seafloor just after the K/Pg extinction event. This observation is in severe conflict with models that argue for an almost complete cessation of food supply to the deep-sea floor for several hundred thousands of years (Strangelove Ocean and Living Ocean models). K-Pg benthic foraminiferal assemblages could not have survived such a prolonged period without food, and would have suffered significant net extinction. The benthic foraminiferal turnover could be explained by the occurrence of large blooms of opportunistic primary producers other than carbonate-secreting surface dwellers, occupying the niches emptied after the extinction, and delivering food to the seafloor that varied in amount and composition over time. If primary producers in the oceans recovered quickly (in terms of biomass), the collapse of the vertical carbon isotope gradients must be explained by another factor than prolonged collapse of the primary productivity or biological pump.

S3 - BENTHIC FORAMINIFERAL RECORD OF THE LATE PALEOCENE AND EARLY EOCENE WARMING EVENTS IN THE WESTERN TETHYS

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A major perturbation of the global carbon cycle occurred during the transition between the Paleocene and the Eocene epochs, as inferred from the pronounced negative excursion in stable carbon isotopes ($\delta^{13}C$) in marine and terrestrial sedimentary components. Rapid changes in terrestrial and marine biota occurred during this period of extreme global warming (Paleocene-Eocene Thermal Maximum; PETM), including the largest extinction of benthic foraminifera during the Cenozoic. Very few locations are available where the sequence of events at the onset of the PETM can be studied, mainly because of the severe carbonate dissolution and thus incompleteness of records. The completeness of the sedimentary record across the PETM at the bathyal-abyssal Alamedilla section, which is less strongly affected by dissolution than other Tethyan sections, makes it one of the most suitable sections to study the biotic and environmental evolution across the PETM in the deep-sea. In addition, recent studies have pointed out the occurrence of similar events, but of much lesser magnitude, during the early Eocene. These events, called hyperthermals, are also represented by transient $\delta^{13}C$ excursions. Their effects on the biota have not been documented in detail so far, mainly due to the lack of records with sufficient temporal resolution. The analysis of the benthic foraminiferal turnover in the Alamedilla section may help to understand the causes and consequences of the early Eocene hyperthermals.

S2 - CHANGING PALAEONTOLOGICAL CONCEPTS OF SPECIES AND THEIR ROLE(S) IN 20TH CENTURY MACROEVOLUTIONARY THOUGHT

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Palaeontological views of species in the late nineteenth and early twentieth centuries occupied a spectrum between two very different perspectives. This situation did not change with palaeontology's integration into evolutionary biology by the Modern Synthesis and continues to the present day. At one end of this spectrum is the view that species are either completely impossible to recognize in the fossil record, or completely subjective, and therefore not comparable units to what neontologists call species. This view is reflected, for example, in the common practice of using genera and families for diversity analyses in the fossil record instead of species. The other view is that species are the basic units of macroevolution. This view has roots in pre-Synthesis ideas, but was first formalized in Simpson's "evolutionary species definition" and became the central concept of post-Synthesis palaeobiological ideas like punctuated equilibrium and species selection. Modern palaeontological views of species persist in this strangely Janus-like tradition: we use species but we don't uniformly respect them. We constantly discuss species evolution, but are simultaneously a bit queasy about taking them seriously. This matters because much of macroevolutionary theory - at least in its current form – can only be tested with concepts of species. We therefore need, if not a uniform then certainly an explicitly stated concept of palaeontological species.

S26 - COLOUR AND TEXTURE BANDING IN A LATE NEOPROTEROZOIC, MICROBIALLY VARIEGATED SABKHA OF THE TAOUDENI BASIN, ADRAR, MAURITANIA

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The Pan-African II or Rokelide orogen (550-530 Ma) exerted a strong influence upon the interior of the Taoudeni Basin, West African craton. In the Adrar of Mauritania, the Teniagouri and Nouatil groups are episodically punctuated by major erosive unconformities that separate a series of tilted, but internally undeformed, shallowing-upward successions regarded as post-accretionary molasses-type deposits. Episodic regional uplift must have erected a landscape with considerable relief with initial deposition of alluvial fans and braided rivers that formed progradational-retrogradational packages of strata. Flooding of these lags led to the record of offshore-dominated shales, subsequently covered by regressive stromatolitic reefs, foreshore dolostones, and back-barrier heterolithic sabkhas. The latter are easily recognisable by their variegated colours, which are directly controlled by the episodic occurrence of biofilms, microbial mats and bioherms, and oxidized hardgrounds. Alternation of hematite- and goethite-rich bands in specific microbial strata exerts a distinct colour effect.

S13 - AFTERMATH OF THE MID LANGUEDOCIAN (MID CAMBRIAN) REGRESSION IN SOUTHWESTERN EUROPE

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In SW Europe, the Caesaraugustan-earliest Languedocian (mid Cambrian) acme in benthic diversity was followed by a gradual decline and a barren interval associated with the onset of the mid Languedocian regression. The aftermath of the regression is characterized by a late-Languedocian major faunal turnover of trilobite and brachiopod families, followed by a renewed Furongian-early Tremadocian radiation related to the stepwise immigration of invaders from North and East Gondwana, under persistent transgressive conditions. In contrast, other groups, such as echinoderms, which are only represented by cinctans, reappeared patchily in late-Languedocian monospecific coquinas and finally disappeared before the Furongian. Previously, this benthic replacement was only reported in mixed (carbonate-siliciclastic) platforms. The scarcity or lack of late Languedocian faunas in siliciclastic units might be associated either to: (i) the absence of carbonate substrates and their colonization by stenotopic benthic assemblages, (ii) taphonomical constraints recorded exclusively in the shale counterparts, or (iii) sampling biases. Recent exhaustive sampling in the Iberian Chains, NE Spain, has identified a new level with numerous siliceous nodules that are rife with trilobite, hyolithid, brachiopod, small skeletonized microfossils, and hexactinellid (siliceous) sponge spicules, which provide a preservational window in which to reconstruct the replacement of temperate-water, benthic communities in the aftermath of the mid Languedocian regression. A re-assessment of the late Languedocian immigration of benthic communities both in carbonate and siliciclastic substrates seems necessary in south-western Europe in the light of the fact that preservational and sampling biases directly control the knowledge of early Palaeozoic palaeoecological processes.

S12 - DEPTH-RELATED ECOLOGIC STRUCTURE IN FOSSIL COLD-SEEP AND WHALE-FALL COMMUNITIES IN JAPAN

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Fossil chemosynthetic communities can retain their original faunal composition and ecologic structure when they are preserved *in situ*. Except for many Cenozoic *Conchocele-Lucinoma* communities, twenty-five chemosynthetic communities from Japan of Cretaceous to Pliocene age were analyzed, including twenty-three methane-seep sites and two whale-falls. The fauna consisted of chemosynthetic bivalves including solemyids, bathymodiolins, lucinids, thyasirids, and vesicomyids, heterotrophic taxodont bivalves, bacterivore, carnivore or scavenging gastropods. Among the fauna, thyasirids and vesicomyids co-occurred more frequently than any other taxa. The majority of the communities consisted of three to nine species and a maximum of fifteen species. Diversity and ecologic structure showed a bathymetric trend: the shallow-water communities show a lower evenness as well as higher diversity than the deep-water communities. Moreover, the communities with higher diversity showed a lower proportion of obligate chemosymbiotic taxa than those communities with lower diversity. It is suggested that this depth-related structure develops because increasing depth might decrease the efficiency of predators in mediating the communities. Temporal trends in diversity were not observed throughout the investigate time interval.

S27C - WHEN NEW FOSSILS MAKE THE DIFFERENCE

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Recently discovered Macaronesian fossils can be the key to historical biogeography, phylogeographical studies or molecular dating of single plant groups - as well as helping to resolve a disjunct complex floristic pattern such as the “Rand Flora”. We give examples of how one fossil flora is used in ongoing biological studies of different kinds, and how it can revise our knowledge in several areas - or even change a biologists view.

S17 - COMPLEX STRUCTURE IN EARLY JAW SYSTEMS: LINKAGE KINEMATICS OF ARTHRODIRE PLACODERMS

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Biomechanical models offer a powerful set of tools for quantifying the variation of potential function across fossil taxa. Models of four-bar linkage mechanisms in the feeding apparatus of modern fishes correlate well with observed feeding kinematics and prey preference. I apply a computer-based linkage model developed to describe potential feeding kinematics of *Dunkleosteus terrelli* to several arthrodire placoderm taxa from different lineages. Arthrodire placoderms are a group of basal gnathostome s showing one of the earliest diversifications of jaw structures . I use the model to compare biomechanical variation across taxa and identify trends in skull morphology amongst arthrodires that potentially influence function. It is then possible to explo re the role of linkage systems in the early jaw evolution utilizing insights from these morphological and functional comparisons. Results indicate that the arthrodire feeding system may be more diverse and complex than previously thought. A range of po tential kinematic profiles among arthrodire taxa illustrate a diversity of feeding function comparable to modern teleost fishes. Previous estimates of bite force in *Dunkleosteus* are revised based on new morphological data and compared with estimates from m odern groups. Morphological comparisons across arthrodire taxa indicate that there were several morphological solution to obtaining fast kinematics. This “many-to-one” relationship of linkage morphology to function allowed different taxa to achieve similar kinematic profiles while varying other aspects of the feeding apparatus. Mapping key morphological components of the linkage system on placoderm phylogeny illustrates the potential importance of four-bar systems to the early evolution of jaw structures.

S22 - CONVERGENCE IN DENTAL HISTOLOGY BETWEEN THE UPPER TRIASSIC SEMIONOTIFORM *SARGODON TOMICUS* (NEOPTERYGII) AND A PYCNODONTID (NEOPTERYGII: PYCNODONTIFORMES) FROM THE UPPER CRETACEOUS

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Microstructural investigation, under SEM, was performed on sectioned incisiform teeth of *Sargodon tomicus* an undetermined Upper Cretaceous pycnodontid. The results for both taxa point to the presence of numerous, wide canals issuing from the pulp cavity and penetrating the overlying dentine and acrodin tissues; this is the first detailed account of dental histology comparable to that of *Sargodon* seen in another actinopterygian. The canals most likely housed blood vessels and display a pattern of radiating tubules of odontoblastic origin that propagate into the hypermineralized bundles of the surrounding acrodin. A new and peculiar feature of *Sargodon* teeth is the discovery of a basal lamina at the dentine-acrodin junction, implying that deposition of the acrodin organic matrix proceeded centrifugally, probably with joint influence by odontoblasts and cells of the inner dental epithelium, as characteristic of enameloid tissues. In the pycnodontid teeth examined, the formation of acrodin is thought to occur within the basal lamina, in a typical actinopterygian fashion. These observations conform with the notion of independent origin, in certain Semionotiformes and Pycnodontiformes, of hypermineralized, vascular dental tissues, presumably related to the development of durophagous dentitions in both groups.

S27B - A HITCHHIKERS' GUIDE TO THE LIASSIC: EPIFAUNAL WORM TUBES ON LOWER JURASSIC AMMONITES FROM DORSET

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Over forty ammonites with epifaunal worm tubes have been identified from the Lower Lias of Dorset. Epifaunal serpulids that were overgrown by the ammonites or that responded to the ammonites' growth attached to juvenile, living ammonites. Some epifaunal serpulids attached post-mortem, but indicate oxygenated bottom water, which was rare in the Dorset Lower Lias. Other serpulids do not conform to either pre- or post-mortem growth predictions and require individual assessment. The commonest pattern of growth for serpulids on live juvenile ammonites was attachment in the umbilical seam, later growth onto and finally around the venter. Reconstructing this pattern shows that serpulids kept their aperture at 6 o'clock with respect to the orientation of the living ammonite (about 105-115° behind the ammonite aperture) throughout life. Reorientation of growth lines just before the aperture suggests some worm tubes were fully grown. The 6 o'clock position of the aperture enabled feeding currents generated by the worms to parallel currents generated by swimming ammonites, thus maximizing food gathering. The mid-ventral position enabled the worm to deploy its branchia on both sides of the ammonite. Growth on ammonites was beneficial to the worms, but parasitic to the ammonites. *Promicroceras* with epifaunal worm tubes died at smaller sizes than unencumbered examples and size at death correlates inversely to the extra weight of worm tubes. Uniformitarian comparisons suggest fossil worms grew in one season and that *Promicroceras* reached full size in a year.

S7 - SEASONAL PROFILING IN A MISSISSIPPIAN GIGANTOPRODUCTID SHELL OF PALAEOEQUATORIAL BRITAIN

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Gigantoproductus okensis is a large, thick-shelled species which has been collected from bioclastic packstone/grainstone deposited under tropical shallow marine conditions in the upper Viséan Monsal Dale Limestone of Derbyshire. In longitudinal section, this brachiopod shows about 20 growth lines indicating a reduction of growth caused by regular perturbations in the environment, suggesting a life span of 20 years in agreement with the expected survival rates of living brachiopods. To constrain the age of the brachiopod with spiral deviation analysis, the ventral valve has been processed to detect minima of deviations from the logarithmic spiral. About two growth lines occur between the minima and assuming a maximum growth length of 100 growth units, the fitted logistic curve provides an estimated age at death of about 20 years. The shell was sampled for geochemical analyses consecutively at 121 points across the growth lines along the preserved and mostly non luminescent shell interior. Isotope variation shows that growth and geochemistry is periodical, showing regular oscillation of about 1.1‰ for δ180 and 0.5-1 for δ13C. δ180 and δ13C periodicity were correlated with growth lines and Fourier analysis demonstrates that this periodicity is annual in form and thus seasonal, though other types of periodicity were also present. The seasonal oscillation for δ180 indicates sea surface temperature (SST) variation of ~ 5-6 ºC. Therefore, the study of this gigantoproductid shell revealed a high seasonal isotopic variation which may have been related both to strong monsoon circulation, and to the growth of ice sheets of limited extent on Gondwana.

S27A - GEOCHEMICAL PROPERTIES OF PATHOLOGIC BONE IN EXTINCT AND EXTANT ARCHOSAURS

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Because the basic physiological processes of fracture healing are similar in extant vertebrates, these patterns may be recognisable in fossil taxa. By comparing fracture healing in extinct and extant species, inferences can be drawn regarding physiological processes in extinct organisms. We expect that the crystallinity of bone apatite should be different in pathological (immature) and normal (mature) bone and should change as remodeling occurs during the healing process. In this study, we use histological, x-ray diffraction (XRD), and Raman Spectroscopy analyses to examine fracture pathologies in pedal phalanges from the theropod dinosaur *Allosaurus fragilis*, and two modern bird species, *Branta canadensis* (Canada goose) and *Cathartes aura* (turkey vulture). We also analyzed rare earth elements (REE) in fossil material to determine if differences in REE patterns exist between pathological and normal bone. Preliminary results from modern avian bone confirm differences in crystallinity between normal and pathologic bone. Raman spectra of normal and pathological bone from the same individual exhibit both peak shifts and the presence and/or absence of different peaks in the two types of tissue. In addition, XRD spectra show small peak shifts and differences in peak widths between pathologic and normal bone. Similarities in the pattern of crystallinity in normal versus pathologic bone in *Allosaurus* and extant birds would suggest a common physiological response of fracture healing. This would provide additional support for the theropod ancestry of modern birds, although future research on non-theropod dinosaurs and crocodilians will be necessary to determine if the signal is universal among archosaurs.

S9 - POST-HANGENBERG BIOVENTS: AN INVENTORY OF MISSISSIPPIAN BIOEVENTS

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Bioevents are widely recognized in Devonian times and gained much attention over the last decades. Contrary, in the succeeding Mississippian, a time of profound global changes with major destructions and reorganizations of ecosystems, post-Hangenberg bioevents have gathered little interest. Mississippian time bioevents can be found on regional, basinal and global scales. An example for the first group are the coral biostromes in the Upper Viséan of Ireland, which represents colonization events of different *Siphonodendron* species adapted to specific palaeoenvironmental constraints. The marker beds of the late Asbian *crenistria* Event can be traced in the deeper water facies of the entire Rhenohercynian Basin, but it becomes indistinct in shallow successions. This facies dependence is characteristic for basinal bioevents. This holds also true for the successive bioevents related to the Variscan Orogeny, e.g. Viséan-Namurian Event in Central Europe. Their spatial extension is always limited, and sections outside the collision scenario do not represent these events. Global Mississippian bioevents are in ascending order: Mid-Tournaisian Lower Alum Shale Event, Upper Tournaisian Awins Event, basal Viséan event, *Bollandoceras-Dombanites* Event in the Middle Viséan deeper water facies, and Mid-Carboniferous Boundary Event at the end of the subsystem. The later causes the most important extinction and faunal turnover of the Carboniferous time. These global bioevents are mainly connected to important sea-level changes, which result in major perturbations of oceanographic and biological cycles. Some have a disastrous effect, whereas other are positively coupled to organic developments through the breakdown of palaeobiogeographic barriers and the provision of new ecospaces.

S15 - RECONSTRUCTING ORDOVICIAN CLIMATE FROM THE DISTRIBUTION OF RADIOLARIAN CHERTS: WAS COOLING THE CAUSE OF THE GREAT ORDOVICIAN BIODIVERSIFICATION?

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Carbon cycle models and stable isotopic data indicate global cooling through the Early Ordovician. Based on $\delta^{18}O_{conodont}$ values modern Equatorial temperatures were reached in the Middle Ordovician and have been considered a trigger for the Great Ordovician Biodiversification of marine invertebrates (GOBE). Unfortunately there are significant errors on the temperature estimates derived from $\delta^{18}O_{conodonts}$ and these are at variance with values derived from brachiopods and bulk rock. It is not clear from these data when modern Equatorial temperatures were reached and C-cycle models indicate pre-industrial mean global temperatures may not have been reached until the Devonian. Here we use the distribution of bedded radiolarian cherts to reconstruct proxy climate maps for the Floian (470Ma) and Darriwillian-Sandbian (~460Ma). We observe chert distributions are similar in both of these time periods, and within palaeogeographical error, show pan-oceanic belts: at the equator and 20°N and S of the equator. In comparison with published Upper Ordovician climate maps derived from GCM and zooplankton biotopes we interpret the equatorial belt as equivalent to the upwelling zone associated with the Intertropical Convergence Zone. The belts north and south of the equator formed as a result of coastal upwelling associated with offshore winds at the boundary between the Hadley and Ferrell atmospheric circulation cells. This configuration is broadly similar to the present day and suggests modern equatorial SST and atmospheric circulation patterns were established by the late Floian, approximately 5 myrs before peak taxonomic diversity. The relationship between cooling and GOBE appears more complex than the simple cause and effect previously hypothesized.

S9 - CONODONTS IMPRINTS FROM VOLCANOGENIC-SILICEOUS DEPOSITS – AN IMPORTANT PALAEONTOLOGICAL BASE FOR BIOSTRATIGRAPHICAL SUBDIVISIONS IN FOLDED AREAS

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The Devonian in the eastern South Urals is formed by widespread oceanic, volcanogenic sedimentary deposits comprising nearly 70% of the complete succession. Limestones with traditional fauna are extremely rare and don't exceed 3%. Many aspects of the regional stratigraphy were the matter of various subjective speculations before the early eighties of the last century. The absence of fauna in most volcanogenic units, different facies changes at short distances and thickness variations favor the application of conodont faunas for lithological subdivision and age determinations, especially for the correlation of the volcanic rocks. We use the visual search for conodont imprints on bedding planes in siliceous rocks (jaspers, cherts, clay, shales etc.). Over many years we assembled a very rich collection of conodont imprints from siliceous rocks covering the whole Devonian sequence at the eastern slope of the South Urals. It numbers more than 10.000 specimens. Now all stratigraphic units are dated by conodonts. Thus, the revised stratigraphical scheme of the Devonian deposits within the Magnitogorsk Megazone is characterized by a high degree of detail. The biostratigraphic resolution comes close to that of the standard conodont zonation. There are characteristic conodont complexes including zonal index-species associated with other typical forms. On the base of conodonts the continuity of the stratigraphical succession is proven. Lower boundaries of lithological units can be correlated with specific zones: *partitus* – Irendyk, *australis* – Yarlykapovo, *punctata* – Mukasovo, Upper *triangularis* – Zilair Formations. Two copper-pyrite-bearing Baimak-Buribai and Karamalytash units are dated as *serotinus* – *patulus* and *australis* – *kockelianus* zones, respectively.

S6 - DISCRIMINATING BLASTOID SPECIES USING 3D MORPHOMETRICS

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New techniques involving 3D data collection and landmark analysis provide an opportunity to make breakthroughs in understanding blastoid morphology. Blastoids are an ideal organism for 3D morphometrics because they have a highly variable gross morphology superimposed upon an extremely conservative body design. Quantitative methods can be used to discriminate between species, explore ontogeny, examine phenotypic plasticity, and describe evolutionary change. This pilot study examines morphologic variation of four species, *Pentremites pyriformis, P. tulipiformis, P. godoni*, and *Pentremites* n. sp., collected from the Upper Mississippian Glen Dean Formation. All specimens used in this study have a fully inflated theca and were collected from the same bed. Consequently, these specimens are assumed to be approximately coeval and have been subjected to the same environmental pressures minimizing temporal and ecophenotypic variation. For this study, laser images were acquired for all specimens using a NextEngine 3D Laser Scanner. From these images, three-dimensional coordinates for a series of homologous landmarks that fully describe specimen morphology were collected. These data were analyzed using the *MorphoJ* morphometrics package via a canonical variate plot after a *Procrustes* alignment. Multivariate analysis of biometric data showed that species could be assigned using morphometric techniques alone and that there was significant separation between species in the morphospace.

W1 - WHAT IS A CRINOID?

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Numerous well-defined pelmatozoan clades existed during the Cambrian and Ordovician. However, many genera are not nested confidently within these clades, and there is little agreement on their phylogenetic relationship among pelmatozoans. Indeed, there is not even uniform agreement as to whether the pelmatozoans are an evolutionary clade or a morphological grade and how they relate to other echinoderm clades. Here, we define Ordovician crown crinoids as the result of the first radiation of well-defined crinoids. This is the crown group of middle and late Ordovician crinoids comprised of the well-defined clades of the Camerata, Cladida, Disparida, Hybocrinidae, and Flexibilia. In an ideal world, we should be able to trace these crinoids back to a single divergence point and a single ancestor. This is not possible. The oldest known crinoids first appear during the early Ordovician. At this time the morphologies of the groups of Ordovician crown crinoids are well developed, and the full range of crinoid morphological disparity already existed. Therefore, the oldest known Ordovician crinoids do not inform us as to the morphology of the ancestor of the Crinoidea. Here, the question of crinoid origination is addressed by defining Ordovician crown crinoids and by delineating what is known, what is disagreed upon, and what is not known about the early evolution of the Crinoidea. Cambrian and Ordovician taxa are evaluated for their potential as sister-group taxa positioned near the divergence of the Ordovician crown crinoids. The result is a perspective from which to understand the acquisition of characters.

S27B - WHY ARE OCEANIC ISLANDS' SHORES SO DEVOID OF LIFE? A 5MY STORY FROM THE AZORES (NE ATLANTIC)

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The fauna and flora that inhabit the intertidal zone of sandy beaches are usually impoverished in relation to those of rocky shores. Previous researchers explored in detail the few sandy beaches that, nowadays in the Azores, have some expression, and concluded that they are almost devoid of animal life in the intertidal zone. These authors postulated that this pattern was probably due to the isolation of the Azores archipelago or to the oligotrophic nature of the islands, as most of the species living in beaches are dependent on the allochthonous supply of nutrients from the sea. The fossiliferous outcrops of Santa Maria Island (Azores archipelago, Portugal) have been studied by the author and colleagues for the last 10 years, and evidence was found that explains the impoverished biodiversity of the sandy beaches of oceanic islands, a widespread phenomenon in this type of island. An explanation is provided for both the very low biodiversity of the present-day sandy beaches of the Azores and also for the local disappearance of certain species during glacial episodes; this theory may be applied to all oceanic islands affected by sea-level oscillations. The most probable routes of colonization and the biogeographical relationships of the marine fauna of the archipelago of the Azores are also discussed.

S4 - PALYNOLOGICAL ANALYSIS OF AN AMBER-BEARING CLAY FROM THE LOWER CRETACEOUS OF LEBANON

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An amber-bearing layer of clay from the Lower Cretaceous of Central Lebanon (Mderej-Hammâna) yielded a well-preserved palynoflora, including both land plant material and marine microflora. Detailed analysis, including a full inventory, allows us to propose a paleoenvironmental reconstruction and to deduce the paleoclimate: an estuarine area under a humid, temperate climate; a variety of ferns grew near the shore and in the inward land. The marine microflora, poorly diversified, includes chitinous foraminifer linings and dinoflagellate cysts, including Early Aptian guide taxa; their occurrence slightly narrows the stratigraphic range indicated by the palynomorphs derived from land plants. A tiny piece of amber allows precise dating as angiospermous pollen grains of stratigraphic interest are embedded within: a dislocated polyad of about 22 monosulcate pollen grains whose tectum supports sculptural elements arranged in a crotonoid pattern. These pollen grains are related to the biorecord Superret-*Nobarg* from the Lower to Middle Aptian (Penny 1991), equivalent to *Stellatopollis doylei* from the Upper Barremian to Aptian (Ibrahim 2002), both taxa from the Western Desert of Egypt. So the well-known Lebanese amber highlights an early radiation phase of angiosperms, and this provides a robust age assignment for the numerous arthropods which were trapped in this fossil resin.

S6 - LIMBS IN COMPOSITIONAL MORPHOSPACES: PRIOR AND NEW APPROACHES

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This work quantifies and evaluates the morphological disparity of various limb morphospaces in two sub-studies in different taxa - Aves, Pterosauria and Chiroptera (955 specimens); and sauropodomorph dinosaurs along with other groups of Archosauria and Mammalia (600 specimens). Six homologous units, both from fore and hind limbs were compared. Morphospaces of proportions, and its operative instrument - ternary diagrams - have been used as tools for both theoretical and empirical analysis in numerous biological, paleontological and anthropological studies. These prior investigations revealed different quantitative definitions/metrics for similar data in their proportions morphospaces. An introductory review of the morphometric techniques used in some of previous works will be provided in order to establish a methodological framework that can be contrasted with the compositional data analysis (CDA) method. As the present work targets morphospace structure and occupation, the presentation will focus on the morphological organization of appendicular elements under the macroevolutionary concepts of disparity, phenotypic integration and modularity, as well as introducing the relationship between size and proportions. Biological and conceptual contexts are addressed in detail in two main aspects — locomotor convergences reflected in the appendicular skeleton parts proportions, and the variation patterns among each analyzed group — in order to characterize the level of evolutionary stability. Results of everal analyses will be reviewed, thus increasing and enriching interpretability of the results, particularly concerning morphospaces occupation and disparity among the analyzed tetrapods.

S27D - INFERENCES ABOUT THE FEEDING HABITS OF THREE CAMBRIAN ARTHROPODS BASED ON FOSSILISED ALIMENTARY TRACTS

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New specimens from Cambrian Series 3 of Millard County, Utah, USA, show preserved non-biomineralised anatomy that allows inferences to be made on the feeding behaviour and diets of three arthropod species. Two specimens of the arachnomorph *Naraoia compacta* (Marjum Formation) show features comparable to those known from Burgess Shale (British Columbia) material. A large stomach cavity beneath the anterior shield is followed by a straight, narrow medial alimentary tract terminating near the posterior margin. Lateral diverticulae are in the anterior shield, and paired, metamerically divided, foregut and midgut glands are bilaterally disposed submedially. A non-durophagous carnivorous feeding habit is implied by the lack of sediment or other filling of the gut, indicating that it was fluid-filled at the time of death and burial. A taphoglyph of the trilobite *Hemirhodon amblipyge* (Marjum Formation) shows a compacted exoskeleton, indistinct appendages encased in calcite masses (presumably resulting from early calcification around a biofilm-enveloped corpse), and a crushed axis. The stomach cavity lacks any sediment or other filling, implying that it was fluid-filled, and that *Hemirhodon* was a non-durophagous carnivore. An *Anomalocaris canadensis* (Wheeler Formation) specimen shows a well-exposed trunk with lateral lobes, lateral lobe supports, and dorsal vanes, but the head is covered by matrix. A straight medial tube, the alimentary tract, is filled in places with indistinct masses of calcitic material and includes macerated calcite sclerites, inferred to be from trilobites. This supports previous evidence, including predation scars on the co-occurring trilobite *Elrathia kingii*, that *Anomalocaris* was a durophagous predator.

S18 - DIVERSITY DYNAMICS OF MIOCENE RODENTS IN RELATION TO TECTONIC AND CLIMATIC HISTORY

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Continental biodiversity gradients result from ecological, evolutionary and geohistorical processes. The evolutionary and geohistorical processes are best evaluated through analysis of origination and extinction rates and biotic turnover in relation to landscape and climatic history over millions of years. We investigated the evolutionary and historical contributions to the biogeographic gradient of increasing mammalian species richness with increasing elevation and topographic complexity. We analyzed a dataset of 418 rodent species from Miocene fossil localities of western North America spanning the interval from 25 to 5 Ma, comparing diversification histories between tectonically active (montane West) and quiescent (Great Plains) regions. Although diversification differed between the two regions, species richness, origination rate, and extinction rate per myr were not systematically different over the 20-myr interval. In the montane region, the greatest increase in originations and species richness coincided with a Middle Miocene episode of intensified tectonic activity and global warming. During subsequent global cooling, species richness declined in the montane region and increased on the Great Plains. These results suggest that interactions between tectonic activity and climate change have stimulated diversification in mammals. The elevational diversity gradient prevalent among modern mammalian faunas arose only during particular historical episodes and was not a persistent feature over geologic time.

S26 - LITHOLOGIC SIGNATURE OF THE LATE MIDDLE DEVONIAN TAGHANIC BIOEVENT IN ITS TYPE AREA: ANOMALOUS CARBONATE AND CHAMOSITE ACCUMULATIONS IN THE TULLY FORMATION INTERVAL, NEW YORK STATE

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The Middle Devonian (late middle Givetian) Tully Formation in New York State is the type regional expression of the global Taghanic Biocrisis. It is marked by anomalous development of massive to rhythmically bedded, micritic limestone deposits within a vastly thicker Acadian foreland basin clastic succession. Lower-medial Tully carbonates record the incursion of tropical Old World Realm taxa and the outage of the long-standing, cooler-water, endemic Hamilton Fauna. Succeeding Tully strata record a return of the Hamilton Fauna, but lime mud continued to accumulate until widespread dysoxia, associated with peak Acadian thrust loading, overspread the basin to produce the Geneseo black shale. Thick, unfossiliferous, rhythmically-bedded Tully carbonate deposits in central Pennsylvania are interpreted as allodapic basinal facies derived from the erosion of medial Tully deposits on the western New York carbonate platform. Discrete, thin (1-20 cm) layers of concentrated, discoidal grains of black, “oolitic”, chamosite, are observed in detrital deposits in east-central New York which are coeval to Tully platform carbonates. These beds are typically intensely bioturbated, rich in diagenetic phosphate and siderite, and are characterized by corroded remnants of low-diversity fossil assemblages. This problematic sediment is observed to occur both in deep- and shallow-water facies. Work by others suggests that it records minimally reducing, post-oxic conditions with minimal organic matter in a warm, wet, climatic context. Tully chamosite appears to record unusual conditions of sediment-starvation and possible, localized basin upwelling. These deposits await C and O isotope analyses.

S9 - MIDDLE AND UPPER DEVONIAN OSTRACODS FROM THE SALAIR AND KUZNETSK BASIN, RUSSIA

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The alignment of regional stratigraphic charts with international schemes is of high priority. Data on brachiopods, trilobites and ostracods are widely used for the shallow-water shelf facies along with conodont, dacryoconarid and ammonoid data. The Eifelian ostracod complex of the Salair is considerably less diverse compared with the Emsian. It is represented by 24 species from bioclastic limestones of the Malaya Salairka and Pesterevo Beds. Four taxa are traced from the carbonate facies of the Shanda to the Mamontovo Horizon and go extinct at the end of the latter. More than 20 species, previously established in the younger Kerlegesh and Safonovo horizons, appear already in the Mamontovo Horizon. The Givetian ostracod complex (Kerlegesh and Safonovo horizons, Salair, and Mozalovsky Kitat horizon, Kuznetsk Basin) is mainly derived from the Mamontovo Horizon. More than 25 species were identified. Four species were first time described by E.N.Polenova from the upper Givetian of the Russian Platform. The Frasnian ostracod complex of the Kuznetsk Basin is comprised of taxa recovered from the Yaya and Yaya-Petropavlovskoe Beds, analogues of the Strel’naya and Pozharishchevo Beds (Vassino Horizon), and from the Solomino Horizon. The lower Frasnian sub-complex is represented by nine species, the upper Frasnian sub-complex by 15 species. The Famennian complex of the Kuznetsk Basin is represented by six species from the middle Peshcherka Horizon and contains abundant specimens. In the Givetian and Frasnian, close zoo-geographic relations of ostracod complexes from the Kuznetsk Basin, eastern part of the Russian Platform, Poland and Belgium could be traced

S3 - "NEW" CARBONATE DISSOLUTION INDEXES BASED ON THE FRAGMENTATION OF SINGLE COCCOLITHOPHORE SPECIES

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The alteration of calcareous microfossil assemblages by calcium carbonate dissolution has been widely investigated. One of the most commonly used dissolution indexes is the quantity of damaged and fragmented planktonic foraminifer tests relative to whole tests. Here we present two dissolution indexes based on the fragmentation of single coccolithophore species. A dissolution index based on a single species is a good strategy for dealing with uncertainties in the knowledge of the original micropaleontological composition of the assemblage, as has been proposed by Peterson & Prell (1985). The high abundance of the dissolution-resistant species *Coccolithus pelagicus* during the late Pliocene in site ODP 1090, allows us to count both entire coccoliths and fragments under the light microscope. Additionally, we interpret the rupture of the proximal and distal shield of *Calcidiscus leptoporus* as a sign of dissolution, and therefore we quantify the proximal shields relative to the whole individuals. These species were the best choice because the fragments are easily recognized in light microscope and relatively common ocean-wide. These indexes can help us to identify episodes of dissolution, an important feature for further paleoceanographic interpretations.

S17 - USING SINKING EXPERIMENTS TO UNDERSTAND GRAPTOLOID FUNCTION

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Across their evolutionary history, the colony forms of the Graptoloidea display both spectacular morphological trends and decoupled changes between morphological disparity and taxonomic diversity. However, the functional implications of these morphologies are not fully understood. Although models of locomotion and life-mode have been suggested, they have rarely been tested. Sinking experiments have been used to study colony orientation, but previous studies (some unpublished) have yielded conflicting results. This analysis attempts to clarify matters by focusing on the best replica of a graptoloid possible: isolated three-dimensionally preserved specimens, extensively checked for damage or internal allochthonous deposits. These specimens were taken from a broad range of taxa, colonial morphologies, and growth stages. The relationship between growth, colony form, and sinking orientation is explored. In addition, new data on the range of densities of pterobranch coenecium is used to test previously suggested models of graptoloid locomotion. Finally, I discuss the implications of this work to our larger understanding of graptoloid function and ecology.

S15 - THE ONSET OF THE CARBONIFEROUS GLACIATION – STABLE ISOTOPE EVIDENCE FROM IRELAND

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Despite many years of research, details of the timing and scale of the onset of the Permo-Carboniferous glaciation remain enigmatic. Difficulties in correlating and quantifying proximal and distal sedimentological indicators of this event have led to some degree of contradiction and confusion in the literature. The use of geochemical proxies for palaeoclimatic conditions such as the stable isotopes of oxygen bound in the remains of fossils has been suggested as a possible solution. Advancements in the analytical limits and reproducibility of $\delta^{18}O$ values preserved in high fidelity biogenic phosphate of conodonts and fish have paved the way for the generation of highly accurate isotopic curves. Many previous studies, involving both isotopic and lithological indicators of glaciation, recognise the Viséan – Serpukhovian boundary in the Mississippian (Lower Carboniferous) as representing either the onset of, or significant increase in, global cooling and ice sheet growth. Continuous marine sedimentation in Ireland at this time makes it an ideal laboratory to search for geochemical and sedimentological indicators of this global climate shift. The results of isotopic analysis of fish and conodont micro-remains in this study suggest that cooling began earlier, in the Asbian (Late Viséan) and that the environment had largely stabilised by the base of the Serpukhovian. These data are in good agreement with the facies controls identified in the geographically distinct locations studied in the west and northwest of Ireland.

S1 - CALIBRATING THE 'SIXTH MASS EXTINCTION' FOR MAMMALS

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During the Phanerozoic Earth witnessed five mass extinctions, typically defined as geologically short intervals when ≥ 75% of species went extinct. Biologists now fear we are in a Sixth Mass Extinction, based on criteria like estimated losses of arthropod species as tropical forests are cut down, observed recent global decline of amphibians, and the endangered status of approximately 25% of the world's mammal species. However, due to the difficulties in quantitatively comparing observations on modern species with data from the geological and fossil record, it has been unclear just how far down the path of the Sixth Mass Extinction we have actually traveled. Here we estimate where on the mass-extinction trajectory mammals fall, as an exemplar group that has a particularly good fossil record. We used information from two paleontological databases, MIOMAP and FAUNMAP, to determine species-area relationships (SARs) at several temporal intervals ranging from ~30 million to 500 years ago in several different biogeographic provinces in the USA. The methodology includes rarefaction to adjust for sampling and temporal-bin biases, and the SARs adjust for differing geographic sampling. We found that mammalian diversity remained relatively stable from 30 million years ago up until the Holocene, then crashed dramatically such that today it is between 15% and 42% too low, depending on biogeographic province. That means that in our study area, mammals have progressed one fifth to halfway towards a true mass extinction. It is still unclear how these results for mammals translate to other kinds of organisms.

S26 - SEQUENCE STRATIGRAPHIC INTERPRETATION OF 'THICKETING INTERVALS' IN THE MIDDLE DEVONIAN OF EASTERN NORTH AMERICA

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The Lower Givetian 3rd-order Ludlowville Sequence of the Appalachian and Michigan basins contains a number of distinct expanded intervals, herein referred to as 'thicketing intervals', represented by reefal and biostromal buildups dominated by rugosan corals. Within the Appalachian Basin there are two such thicketing intervals contained within the late transgressive to early highstand phases of the Ludlowville 3rd-order sequence. The lower, Staghorn Point Coral Bed is a biostrome up to 2m thick of densely packed rugosans. The upper, Joshua Coral Bed is also a biostrome up to 25m thick containing a similar assemblage of rugosan corals. In each case, the biostrome developed above a compact siltstone that formed during the falling-stage interval of a small-scale depositional sequence with growth of the coral thicket during the following small-scale transgressive interval. Larger reefal buildups occur within the Alpena Formation that was deposited during the late highstand phase of the Ludlowville 3rd-order sequence in the Michigan Basin. Reefs up to 20m in thickness contain core-reef deposits dominated by stromatoporoids and colonial rugosans with well-developed flank beds consisting of material shed from the reef core. As with the time-poor thicketing intervals of the Appalachian Basin, those in the Michigan Basin were also initiated during small-scale transgressive events. It is interesting to note that, although smaller reefal and biostromal deposits can be found during larger-scale transgressive events, the greatest development of thicketing intervals usually occurs during smaller scale transgressive events, perhaps indicating a correlation to the rate of sea level rise.

S7 - CRANIIFORMEA AND THEIR POSITION WITHIN CROWN GROUP BRACHIOPODS

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As currently defined, the Subphylum Craniiformea is the smallest and probably the most conservative clade within crown group Brachiopoda. In detail, phylogenetic relationships with two other major brachiopod clades, the Linguliformea and Rhynchonelliformea, remain controversial. Biomolecular data derived from SSU (18S) and partial LSU (28S) sequences pointed initially towards craniiforms being a sister group of linguliforms and phoronides. However, this brachiopod molecular phylogenetic model has since been challenged by further LSU and SSU data, suggesting that Brachiopoda, Phoronida, and Bryozoa are not a monophyletic entity. At the same time, it is becoming clear that the craniiform lecithotrophic larva evolved independently from rhynchonelliforms. Current study of well preserved specimens of the Early Palaeozoic craniiform brachiopods *Orthisocrania* and *Craniops* provides clear evidence of a lecithotrophic larval stage, indicating the loss of planktotrophy early in phylogeny. Although strophomenate brachiopods and the enigmatic chileide-like *Salanygolina* most probably had a planktotrophic larva, they exhibit a remarkably similar pattern to craniiforms of metamorphosis after settlement, including the early loss of larval attachment on the posterior part of the body, replaced by adult attachment structures secreted by the ventral mantle, which are not homologous to the pedicle of rhynchonellates; there was no mantle reversion, while differentiation of the ventral mantle and secretion of the ventral valve took place later in metamorphosis. In this interpretation the delayed formation of the ventral valve in craniiforms and strophomenates can be interpreted as an apomorphic state.

S24 - ECOLOGICAL ADAPTATION OF ALGAL COMMUNITIES IN BILLION-YEAR-OLD LAKE BASINS

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Phosphatic nodules in 1000Ma Torridonian rocks of northwest Scotland preserve, in exceptional 3D detail, a diverse community of cellular fossils. The assemblage, which includes both prokaryotic and eukaryotic cells, comprises the oldest known diverse terrestrial body fossil asemblage. Environments of the Proterozoic lake basins varied considerably over space and time. Lacustrine shales belonging to the Diabaig Formation are either black and finely laminated from the hypoliminion, or rippled, with desiccation cracks from the epilimnion. A younger lake system, forming the Cailleach Head Formation, has a distinctive cyclothem pattern, indicating periodic lake level fluctuations and associated progradation of fluvial fans. Occurrence of phosphatic nodules throughout the shaley phosphate facies permits analysis of fossil assemblages characteristic of each lithology and environment. Our data show marked ecological adaptation of the algal communities to the varying conditions, including notable dominance by simple, more resistant forms in areas where stress levels are inferred to have been high. Further, the existence of the same fossil morphologies in lake basins separated in time by almost 20Ma, suggests that these algae were adapted to cope with longer term desiccation and basin migration, and that evolution at this time was not rapid. Preservation in these phosphatic nodules offers a unique opportunity to conduct such ecological studies. The remarkable fidelity of preservation allows even the most delicate cellular cluster to be preserved, almost as in life. As such, meaningful estimations of diversity and ecological dominance can be made under the assumption that the preserved assemblages are unbiased by taphonomy.

S14 - PERFORMANCE OF RELAXED CLOCK METHODS IN ESTIMATING EVOLUTIONARY DIVERGENCE TIMES AND THEIR CREDIBILITY INTERVALS

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The rapid expansion of sequence data and the development of statistical approaches that embrace varying evolutionary rates among lineages have encouraged many more investigators to use DNA and protein data to time species divergences. Here, we report results from a systematic evaluation, by means of computer simulation, of the performance of two frequently-used relaxed-clock methods for estimating these times and their credibility intervals (CrIs). These relaxed-clock methods allow rates to vary in a phylogeny randomly over lineages (e.g., BEAST software) and in autocorrelated fashion (e.g., MultiDivTime software). We applied these methods for analyzing sequence datasets simulated using naturally derived parameters (evolutionary rates, sequence lengths, and base substitution patterns) and assuming that clock-calibrations are known without error. We find that the estimated times are, on average, close to the true times as long as the assumed model of lineage rate changes matches the actual model. The 95% credibility intervals (CrIs) also contain the true time for ≥ 95% of the simulated datasets. However, the use of incorrect lineage rate model reduces this frequency to 83%, indicating that the relaxed clock methods are not robust to the violation of underlying lineage rate model. Because these rate models are rarely known *a priori*, and are difficult to detect empirically, we suggest building composite CrIs using CrIs produced from MultiDivTime and BEAST analysis. These composite CrIs are found to contain the true time for ≥ 97% datasets. We also evaluate the effect on these results of using minimum-boundary calibrations instead of perfect ones.

S20 - SKELETAL TAPHONOMY OF MARINE REPTILES FROM THE MIDDLE TRIASSIC OF MONTE SAN GIORGIO, SWITZERLAND

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A diverse fauna of marine reptiles is preserved in Middle Triassic (late Anisian to late Ladinian) sediments from Monte San Giorgio, Southern Switzerland. Taxa from the Besano Formation and three distinct horizons within the lower part of the succeeding Meride Limestone are used to develop the first comprehensive taphonomic model for this fauna. The free-swimming, marine, pachypleurosaurids *Serpianosaurus* and *Neusticosaurus* occur in the Besano Formation and the Meride Limestone, respectively. Semi-quantitative indices of the completeness and articulation of skeletons of each taxon were defined for the following skeletal groupings: skull, neck, ribs, thorax, four limbs, tail. From this, values for the completeness and articulation of each skeleton were calculated. In *Serpianosaurus* a decrease in skeletal articulation and completeness are positively correlated. Articulation in *Neusticosaurus* is extremely variable (40-100%), but values for completeness consistently high (>75%). *Serpianosaurus* and *Neusticosaurus* are similar in size and body plan; the pattern of progressive disarticulation is similar in each (limbs first, followed by tail and head, neck, ribs and finally the thorax). The different taphonomic pathway each followed thus reflects variation in environmental conditions. Specimens of *Neusticosaurus* came to rest on the sediment-water interface while wholly or largely intact; skeletal elements liberated from the carcass by decay of the 'soft tissues' remained associated with the carcass. In *Serpianosaurus* isolated skeletal elements became dissociated from the remainder of the carcass. As limbs on the opposite sides of the same skeleton often show markedly different values for completeness and articulation this occurred after, not before, their deposition.

S3 - CHANGES OF LATE PLEISTOCENE NANNOPLANKTON CALCIFICATION IN RESPONSE TO OCEAN CARBONATE CHEMISTRY

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Coccolithophores produce the major fraction of pelagic carbonate, a key component of the carbon cycle, yet the effect of changing CO_2 on their calcification is poorly understood : contrasted results have been obtained from cultured and natural oceanic environment studies. The role of carbonate concentration appears to be determinant on the degree of calcification. However, the strain and species composition appears to play also an important role. We used a novel automated method for pattern recognition and morphometric analysis to quantify the calcite mass of gephyrocapsid coccolithophores for the last 800-Kyr in order to understand how the calcification evolved in comparison with the EPICA's atmospheric CO_2 record. Core MD05-2930 has been retrieved in the Gulf of Papua on a topographic high (1400 m), and in a relative oligotrophic Coral Sea. This 37m core covers the last 800 ka. Mg/Ca reconstructions of Sea Surface Temperature indicate a rather stable temperature conditions. The mass of coccoliths follow atmospheric CO_2 variations, with higher mass during glacials and lower mass during interglacials. This add to the growing evidences that coccolithophore calcification is negatively impacted by ocean acidification. A longer term trend is also observed which is due to evolution : for example the appearance of the presently dominant species *Emiliania huxleyi* at ~270 Ka induces a general decrease of gephyrocapsids mass, this species being relatively light. We therefore discuss the relation between evolution and the history of carbonate chemistry changes.

S9 - AN UPDATE OF MIDDLE/UPPER DEVONIAN GLOBAL EVENTS IN SOUTHERN MOROCCO

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Due its superb outcrops, facies transitions, and well established biostratigraphy, the Devonian of the Anti-Atlas is globally one of the best areas to investigate the precise timing, environmental changes, extinction and recovery patterns associated with global events. Event magnitudes, palaeoecological trends, and phases of events (within single biozones) and multi-phase crisis intervals (of several biozones) can be compared. New facies and high-resolution conodont and ammonoid age data will contribute to a revised global eustatic curve for the Middle and Upper Devonian. New results are available for a sequence of lower Emsian events, the Daleje (basal upper Emsian), Choteč (lower Eifelian) and Kačak Events (upper Eifelian), the extended Taghanic Crisis (middle Givetian), the Frasnes Events (Middle/Upper Devonian boundary), the Timan Event (high in the lower Frasnian), the *semichatovae* Transgression, the Kellwasser (upper Frasnian), *Annulata* and the Dasberg Event (both upper Famennian). Two key sections of the Tafilalt (Mdoura-East, Seheb-el-Rhassal) provide new data on a complex of closely-spaced sea-level changes and hypoxic pulses in the lower part of the middle Frasnian, including black styliolinites of the Rhinestreet Event. These are preceded by two important regressive episodes. Transgressive pulses of the Rhinestreet and Kellwasser Events can also be recognized in the eastern Dra Valley, always associated with the spread of hypoxic ammonoid facies. North of the Tafilalt, in the Tinjdad region, the Daleje and Kačak Events are pronounced. In the western Dra Valley, the Choteč and Kačak Events can be recognized in a mixed pelagic-neritic setting overprinted by gradual deepening.

S27B - MIOCENE SHALLOW MARINE TRACE FOSSILS AND BIOTURBATION IN THE CAMP DE TARRAGONA BASIN (NE SPAIN)

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This contribution presents the current knowledge about bioturbation trace fossils in the shallow marine deposits of the Camp de Tarragona basin, located in the north-east of the Iberian peninsula. This basin is a SW-NE elongated half-graben infilled by Miocene continental sediments and intercalated marine units. Studied outcrops correspond to the Ardenya Unit, which was deposited during the Serravalian (Middle Miocene) in a mixed siliciclastic-carbonate shelf environment. A variety of trace fossils and ichnofabrics have been recognized that are associated to lithofacies and palaeoenvironments. Distal, offshore, glauconitic, silty facies are characterized by a highly-bioturbated *Cylindrichnus concentricus* ichnofabric resulting mainly from the intense burrowing activity of terebellid polychaete worms in environments under low-sediment rates and low-energy conditions. This ichnofabric is overlain by highly bioturbated silty facies with a more diverse ichnofabric dominated by *Ophiomorpha* isp, and discrete horizons of *Thalassinoides suevicus*, which are related to the activity of decapod crustaceans in areas with an increasing influence of storms. Littoral, coarser-grained facies consist of calcarenites and coquines where bioturbation is more sparse. Predominantly vertical *Ophiomorpha* isp. is the most common ichnotaxon, together with possible spatangoid burrows (*Scolicia/Bichordites?*) and occasional *Sinusichnus sinuosus*. Additionally, sandy siliciclastic units, tentatively interpreted as estuarine facies, contain *Ophiomorpha* isp. and *Dactyloidites ottoi*., respectively produced by decapods and annelids. Ichnological data combined with other palaeontological, taphonomical and sedimentological information allow for refining the depositional interpretation of the studied units.

S27D - COPING WITH GIGANTISM IN THE TRILOBITE ORDER ASAPHIDA: PATTERNS OF BODY-SIZE EVOLUTION ACROSS ALL MOST PARSIMONIOUS TREES

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Cope's rule, a driven trend in organismal body size across lineages, is a commonly studied pattern in evolutionary biology. The Order Asaphida is a highly diverse clade ranging from the Upper Cambrian to the Upper Ordovician and contains several of the largest recorded trilobite species. A phylogenetic analysis was undertaken of the derived superfamilies of the Asaphida (i.e Asaphacea + Cyclopygacea). Where previous investigations into Cope's rule have involved either composite topologies or supertrees for the analysis, here all 165 most parsimonious trees were considered. In every case ancestral values were calculated through weighted squared-change parsimony and four evolutionary models were fitted; Brownian motion, Brownian motion with a driven trend , Ornstein-Uhlenbeck and stasis. Comparisons with AICc values show the Ornstein-Uhlenbeck model, or evolution towards an adaptive mean, to be consistently the most likely across all trees. Also no correlation was supported between body size with patristic distance or through the use of a Mantel test to compare distance matrices of each topology. An important distinction between active and passive trends is the change of the lower size bound, or 'left wall', over time, here this is shown to be invariant across the both the Trilobita and Asaphida. The benefits of using multiple parsimonious trees and the effects of trilobite ontogeny when considering the left-wall are discussed.

S27A - NEW RECORD OF A REBBACHISAURIDAE (DINOSAURIA, SAUROPODA) FROM THE CANDELEROS FORMATION (ALBIAN-CENOMANIAN) OF NORTHERN PATAGONIA, ARGENTINA

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During a fieldtrip made during 2006/2007 to the Late Cretaceous outcrops of the Aguada Pichana site, Neuquén Province (Northern Patagonia, Argentina), a new sauropod dinosaur was found in rocks of the Candeleros Formation (Neuquén Group, Rio Limay Subgroup). The fossil material is embedded in a medium-grained dark red sandstone of fluvial origin. The specimen comprises several anterior caudal vertebrae, humerus, radius, pubis?, fragmentary ilium and incomplete elements of ribs and sacrum. The vertebral centra are platicoelous, short and high without pleurocoels and their lateral sides are slightly concave antero-posteriorly, while the ventral side is flat. The transverse processes are short and robust. The neural arch is tall and borne in the anterior border of the centrum. The vertebral morphology together with the shape of the humerus and radius resemble those described for *Rebbachisaurus tessonei* (Calvo and Salgado, 1995) from the Candeleros Formation of El Chocon , Neuquén. A preliminary study of the material in the field indicates a close relationship to *R. tessonei*; however, we may include this specimen as a member of a Rebbachisauridae.

S19 - ORIGINS OF MULTICELLULARITY

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Selection for larger size is a strong factor in evolution, and multicellularity is an efficient way of attaining it. The advantages in competition and predation are poised against the disadvantages of having lower volume-to-surface ratios and higher dependence on internal transportation mechanisms. To qualify as multicellular (or multinucleated [syncytial] – the distinction can rarely be upheld in fossil material) there should be some measure of individuality – just forming a mat on the seafloor is not sufficient. Living organisms represent more than a dozen independent origins of multicellularity. We should expect that during the long history of Proterozoic evolution under more-or-less oxygenated conditions, a much larger number of clades attempted the step up to multicellularity, even though only a dozen or so survived the attempt. A scarce record of early megafossils suggests that multicellular organisms of centimeter size were present already in the middle Palaeoproterozoic and that eukaryotic multicellularity was diversifying by the end of the Palaeoproterozoic. Advanced multicellularity, involving cell and tissue differentiation, is not evident in the fossil record until the Neoproterozoic. A precursor to the spatial cell differentiation in metazoan development may be the temporal cell differentiation in protists with complex life cycles, as recently suggested by Mikhailov *et al.* (2009; *BioEssays 31*).

S15 - THE OSTRACOD TERRESTRIALISATION EVENT IN THE MISSISSIPPIAN

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The colonisation of freshwater environments is a key step in the evolution of life in the late Palaeozoic. Ostracods are small crustaceans, widespread in all aquatic environments, ranging from Ordovician to present. They first colonized terrestrial water-bodies in the Carboniferous. The effects of the Mississippian glaciation in the marine realm may have acted as a driver for this ecological shift. In the Mississippian of the Midland Valley of Scotland ostracods are present in marine, marginal marine, brackish and freshwater environments, as recognised by a multi-proxy assessment of the sedimentology, macrofauna and palynology. Thus, the presumed freshwater *Carbonita* ostracods are associated with other freshwater indicators such as Spinicaudata, *Anthraconaria, Carbonicola, Naiadites,* fish fragments, algal palynomorphs and abundant plant debris. The stable isotope composition of pristine ostracods can be an important palaeoenvironmental proxy for marine vs. non-marine conditions. Prior to isotopic analysis, a detailed diagenetic protocol assesses the ultrastructure and composition of ostracod carapaces. Despite shallow diagenetic recrystallisation, neomorphic calcite ostracod specimens do preserve a palaeoenvironmental signal. Marginal marine and marine palaeoenvironments can be determined, and have isotope values similar to that estimated for Carboniferous seawater from brachiopod carbonate. Future work will aim to expand the ostracod data set and fully define an ostracod palaeoenvironmental proxy for Carboniferous marine and non-marine environments.

S2 - FOSSILS AND MOLECULES: MACROEVOLUTION IN THE QUATERNARY

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Darwin's *On the Origin of Species* has lead to a theory of evolution with a mass of practical detail on population genetics below the species level together with heated debate on the details of macroevolutionary patterns above the species level. Most of the main principles are generally accepted, notably that life originated once, and has evolved over time by descent with modification. However, there has never been a clear description of how species originate, and few observations of this occurring in nature are visible from the fossil record. On Quaternary timescales, organisms respond to environmental changes by movement, extinction and evolution, but movement appears to be the most frequent. The connection between environmental change and evolution appears to be weak, which is not the result that might have been expected from Darwin's original hypothesis. I suggest that the explanation of this unexpected result lies in non-linear dynamics of the relationship between genotype and phenotype. The 'origin of species' becomes essentially unpredictable, but is nevertheless an inevitable consequence of the way that organisms reproduce through time. The process is `chaotic', but not `random'. I suggest that life's diversity is best considered as a continuously branching system of lineages, where `species' are the branch tips. The diversity of life should thus, (i) be in a state of continuous increase, and (ii) show continuous discrepancies between genetic and morphological data in time and space. Whether or not this is so constitutes a test of the ideas presented here.

S1 - MESOZOIC MARINE TETRAPOD DIVERSITY: TEMPORAL AND ECOLOGICAL HETEROGENEITY IN SAMPLING BIASES, AND INSIGHTS INTO THE 'COMMON CAUSE' HYPOTHESIS

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Analyses of marine invertebrates show that geological megabiases profoundly influence fossil preservation and discovery, obscuring true diversity signals. Comparable studies of vertebrate palaeodiversity remain in their infancy. A new species-level dataset of Mesozoic marine tetrapod occurrences was compiled, and species were assigned to discrete ecological categories based on inferred habitat preferences (shallow vs. deep water). Diversity was compared with a sampling proxy (number of marine fossiliferous formations), as well as with estimates of sea-level and shallow marine area. A strong correlation between total taxic diversity and sampling is present during the Cretaceous. Weaker correlation of Jurassic data suggests a qualitatively different sampling regime resulting from five apparent peaks in Triassic–Jurassic diversity. These correspond to a small number of European formations that have been the subject of intensive collecting, and represent 'Lagerstätten effects'. The observed diversity of shallow water taxa is strongly correlated with shallow marine area, while the diversity of deep water taxa is strongly correlated with sampling. Observed diversity patterns among shallow water taxa likely result mainly from species-area effects driving 'true' ancient biodiversity, suggesting that 'correcting' these patterns for uneven temporal sampling may be inappropriate due to ' common cause' effects. However, the observed diversity patterns of deep water taxa more closely tied to sampling biases. These results reveal substantial temporal and ecological heterogeneity in the nature of sampling biases affecting marine tetrapods, indicating that a single correctional regime may not be sufficient to unpick the patchwork of geological megabias affecting vertebrate preservation.

S1 - THE QUALITY OF THE VERTEBRATE FOSSIL RECORD AND GEOLOGICAL RECORD

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Ever since Darwin, geologists and palaeontologists have been concerned about the validity of inferences from the rock and fossil records. The imperfections of both records are clear, and yet the key questions are to determine (1) the *adequacy* of the records for particular analyses, and (2) whether there are ways to *correct* the existing record so that it may be used for other analyses. Current opinion is divided, with views ranging from optimistic to pessimistic. At the pessimistic end, a number of recent studies have sought to 'correct' marine and continental fossil records by using proxies for sampling such as number of geological formations or rock outcrop area. In many cases, the resulting 'corrected' record is very different from the empirical data. There are two concerns with this approach: (1) are the correction factors independent of the signal they seek to correct, and (2) do the proxies factually reflect sampling? I shall present evidence that global proxies so far proposed are not independent, and do not reflect sampling; in the end, there are unlikely to be any meaningful global proxies for sampling, and fossil record quality should be queried/ corrected at the local, sample scale. Further, there is a wealth of data in comparisons of fossil records with large phylogenies that provides indications of sampling quality, while at the same time illustrating major features of evolution. Using examples from the early evolution of tetrapods, new work on the Late Palaeozoic and the end-Permian and end-Triassic mass extinctions will be presented.

S24 - NEW TALES FROM THE OLDEST FORESTS

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The appearance of forests in the Devonian is widely regarded as one of the most significant steps in the evolution of the carbon cycle and development of terrestrial ecosystems. The Late Devonian progymnosperm *Archaeopteris* had until recently been considered the archetypal primitive forest tree. Palaeobotanists are contributing to the understanding of afforestation by developing increasing well-founded reconstructions of earlier plants based on significant new discoveries amongst three groups, Pseudosporochnales, Archaeopteridales and Lycopsida. Each achieved tree status in the Middle Devonian, using very different growth strategies and architectures, which will be briefly reviewed. In addition to recently published studies of *Pseudosporochnus* and *Wattieza* (the 'Gilboa tree') we can now show fossils of complete plants of the early Middle Devonian *Calamophyton*, which include the for the first time the apex, 'branches', trunk and roots. Amongst Archaeopteridales, we can now show the detailed 'frond' morphology and frond and trunk anatomy in early examples of this lineage. In the context of such breakthroughs, more sense can now be made of the record of fossil soils in which these plants grew. The record of *in situ* structures of these three plant groups will be evaluated.

S8 - ROLE OF OXYGEN IN HIRNANTIAN GRAPTOLITE EXTINCTIONS

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Finney and others (2007) analyzed the influence of oxygen minimum zone (OMZ) denitrifying seawater on Hirnantian graptolite extinctions and concluded that Late Ordovician DDO (Dicranograptid-Dicellograptid-Orthograptid) species became extinct gradually, not precipitously. Although most DDO species become extinct prior to the Hirnantian a few continued into and through it. Graptolite occurrence and lithology data suggest that Late Ordovician DDO graptolites existed as long as OMZ denitrification zone waters persisted. Analysis of the relationship between oxygen concentration and calanoid copepods in modern oxygen minimum zones in the Arabian Sea (Wishner and others, 2000, 2008, Gooday and others, 2009) suggests an explanation for this pattern of Hirnantian graptolite extinctions. A unique copepod community occurs in the core of the Arabian Sea OMZ. Other copepod species are distributed along an oxycline that extends from that OMZ core upward and downward coincident with increasing oxygen concentrations. A significant rise in biodiversity, which is linked to increases in oxygen, occurs below Arabian Sea OMZ core waters. Analysis of modern OMZ copepod occurrences that are linked closely to oxygen concentrations in waters they inhabit suggests, by analogy, that DDO graptolite species that existed not only to the Hirnantian but also into and through it did so because of the very low oxygen concentration of the waters they inhabited As oxygen concentrations in most Late Ordovician oceanic hypoxic waters increased prior to and during the Hirnantian, DDO species became extinct gradually at slightly different times in different areas as noted by Finney and others (2007).

S9 - BRYOZOAN DIVERSITY IN THE DEVONIAN OF FRANCE AND BIOEVENTS

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Most Devonian bryozoan faunas of the Armorican Massif are located in the Central Synclinorium. In the eastern part (Laval area), the Saint-Cénéré Formation (Pragian) yields a balanced diversity between fistuliporids, trepostomes (halloporids, stenoporids) and fenestrates. More westerly (Gahard), the Marettes Formation (Emsian) yields a quiet diverse fauna of fistuliporids, trepostomes (halloporids, heterotrypids, trematoporids, amplexoporids, atactotoechids), fenestrates, rhabdomesids and ptilodictyids as well. In the western part (Roads of Brest area) occurs the best preserved bryozoan fauna, especially from the reefal environment of the Armorique Formation (Pragian), and with a high diversity: trepostomes (heterotrypids, trematoporids), fenestrates and rhabdomesids. One of the best regions that yield Middle and Upper Devonian bryozoan faunas is the Boulonnais (Northern France). High diversity exists in the Blacourt Formation (Givetian), Beaulieu and Ferques Formation (Frasnian), respectively. It is more pronounced in the Beaulieu Formation, with trepostomes (amplexoporids, atactotoechids), and in the Ferques Formation, with fenestrates and rhabdomesids. In the Montagne Noire (Southern France) bryozoan localities are more scattered. In the Cabrières Klippen, the bryozoan diversity of the Falgairas Formation (Pragian) is not significant, unlike the Mont Peyroux, where the Bissounel Formation (Emsian) shows bryozoan-rich build-ups, dominated by fenestrates. Our current knowledge of bryozoan diversity depends on the sedimentary environment. Tectonics may be mentioned because of strata disruption. It is the key of their location in relation with Devonian Bioevents.

S13 - EVOLUTION OF PHOTOSYMBIOSIS AND RECOVERY OF THE CARBON SYSTEM AFTER THE END CRETACEOUS MASS EXTINCTION

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The end Cretaceous mass extinction seriously affected the marine ecosystem. Surface to deep-ocean carbon isotope gradients and carbonate accumulation records suggest that the extinction coincided with a crash in organic matter flux to the sea floor and was followed by a long (3Myr) delay in recovery. This critical interval in Earth's history is crucial for understanding how the marine ecosystem reacts to major perturbations. Palaeoceanography and palaeoecological studies are largely dependent on stable isotopes of planktonic foraminifera, but the foraminifera themselves were profoundly affected by the extinction as they re-diversified. Disentangling the effects of changing ecology and depth habitats on the isotopic composition of their tests is crucial for understanding how the carbon system recovered. Here we present new multi-species foraminiferal stable isotope data and planktic shell size distributions from a new, well-dated and continuous Atlantic deep-sea core. The data document the evolution and diversification of photosymbiosis in Paleocene planktonic species 3 million years after the end Cretaceous extinction when the pelagic carbon system finally recovered. The data show that the geochemical signature of photosymbiosis evolved in an initially thermocline dwelling species.

S27A - PALAEOZOIC VERTEBRATE BIODIVERSITY AND BIOEVENTS: A MACROECOLOGICAL HYPOTHESIS

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In respect of evolutionary models, the Court Jester model (i.e. that biodiversity depends on fluctuations in climate, landscape, food supply, etc.) best fits a long time scale and a macroevolutionary pattern at a higher taxic rank level. It is opposed to the Red Queen model, which would better fit a microevolutionary pattern (i.e. at the species or infra-species level and a shorter time scale). Both models are in need of precise taxic databases. Preliminary studies of Palaeozoic vertebrate biodiversity have been made at different taxic levels and for different time slices. Here, I focus on all Palaeozoic vertebrate families of both agnathans and gnathostomes, including tetrapods. This review is based upon the Fossil Record 2, with corrections implemented using recent publications for the Cambrian to Early Carboniferous. The result is compared to various biodiversity curves that have been published for various sets of taxa (marine invertebrates, eurypterids, terrestrial plants, insects). It is also compared to a series of physical fluctuations of the Earth surface through the Palaeozoic (global eustatic variations, palaeoclimatic changes, tectonic activity, volcanism, including spreading velocity of mid-oceanic ridges, etc.) and to the evolution of eurypterid biodiversity and size (Cope's Rule and Romer's theory), thus within a macroevolutionary/macroecological perspective. A macroevolutionary rule may be hypothesized: biotic events and macroecological novelties in vertebrates follow (appear later than) those in plants and invertebrates. This would be due to the structure of food webs in the biosphere at a global scale and in ecosystems locally.

W9 - ANASPID AFFINITY AND THE EVOLUTION OF EARLY VERTEBRATE CHARACTERS

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Our understanding of the origin and early evolution of vertebrates relies heavily on data from various fossil jawless groups, some of which possess characteristics such as paired fins and bone that today only occur in gnathostomes. These are some of the characters that have supported a consensus that the so-called “ostracoderms” are closer to gnathostomes than to either lampreys or hagfishes, and are therefore members of the gnathostome stem group. Among these “ostracoderms” are the anaspids, a group that superficially resemble lampreys to which they often have been associated based on the overall body shape, organization of the gill openings and an inferred dorsal nasohypophysial opening. Anaspids have been of particular interest in the context of the origin of paired fins, since their supposed elongated paired fins have featured in discussions around the lateral fin-fold theory. Recent work on new anaspid material has revealed novel information on the nature of paired and median fins, which has emphasized the importance of revising the affinity of anaspids and their relatives. Phylogenetic analysis suggest that anaspid monophyly can be challenged in the absence of synapomorphies and that typical anaspid features probably are plesiomorphic and thereby revealing new information regarding the order in which many of the typical vertebrate characters are acquired. This further stresses the importance of exploring and revising also the morphology of other fossil jawless vertebrates in order to better understand the origin of the gnathostome body plan.

S2 - ESTIMATING TEMPO AND MODE OF EVOLUTION FROM NEONTOLOGICAL DATA

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It remains largely unknown how phenotypic differences between biological species develop over time. From his early writings, it seems that Darwin initially envisioned macroevolution as the long-term consequence of the accumulation of microevolutionary changes within populations. Critics of this idea point out that fossil species often appear fully differentiated – ostensibly the result of rapid evolution associated with species formation – to remain virtually unchanged until going extinct. Intense debate on whether this pattern reflected the real mode of evolution dwelt on the question of whether biological species can be distinguished among fossil remains. Hence, most evolutionary biologists continue to assume gradual phenotypic evolution. I have developed methods to compare models of phenotypic evolution with rapid change during speciation to purely gradual evolution using phenotypes and molecular phylogenies of extant, present-day species. These methods have the disadvantage of not incorporating fossil evidence but circumvent the contentious issue of distinguishing biological species from fossil evidence. Also, these methods allow traits that are rarely or never observed from fossil remains to be analysed, such as many physiological properties, gene (co-)expression, gene copy number, and nucleotide sequences. The results so far obtained with these recent methods suggest that speciation may indeed be the dominant source of phenotypic variation between species. I discuss how these methods can be extended and used to shed light on the question of which processes (such as natural selection or genetic rearrangements) accelerate evolution during speciation.

S27A - NEW ASSEMBLAGES OF EOCENE SQUAMATES FROM SPAIN

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Squamate faunas are well known from the Eocene of Western Europe (France, Germany, Switzerland, Britain). In contrast, the Iberian record has been limited to the Early Eocene Portuguese fossil site of Silveirinha (MP7) which has yielded a diverse squamate assemblage including pleurodont and acrodont iguanians, gekkotans, scincomorphs, anguimorphs, amphisbaenians and snakes. However, a comparable herpetofauna, including amphibians, crocodiles, turtles, lizards and snakes, has now been recognised from Spain as a by-product of screen-washing for mammals in the 1980's and 1990's. Localities in Catalonia and Castilla y León cover a range of stratigraphic levels from MP 8+9 to MP 19/20 and have yielded jaw elements, vertebrae, osteoderms, and rare cranial bones. Here we report for the first time the presence of pleurodont iguanians, possible gekkotans, glyptosaurines, anguines, necrosaurs, amphisbaenians and snakes in the Spanish Eocene. Glyptosaur remains dominate many of the assemblages (MP8 to MP17), but anguines seem to replace them in the younger deposits (MP19/20). Necrosaurs and amphisbaenians are rare, whereas a diversity of snakes occurs throughout. Pleurodont iguanians are certainly present in the older horizons, but fragments of tricuspid dentition from some younger localities differ in morphology and could belong to scincomorph groups such as teiids, cordylids or lacertids. The Spanish localities thus broadly resemble Silveirinha, although agamids have yet to be identified. With more extensive sampling, the Eocene squamate fauna of the Iberian Peninsula is likely to prove comparable in its diversity to those of well-known western European localities.

S3 - HIGH- AND LOW-LATITUDE CALCAREOUS NANNOPLANKTON RESPONSES TO AN ABRUPT CHANGE IN SURFACE OCEAN CONDITIONS DURING THE LATE PLIOCENE

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During the late Pliocene (~3 to 2.5 Ma), globally distributed records of past export productivity display an inferred secular shift towards lower values in the high latitudes and higher values in the low and mid-latitudes, coincident with a decrease in pCO_2 inferred from boron- and alkenone-based proxies. However, due to the nature of palaeoproductivity proxies and the nonlinear processes associated with production, export, and preservation, their interpretation is often complex. Here, we investigate the relationship between magnitude of inferred export production changes and surface water primary production signal, as recorded by calcareous nannoplankton, an important phytoplankton group contributing to both the biological and carbonate pumps. We present new records of nannofossil assemblage variability, and compare these with new and published records of C_{37} alkenone concentration, an emergent palaeoproductivity proxy, using high- and low-latitude datasets (from North Atlantic ODP Site 982 and eastern equatorial Pacific ODP Site 846). With our results we are able to assess the contributing influences of temperature and nutrient availability on the production of calcareous plankton, corroborating the interpretation of C_{37} alkenone concentrations.

S23 - PRECISE COINCIDENCE OF MASS EXTINCTION AND VOLCANISM IN THE MIDDLE PERMIAN OF CHINA: MICROFOSSIL AND CARBON ISOTOPE RECORDS FROM THE EMEISHAN LIP

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The relationship between volcanism and extinction is of great importance to the Earth Sciences. The Emeishan Large Igneous Province of southwest China offers a unique opportunity to directly examine this relationship, because limestones recording the detailed events of the Middle Permian mass extinction are interbedded with mafic volcaniclastics and basalts. Key sections in the region show that the onset of volcanism was marked by both large phreatomagmatic eruptions and heavy losses amongst fusulinacean foraminifers and calcareous algae. The temporal coincidence of these two phenomena supports the idea of a cause-and-effect link, and provides a potent causal mechanism for the Middle Permian mass extinction. New conodont dating of these sections indicates that losses occurred in the mid-Capitanian, placing the Guadalupian extinction well within that stage, much earlier than most previous estimates. The crisis predates the onset of a major negative carbon isotope excursion (seen to be of wide extent) that points to subsequent severe disturbance of the ocean-atmosphere carbon cycle.

S3 - JURASSIC PALYNOSTRATIGRAPHY OF THE SAGRES REGION (ALGARVE BASIN) AND THE CARRAPATEIRA OUTLIER: PRELIMINARY RESULTS

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The Algarve Basin (AB) corresponds to the southernmost geological province of mainland Portugal. More than 3000m of essentially marine sediments accumulated during Mesozoic-Cenozoic times in the AB. The Sagres region is the reference area for the Mesozoic fill of the Western sub-basin where Jurassic strata outcrops in the cliffs at Armação Nova, Mareta and Cilheta beaches. The Carrapateira Outlier (CO) is located 20km north of the main AB and consists of Upper Triassic to Kimmeridgian sediments. The palynostratigraphical study of the Jurassic successions in the Sagres region and the CO has yielded new biostratigraphical data based on dinoflagellate cysts and miospores biostratigraphy. The samples collected from Lower Jurassic (Armação Nova) proved extremely sparse palynologically, due probably to the intensely dolomitised nature of this carbonate succession. The organic residues from Middle and Upper Jurassic are abundant and comprise well-preserved dinoflagellate cysts. The dinoflagellate cyst from the lower part of the Mareta succession are indicative of the Batonian stage; the uppermost strata of this succession match to the Cilheta outcrop and contain species indicative of the Callovian Stage. The dinoflagellate cysts from the Callovian, from further north in Europe, are normally significantly more diverse, maybe due to the relatively enclosed basin and/or preservational factors in southern Portugal. The dinoflagellate cyst associations from the CO are indicative of an Oxfordian age. These results confirm, and refine, the existing macrofaunal age of these successions. However, the palynostratigraphical research in the AB and CO is currently still in progress.

S10 - MICROBIAL SEDIMENTARY STRUCTURES AT CRITICAL INTERVALS IN EARTH HISTORY

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Evidence from Precambrian carbonate (e.g., stromatolites) and siliciclastic (e.g., wrinkle structures) microbial sedimentary structures indicates that in marine settings before the Cambrian biological conditions of seafloor sedimentary environments were largely controlled by microbes and the mats which they form. During the Ediacaran-Cambrian transition a vertical component to marine bioturbation evolved, as well as overall increased seafloor bioturbation. These changes in bioturbation caused a decrease in the ability of seafloor microbes to form extensive subtidal mats that could be preserved as sedimentary structures in the carbonate and siliciclastic stratigraphic record. The "Cambrian substrate revolution" includes the evolutionary and ecological effects that occurred due to these substrate changes. Through the remainder of the Phanerozoic subtidal microbial sedimentary structures re-appear in some abundance in the stratigraphic record during periods characterized by unusual environmental stress. These may range from times of local to global stress, and involve reductions in eukaryotic activity such as bioturbation as well as geochemical changes. Several "Big Five" global mass extinctions have associated increases in subtidal microbial sedimentary structures, interpreted to be related to the environmental stress that caused the mass extinction, but this is not a uniform phenomenon. This differential appearance of microbial sedimentary structures in the stratigraphic record after global environmental crises can be used to provide a comparative understanding of the causes of mass extinctions. For example, the different record of microbial sedimentary structures found occurring after the end-Permian and end-Cretaceous mass extinctions implies different causes for these two times of global environmental stress.

S20 - PRESERVING THE SMALLEST FOSSILS – LEARNING FROM EXCEPTIONALLY PRESERVED CALCAREOUS NANNOFOSSILS (COCCOLITHOPHORES) FROM TANZANIA

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Nannopalaeontologists routinely examine tens of thousands of fossil specimens in samples representing near stratigraphic continuity from localities that range from marginal marine settings to the mid-ocean gyres. The overwhelming volume of data and rather uniform preservation in marine calcareous sediments, have together been considered evidence of a reasonably complete fossil record. However, recent discovery of extraordinary nannofossil preservation from Tanzania (Cretaceous-Paleogene) together with revised estimates of modern coccolithophore diversity, which is far higher than the preserved Holocene record, suggests our understanding of the taphonomy of these plankton is incomplete. The Tanzanian Kilwa Group hosts nannofossil assemblages with very high species diversities, distinct taxic compositions, and conserved small and fragile coccoliths, many of which are new to science. The nannofossils are best viewed by electron microscopy of broken, untreated rock surfaces, where they occur in unaltered concentrations, which most likely represent zooplanktonic fecal pellets or organic aggregates. The assemblages provide a benchmark against which to compare other biodiversity data, but also provide valuable insights into the evolution and origination of the modern coccolithophore groups, in particular, those that have little or no previous fossils record, such as the deep photic zone *Gladiolithus*, as well as yielding information on cell, coccolith and coccosphere sizes and morphology. The controls on this exceptional microfossil preservation remain only partially understood, but we suggest that in large part it was facilitated by the potentially unique juxtaposition of highly diverse "blue water" oceanic coccolithophore assemblages and underlying rapidly-deposited hemipelagic claystones, which were never deeply buried.

S3 - OSTRACODA (CRUSTACEA) IN THE ENCYCLOPEDIA OF LIFE

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Ostracods are “living encyclopedias”, providing valuable evolutionary and palaeoenvironmental information on the last 450 million years. These crustaceans possess two calcified valves, which fossilize easily and efficiently. Therefore, the class Ostracoda shows one of the most extensive fossil records among all metazoans. Interestingly, the small body size typical for ostracods (i.e. body length mostly <1mm) guarantees that small sample sizes (e.g. one piston corer) can obtain several hundreds of specimens. This in turn guarantees that intuitive conclusions for example on biodiversity changes through geological time scales may be statistically tested. As a consequence, ostracods have been successfully used as proxies in palaeoenvironmental reconstructions on marine and freshwater ecosystems. However, the main problem which hinders the even wider usage of Ostracoda in biodiversity studies is the difficulty to obtain the taxonomic bibliography. Therefore, we began to create online “species pages” (e.g. *http://ostracoda.lifedesks.org/pages/4178*) with illustrations, diagnoses and descriptions of single species in the Encyclopedia of Life (http://www.eol.org/). Our objective is to generate such a page for at least 500 ostracod species and stimulate other scientists to create more species pages. We intend therefore to contribute to accurate species identifications and consequent precise scientific conclusions on biodiversity and biogeographical patterns in the different geological periods and geographical regions.

S3 - BIOGEOGRAPHY AND AUTOECOLOGY OF SOUTHERN OCEAN *POSEIDONAMICUS* SPECIES (CRUSTACEA, OSTRACODA)

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Most of the published information concerning the Southern Ocean Ostracoda involves morphology and systematics, while ecological studies are relatively rare and biogeographical analyses are almost completely lacking. In the present study, we aim to: (1) investigate the biogeographical patterns of Southern Ocean ostracods; (2) provide details on ecological preferences of single ostracod species, which can be used as the basis for paleoenvironmental and paleoclimatic reconstructions; and (3) to describe new species recently collected during the ANDEEP project. The first taxon we are investigating is the genus *Poseidonamicus* Benson, 1972, which is an excellent model taxon for biogeographical and biodiversity research because: (1) It has been widely distributed, abundant and common in the deep-sea worldwide since the Eocene (40 million years). (2) Based on its extensive fossil record, numerous studies have been published on *Poseidonamicus*’ evolution, morphology and taxonomy. We are currently working on a database with all Southern Ocean and deep-sea records of the genus *Poseidonamicus*, which will be the base for the biogeographical and the autoecological studies. Our first results include the description of 2 new *Poseidonamicus* species. The preliminary database indicates that single Southern Ocean *Poseidonamicus* species have narrow bathymetrical distribution, showing its potential as proxies in paleobathymetric reconstructions.

S10 - EARLY LIFE, THE PHOSPHORUS CYCLE AND THE 1900 Ma GUNFLINT CHERT

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Evolving patterns of phosphorus recycling were fundamental to major biosphere revolutions in Deep Time. In this paper, we report on our recent discoveries and studies of phosphorites from the Gunflint Chert of Canada, about 1900 Ma, and compare them with younger Proterozoic through to upper Cambrian and younger examples. These findings allow us to test the Mixed Layer Model put forward by Brasier and Callow (2007, *Memoirs of the Association of Australasian Palaeontologists*, 34, 377-389) and Brasier (2009, *Darwin's Lost World,* Oxford University Press) which predicted the following taphonomic changes from the Proterozoic to post-Cambrian times: 1, a departure from high-fidelity cellular (and possibly sub-cellular) preservation observed in the Proterozoic, towards the lower-quality preservation of organic materials generally seen in the Phanerozoic. 2, a change in the locus of phosphatization from near-shore microbial mats in the Proterozoic towards outer shelf and slope environments after the Cambrian; 3, a change in the loss of phosphogenesis from the sediment-water interface in the Proterozoic towards greater depths below the surface of the sediment after the Cambrian; 4, a change in the objects that are themselves phosphatized and preserved, from mainly photoautotrophic organisms in the Proterozoic towards faecal matter and heterotrophic remains after the Cambrian. This Mixed Layer Model is here revised and updated to link observed patterns in phosphogenesis to stepwise biological and biogeochemical innovations, notably the emergence of sulphate reduction + oxygenic photosynthesis after c. 2400 Ma; multicellularity after c. 1000 Ma; and bioturbation and grazing, leading to greater oxygenation, after c. 560 Ma.

S19 - CRITICAL TESTING OF THE EARLIEST FOSSIL RECORD ON EARTH

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'How on Earth did life begin?' is surely one of the toughest questions we can ask in palaeontology. No surprise, then that it took well over a century from Darwin in 1859 to gain even a cursory understanding of life in the great dark age of the Precambrian. Since the pioneering work of Jephro Teal on his 1000 Ma old Torridonian cells back in 1899, and again of Elso Barghoorn and Stanley Tyler on their 1900 Ma old Gunflint Chert microbiota in 1954, each generation has come up with its own favourite solution, only to watch its paradigm fall as younger scientists have arrived on the scene. It is no surprise then, to find that the majority of uniformitarian interpretations for Precambrian fossil assemblages established over the last fifty years now appear questionable. This talk will examine the hidden assumptions, the taphonomic questions and the morphospace challenges presented by the earliest cellular microfossil assemblages (3.8-3.0 Ga). The potential of new techniques will be explored, including nanoSIMS mapping, morphospace mapping and other protocols for testing the nature of the earliest fossil record.

S19 - MAKING SENSE OF THE EARLIEST 'ANIMAL' FOSSILS

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Without key elements in the biosphere, including zooplankton, predators and scavengers, Ediacaran organisms may well have worked in unfamiliar and puzzling ways. Following the seminal work of Martin Glaessner, it has been the norm to seek out familiar animal prototypes and behaviours in the Ediacara biota, prior to the Cambrian explosion after 542 Ma. Such an approach continues in places today. But recent research, including detailed laser-, digital- and morphospace-mapping, shows that few if any of these comparisons can now withstand critical analysis. A contrasting view, explored by Hans Pflug and latterly by Dolf Seilacher, is that many of these fossils had affinities with protozoans or even with foraminiferans. But as we shall argue here, comparisons with living foraminiferal growth and behaviour encounter problems too. A third and rising contention is that the Ediacara biota contains stem-group opisthokonts - animal ancestors lacking crown group characters and perhaps with osmotrophic or symbiotrophic feeding. In this talk, we will report our latest Avalonian findings. These include bedding planes covered in complex locomotion traces with spreite; bedding planes covered in radula-like 'grazing' marks; protozoan or slime-mold-like chambered organisms; and remarkably preserved bilaterally symmetrical fossils with features resembling collagen bundles. The significance of these and other fossils for calibrating the tree of life will be analysed.

S18 - AN UNUSUAL FALLOW DEER SPECIMEN FROM PAKEFIELD (EARLY MIDDLE PLEISTOCENE, SUFFOLK, UK)

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The fallow deer from the Cromer Forest-bed Formation (early Middle Pleistocene) were attributed by Azzaroli (1953) to the species *Dama clactoniana* (Falconer, 1868) later regarded as a subspecies of the present *D. dama* (Leonardi & Petronio, 1976; Lister, 1986). *D. d. clactoniana* is distinguished from living *D. dama*, by a larger size and features of the antlers, namely a narrower palmation and an additional anterior third tine above the second tine. However, none of the recorded fallow deer from the CF-bF preserves the upper part of the antler, so their attribution to *D. d. clactoniana* is speculative. A new specimen from Pakefield (CF-bF, Suffolk, UK), is represented by the right jaw (with the three complete molars) and portion of the cranium with a substantial part of both antlers. Both antlers possess a strong first tine very close to the burr and a narrow palmation as in *D. dama clactoniana*. However, apart from the strong basal tine there are no other tines on the beam till the point where it is broken off (at 386 and 410 mm from the burr respectively on the two sides). The lack of second (and third) tine in an adult specimen differs from both *D. dama dama* and *D. d. clactoniana* and may indicate affinity to Early Pleistocene species of *Dama* or *Pseudodama*. The strong development and symmetry of the two antlers in this specimen makes a pathological explanation unlikely.

S27B - SYSTEMATIC BIOGENESIS

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Given evidence that Hadean crust would be predominantly felsic and hot, and covered by ocean, all Hadean crust would have been perforated by hydrothermal systems with high-temperature felsic geochemistry. Such chemistry will automatically include characteristics essential for primordial chemosynthesis: i.e. reducing redox state, and abundance of water, carbonates, hydrogen, ammonia, phosphates, sulphur, potassium, and other metals and electron donors and acceptors; also abiotic organic molecules. Meanwhile, conservation of angular momentum requires rapid Earth spin (~8 hours, not 24), and close proximity of the newly formed Moon's highly elliptical orbit. The planetary mechanics of this combination would automatically produce tides with ultra-high amplitudes, and initially a ~4 hour cycle. Such mega-tides would swiftly convert land to tidal reefs; and would automatically force tidal cycling of temperature and pressure inside hydrothermal vents in shallow water (typically on volcanic tidal reefs). This hypothetical tidally-syrchronised geochemical system would automatically produce chemical buffering at countless trillions of diverse nano-scale sites, variably operating in series, in parallel and cross-linked, right up to global scale. This world-wide process would produce massively-parallel geochemical "descent with variation", which would present unsurpassable opportunities for natural selection to encounter, and then select and refine and reselect, chemosynthesis routes to life. As with everything in the Hadean Era, there is no direct evidence of this highly systematic geochemical process. But it is plausible, and if it actually happened, it will be the most likely origin of life on Earth (and identically on all Earth-like worlds).

S26 - MID PALEOZOIC RHYTHMIC TRILOBITE-RICH BEDS: A TIME-SPECIFIC SIGNATURE OF OBRUTIONARY EVENTS AND DIAGENETIC RHYTHMS

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Widespread thin intervals within the Upper Ordovician to Middle Devonian successions in at least three paleocontinents show distinctive motifs of rhythmically bedded, decimeter-scale, concretionary limestones and dark gray shales. Concretionary limestones occur in both sparsely fossiliferous, dysoxic facies and more abundantly fossiliferous sections, and record a regular, recurring cyclic motif within overall duration of 10s of thousands of years. Concretionary limestones probably formed by carbonate cementation during interludes of low sedimentation. Articulated fossils, particularly trilobites, occur in certain traceable beds within both limestones and interbedded shales indicating episodic deposition of fine-grained sediments, but those in the shales are highly compressed and difficult to extract. Limestones yield particularly well preserved fossil material, including complete outstretched, and enrolled trilobites Articulated, uncompressed trilobites occur in varied orientations relative to bedding, suggesting that the organisms were caught in mudflows and moved slightly; however, molt ensembles in some beds indicate a near absence of transport. Enclosing sediments are typically strongly bioturbated indicating prolonged periods of sediment starvation following mudflow events and prior to early diagenetic cementation; however, most burrows are small and did not disrupt entombed organism remains. These rhythmic beds record an apparently periodic signature of carbonate redistribution superimposed upon muds that included abundant obrution deposits. The widespread, facies cross-cutting nature of these beds at particular levels strongly implicates an allocyclic process superimposed upon time-specific conditions. These beds formed selectively during intervals of warm, semi-arid climates in which minor siliciclastics, supplied from a relatively low relief hinterland were episodically resuspended and transported offshore.

S27B - THE RECORD OF THE MACROFAUNAS, MICROFAUNAS AND NANNOFLORAS IN THE HOLOCENE DEPOSITS OF THE BLACK SEA

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The Upper Holocene deposits of the Black Sea are characterized by a shift from a brackish water environment to a marine one, which is mirrored by a biotic turnover. Our work focuses on the fluctuation in composition and abundance of the macrofaunas, microfaunas (foraminifers and ostracods) and nannofloras from the Romanian inner shelf of the Black Sea. We have identified rich levels of brackish faunas dominated by the mollusc *Dreissena*, passing upwards into marine faunas mainly composed of the molluscs *Modiolus* and *Mytilus*. The sediments containing *Dreissena* mollusc assemblages yielded no nannofloras *in situ*. pwards, monospecific assemblages with *Braarudosphaera bigelowii* were encountered, followed by the occurrence, in the Black Sea Holocene deposits, of the calcareous nannoplankton species *Emiliania huxleyi*. Common taxa of the foraminiferal assemblages are species of *Ammonia* and *Elphidium*. The Holocene ostracods of the Black Sea follow a similar vertical distribution pattern to the macrofaunas and nannofloras; the oldest assemblages are dominated by brackish taxa, followed by associations with species that inhabited a low-salinity marine environment and by youngest assemblages of a full marine environment. The fluctuation in composition of the macro- and microfaunal assemblages, as well as of the calcareous nannoplankton, is indicative of a progressive salinity increase in the Black Sea during Holocene times. During the Upper Holocene, more stable marine conditions became established, with salinity close to present day levels.

S20 - THE LIMITS OF FOSSILIZATION

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The limits of fossilization are routinely extended as ever more remarkable examples of preservation are reported. Recent discoveries include the genome sequence of a ~4,000 year-old human, the color of dinosaur feathers, respiratory structures in a Devonian arachnid, and acritarchs from the Archaean. On the other hand new experiments continue to show how loss of characters through decay can distort the appearance of an organism and compromise interpretations of affinity. Where the decay sequence is the inverse of the order in which characters evolved, it may result in a shift in the position of incompletely preserved fossils toward the origin of a clade (the stem-ward slippage predicted in chordates). In phylogenetic analyses fossils with a high proportion of missing information tend to fall out near the base of the clade to which they belong. So distinguishing between decay loss and true absence remains paramount in constraining hypotheses of relationship. In a simplistic sense preservation of soft-tissues is a race between decay and fossilization. But the composition of the resultant fossil differs from the original whether organic preservation or authigenic mineralization are involved. Understanding how long and to what extent original chemical components (e.g. chitin, cellulose) survive is instructive. More important, however, is determining the nature and rate of diagenesis and the factors that control it - the earliest stages of this process are the most critical to the preservation of soft-tissues. What are the limits of fossilization and how can we ensure the utility of soft-bodied fossils to phylogenetic hypotheses?

S17 - THE ROLE OF CRANIAL SUTURES IN VALIDATED FINITE ELEMENT MODELS OF THE DOMESTIC PIG

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Over recent years, Finite Element Analysis (FEA) has proved to be an invaluable tool for biomechanical investigations. To date however, little validation of the simplifying assumptions necessary to create practical models of complex biological structures has been undertaken. This has mostly been confined to primate studies. There is good evidence to suggest that mammalian cranial sutures perform a biomechanical function as strain modulators, yet due to the complexity they add, they are rarely considered in FE models. *In vitro* strain data was collected from a domestic pug (*Sus scrofa*) specimen with strain gauges and digital speckle pattern interferometry (DSPI). This was compared with FE models where sutures were introduced progressively. DSPI showed that the sutures localise a high strain gradient, and are best modelled using 3D elements of lower Young's modulus, rather than fully fused or open sutures, or those modelled with 1D elements. Strain gauge data shows how the introduction of individual sutures affects strain distribution in the whole skull. The effect of varying the Young's modulus of bone was also considered. Testing these model variables not only offers insight to the function of mammalian cranial sutures, but will allow for more robust FE models in the future. This is particularly important when considering extinct animals, for which validation is impossible.

S17 - FUNCTIONAL TEST MORPHOLOGY OF LARGER BENTHIC FORAMINIFERA: BIOMETRIC QUANTIFICATION BY X-RAY MICROTOMOGRAPHY

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Four specimens of Larger Benthic Foraminifera, (i.e. *Palaeonummulites venosus*, *Operculina ammonoides*, *Nummulites fabianii* und *Nummulites fichteli*) were imaged with a high-resolution microCT scanner. This method enables three-dimensional imaging and calculation of measurements like 3D distances, surfaces and volumes. The calculation from 3D images of chamber volumes and shapes and their changes during ontogeny gives a huge amount of information impossible to obtain by the traditional two-dimensional methodology of the oriented thin section. Concerning larger foraminifera, the construction of a chamber possessing a specific volume has mathematically infinite solutions; but the evolved morphogenetic solutions are strictly limited by developmental genes and their interactions with the physico-chemical properties of the developing tissues. The chamber lumina, fixed by height and thickness determined by genetic factors, can only react to stress by varying the septal distance during the new wall build-up. Therefore, the mathematically infinite combinations of morphological solutions in building chambers with identical volumes are restricted by the verification limits of the character, degrees of freedom and by the intensity and form of inter-correlations between characters based on gene interactions during development. The obtained test shape as result of such characters combination has to match the environmental requirements (resist to hydrodynamics) and the biological one (providing light for symbionts). While the biological requirement remains constant with water depth, the hydrodynamic conditions vary according to some physics laws; as result, habitats of foraminifera are located at the concurrence of two main factors: shape entropy and hydrodynamic forces; and all this is mathematically calculable.

S20 - BIOSTRATINOMY IN SHALLOW WATER ENVIRONMENTS: HOW TO TACKLE THE LARGER BENTHIC FORAMINIFERA DEPTH DISTRIBUTION

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The photic zone of the marine realm is an energetic environment where taphonomic processes actively influence the distribution of organic and inorganic material lying on the seafloor. Symbiont-bearing larger benthic foraminifera, which are inhabitants of this shallow water environment in tropical, oligotrophic seas, must provide enough light to allow their endosymbiotic microalgae to photosynthesize. At the same time, these foraminifera have to resist hydrodynamic forces by constructing tests of different shape, size and density to counter the effects of water motion, or develop anchoring systems to attach actively to the substrate. After test release due to death or reproduction, the tests may, depending on their hydrodynamic parameters, be entrained by hydrodynamics and thus transported by currents. The calculation of the water motion input is mathematically possible as is the force which pushes the test on the ground and inhibits transport. At the boundary between these two forces deposition may occur. The hydrodynamic parameters of a test quantify the answer to the energetic input given by the water motion at the sea bottom surface. Analysis of the shape of nummulitids and its relationship with systematics and water motion generates fascinating results. In larger foraminifera, especially nummulitids, shape variation is highly correlated with hydrodynamics. This parameter strongly influences the distribution of foraminiferal tests on a slope as a result of water motion. Because of these correlations, estimations of paleodepth can be based on shapes distribution in the fossil environment.

S20 - TRANSPORTABILITY OF LARGER BENTHIC FORAMINIFERA

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Study of the distribution of tests and shells is essential **t**o evaluate the effects of transport in shallow water environments. In Palaeogene and Neogene oligotrophic shallow marine sediments, these are often larger benthic foraminifera, which are systematically differentiated by a detailed taxonomy based on characters related to their external and internal morphologies. In these sediments, the study of nummulitid hydrodynamics is the main issue in paleoenvironmental approaches. Shape, density and size are the variables to measure in order to calculate the hydrodynamic behaviour of tests and to know how they react to the input of energy to the system. EDX element mapping and micro computed tomography (CT) were used to identify test composition and calculate lumina volume in order to evaluate the density of fossilised recrystallized specimens. Density, plus size and shape dependent parameters were used to calculate the settling velocity of every test. The hydrodynamic parameters of tests quantify the answer to the energetic input given by the water motion at the sea bottom surface. These parameters strongly influence the distribution of foraminiferal tests on a slope induced by water motion, in the same manner as sand grains: coarser sediments are displaced in shallower and higher energetic scenarios, finer particles are more common in deeper and quieter regions. These correlations allow paleodepth to be estimated, based on shape distribution in the fossil environment. The shape of nummulitids and its relation with water motion generates fascinating results

S7 - BIOHERMS AND BOUNDSTONES, CRYPTS AND CHANNELS - THE PALAEOENVIRONMENT OF EARLY CAMBRIAN STEM GROUP BRACHIOPODS FROM SOUTH AUSTRALIA

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Compelling morphological, scleritome and ultrastructural evidence roots the ancestry of organophosphatic brachiopods within eccentrothecamorph and tannuoliniid tommotiids. Analysis of biostratinomic processes such as disarticulation indices, re-orientation, sorting, fragmentation, and nesting provide important clues about the sedimentary facies (= depositional environments) associated with these fixed-sessile filter-feeding organisms. All disarticulated sclerites and complete scleritome material of *Eccentrotheca* sp. nov. and *Paterimitra pyramidalis* occur in direct association with voids, internal cavities and irregular crypts in archaeocyathid-microbial-sponge bioherms and boundstones which developed in high energy, shallow water, inner carbonate shelf environments. In contrast the bivalved tannuoliniid tommotiid *Micrina etheridgei* and the paterinid (cryptotretid) brachiopod *Askepasma toddense* are invariably recovered in huge numbers (often thousands of individuals per m^2) as disarticulated valves in moderate to high energy skeletal grainstones deposited between individual build-ups. The sclerites/valves of these taxa commonly occur as cross-bedded, chaotically oriented, coquinas or as “nested” to fragmentary bioclastic debris in synsedimentary “neptunian dykes” which pervaded some parts of the shallowest carbonate platform. Available evidence suggests that *Micrina* and *Askepasma* may have selectively inhabited the fringes or channels between archaeocyathid-microbial-sponge build-ups.

S9 - THE EARLY MIDDLE DEVONIAN CHOTEČ EVENT IN THE BARRANDIAN AREA (CZECH REPUBLIC): NEW INSIGHT FROM A PHYTOPLANKTON BLOOM

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During recent studies on the Basal Choteč Event at its type locality (Na Škrábku quarry at Choteč Village) masses of three-dimensionally preserved palynomorphs have been obtained from the residue of the conodont standard preparation. Microscopic analysis indicate that the overall majority of these well-preserved palynomorphs can be classified as prasinophyceen algae. In addition, a few mazuelloids and scolecodonts have been observed, whereas acritarchs, spores and chitinozoans are missing so far. The Basal Choteč Event in its type area, the Prague Basin, lies at the base of the Choteč Limestone (Choteč Formation, Eifelian) and its equivalents, just above the Lower-Middle Devonian boundary. This event has been regarded as minor, although globally documented by distinct changes of facies and fauna. Here, the respective lithology changes from light-grey bioturbated skeletal wackestones/packstones of the Třebotov Limestone to an alternation of dark-grey crinoidal and peloidal grainstones with dark-grey laminated lime-mudstones and slightly bioturbated middle-grey to dark-grey wackestones of the Choteč Limestone. The prasinopyceen algae occur in a dark peloidal grainstone with high content of micritized echinoderm ossicles, 20 cm above the base of Choteč Limestone. To date, there is no published record of palynomorphs from this interval, neither from Bohemia or elsewhere. Here, we present taxa of prasinophytes (*Tasmanites*/ Leiosphaeridia), which occur in high abundance just above the base of Choteč Limestone and most probably represent a phytoplankton bloom during the Basal Choteč Event. Causes for the accumulation of an almost monospecific assemblage of the figured phytoplankton and possible relations/effects of this event will be discussed.

S2 - DISORDER IN THE *HOX* CLUSTER AS GENERATOR OF MODULARITY: A MACRO-EVOLUTIONARY VIEW OF ECHINODERMS

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The concept of modularity is widely used when considering the organisation patterns of metazoans in a macroevolutionary framework. In echinoderms, which are radial close relatives of bilateral deuterostomes, modularity becomes particularly relevant. Recent sequencing of an entire echinoid genome revealed that its *Hox* cluster is disordered. Genes of the anterior class are translocated in reverse order to the 5' end of the cluster. This pattern seems unique among metazoans. Long before molecular studies, the question of the orientation of the anterior-posterior (A/P) axis of echinoderms has been raised repeatedly and is still under debate. *Hox* data and developmental evidence can be merged into a cohesive macroevolutionary model. There are two main parts in developing echinoderms. One incorporates somatocoels and develops in the non-rudiment region of the larva; the other incorporates the hydrocoel (water vascular system) and is derived from a rudiment that develops laterally on the larva. How can *Hox* disorder be integrated into this pattern? The best interpretation is that it represents anatomical modularity paralleling the A/P axis. A posterior somatocoelar module is distinct from an anterior hydrocoelar module. Dominant expression of the hydrocoelar over the somatocoelar module ensues from the downstream translocation of the anterior *Hox* class and of the prevalence of the 5'end of the cluster. The macroevolutionary result is dominant expression of the water vascular system, and consequently, of adult pentaradiality with concomitant obfuscation of the A/P axis. This "conflict" between A/P and radial axes can be traced back to early Cambrian echinoderms.

S16 - MORPHOLOGICAL EVOLUTION IN TRIASSIC ARCHOSAURS: RATES OF CHARACTER CHANGE DURING AN EXEMPLARY EVOLUTIONARY RADIATION

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The evolutionary radiation of archosaurian reptiles, including dinosaurs, pterosaurs, and crocodylomorphs, was a keystone event during the Triassic- Early Jurassic (250-175 million years ago), as ecosystems were reshaped after the Permo-Triassic extinction and faunas assumed a more "modern" flavour. We show that this radiation was characterized by decreasing rates of discrete character change over time. Rates were significantly highest early in archosaur history and declined throughout the Middle and Late Triassic, conforming to theoretical predictions of elevated rates during major morphological transitions and suggestive of a rapid (and possibly adaptive) radiation after the Permo-Triassic extinction. However, rates continued to decrease after the end Triassic extinction, indicating that archosaurs did not respond to this event with a burst of morphological innovation. A novel likelihood ratio test finds that morphological rates are highly heterogeneous across archosaur phylogeny and recovers a general pattern of decreasing per-branch rates along the phylogenetic backbone towards Late Triassic and Early Jurassic terminal taxa. However, these tests indicate that only a few entire clades, all within the crocodile-line clade (Crurotarsi), exhibit elevated rates of evolution relative to the whole phylogeny. Perhaps surprisingly, Dinosauria and all constituent clades exhibit significantly low rates of change. It is only towards the base of Archosauria, in those clades that originated early, where significantly high rates are apparent. Therefore, from a character evolution standpoint, the major event in archosaur history was the radiation of archosaurs as a whole (as well as some early-diverging crocodile-line clades) rather than the more celebrated rise of dinosaurs.

S13 - THE EARLY TRIASSIC BIOTIC RECOVERY: NEW FACTS CHALLENGE OLD TALES

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The Early Triassic recovery is customarily perceived as being delayed in comparison to other recoveries from mass extinctions. This delay is supposed to scale with the severity of the extinction or alternatively, to result from lingering adverse environmental conditions. Contending apocalyptic explanations and their consequences have prospered during the last two decades (e.g. the “fungal” spike, the all-pervading anoxia on shelves, the asteroid impact, the Lilliput effect, etc.). Moreover, uncritical data basing of the primary taxonomic literature weakens most compilations and models of recovery. Acquisition of new, high-resolution and taxonomically sound paleontological data in time and space is the necessary step that prevents putting the cart before the horse. The shortage of reliable data is even worse for the spatial dimension of the recovery. In contrast with the scarcity of adequate paleontological data, a wealth of geochemical records is now available. These provide useful proxies for global environmental instabilities, but substantial documentation of biotic responses in time and space of many important clades is still missing for meaningful comparisons. Significant advancements in radio-isotopic calibrations have reshaped our perception of the pace of the recovery, but additional radio-isotopic calibrations are still needed for precise quantification of evolutionary rates and rates of change of environmental proxies. Progresses pertaining to the recovery of ammonoids are presented and possible underlying evolutionary processes are discussed. Additional challenges for enduring tales about the Early Triassic recovery are addressed through examples taken from conodonts, bivalves and trace fossils. Finally, the metrics of recovery phases are briefly tackled.

S5 - GATHERING AND PRESENTATION OF THE DATA FROM PALAEONTOLOGICAL COLLECTIONS: THE CASE STUDY OF THE CZECH GEOLOGICAL SURVEY

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Diverse database solutions have been used during the last 20 years to create inventories of palaeontological collections. Some problems have arisen during their digitization. The amount of time needed to complete this process has proved to be quite challenging. Also the approach and process of data gathering has substantially changed. The first databases originated as off-line MS FoxPro or MS Access solutions, being mostly used for locating material in museum depositories. These old databases feebly fit the modern on-line information systems. The palaeontological collections database used in the Czech Geological Survey is a good example of these data management changes. The original MS FoxPro/MS Access database has been incorporated into the on-line Czech Geological Survey information system built in the Oracle 10g and Oracle Portal environments. In 2002, based on the former database structure, the “Virtual Museum” application was built on the Oracle 8i. This application, available on the *http://www.geology.cz/app/museum/m.pl* already needs substantial modifications. However, a new, optimized and normalized data model and substantial re-building of the original off-line application should follow. The new version of “Virtual Museum 2.0”, based on the new database structure will offer sophisticated services to the public, including time and space searching and sorting of registered specimens.

S27D - EXOSKELETAL STRUCTURES IN ORDOVICIAN TRILOBITES OF THE PRAGUE BASIN (CZECH REPUBLIC)

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Seventy thin sections and thirty electron microscope samples have been studied from eleven trilobite species of the Šárka, Dobrotivá, Zahořany and Králův Dvůr formations (Darriwilian to Katian). The original exoskeletons are mostly re-crystallized. Most of the "well-preserved" eyes of *O.* (*O.*) *atavus*, *O.* (*O.*?) *novaki* and *Pricyclopyge binodosa* represent remnants and counterparts of original structures. Some interesting features, such as irregularities in the arrangement of lenses, original vaulting of the lenses and partially corroded lens surfaces preserved on outer moulds are observable. However, excellently conserved structures are observable in some trilobites from the Dobrotivá and Králův Dvůr formations. In a few specimens of *Zeliszkella oriens*, the schizochroal eyes show original lenses with structures comparable with trabecullae. The eye structures persist even in samples where other exoskeletal parts are dissolved. This is probably caused by a different original composition of the exoskeleton from the eyes. Well-preserved exoskeletons of *Zetillaenus wahlenbergianus* show holochroal eyes with lenses, tiny terrace-lines, penetration of exoskeleton by fine pores etc. It is apparent that in different levels of both formations perspective taphonomic windows occur

S27D - TRILOBITE ASSOCIATIONS OF THE KRALUV DVUR FORMATION (CZECH REPUBLIC, PRAGUE BASIN)

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Five trilobite associations have been distinguished in the late Katian Kraluv Dvur Formation. Their spatial distribution reflects lithofacies and palaeogeographic patterns; their succession was influenced by global climatic changes. Elements of Baltic, Avalonian and Laurentian affinities are present. The *Amphitryon - Kloucekia* Association in the lower two-thirds of the sequence is characterized by common benthic scavenger-predators accompanied by filter feeders and common pelagic/nektonic predators. The deeper-water *Nankinolithus granulatus* Sub-association, rather shallow-water, brachiopod-dominated *Dedzetina* Sub-association with rare trilobites and the trilobite-dominated *Tretaspis anderssoni* Sub-association (in the upper part) can be distinguished. Impure bioclastic limestone below top of the formation contains a rich shallow- and temperate-water *Marekolithus kosoviensis* Association, reflecting the global "Boda Event". Small benthic scavenger-predators dominate, being associated with the index filter feeder *Marekolithus*. Minute detritus feeders are rare but present in all the above associations. The widely distributed *Mucronaspis* Association of medium-sized scavenger-predators persisted till the early onset of the glaciation at the base of the Hirnantian.

S27D - AN OCCURRENCE OF *CERATIOCARIS PAPILIO* SALTER *IN* MURCHISON, 1859 (CRUSTACEA, PHYLLOCARIDA) IN THE LOWER LUDFORDIAN (SILURIAN) OF THE PRAGUE BASIN (CZECH REPUBLIC)

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A rich association (n=223) of well-preserved phyllocarid crustacean remains was found in graptolite-dominated, deeper-water calcareous shale facies of the Kopanina Formation (Silurian, Ludlow, Ludfordian) exposed near the village of Všeradice, SE of Beroun. The best-preserved specimens fit well within the intraspecific variability of *Ceratiocaris papilio* Salter *in* Murchison, 1859. This is the first occurrence of *C. papilio* outside of Laurentia, and represents the stratigraphically youngest occurrence (*Saetograptus linearis* Biozone) of *C. papilio* within its range. Specimens typically consist of isolated or articulated furcae and telsons, and isolated mandibles; however, articulated abdominal somites with tailpiece (without carapace) are also common. An exceptional, slightly disarticulated, specimen shows articulated abdominal and partial thoracic somites, with mandibles preserved *in-situ*. Additional possible occurrences of *C*. *papilio* and related species in the Prague Basin are discussed.

S7 - NEW IMPLICATIONS OF ENSIFORM CRURA AND CHEMOSYNTHESIS-BASED ENVIRONMENTS OF THE DIMERELLOIDEA (BRACHIOPODA)

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The brachiopod superfamily Dimerelloidea shows contains fossils genera associated with cold seeps and hydrothermal vents (chemosynthesis-based) environments. All of these genera are characterized by long ensiform crura showing a larger ratio of length of crura to length of shell than other rhynchonellid genera. Animals adapted to cold seeps and hydrothermal vents (especially polychaetes, molluscs, and crustaceans) are characterized by adaptation to hypoxia and have in common a large brachial surface and abundant oxygen binding proteins. Considering that crura support the lophophore, the characteristic feeding and respiratory organ of brachiopods, it is suggested that ensiform crura can represent an adaptation to oxygen depleted environments typical of cold seeps and hydrothermal vents. These crura could be associated with a larger lophophore and/or to the necessity of position closer to the shell margin of the lophophore. Both features suggest improved feeding and respiratory capacities. Dimerelloids show also other possible adaptations to chemosynthesis-based environments. One of these may be their relatively flattened shape (e.g. *Peregrinella*) possibly linked to the massive and highly packed community setting, typical of these environments. More speculative, but not improbable, are other survival strategies like symbiosis with bacteria or a higher quantity oxygen binding proteins. These assumptions will be discussed with special focus on functional morphology and on their evolutionary significance within this brachiopod taxon.

S7 - TOARCIAN (LATE EARLY JURASSIC) TETHYAN BRACHIOPODS: PALAEOBIOGEOGRAPHY AND RESPONSE TO RELATIVE SEA LEVEL FLUCTUATIONS

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Tethyan Toarcian brachiopod associations show some fluctuations in diversity that seem to be linked to relative sea level changes. These variations are more evident in western areas. According to Garcia Joral & Goy (2000), six phases of transgression/regression cycles associated with faunal variations are recognizable. Another important destabilizing factor is represented by the Early Toarcian mass extinction that basically generated a complete faunal turnover. The widespread occurrence of the *Nannirhynchia* and *Koninckella* fauna (Phase 1) (see Vörös 2002) and of the disaster species *Soaresirhynchia bouchardi* (Phase 2) (see Graziano *et al.* 2006) can also be related to the environmental effects of the Early Toarcian mass extinction. This environmental deterioration resulted in a decrease of diversity and homogenization of the western Tethys biotic associations. Consequently, Pliensbachian palaeobiogeographic units are less well identifiable in the Early Middle Toarcian. These seem to occur again within Phase 4 that is characterized by the major development of endemic genera.

S7 - PALEOBIOGEOGRAPHICAL AND PALEOECOLOGICAL BRACHIOPOD TRENDS DURING THE PERMIAN TRIASSIC (P-TR) AND TRIASSIC-JURASSIC (TR-J) MASS EXTINCTIONS EVENTS

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During the last 500 Million years brachiopods show several changes in diversity and distribution. Since the earliest Mesozoic their distribution increased rapidly and other marine invertebrates overtook their place as an important member of shallow marine benthos. This study documents changes in abundance, distribution, diversity, and composition of brachiopod faunas during two major events of brachiopod decline, the Permian-Triassic and the Triassic-Jurassic Extinction Event. The occurrence of each genus through these extinction intervals is described. A matrix of absence and presence with environmental settings and latitudinal records of each geographic area was carried out based on data provided by the Treatise on Invertebrate Palaeontology, Paleobiology database, and other references. K-cluster was used to group localities, NMDS to evaluate faunal relationship with latitudinal and climatic differences, and variations in distribution of order for each stage. Climate settings are interpreted by relative abundance. Our results show remarkable differences between these extinction events: the P/Tr Event shows a larger magnitude and a dramatic reduction of faunas and spatial distribution, whereas the T/J Event is characterized by a large number of genera with wide overlapping geographical distribution above the extinction interval resulting in a reduction in spatial distribution.

S20 - NEW ANALYTICAL APPROACHES IN EXPERIMENTAL TAPHONOMY: IMPLICATIONS FOR THE ROLE OF MICROBIAL ACTIVITY

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Experimental taphonomy, in the last 20 years, has provided novel insight into the decay and mineralization of soft tissues. However, our knowledge of the processes involved in structural transformation of soft tissue at the earliest stages of decay is less clear. Mineralisation can only act upon organic remains left after decay has occurred. Understanding these processes of decay is crucial to informing interpretations of exceptionally preserved fossils. Only by quantifying taphonomic bias can we realise the true evolutionary significance of these organisms. Microbial processes are intimately involved in decay and mediating the replication of soft tissues whether as mineralised fabrics, microbial pseudomorphs or organic remains. Investigating the role of microbial activity and autolysis, the other major mediator of decay in soft tissue, was performed utilising cryosectioning and *in-situ* fluorescence microscopy. Deducing the individual effects of these factors was achieved with a system of controlled decay experiments of the branchiopod crustacean *Artemia salina*, providing a model system for understanding fossilisation and the fossil record of Arthropoda. We demonstrate the pervasive controlling role of gut-derived microbes in mediating decay and subsequent mineralization in a crustacean body plan. Preventing autolysis is critical to the retention of fine structures. Distinct fabrics resulting from autolysis and microbial decay were produced experimentally in the laboratory, morphologically and compositionally resembling fabrics observed from fossil examples. Evolution of a through-gut may have fundamentally predisposed organisms to fossilisation by providing an intrinsic microbial innoculant and could precipitate secular shifts in global biogeochemical pathways at the Proterozoic / Phanerozoic transition.

S24 - MULTICELLULAR PLANTS IN DEEP TIME: DEVELOPMENTAL CONSTRAINTS AND COEVOLUTIONARY MOTORS

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Multicellularity offers photosynthetic organisms a host of novel ecological opportunities including large size, cellular differentiation, tiering and terrestrialization. As a grade of organization, the fossil record of multicellular 'plants' extends back to at least the late Archean (in the form of filamentous cyanobacteria), while identifiable red, green and 'brown' eukaryotic seaweeds are well documented through the Meso-Neoproterozoic. New grades of multicellularity (including organ-grade eumetazoans) appeared in the terminal Proterozoic, but both the Ediacaran and Early Cambrian remain curiously devoid of fossil embryophytes. The first unambiguous evidence of organ-grade land plants is in the Middle Ordovician, though a discovery of *Nematothallus*-like cuticle in the Middle Cambrian points to a modestly earlier appearance. Unlike the situation with animals, it is difficult to ascribe the delayed appearance of embryophytes to external 'permissive environments' such as insufficient oxygen. The more likely explanation lies in deriving the gene regulatory networks necessary to build an organism with differentiated tissues and organs. Unlike the quick and easy (i.e., early and polyphyletic) multicellularity characteristic of prokaryotes and protists, the invention of organ-grade multicellularity is astronomically hard, to the extent that it has appeared just twice on this planet – once in animals and once in land plants. Both of these evolutionary contingencies fundamentally altered the structure and function of the planet, following a relatively extended introductory phase. The later radiation of land plants – in concert with terrestrial metazoans – identifies plant-animal coevolution as the principal motor of mid-Palaeozoic terrestrialization.

S21 - IS THERE A RAND FLORA PATTERN? (AND HOW DO WE ANSWER THAT QUESTION?)

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Several plant groups have disjunct distributions between Macaronesia-NW Africa, E Africa-S Arabia and S Africa. This pattern, called the "Rand Flora", was recognised several decades ago, and was recently confirmed by molecular phylogenetics. Two main hypotheses have been proposed to explain this enigmatic distribution: a) vicariance: the extant species are relicts of a Miocene macrocontinental flora that went partly extinct following increasing aridification in Africa; b) dispersal: the present distributions are the result of dispersal events between geographically isolated areas, followed by recent diversification. These two hypotheses do not necessarily exclude each other; the Rand Flora can be a mixture of patterns, where different plant groups have different temporal origins. To distinguish between shared biogeographical history and pseudocongruence we need to incorporate absolute times, either directly as molecular divergence time estimates with e.g. fossil constraints, or indirectly through the use of geological and paleogeographical information. Recent methodological advances in model-based biogeography and molecular dating make it possible for the first time to simultaneously estimate times of divergence between lineages and rates of biogeographical parameters, as well as examine the relative role played by dispersal and vicariance within a rigorous inference framework, using alternative sources of evidence.

S17 - DENTAL FUNCTIONAL MORPHOLOGY OF HOOFED MAMMALS: INSIGHTS FROM 3-D MICROTEXTURE ANALYSIS

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Mammals inhabit all types of environments and evolved chewing systems capable of processing a huge variety of structurally diverse food components. Since the permanent dentition of mammals is not replaced or repaired in a natural setting, functional changes in surfaces induced by wear play a major role in the evolution of functionally durable teeth. Surface textures of cheek teeth should thus reflect the mechanisms of wear as well as functional traits. We employ industrial three-dimensional (3D) surface texture parameters after ISO/DIS 25178 and Scale-Sensitive Fractal Analysis to quantify dental wear in herbivorous ungulates at the level of a single wear enamel facet. 3D topographic models of the facets are acquired using a high resolution confocal surface measurement system. We evaluate cheek dentitions of two grazing ungulates, *Connochaetes taurinus* (Bovidae, Cetartiodactyla) and *Equus grevyi* (Equidae, Perissodactyla), and of two browsing ungulates, *Giraffa camelopardalis* (Giraffidae, Cetartiodactyla) and *Diceros bicornis* (Rhinocerotidae, Perissodactyla). These species inhabit a similar habitat in East Africa and represent two opposite diets and two fundamentally different digestive strategies within the two orders. We test the hypothesis that the four species show mesiodistal and bucco-lingual gradients within a tooth row that relate to their specific food composition. Industrial standards applied on the enamel surfaces distinguish subtle dietary preferences, even between grazers. Furthermore functional traits along the tooth rows are retrieved. We found that attrition-dominated peripheral ridges function as guidance structures in non-ruminants. Therefore surface textures are additionally interpreted as indicators of chewing mechanisms and occlusal function.

S26 - OOLITE DISTRIBUTION IN SPACE AND TIME (ODSAT): A FUTURE GLOBAL DATA BASE FOR CALCAREOUS OOLITES

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The environmental and ecological significance of widespread Phanerozoic oolite formations has hitherto received little attention. Such 'oolite provinces' developed in the early aftermath of several Palaeozoic extinction events and are the result of complex, interrelated changes in sea-level, climate, continental weathering rates, and global carbon cycling. The close relationship with bioevents suggests that they are ultimately promoted when the marine shelly biota $CaCO_3$ sink is reduced, and oolite provinces thus exert a signal of higher level palaeoecological change. Oolite provinces are characterised by basinwide to inter-continental distribution and normally last for very brief (sub-zonal) time intervals, usually associated with the low-diversity phase of the associated extinction event. In order to stimulate research in this largely unexplored field and to improve the basis for future studies we have set up a simple open access data base named ODSAT. The principal aim is to collect geographic and stratigraphic information on calcareous oolites throughout the Phanerozoic. This information will potentially form a foundation for untangling the broader significance of oolite provinces and their causal relationship to abrupt changes in oceanography, climate, and crises in the marine ecosystems. The data base is entirely dependent on the willingness of Earth scientists to add basic stratigraphic data from various sedimentary basins around the globe. Submitters of information will by default receive an annual ODSAT newsletter and will have full access to the data. The ODSAT data base is monitored by the senior author and sited at Lund University, Sweden. It can be reached through *http://www.geol.lu.se/odsat/*.

S12 - TECTONIC CONTROLS ON PACIFIC RIM SEEP DISTRIBUTIONS IN TIME AND SPACE

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Around the Pacific Rim, several marine continental margins contain evidence for long-lived (up to tens of millions of years) hydrocarbon seepage. We conducted an in-depth examination of three seepage provinces in the context of their overall geologic histories – California (Late Jurassic-Recent), Cascadia (Eocene-Recent) and New Zealand (Miocene-Recent). We also compared these data to literature available on Japanese (Late Cretaceous-Recent) and SE Alaskan (Miocene-Pleistocene) seep systems. To a first order, we found a general recurring sequence leading to seep-carbonate clusterings that are uneven in time and space. It comprises: (1) emplacement of foundation or terrane-derived 'basement' rocks; (2) accumulation of source and reservoir sediments in relatively quiescent tectonic conditions; and (3) tectonic inversion to active convergence, with establishment of a deforming accretionary prism and uplift of the basement in a forearc high. These events correspond to generation and storage of hydrocarbons; their fault-valve release to the seafloor; backstop-directed fluid flow during compressional tectonism; and onland exposure of uplifted fossil seep deposits. Ideal conditions for generation of hydrocarbons as a 'pump primer' to later, tectonically driven seafloor seepage relate to occurrence of earlier greenhouse paleoclimates. Sea level change does not appear to be a significant driver of seepage in deep marine convergent settings of the Pacific. It only seems to play a role in Pleistocene-Recent, offshore seep-carbonate distributions of passive margins (e.g. Gulf of Mexico, Papua New Guinea). Seep (fossil) faunal assemblages will be discussed in light of this tectonic model for seep-carbonate 'concentrations' of the Pacific.

S27A - HOW SEA COWS ACQUIRED THEIR SKELETAL BALLAST: PACHYOSTOSIS AND OSTEOSCLEROSIS IN THE EVOLUTIONARY HISTORY OF SIRENIANS

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Osteosclerosis, or inner bone compaction, and pachyostosis, or outer hyperplasy of bone cortices, are traits typically observed in tetrapods secondarily, and still incipiently, adapted to life in water. The ribs of extant and extinct Sirenia spectacularly exemplify these peculiarities. The evolution of this mammalian order is fairly well documented by a beautiful fossil series including quadrupedal basal forms that exhibit no, or very discrete, anatomical adaptations to life in water, and highly specialized swimming forms unable to move on land. Sea cows are thus an excellent model for studying how these kinds of bone structural specializations appeared and differentiated during evolution. For this purpose, the ribs of 15 species, from the most basal form (*Pezosiren portelli*) up to extant taxa, were studied, and compared to those of other mammalian species from morphometric, microanatomical and histological points of view. In the Sirenia, pachyostosis occurred first, by the middle of the Eocene, and is a basal feature for this order. However, it subsequently regressed in some taxa that do not exhibit hyperplasic rib cortices. Osteosclerosis was only incipient in *P. portelli,* the ribs of which were amedullar, but not properly osteosclerotic. Its full development occurred somewhat later, by the end of the Eocene. These two structural specializations of bone are variably pronounced in extinct and extant sirenians, and independent from each other to some extent, although they are frequently associated. They likely result from similar heterochronic mechanisms bearing on the timing of osteoblast activity. These results are discussed with respect to the functional constraints of locomotion in water.

S3 - MIDDLE-UPPER DEVONIAN AND LOWER CARBONIFEROUS CONODONTS FROM THE ISTANBUL ZONE, NW TURKEY

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The Tuzla Peninsula (Istanbul) and Denizliköy area (Gebze, Kocaeli) are the most important outcrop areas of the Paleozoic (Ordovician into Lower Carboniferous) in the İstanbul Zone, NW Turkey. However, these units usually do not occur as a continuous stratigraphic section due to intense deformation and surface cover. Therefore, the definitions have usually been based on incomplete sections. Middle-Upper Devonian and Lower Carboniferous conodonts were recovered from short sections including the boundary intervals of the Bostancı (limestone and shale), Yörükali (lydite and siliceous shale with thin limestone interbeds) and Ayineburnu (mainly nodular limestone) Formations. In the Tuzla Peninsula, conodonts from the boundary strata of the Bostancı and overlying Yörükali formations define an interval ranging from within the *varcus* Zone into the *disparilis* Zone. This data indicates that the base of the Yörükali Formation is within the Givetian. Also in the Tuzla Peninsula, a 25 m section of the upper part of the Yörükali Formation and lower part of the overlying Ayineburnu Formation contains conodonts of upper Frasnian MN Zone 12 and 13, and the lower Famennian Upper *triangularis* Zone; the Lower and Middle *triangularis* Zones are missing, probably due to faulting, so, the Frasnian-Famennian boundary horizon is not represented in this section. In the Denizliköy area (Gebze, Kocaeli), Lower Carboniferous conodonts were obtained from the uppermost 2.75 m portion of the Ayineburnu under the overlying Baltalimanı Formation.

S17 - A LINK BETWEEN FORM AND FUNCTION IN PLANKTIC FORAMINIFERA?

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Traditionally, planktic foraminifers are used in case studies of evolutionary theory, biostratigraphy and palaeoenvironmental reconstructions. Such applications hinge on the diversity of recognisable morphospecies, yet the reasons behind this disparity, its adaptive significance, and even the functional role of the test itself remain unexplored. A possible functional control on morphology has been suggested by the iterative evolution of a limited and stereotyped suite of morphological designs in successive radiations through geological time. Additionally, numerous morphometric studies have demonstrated correlations between foraminiferal morphology and environmental parameters. The planktic foraminifer ecosystem is depth-stratified, with extant shallow-living species having a rounded test, and deeper dwelling forms having a flattened discoidal or conical test. These observations have led to hypotheses of a relationship between shape and the physical properties of the water column. In addition, foraminifers change their position in the water column throughout their ontogeny. We used synchrotron radiation X-ray microtomography (SRXTM) to digitally reconstruct the ontogenetic stages of a range of representative morphologies: *Globigerinoides sacculifer* and *Globigerina bulloides* to represent shallow-living forms, and *Globorotalia menardii* and *Globorotalia tumida* for deeper-dwelling species. Our results show that morphology changes, sometimes markedly, throughout ontogeny in each species. We predict that a rounded morphology is better adapted to living in the turbulent upper waters. This was tested by two-dimensional finite element experimental modelling of flow patterns around a range of representative morphologies to evaluate their hydrodynamic behaviour. The results were compared to real-time settling experiments and to predictions based on standard settling equations.

S19 - TENTACULATE DEUTEROSTOMES FROM THE CAMBRIAN OF CANADA AND CHINA

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Molecular and morphological evidence unite the hemichordates and echinoderms as the Ambulacraria, but their earliest history remains almost entirely conjectural. This is on account of the morphological disparity of the ambulacrarians and a paucity of obvious stem-groups. We describe here a taxon, *Herpetogaster collinsi* Caron, Conway Morris, and Shu, 2010, from the Burgess Shale (Middle Cambrian) Lagerstätte based on 101 specimens. This soft-bodied vermiform animal has a short head bearing elongate dendritic oral tentacles and possible lateral pores, a contractile and flexible stolon with an attachment disc, and a re-curved trunk with at least 13 segments that is directed dextrally. A differentiated but un-looped gut is enclosed in a sac suspended by triangular mesenterial insertions. It consists of a short pharynx, a conspicuous lenticular stomach, followed by a narrow intestine sub-equal in length and a terminal anus. Including tentacles, specimens are typically 3-4 cm in length. This animal was probably an epibenthic suspension feeder, occupying the intermediate feeding tier. We interpret *Herpetogaster*, together with the Lower Cambrian *Phlogites* and more intriguingly the hitherto enigmatic discoidal eldoniids (Cambrian-Devonian), to form a distinctive clade (herein the cambroernids). Although one hypothesis of their relationships would look to the lophotrochozoans (specifically the entoprocts), we suggest that the evidence is more consistent with their being primitive deuterostomes, with specific comparisons being made to the pterobranch hemichordates and pre-radial echinoderms. On this basis some of the earliest ambulacrarians are interpreted as soft-bodied animals with a muscular stalk, and possessing prominent tentacles.

W9 - THE EVOLUTION OF GNATHOSTOME REPRODUCTIVE STRATEGIES: PLACODERM EGG CASES

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A range of reproductive strategies have been documented among extant gnathostome fishes (Osteichthyes and Chondrichthyes). Internal fertilization is derived independently in chondrichthyans and osteichthyans. Among chondrichthyans, claspers (an intromittent organ) are present in all extant taxa and most stem group members (except the cladoselachians and eugeniodontids) suggesting that claspers and internal fertilization is the plesiomorphic condition for the group. Chondrichthyan internal fertilization results in oviparous egg cases (approximately 40% of extant elasmobranches and all the chimaerids) or retained oviparity (yolk-sac viviparity to placental viviparity). A third taxon, the Placodermi (sister group to chondrichthyans + osteichthyans or + fossil acanthodians = telostomes), is critical to this analysis. Among placoderms, only ptyctodonts have preserved claspers. The recent discovery of an *in situ* embryo with attached yolk sac in ptyctodonts suggests that retained oviparity may represent the plesiomorphic condition for gnathostomes. More recently, the discovery of an embryo in an arthrodiran placoderm further strengthens the ubiquitous nature of a retained oviparous strategy. However, the discovery of a number of egg cases in the Cleveland Shale (Famennian) with one that clearly demonstrates the presence of arthrodire bone shows that oviparity is a documented strategy among placoderms. Despite the amount of missing data for placoderms, it appears that internal fertilization is a gnathostome synapomorphy. The presence of oviparity and retained oviparity in both placoderms and chondrichthyans demonstrates the diversity of reproductive strategies associated with internal fertilization early in the gnathostome lineage, but insufficient data exists to determine the polarity of oviparity and retained oviparity.

S14 - ICE-AGE PHYLOGEOGRAPHIC GENOMICS IN HOLARCTIC TERRESTRIAL & NORTH ATLANTIC MARINE ENVIRONMENTS: CASE STUDIES OF FOUR PRE- & POST GLACIAL POPULATION STRUCTURES

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Repeated glaciation cycles during the Quaternary have affected the habitability of terrestrial and continental shelf environments in different ways. The geological record provides precise time lines and geographic patterns for temperature cycles and deglaciation of Atlantic Canada and the North Atlantic over this period. Use of "NextGen" DNA biotechnology provides whole-genome mtDNA sequences from multiple individuals within several animal species simultaneously. Coalescent analysis allows construction of highly-resolved "gene trees" of genetically unique individuals, and traces their lineages in time and space with great precision. I present case studies of marine and terrestrial species whose genetic structures reflect either ancient pre- [Harp Seals and Atlantic Cod (Carr & Marshall 2008 *Genetics* 180,381)] or recent post-glacial [wolffish and caribou] returns to the island of Newfoundland.

PUBLIC LECTURE - REMARKABLE CREATURES: EPIC ADVENTURES IN THE SEARCH FOR THE ORIGINS OF SPECIES

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The search for the origins of species, both in general and of specific kinds of creatures, has entailed a series of truly epic adventures over the past 200 years. I will chronicle the exploits of a group of explorers who walked where no one had walked, saw what no one had seen, and thought what no one else had thought. Their achievements sparked a revolution that changed, profoundly and forever, our perception of the living world and our place within it.

S2 - MAJOR TRANSITIONS IN AN EARLY DIVERGING ANIMAL LINEAGE: SYNTHESIZING EVIDENCE FROM MOLECULAR PHYLOGENETICS, PALAEONTOLOGY AND DEVELOPMENTAL BIOLOGY

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A new synthesis in evolutionary biology is emerging that incorporates information from disparate areas of biology, such as molecular phylogenetics, palaeontology, genomics and development. Integration of these different areas is essential if we are to tackle the remaining grand challenges in evolutionary biology. A comprehensive understanding of early animal evolution is one such grand challenge, which has proven difficult due to the ancient and rapid origins of major animal lineages. With modern molecular techniques, it is now possible to elucidate the patterns of evolution through a phylogenetic approach and the molecular mechanisms responsible for morphological evolution through a developmental genetic approach. An investigation of the patterns of diversification and morphological evolution of the early diverging animal lineage Hydrozoa will be presented. Information from fossils reveals that the major hydrozoan lineages diversified in the early Cambrian. A dense taxonomic sampling of a molecular phylogeny of hydrozoans reveals complex patterns of life cycle evolution with concomitant morphological transitions in body plans. These patterns contradict our traditional understanding of hydrozoan evolution and reveal that characters used for higher-level classification are more labile than previously thought. Using information from comparative genomics, candidate genes have been identified that may be responsible for these life history and morphological transitions. These genes are being investigated through developmental gene expression studies to determine if changes in their expression are correlated with evolutionary changes in life history/morphology. Through integrating and synthesizing these disparate data, a new view of hydrozoan evolution will be presented.

S27B - THE EARLY TOARCIAN OCEANIC ANOXIC EVENT IN WESTERN NORTH AMERICA

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A significant disturbance in ocean water geochemistry is recorded in the Early Toarcian part of the Whiteaves Formation exposed in the Queen Charlotte Islands (QCIs) of western Canada. Simultaneous excursions in $d^{13}C_{org}$, $d^{13}C_{wood}$ and Total Organic Carbon, are temporally well constrained to the Early Toarcian *kanense* Zone by previously published ammonite and $^{87}Sr/^{86}Sr$ data. A pronounced negative shift in $d^{13}C_{org}$ of ~ 6‰ correlates with a similar shift in $d^{13}C_{wood}$ of ~5–8‰, indicating both the atmospheric and oceanic environments were affected simultaneously. The $d^{13}C_{org}$ negative shift has a similar profile and occurs over comparable stratigraphic thickness to well known curves documented for the Early Toarcian of Wales (Mochras borehole) and northeast England (Hawsker Bottoms and Port Mulgrave). The $d^{13}C_{org}$ values become increasingly negative throughout the upper *falciferum–bifrons* Zones of northwest Europe and the correlative upper *kanense–hillebrandti* Zones of western North America. Previous geologic and paleo-biogeographic data indicate that during the late Early Jurassic, the Wrangellia terrane (of which the QCIs were a part) was located in the northeastern palaeo-Pacific near the present Canadian/US border at an unknown distance west of the North American margin. In contrast to European sequences, the Whiteaves Formation was deposited below wave base in an open ocean environment. Consequently, the Early Toarcian $d^{13}C$ disturbance that is well recorded in the shallow water successions of the western Tethys Ocean was not a local but a global event affecting both the atmosphere and the oceans.

S18 - THE EUROPEAN FAR WEST: MIOCENE MAMMAL DIVERSITY DYNAMICS IN THE IBERIAN PENINSULA

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We analyze the diversity dynamics of the Miocene mammalian faunas of the Iberian Peninsula during the Miocene stepwise cooling that started around 15 Ma. Genus-level faunal lists were compiled for a total of 299 localities from the Iberian Peninsula spanning from the latest early Miocene to the early Pliocene (about 17-4 Ma). We calculated mean standing diversity, as well as origination and extinction rates for the Iberian Peninsula. On the other hand, we also included in our database 331 localities from the same time span and two close geographic areas (Central Europe and the Eastern Mediterranean) in order to evaluate whether diversity patterns are related to changes in the affinity of the Iberian mammalian faunas with those of other regions. Our results indicate that diversity changes in the Iberian macromammalian faunas coincide with periods of increased faunal similarity with other regions, thus suggesting a relation to expansions and contractions of the geographical range of the constituent taxa. This pattern is not recognized for micro-mammals; that is, their diversity trends are not related to changes in geographical ranges. We suggest that Miocene climatic changes would have resulted, on the one hand, in expansions or contractions of the geographic ranges of large mammals due to changes in the distribution of their preferred habitats. On the other hand, small mammals would have been more severely affected by climatic changes because of their more restricted range size and dispersal ability.

S6 - DISCONTINUITIES AND DISPARITY OF THE PALAEOZOIC PLANT FOSSIL RECORD: A GLOBAL MUTLIVARIATE ANALYSIS

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This paper reports a large-scale methodological inference based on a complete set of multivariate methods of the Palaeozoic plant fossil record. A global analysis based on similarity and hierarchical clustering methods was performed though a comparison between two similarity measures, the descriptive measure of the Jaccard´s coefficient and the Raup-Crick probabilistic measure of taxonomic similarity. The results show that although the Raup-Crick Coefficients undoubtedly have the potential for providing more robust results, the consequences of the extinction processes are better reflected in the similarity analysis based on the Jaccard Coefficients. The cluster analysis based on UPGMA algorithm shows four robust clusters and reveals new evidence for the singularity of Mississippian flora. Subsequently, non-metric multidimensional scaling and detrended correspondence analysis were used together with a set of complementary abundance measures for studying the discontinuity patterns in the data structure and to test the robustness of the observed clusters. Ordination and abundance results reveal four significant discontinuities in terms of taxonomic composition and record representativeness during the Early-Middle Devonian, Devonian-Carboniferous, Mississippian-Pennsylvanian and Early-Late Permian. These results emphasize and corroborate the methodology as a powerful tool to interpret the consequence of the processes modifying the taxonomic composition in the plant fossil record. Due to the controversial character of the plant fossil record data and the effect of mass extinction events, these results can be explained in taxonomic turnover and ecological reorganization terms emphasizing the crucial role of the geological constraint in palaeobiological inference.

S17 - MORPHOLOGICAL ADAPTATIONS TO A PELAGIC LIFESTYLE IN EARLY CAMBRIAN CHAETOGNATHS

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Several Early Cambrian Burgess Shale-type Lagerstätten record an apparently sudden conquest of pelagic niches by 10 groups of planktonic or nektonic metazoans. As they are essential predators of modern planktonic ecosystems, the fossil chaetognaths (*E. ercainella*) discovered from the Early Cambrian Maotianshan Shale of South China were quickly assigned to the pelagos. However, since both benthic and pelagic chaetognaths occur in present-day environments, this hypothesis should be tested by more detailed anatomical and functional analysis. Both Recent benthic and pelagic species display a “burst-and-sink”-type of motion but pelagic chaetognaths that have to maintain their position or swim in the water column spend more energy for their locomotion. Pelagic chaetognaths have developed morphological adaptations that increase their buoyancy and, as a consequence, the resistive forces produced during their movement. By using a motion model proposed by Jordan in 1992, we could compare the energy dispersed in friction during the undulatory movement of both benthic (*Paraspadella gotoi*) and pelagic (*Sagitta elegans*) forms. Our results show that the increase of size contributes to a higher drag opposing to the natural sinking of the pelagic forms, while the shorter tail balances this effect by reducing the wetted surface subject to friction during the burst phase. Thus, for chaetognaths, a larger body and a shorter tail is an adaptive response to a pelagic lifestyle. This mechanical approach added to the analysis of body ratios confirm the hypothesis that Early Cambrian chaetognath exemplified by *E. ercainella* were pelagic organisms.

S27D - EXCEPTIONALLY WELL PRESERVED ISOLATED EYES FROM THE CAMBRIAN 'ORSTEN' FAUNAL ASSEMBLAGES OF SWEDEN

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The 'odds & ends' in the Swedish 'Orsten' material collected by Professor Klaus J. Müller, Bonn, include six isolated tiny compound eyes, each arising from a long stalk. All are from Gum at the Kinnekulle (Västergötland, Cambrian, Series 3, Agnostus pisiformis zone). The eye itself is egg-shaped and asymmetric. Its surface is a mosaic of regular to somewhat irregular hexagonal facets. Within the same specimen, ommatidia size changes from one side to the other. Differences between the specimens in size, size and numbers of ommatidia, and eye shape indicate that the material is composed of at least two different instars of the same species. The morphology of the stalked eyes is unique among the eyes of 'Orsten' animals. The crustacean *Henningsmoenicaris scutula* (Walossek & Müller, 1990) is the only species with a stalked eye, but in its latest bodily preserved stages the eyes are much smaller and facet-less compared to the new eyes. Yet, from the occurrence it might be that the eyes belong to more advanced stages of *H. scutula* that are still not known from their bodies. Preliminary analysis of the compound eye with regard to possible physiological properties by one of us (BS) reveals that the eye possesses four distinct areas of different structure and character (acuity, sensitivity and geometry). Hence it seems to be an appositional type of a compound eye, which would be the oldest report of this type. Its owner might have had a predatory life style using an extended visual field and, additionally, a strong binocular field toward the front.

S3 - CHANGES IN THE THERMOCLINE DEPTH THROUGH THE LAST GLACIAL MAXIMUM IN THE EAST ATLANTIC AS REVEALED BY THE SPECIES-SPECIFIC GEOCHEMISTRY OF COCCOLITHOPHORES AND FORAMINIFERA

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Quantifying the rate of meridional overturning circulation is crucial to our understanding of how ocean circulation may change with the onset of rapid climate change. At the eastern boundary of the ocean, changes in thermocline depth are sensitive to the amount of deep water formation in the North Atlantic (Johnson *et al.*, 2007, Climate Dynamics 29). Planktonic marine calcifiers from their habitat in the uppermost water column are well placed to provide isotopic data on the variation of the ocean temperature structure and trace fluctuations in the thermocline depth. By performing isotopic analyses on foraminifera and coccolithophores at the species specific level (Minoletti *et al.*, 2009, Nature protocols 4) we have studied oxygen and carbon isotope ratios from Pleistocene-Holocene sediments off the coast of Mauritania and Portugal (ODP site 659 and OMII-9K, respectively). The record throughout the climatic shift shows a large variability in both nannofloral assemblage (relative abundances of *Calcidiscus* spp.*, Coccolithus pelagicus, Gephyrocapsa* spp.*, Emiliania huxleyi,* and *Florisphaera profunda*), and isotopic ratios. To measure the maximum temperature offset from coccolith data, we used the Noelaerhabdaceae taxa, thriving in the mixed layer, versus *Florisphaera profunda,* a deeper dweller, and calculate a maximum thermal gradient. Combining all the coccolithophorid and foraminiferal data affords a more comprehensive idea of the changes occurring to the thermocline through large changes in palaeoceanographic and climate regimes.

S24 - A 400 MILLION YEAR HISTORY OF SILICON ACCUMULATING PLANTS IN GEOTHERMALLY INFLUENCED WETLANDS?

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Silicon accumulation is observed in diverse plant groups, including the angiosperm family Cyperaceae, sphenophytes and lycophytes. Numerous data points from active environments to fossil deposits extending back to the Devonian illustrate a continued association of silicon accumulator plant groups and silica-rich waters in geothermally influenced wetlands associated with silica depositing hot springs. Cenozoic geothermal wetlands contain evidence of colonization by members of the Cyperaceae (e.g. *Carex*, *Cyperus*, *Eleocharis*, *Scirpus*) plus *Equisetum*. Equisetaceae appear in hot spring settings as far back as the Late Jurassic. More ancient sphenophyte lineages apparently colonized Lower Carboniferous and possibly Late Devonian thermally influenced settings. Late Devonian herbaceous lycopsids dominated wetlands in the oldest well preserved and exposed hot spring complexes. *Asteroxylon* (Lower Devonian) is the oldest plant with analogous extant silica accumulator relatives. Silicon accumulation has a range of beneficial properties including the relief of abiotic stresses (e.g. metal toxicity, salinity, drought and temperature stresses). The abiotic stresses listed are all present in hot spring influenced settings where hot waters carry not only silica but dissolved metals and salts. Observations of plants preserved through geological time plus limited data on physiological processes involved in chemical and water stress management in extant plants suggest that the plant–environment associations are not mere chance. Silica accumulation may be a requisite physiological feature for colonization of this very specific environment suggesting that the record of silicon accumulators extends to the plants of the oldest terrestrial hot spring deposit yet known, the Lower Devonian Rhynie chert.

S10 - MOLECULAR RECORDS OF MICROBIALITES FOLLOWING THE END-PERMIAN MASS EXTINCTION IN CHONGYANG, HUBEI PROVINCE, SOUTH CHINA

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By using gas chromatograph (GC) and GC-mass spectrometry, a series of biomarkers were identified in the aliphatic fractions of the extracts from microbialites following the end-Permian faunal mass extinction in Chongyang section, Hubei province, South China. The dominance of lower-molecular-weight *n*-alkanes in the samples from the section suggests that algae and bacteria were the dominant contributors to the organic fraction preserved in this marine section, with bacteria particularly enhanced within stromatolites. A short-term suppression of autotrophs, indicated by the ratio of pristane (Pr) and phytane (Ph) to C_{17} and C_{18} *n*-alkanes, and elevated heterotrophs, shown by the ratio of branched to normal C_{17} alkanes, were found to coincide with the great end-Permian faunal turnover. A short-term local oxygenation event during the end-Permian faunal crisis in the shallow marine is indicated by elevated Pr/Ph ratios and lowered C_{27} 18α(H)-22,29,30-Trisnorneohopane to C_{27} 17α(H)-22,29,30-Trisnorhopane (Ts/Tm) and gammacerane to C_{31} homohopane (γ/C_{31}HP) ratios. Three short-term decreases in Pr/Ph ratios across the lithological boundaries in the section were driven by episodes of intensified anoxia following the end-Permian biotic crisis.

S7 - DEVONIAN SPIRIFERIDS IN SOUTH CHINA: CHARACTERS AND EVOLUTION

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During the Early Devonian in South China, there were 24 genera of spiriferids belonging to 11 families. Most, such as *Orientospirifer*, *Rostrospirifer*, *Otospirifer* and *Trigonospirifer* had a smooth fold and sinus and simple lateral plications; their micro-ornament consists of growth lamellae with numerous concentric rows of radially-aligned spines. A few genera, exemplified by *Elymospirifer*, had bifurcating plications in the sinus and on the fold. Endemic taxa with smooth shells, exemplified by *Deltospirifer* and *Lubricospirifer*; had a simple micro-ornament of numerous concentric rows of radially-arranged spines on their growth lamellae. During the Mid Devonian in South China, there were 28 genera of spiriferids belonging to seven families. Commencing in the late Emsian, their micro-ornament became more complex and varied with two or more rows of spines on each growth lamella, as occurs in *Xenospirifer*, *Eospiriferina* and *Indospirifer*. The spiriferid genera of the Early Devonian were replaced by new endemic taxa; prominent among these were *Guicyrtia*, *Qianspirifer*, *Guangxispirifer* and *Paralazuktkinia*. Rhynchospiriferids became abundant during Givetian, typified by *Rhynchospirifer*, *Changtangella*, *Ilmeniopsis*, *Zhonghuacoelia*, *Pseudoundispirifer*, *Undispiriferoides* and *Pinguispirifer*. The Late Devonian of South China has produced 33 spiriferid genera in 15 families. *Cyrtospirifer* and *Tenticospirifer* are common and typical of the Frasnian. *Platyspirifer*, *Sinospirifer* and *Cyrtiopsis* with bifurcating plications on the sinus and folds were common in the early and middle Famennian of South China. Spiriferids became abundant during the *praesulcata* Zone (late Famennian) where *Eochoristites*, *Fusella*, *Eudoxina* and *Spirifer* display the characters of Early Carboniferous taxa.

S8 - CARBON ISOTOPE DEVELOPMENT IN THE ORDOVICIAN OF THE YANGTZE GORGES REGION (SOUTH CHINA) AND ITS IMPLICATION FOR STRATIGRAPHIC CORRELATION AND PALAEOENVIRONMENTAL CHANGE

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New carbon isotope ($\delta^{13}C_{carb}$) data from the Ordovician rocks of the Yangtze Gorges region, South China are presented. The Ordovician rocks are well exposed and dominated by carbonates intercalated with shales yielding abundant graptolites and shelly fossils. 534 samples were collected from five sections: Lianghekou–Chenjiahe (158), Jingshan (85), Laomatou (89), Gaoluo (22), Houping (180). Some 263 samples in total have been processed for $\delta^{13}C$ values. The results suggest: (1) The $\delta^{13}C$ values become steadily negative with a slight decrease in the Tremadocian to Dapingian, and increase progressively to positive values in the Darriwilian, and more positive in the Sandbian to early Katian. (2) The timing of the transition from negative to positive values falls basically within the middle Ordovician, but shows some variations across the five sections. This pronounced shift from negative to positive values may be an important indicator for a significant change in palaeoenvironments. (3) There is a prominent increase of $\delta^{13}C$ in mid-late Tremadocian in most of the five sections, and a negative $\delta^{13}C$ excursion near the Tremadocian/Floian boundary. (4) No significant Mid Darriwilian positive $\delta^{13}C$ excursions are recognized herein, except for one section (Jingshan) where a minor excursion is observed. (5) In the early Katian, a positive excursion of $\delta^{13}C$ is clearly recognized in all the five sections.

S23 - A NEW SPECIES OF ASHICAULIS (OSMUNDACEAE) FROM THE MESOZOIC OF CHINA AND ITS IMPLICATION FOR RELATIONSHIPS AMONGST ASHICAULIS, MILLEROCAULIS AND OSMUNDA

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A new *Ashicaulis* species is reported, based on a specimen collected from the Middle Jurassic of west Liaoning Province of China. The specimen represents a stem surrounded by a mantle of stipular petiole bases and adventitious roots. The stem consists of ectophloic dictyoxylic siphonostele and a two-layered cortex containing leaf traces. Apart from the stele, the leaf traces are a flattened C-shape, with an endarch protoxylem which bifurcates at the base of petiole. The sclerenchyma ring is heterogeneous with an abaxial arch at the base of stipular petiole bases that divide into two lateral strands at the top. A massive heterogeneous sclerenchyma is present in stipular wing. The new species shows similarities in the stele and arrangement of sclerenchyma of the petiole base to Osmunda (Osmunda*),* but not to Osmunda (Plenasium), Osmundastrum, Todea, and Leptopteris in extant Osmundaceae. The new species shared the same arrangement of sclerenchyma in the petiole base with Millerocaulis preosmunda, suggesting a closer relationship between the two genera in question and the new species is possibly transitional from M. preosmunda to the extant subgenus *O*. (Osmunda).

S1 - SKELETAL MINERALOGY AND BIODIVERSITY OF MARINE INVERTEBRATES

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It is now well established that seawater chemistry, as well as influencing non-skeletal marine precipitation ('calcite' and 'aragonite seas'), has affected skeletal mineral secretion in some algal and marine invertebrate groups. Skeletal mineralogy has had a yet more profound consequence on fossil preservation. The realisation that the fossil record of marine organisms with an aragonite shell is widely depleted in some shelf settings though early, effectively syn-depositional, dissolution ('missing molluscs' effect) has led to a re-evaluation of the composition, diversity, ecological and trophic structure of marine benthic communities. For example, in Palaeozoic shelf communities, taphonomic bias relating to shell mineralogy not only accounts for a substantial diversity loss (~30%), but also for ecological and trophic shifts large enough to overturn the classic dominance by epifaunal suspension feeders. Paradoxically, the macroevolutionary record of molluscs such as bivalves appears not to be skewed by skeletal mineralogy. Rare silicified Lagerstätten and other deposits 'capturing' originally aragonitic faunas indicate a temporal shift in contribution to mollusc biodiversity. Among typically rich and diverse assemblages, Palaeozoic examples include significant proportions of new taxa by contrast to very few in a Mesozoic fauna. Increased frequency of thick storm shell beds in the post-Palaeozoic fossil record may account for wider preservation of labile skeletal faunas. Small size is typical of many of the diverse silicified Lagerstätten faunas. Micromolluscs are quantitatively important among modern shell assemblages, yet small size is a major source of taphonomic and biodiversity loss in the fossil record.

S6 - THE TEETH OF ELAPHROSAURUS (DINOSAURIA, THEROPODA): CLASSIFICATION AND MISUNDERSTANDING

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Elaphrosaurus is a medium-sized theropod known from some fragmentary postcranial materials. It was named by Janensch in 1920 who considered it as a coelurosaur. Later, others viewed it as a basal ornithomimid. Recent analysis place Elaphrosaurus within the basal Neoceratosauria or in the basal Abelisauroidea. Janensch (1925) and Lapparent (1960), in spite of the absence of the skull, referred many theropod teeth to Elaphrosaurus. Samples collected from the Tendaguru Beds (Kimmeridgian, Tanzania) have been classified as E. bambergi and from the Continental Intercalaire (Albian-Aptian, North Africa) as E. iguidiensis. These teeth have a very high morphological variability that might be due to a highly diversified dentition, which is an unknown feature in theropods, or they may belong to different dinosaur taxa. Morphological and morphometrical analysis show these these teeth are more similar to other theropod teeth than the basal Neoceratosauria. In fact, these teeth are similar to Abelisauridae, Dromaeosauridae and Coelurosauria teeth. In light of this it is clear that the classification of Elaphrosaurus teeth has been misinterpreted over the past 90 years and that the assignment of isolated teeth to Elaphrosaurus is not recommended.

S15 - MARINE FAUNAL CONSTRAINTS ON TEMPERATURE AND OCEAN CIRCULATION CHANGES IN THE PERMIAN

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The geographic distribution of a marine invertebrate taxon is influenced by its temperature tolerance and dispersal capability. As a result, palaeobiogeographic patterns can provide an estimate of relative palaeotemperature and ocean circulation patterns to help constrain climate model results, analogous to but potentially more sensitive than climate-sensitive sediments. I used a database containing occurrences of more than 2750 marine invertebrate genera at 12,000 Permian fossil localities to produce quantitative estimates of the climatic affinity of the marine fauna. For each genus, the mean palaeolatitude of its occurrences was calculated to provide an estimate of its temperature sensitivity; the palaeoclimate of a 1 degree by 1 degree bin was then estimated from the mean temperature sensitivity value of all genera occurring that bin. The overall pattern closely matches previous palaeobiogeographic reconstructions and is able to quantify trends previously recognized from qualitative approaches, such as the progressive cooling of Boreal regions from the Sakmarian to Wordian. More subtle regional changes can also be reconstructed. Northern hemisphere faunas from eastern Panthalassa have a cooler climate affinity than faunas from similar palaeolatitudes on the western margin, consistent with the expected influence of cool and warm boundary currents. Temporal trends in western Laurentian faunas further indicate intensification or cooling of the southerly-flowing boundary current in the Middle Permian. Similar faunal changes and climatic boundaries can be identified in the Cimmerian continents in Tethys and in eastern Australia, placing constraints on palaeotemperature changes and the location and intensity of ocean currents during major Permian climate fluctuations.

W1 - THE EARLIEST RECORD AND PALAEOENVIRONMENTAL SETTING OF CAMBRIAN ECHINODERM DIVERSIFICATION

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Echinoderms constitute a peculiar deuterostome clade differing from their relatives by their derived pentariadial symmetry, water vascular system and calcitic mesoskeleton (stereom). There have been numerous studies aimed at illustrating how new body plans emerged, mostly based on interpretations of the (basal) Cambro-Ordovician fossil record. However, echinoderm phylogeny is still debated and the different models of emergence of extant radial forms are poorly illustrated by available fossils. Recent studies have claimed this might be the result of a discontinuous Cambrian fossil record of echinoderms that is taphonomically biased. Indeed, palaeontologists have focused their research on the relatively rare articulated specimens preserved in 'echinoderm Lagerstatten' in quiet distal environments, while numerous disarticulated elements preserved in high-energy bioaccumulations remain poorly studied. The remains of the poorly articulated skeletons of early echinoderms, which disaggregate soon after death, can be abundant in these high-energy deposits, and their palaeobiological and palaeoenvironmental value remains underestimated. A review of the first-occurrences of echinoderms across Cambrian palaeocontinents shows most are based on disarticulated plates from proximal, but diachronic, carbonate settings. Material from the lower-middle Cambrian of Laurentia, Gondwana and Siberia show (1) a considerable potential for the study of stem-group palaeobiology and crown group emergence; (2) the effect of our taphonomically-biased knowledge on the understanding of palaeoenvironmental controls (e.g. substrate controls) on Cambrian ecological and biological evolution.

S3 - BENTHO-PLANKTONIC EVIDENCE OF END-TRIASSIC SEA-SURFACE CARBONATE PRODUCTION DECLINE IN AUSTRIAN ALPS

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A high-resolution micropalaeontological study, combined with geochemical and sedimentological analysis from Tiefengraben, Schlossgraben and Eiberg sections (Austrian Alps) was performed in order to characterise the role of sea-surface carbonate production during the end-Triassic crisis. At the end-Rhaetian, calcareous nannofossil assemblages show a decrease in abundance and size of dominant nannolith *Prinsiosphaera triassica,* correlated with $\delta^{18}O$ increasing values and gradual $\delta^{13}C_{carb}$ decline. Benthic foraminiferal assemblages show a loss in diversity and a dominance of infaunal agglutinated taxa. The size change of calcareous nannofossils disturbed the export balance of the biological carbon pump, resulting in feeding strategies changes at the sea-bottom, from deposit feeders to detritus feeders and bacterial scavengers, tolerant to low-oxygen and low-food conditions. Micropaleontological data combined with geochemical proxies suggest that seawater chemistry changes and/or cooling episodes might have occurred in the latest Triassic, culminating in a marked decrease of carbonate production. This situation worsened at the very end-Triassic, as demonstrated by the quasi-absence of calcareous nannofossils and by abundance

peaks of “disaster” benthic foraminifera *Trochammina* on the sea-floor. Central Atlantic Magmatic Province (CAMP) paroxysmal activity, superimposed on a major worldwide regressive phase are presumed to be responsible for global marine environmental deterioration. Specifically, it is speculated that CAMP sulfuric emissions were drivers of cooling episodes and seawater acidification leading to disturbance of the carbonate and surface productivity at the end-Triassic stage.

S13 - EARLY HETTANGIAN BENTHIC-PLANKTONIC COUPLING AT DONIFORD (SW ENGLAND): PALAEOENVIRONMENTAL IMPLICATIONS FOR THE AFTERMATH OF THE END-TRIASSIC CRISIS

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A high -resolution micropalaeontological study integrated with geochemical and sedimentological analyses of the Triassic -Jurassic (Tr-J) boundary at Doniford section (SW England) provides evidence of renewal of surface carbonate producers in the Blue Lias Formation (Early Hettangian) after the end-Triassic mass extinction. High abundance of schizosphaerellids fluctuates in phase with development at sea floor of hyaline benthic foraminifera. This pattern is interpreted as renewed bentho-pelagic linkage translating the initial recovery of the carbon pump. However, monospecific phytoplankton assemblages and benthic foraminiferal assemblages typical of poorly oxygenated environments suggest that environment was still perturbed after the Tr-J crisis. A succession of alternating dysaerobic and anoxic phases favouring black shale deposition prevented a complete recovery. Decoupled carbon isotope records of carbonate and organic matter exclude the methane-release mechanism as a trigger for the global carbon cycle perturbation and greenhouse conditions during the early Jurassic. Besides local control of a high amplitude regression- transgression cycle across the Tr-J boundary, the succession and nature of events at Doniford are consistent with a scenario of global environmental and biotic changes triggered by the physical and chemical effects of the Central Atlantic Magmatic Province (CAMP) volcanism. Long-term CO_2 accumulation in the atmosphere/ hydrosphere system due to the CAMP volcanic activity, and parallel inefficiency of biological CO_2 pumping due to primary productivity crisis, may have been responsible for a super greenhouse climate in the aftermath of the end-Triassic mass extinction.

S27A - FUNCTIONAL MORPHOLOGY OF DEVONIAN DIPNOANS: JAW MECHANICS AND AIR-GULPING BEHAVIOUR

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Lungfish today are represented by just three genera, but during the Devonian Period they were a highly diverse and widespread group. The exquisitely preserved fossil dipnoans from two Australian Devonian reefs provide the opportunity for detailed functional morphology analyses. The world-famous Late Devonian Gogo fauna of north Western Australia, and the Early Devonian Burrunjuck fauna, New South Wales, yield three-dimensional, uncrushed specimens preserved in incredible detail. The use of high-powered x-ray CT

scanning facilities at Australian National University (ANU) enables the in-depth examination of these fossils, including internal anatomy and high-resolution histological detail. The relationships between anatomy, biomechanics and ecology can be explored by comparing the jaw mechanics of Devonian lungfish. On Devonian reefs, lungfish may have filled various roles, from grazers of soft corals and bryozoans, to durophagous predators that could crush hard-shelled prey between powerful jaws. In addition to feeding functional morphology, the fossils can reveal air-gulping behaviour. The ability to breathe air arose independently in tetrapods and lungfishes during the Devonian Period (Clack 2007). It has been hypothesized that aerial respiration in lungfishes evolved in hypoxic freshwater habitats. A new species of *Rhinodipterus* from the Late Devonian Gogo fauna provides the first unequivocal evidence of air-gulping adaptations in a marine lungfish (Clement and Long 2010). A global decline in oxygen levels during the Middle Devonian (Clack 2007), rather than the invasion of freshwater habitats, may have been the driving force behind the evolution of air-gulping behaviour of lungfishes.

S24 - ARTHROPOD FAUNA OF THE UPPER DEVONIAN TETRAPOD-BEARING LOCALITY OF STRUD, BELGIUM

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In 2005 a new Upper Devonian tetrapod-bearing locality was discovered in the Namur Province, Belgium. Since then, several excavation campaigns have been carried out, leading to the discovery of substantial new Devonian vertebrate, invertebrate and plant material. A preliminary dating suggests the Strud quarry to be Late Middle Famennian in age. The exquisite preservation of crustacean arthropods (i.e., branchiopods and malacostracans) in the highest layers of the section allows this taphonomic assemblage to be considered as a biological community. The Branchiopoda association, composed of Anostraca, Notostraca and Spinicaudata, recalls emblematic extant communities of continental temporary pools. The occurrence of different types of resistant eggs, ordered according to size and shape, confirms the ability of these species to live in a temporary aquatic biotope (temporary ponds resulting from flood events). Moreover, the noteworthy preservation of the oldest known notostracans and anostracans enables the fossil arthropods to be compared with more recent groups. Therefore, environmental comparisons of the freshwater ponds are conceivable within a large temporal frame.

S21 - WRONG TREE - RIGHT SIGNAL: DEEP BRANCHING EVENTS IN ACTINOPTERYGIAN PHYLOGENY

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Living actinopterygians (ray-finned fishes) include ~29,000 species, thus constituting the dominant vertebrate radiation. The basal branching order of actinopterygian phylogeny was thought to be understood. Morphological characters supported a nested series of monophyletic groups consistent with a history of discrete radiations reflecting pre-cladistic divisions: 'chondrosteans' (mostly Palaeozoic), 'holosteans' (mostly Mesozoic) and teleosts (mostly Cenozoic). Molecular data (especially mitochondrial genomic data) overturned this consensus. Interrelationships of the major actinopterygian clades were rearranged and divergence date estimates suggest that group origins occurred much earlier than fossils indicate. Such conflicts between molecular- and morphology-based trees are commonplace, but 'wrong' trees and spurious clade-ages can be used productively, as in the present instance, to identify problems with the basic data: gaps in the fossil record, faulty descriptions, lack of analysis, questions about the failure of data to capture the 'right' tree. Reinvestigation of morphological, nuclear and mitochondrial genetic data indicate that standard fossil-based estimates of deep branching events in actinopterygian phylogeny are at least 40 Myr too young. This new timescale suggests a possible explanation for the apparently weak signal in molecular data. It also provides an improved context for exploring links between genomic evolution, cladogenesis and morphological evolution, with particular reference to the fish-specific whole-genome duplication event. Finally, this tree-based investigation places a further set of branching events fundamental to the history of modern vertebrates within the mid- to Late Palaeozoic. This raises new macroevolutionary questions about the consequences of end-Devonian events on the subsequent shape of vertebrate diversity.

W9 - A NEW VIEW OF *ACANTHODES* AND THE ROOTS OF MODERN GNATHOSTOMES

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Acanthodes bronni (Lower Permian,,Germany) remains the only 'acanthodian' known in substantial detail. As such, it is used repeatedly as the standard outgroup for analyses of early chondrichthyan and osteichthyan phylogeny. Until other 'acanthodians' are known to a similar degree of morphological precision, *Acanthodes* will continue to exert a disproportionate influence on estimates of primitive conditions for crown gnathostomes. The most widely accepted interpretation of *A. bronni* presents its neurocranium comparable to early ray-finned fish (actinopterygian); these data have fixed *Acanthodes* to the osteichthyan stem in most analyses throughout the past thirty-plus years. Here, we show that this view of *A. bronni* is incomplete and inaccurate. In fact, *A. bronni* exhibits many features thought to be unique to chondrichthyans, raising the question of its affinity with gnathostomes as a whole: is it primitive shark, or even a stem gnathostome? Analyses show that neither *A. bronni* in particular nor 'acanthodians' in general exhibit strong relations to any of the branches extending from the gnathostome crown-node. Nevertheless, *A. bronni* provides a unique perspective on likely cranial conditions close to the divergence of chondrichthyans from osteichthyans, and highlights the morphological distance between early crown-gnathostomes and other kinds of early, jawed vertebrates branching from the gnathostome stem; most notably, 'placoderms'. The apex of the gnathostome stem group is beginning to reconfigure, but the results are unstable. However, with the collapse of formerly trusted networks of early fishes, there is a new opportunity to address fundamental questions about early vertebrate phylogeny and evolution of gnathostome body-plans.

S16 - ECOLOGICAL CAUSES OF VARIATION IN THE RATE OF MORPHOLOGICAL EVOLUTION

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One of the primary goals in evolutionary biology is to elucidate the factors that cause the uneven distribution of morphological disparity among clades. The fossil record is a rich source of data for identifying these factors, but recently developed phylogenetic methods have allowed neontologists to also investigate diversifying mechanisms using observations for extant species given a phylogeny that relates them. Key to these methods is the incorporation of models for the process of character evolution along the branches of a phylogenetic tree, which generate expectations for variance and covariance in morphological traits among species. I present work that applies this approach to detect the effects of ecological factors, including trophic habits and habitat use, on morphological diversification in centrarchid fishes and agamid lizards. By fitting models that allow rates of evolution to vary among phylogenetic branches that differ with respect to their reconstructed ecology (e.g. piscivory or non-piscivory), I show that piscivory is associated with relatively slow rates of skull evolution in centrarchids and rock-dwelling and arboreality are linked to decreased rates of limb evolution in agamids. These results suggest evolutionary rates may vary as a function of the severity of selective demands imposed by the resources lineages use.

S6 - PRELIMINARY STRATOCLADISTIC STUDY OF *SPISSATELLA* (BIVALVIA, CRASSATELLIDAE)

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Stratocladistics is a development of traditional cladistics that incorporates stratigraphic data into phylogenetic analyses. In stratocladistics, assumptions of non-preservation to explain gaps in the fossil record are scored as ‘stratigraphic debt’ for each tree constructed, and considered equal to the ‘morphologic debt’ of traditional cladistics, incurred by homoplasy. The most parsimonious tree is that with the minimum combined morphologic and stratigraphic debt. Using both morphological and stratigraphic data, it is hoped that more accurate phylogenies can be generated than by the use of morphology alone. Much debate still surrounds the value of this method, and studies have produced both positive and negative evaluations. As stratocladistics depends on the reliability of the fossil record, it is best used on younger datasets of well-preserved, common taxa, such as *Spissatella*. For this study, both cladistic and stratocladistic analyses of the bivalve *Spissatella* were undertaken to test which produces the most parsimonious phylogeny. Spissatella is known only from New Zealand (with the exception of one species from Australia) from the late Eocene to early Miocene. This genus is, therefore, an ideal test dataset for the stratocladistic method. Previous studies that dismiss stratocladistics have used datasets from much wider ranges and earlier time periods and, perhaps unsurprisingly, turned up disappointing results. Results of a preliminary stratocladistic and cladistic study of *Spissatella* performed in order to test the principle points of the analysis are reported. Software used includes MacClade, TNT and Strata-Phy.

W5 - VIRTUAL PALAEOBOTANY AND TAPHONOMY: APPLICATIONS FOR MESOFOSSILS

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Synchrotron radiation X-ray tomographic microscopy (SRXTM) is being evaluated for multiple applications in the study of a wide variety of fossil plants and their living relatives. Examples will include (i) visualizing fine details (1-100µm) such as surface hairs and internal cells; (ii) discriminating different chemical compositions in plant tissues; (iii) distinguishing tissue structure in exceptionally preserved yet strongly compressed fruits and seeds from the Eocene Messel oil shales; (iv) using virtual taphonomy to mimic various plant fossil preservation states (e.g., fruit, fruit stone, internal cast of cavity within fruit stone) to enable comparison between floras like the Eocene London Clay and Messel; and (v) establishing if all preservation states (e.g., organic, charred, permineralised) are suitable for study. In addition, visualization of fine detail and discrimination of tissue structure and chemistry will be compared between SRXTM and Nano-CT using the Gatan XuM (x-ray ultramicroscope).

S23 - THE SEGMENTATION OF YUNNANOZOANS

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Segmentation is thought to be one of the triggers for the diversification of metazoan body plans during the “Cambrian Explosion”. The segmented fossil problematica of this interval, e.g. the yunnanozoans from the Chengjiang Lagerstätte, are essential to resolve this issue. However, there have been controversies over the segmented nature of yunnanozoans ever since they were first reported. An exhaustive examination of the specimens from all localities known so far shows that yunnanozoans have different segmented organs. Their dorsal units are a segmented cuticular skeleton rather than muscle blocks, revealing that the most anterior triangular segments have a clear brim, the anterior rectangular segments are imbricated with each other, and some segments show clear lateral margins. Additional segmented organs include seven pairs of gills, a segmented axial structure and four pairs of gonads. This body plan disproves the previous phylogenetic placements of yunnanozoans, such as within the chordates or hemichordates. Furthermore, comparison with other segmented bilaterian groups indicates that the segment mismatch of the yunnanozoans supports the hypothesis that organ segments are primarily independent and the evolution of segmentation is actually the process of integration of different segmented organs.

S2 - THE GREAT EQUALIZER OF EVOLUTIONARY BIOLOGY; MASS EXTINCTIONS AS LARGE-SCALE ANALOGUES OF SPECIES TURNOVER

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Cyclicity plays a large role in the history of life. Modern studies of individual populations, such as the Grants' work on Darwin's Finches, have shown large cyclic shifts in phenotype/genotype that correlate with climatic variations. At the hierarchical level of the species, similar patterns can be observed in the climatically mediated turnover of species (i.e., Vrba's Turnover Pulse Hypothesis). These patterns are analogous to the climatic variations occurring at the population level, but not homologous because they cannot be explained through simple extrapolation of these population-level variations to the species level. The cyclicity of mass extinction events may have a similar analogous relationship to species turnover operating at the clade level. Mass extinctions rewrite the *status quo*, often pruning successful clades while allowing less successful clades an opportunity to thrive—a "clade turnover." A test is conducted to ascertain if such an analogous relationship exists between species turnover and mass extinction events. In particular, the end Ordovician mass extinction event is modelled as a large-scale analogue to Vrba's Relay Model using phylogenetic and biogeographic analyses of Ordovician-Silurian trilobites. The existence of clade-level patterns suggests the reality of these higher hierarchical entities. These large-scale processes (species turnover and mass extinctions) are possibly the most important elements directing the evolution of life on this planet, yet the Modern Synthesis would not predict their existence because of its focus on extrapolating smaller-scale population-level processes to the levels of the species and the clade.

S27B - PALEO- AND NEO-BIOGEOGRAPHIC RELATIONSHIPS OF THE SHALLOW-WATER MARINE GASTROPODS OF THE AZORES

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The geographical location of the Azores, midway between Europe and America, poses interesting problems regarding their colonization and the biogeographic affinity of the biota presently living there. Although the Azores are under the influence of the Gulf Stream, the marine biota are predominantly European. Previous studies on the Pleistocene and Recent littoral molluscan fauna of this archipelago have also shown that they are biogeographically related to the eastern Atlantic. The preliminary results reported here of the work on the late-Miocene/early-Pliocene Azorean marine molluscs point to similar affinities. Therefore, there is no accordance between the present day sea-surface currents in the north Atlantic and the origin of the Azorean colonizers. Although there are already hypotheses about the processes and routes of dispersal to the Azores, there is still no complete understanding of this biogeographic paradox. In order to better understand this distributional pattern, we intend to investigate the phylogeographic patterns of the shallow-water marine gastropods of the Azores. Selected species with contrasting modes of development (planktotrophic and non-planktotrophic) will be used: i) for a gene flow study at different scales (local, regional and north Atlantic-scale); ii) to establish the most probable routes of dispersal to the Azores, and iii) to determine a probable temporal range for the arrival of the colonizers in the Azores.

S6 - QUANTITATIVE DEVELOPMENTAL TINKERING AND SOFT-TISSUE 3D NANO-CT SCANNING OFFER DEVELOPMENTAL INSIGHT INTO PALAEONTOLOGICAL PHYLOGENETICS

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Empirical and experimental results from developmental biology can help investigate dental characters used for palaeontological phylogenetic and evolutionary analyses. Using wild-type (empirical data) and Tabby (experimental data) mice, and ShhGFP fluorescent reporter genes, plus cutting-edge, soft-tissue, 3D, nano-CT, we examined the order of cusp appearance and cusp mineralization to determine whether the two were linked. Results confirm this - the first appearing and first mineralizing cusps of the lower molar are the protoconid and metaconid. Features located lower in the crown appear later; those at the anterior and posterior extremities of the tooth appeared and mineralized latest and are also the first to be lost and gained under novel quantitative manipulation of ectodysplasin (Eda) levels. We then examined a recent comprehensive data matrix of fossil and extant primate relationships from a developmental perspective. Empirical development and population-level variation studies show that features that appear chronologically later during development tend to be more variable intra-specifically. To determine whether these patterns also hold at the macro-evolutionary level, we examined (a) the frequency of polymorphisms scored in the data and (b) the number of character states of features in different regions of the tooth crown, as measures of variability. Our results show statistically significantly higher polymorphism and average character state numbers in late developing tooth features. We conclude that a developmental perspective is useful for uncovering patterns in character states across taxa. Conversely, in addition to containing hierarchical phylogenetic information, phylogenetic data may inform on development, an underlying mechanism of evolutionary change.

S5 - LASER CLEANING PALAEONTOLOGY SPECIMENS- TREATMENT AND ETHICAL CONSIDERATIONS

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Surface cleaning of palaeontology specimens is often required for conservation, research or display purposes. In the last 20 years interest has developed in the use of alternative, “non-contact”, methods of treatment. This is mainly in response to the fragility of some surfaces and the invasive nature of more conventional methods, such as mechanical and chemical cleaning. Laser cleaning is one such non-contact method. It is now routinely used in many countries in Europe for cleaning of stone and marble. Laser cleaning is virtually unknown within the Natural Sciences and there are few documented instances of its use. Part of any cleaning process should include a review of the suitability of the selected technique and the establishment of safe levels of cleaning. Staff at the Palaeontology Conservation Unit have experimented with laser cleaning on a range of fossil material with particular emphasis on this issue. Laser cleaning has many advantages over more conventional techniques but like any cleaning tool it has to be used with care by the user.

S9 - CONODONT GENUS *PROTOGNATHODUS* AS A POSSIBLE TOOL FOR RECOGNIZING THE DEVONIAN/CARBONIFEROUS BOUNDARY

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The Devonian-Carboniferous boundary is defined at present by the first occurrence of the conodont *Siphonodella sulcata* in the *Si. praesulcata-sulcata* lineage. As a consequence of taxonomic problems with the early siphonodellid lineage, it is suggested that the definition of the D-C boundary might be usefully re-examined. Reconsideration of *Protognathodus*, a genus appearing in the latest Devonian and extending into the Mississippian, appears to have potential for more precise definition of that boundary than is presently available. Four evolutionary species are known from the relevant time span: *Pr. meischneri*, *Pr. collinsoni*, *Pr. kockeli* and *Pr. kuehni*. Previous taxonomic definitions, precise biostratigraphic ranges and biogeographic distributions of these taxa need elaboration prior to any attempt to present a formal proposal for changing the present boundary definition. If a genus, such as *Protognathodus,* would be taken into consideration for a revised definition of the D/C boundary, then the following criteria/questions should be considered: 1) Which of the four species (and conceivably others yet to be discriminated) might be useful for re-definition of the boundary. Presently favoured are: a) selecting the first occurrence of *Pr. kockeli*, whose entry followed immediately after the Hangenberg Event, or b) the first occurrence of *Pr. kuehni* in the *Pr. kockeli-kuehni* lineage. 2) Does the taxon fulfill the criteria for an index fossil: wide geographic distribution, unequivocal taxonomy, easily recognizable range, etc.? Relative advantages and disadvantages of using protognathodids in preference to siphonodellids would then need to be judiciously evaluated.

S27B - *CLOUDINA* FROM THE TERMINAL EDIACARAN OF SPAIN

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The genus *Cloudina* is the best known of the earliest biomineralized fossils which occur in the terminal Ediacaran. It consists of a tube formed by stacked funnel-shaped elements, and is usually interpreted as the external skeleton of an early metazoan. Two distinct morphotypes of *Cloudina* occur in Central Spain. One of them can be readily assigned to the type species *C. hartmannae*, while the other represents a new species, *C. carinata*, characterized (among other features) by the presence of conspicuous longitudinal crests. The exceptional preservation of the specimens from Central Spain is shedding light on aspects of the skeletal organization of *Cloudina*, particularly regarding the imbrication of the funnels, their disarticulation, the role of inorganic cement precipitation in skeletogenesis, and the branching of the tubes interpreted as reflecting asexual reproduction.

S1 - DIVERSITY DYNAMICS OF ENDEMIC MOLLUSCS ON A MOBILE MARGIN: SORTING THE ACTUAL FROM THE APPARENT

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The New Zealand continent is isolated, of moderate size ($6x10^6$ km^2), and has a rich and well-documented fossil record of Cenozoic mollusc species, over 90% of which are endemic. This fauna represents an ideal subject for studies of diversity dynamics and biases in the fossil record at an active margin. Overall, ~30% - 40% of Cenozoic mollusc species have been sampled at least once. Per-stage sampling probabilities for the Neogene range from ~30% - >80%. Once corrected for sampling effects, Cenozoic species diversity shows no secular trend, suggesting that equilibrium diversity dynamics prevailed. Stage-to-stage variations in sampling-standardized diversity were driven largely by changes in origination rate. The long-term trend in sampling probability is related to rock outcrop area. Stage-to-stage variation in sampling probability relates primarily to second-order, tectonic cycles that affected wholesale preservation or destruction of the fossil record. Within this, losses from the record are concentrated in the smallest and largest body-size classes. There is no evidence for a major secular trend in sampling probability related to either body-size or shell compositional biases – e.g., time series of sampling probabilities for calcitic versus aragonitic taxa are indistinguishable. A trend in lithification bias is evident, but is restricted to the past few million years and does not overwhelm the diversity signal. In general, long-term trends in preservational biases may be problematic at the scale of individual basins, but are likely to be diminished when averaging across several basins with different burial and diagenetic histories.

S13 - OSTRACODS (CRUSTACEA) AND PERMIAN – TRIASSIC EVENTS: EXTINCTIONS AND RECOVERY

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During the last few years, some of the most representative sections of Permian-Triassic boundary were sampled for the ostracod (Crustacea) analysis. We studied, among others, the GSSP Meishan section in South China, the Bulla section in the Dolomites (Italy), and the Çürük Dağ section in the Taurus (Turkey), with the aim of evaluating extinction and recovery rates in this group. The specific extinction rate is between 98% and 100% in the three sections. The generic extinction rate is quite low, between 30% and 39%. After the mass extinction event, which always occurs before the Permian-Triassic boundary, ostracod biodiversity is strictly controlled by the environment. We distinguish different phases for ostracod diversity during the Early-Middle Triassic: 1) A survival stage (Griesbachian) with mixed Palaeozoic and Meso-Cainozoic forms; 2) A maximum poverty stage (Dienerian-Smithian) with very low diversity and abundance; 3) A recovery-dispersal stage (Spathian) which registered the beginning of recovery; 4) A radiation stage in the Anisian. Middle Permian ostracod biodiversitiy was not regained until the Ladinian.

S21 - THE MISMEASURE OF A MYSTERY: ANGIOSPERM ORIGINS AND PHYLOGENETICS

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Angiosperms have been a focus of evolutionists for over a century and the “Abominable Mystery” of Darwin has been a diadem in the treasury of the great questions that science has failed to resolve. Consequently, the “mystery” has been the focus of powerful new analytical tools grouped under “phylogenetics”. Yet, instead of clarifying angiosperm origins, contradictory results of applications of phylogenetic methodologies have further confused our understanding of angiosperm relationships. This systemic incongruence has been exacerbated by conflicting treatments of potentially illuminating fossil taxa such as Bennettitales, seed ferns, and *Archaefructus*. Complicating matters is the subtle influence of historical thought which seems to have: 1, affected the way these taxa are coded; 2, affected construction of matrices themselves; and 3, resulted in selective presentation of results. Therefore, cladograms based on structural features or on analyses that include them may reflect outcomes based on more than objective readings of available evidence. Moreover, there has been an inconsistently applied tendency to demand rigor in defining angiosperms and in identifying their characters. Resulting restricted definitions sometimes exclude possibly relevant fossils from analyses thereby obscuring their true lineages. Further confusing the issue is a contrasting tendency to group certain fossils with angiosperms and to then code certain of their characters as homologous, often based on complex scenarios of change. Elimination of encoded hypotheses, recognition of the limits of fossil data, and more objective analysis may improve our ability to identify likely angiosperm ancestors by bringing into play information now hiding in plain sight.

S2 - DISPARITY AND ONTOGENY: HOW THE ENVIRONMENT OR DEVELOPMENTAL CONSTRAINTS INFLUENCE MORPHOLOGICAL CHANGES IN LATE DEVONIAN PHACOPID TRILOBITES

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The morphological changes in trilobites can be approached in terms of both disparity and ontogenetic development using quantitative methods. Among trilobites, the ontogenetic development of the late Devonian phacopids is becoming better known. The discontinuous and isometric changes in relative sizes have been studied by allometric graphs. The complex shape changes have been studied by deformation grids or Fourier transforms in order to understand how the morphological diversity of different ontogenetic stages was structured. A previous comparison of ontogenetic trajectories of two phylogenetically-related species showed a progressive shape change in each species during successive instars and also with size increase. Additionally, this comparison showed a parallel shift of both nearly entire ontogenetic trajectories in morphospace occupation and also with size increase. Such structural difference may be a manifestation of developmental constraints or linked to ecological adaptation. Changes in developmental process (heterochrony, paedomorphosis) have been observed in the late Devonian phacopids. This developmental change in evolution, which evolved several times from conservative rootstock, concerns the regression of the visual complex. This evolutionary trend reflects the balance between limited ontogenetic intrinsic potentialities and ecological extrinsic constraints. These iterations occur in parallel with ecological shifts due to the extension of habitats during sea level rises. Detailed studies of ontogenetic series should be conducted in order to better understand both morphological disparity and developmental patterning and to determine the impact of individual ontogenies on the extent of morphological diversification of their descendant clades.

S27D - A NEW LATE ORDOVICIAN EURYPTERID FROM THE WILLIAM LAKE LAGERSTÄTTE, MANITOBA, CANADA

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Upper Ordovician (Richmondian) dolomudstones of the central Manitoba William Lake Lagerstätte are yielding exceptionally preserved remains of a wide range of soft-bodied and weakly sclerotized organisms associated with a sparse shelly fauna. These sediments were deposited in lagoonal and marginal marine to shallow subtidal conditions. This fauna includes a new species of eurypterid. Eurypterids were a diverse and widely distributed group of Palaeozoic aquatic (primarily marine) chelicerates ranging in age from the Early Late Ordovician to the Late Permian. Because their cuticle was not biomineralized, however, eurypterids are generally rare as fossils. Their greatest diversity is now recorded in Silurian and Lower Devonian Lagerstätten of Europe and North America. Occurrences of pre-Silurian eurypterids are extremely limited, with only a few species so far reported from Canada and just five genera described world-wide. Thus, their early evolutionary history is obscure, and any new material from this interval is potentially significant. These new finds will hopefully aid in elucidating the initial Ordovician radiation of eurypterids. Preliminary analysis of the available material reveals a new taxon that does not easily fit into any of the established clades within the Eurypterida. It has a mixture of characteristics typical of a number of different superfamilies as well as unique characters not seen anywhere else in the Order. At William Lake, eurypterids are represented mostly by three-dimensional mouldic sclerites. Rare articulated and near complete appendage-bearing specimens are often preserved in laterally compressed orientations showing strong dorsal arching; these may represent moulted exoskeletons.

S20 - DISTINGUISHING BIOLOGY FROM GEOLOGY IN THE EDIACARAN DOUSHANTUO BIOTA

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The c.570 Ma Doushantuo biota of south China has yielded important fossils that include the oldest well-accepted animal fossils in the record as well as a suite of specimens with alleged animal, and even bilaterian, affinities. However, several such identifications have been discredited on the basis that key biological structures are, in reality, artefacts of diagenetic mineralization. We attempt to discriminate the phases of mineralization that reflect replication of original biological structure versus diagenetic void filling. To achieve this end we have utilised a combination of Back-Scattered Electron imaging (BSE), Electron Probe Micro-Analysis (EPMA), Electron Back-Scatter Diffraction (EBSD) and Synchrotron Radiation X-ray Tomographic Microscopy (SRXTM). Using uncontroversial fossils, the chemistry (using BSE and EPMA) and crystallographic fabric (using SRXTM, EBSD and BSE) were characterized for (1) preserved biological structures and (2) void filling diagenetic mineralization. The findings allow these two phases of mineralization to be distinguished in more controversial forms. We critically re-evaluate all taxa reported from the Doushantuo Formation in the light of these new data.

W5 - SYNCHROTRON X-RAY TOMOGRAPHIC MICROSCOPY AS A TOOL TO STUDY EARLY ANIMAL EVOLUTION

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Synchrotron X-Ray Tomographic Microscopy (SRXTM) enables the acquisition of complete three-dimensional recordings of fossils with sub-micrometre resolution, making it ideal for the study of fine detail or very small specimens. As a result SRXTM has proven to be an invaluable tool for the study of early animal evolution allowing internal, soft tissue and even sub-cellular features to be visualized in three dimensions. Furthermore, because the x-rays are monochromatic, which allows clear distinction between different mineralogical phases, it has been possible to distinguish diagenetic mineral growth in these specimens. We discuss the application of these techniques to problems in early animal evolution using examples of our work carried out at the TOMCAT beamline of the Swiss Light Source, Villigen, Switzerland. These include constraining the interpretation of sub-cellular structures in the Ediacaran Doushantuo microfossils and using virtual dissection to reveal new anatomical features of Cambrian animal embryos.

S27B - STROMATOPOROID PALAEOECOLOGY OF THE FRASNIAN (UPPER DEVONIAN) OF SOUTHERN BELGIUM

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Stromatoporoid faunas from the Frasnian of southern Belgium are abundant in the carbonate platform and mound environments present in this area. Stromatoporoids dominate the large skeletal organisms, with their principal occurrence in biostromes and mound deposits. Stromatoporoid genera include *Actinostroma*, *Amphipora*, *Euryamphipora*, *Atelodictyon, Clathrocoilona, Idiostroma*, *Salairella, Stachyodes, Stictostroma, Stromatopora* and *Trupetostroma*. Comparable facies were observed in the carbonate platform and in the mound, so it appears that even if the mound and platform were independent, similar stromatoporoids occur in similar facies indicating a strong palaeo-environmental control. From the more distal to the more proximal, facies are: (1) outer platform or off-mound (shales, crinoidal packstones); (2) outer intermediate platform or deep mound (muddy facies with crinoids and reef-builders); (3) inner intermediate platform or shallow mound (muddy facies with algae) and (4) restricted platform or mound (laminites, mudstones, paleosols). Low profile stromatoporoids (dominated by *Stictostroma* and *Salairella*) are often observed at the beginning of sequences, as stabilizers and in facies 1 and 2 (so they likely led to expansion of the carbonate factory). High domical stromatoporoids (dominated by *Actinostroma*, *Atelodictyon* and *Trupetostroma*) ocur in facies 3 and 4, in association with branching stromatoporoids. Stromatoporoid growth forms seem to be related mostly to environmental parameters but there is also some taxonomic control.

S27D - ONTOGENY OF THE REDLICHIID TRILOBITE *METAREDLICHIA CYLINDRICA* CHANG, 1953 FROM THE LOWER CAMBRIAN OF SOUTH CHINA

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New material comprising immature and mature growth stages allows tracing of the morphology and ontogeny of the redlichiid trilobite *Metaredlichia cylindrica* Chang, based on numerous calcareous specimens collected from the Lower Cambrian Shuijingtuo Formation in Hubei Province, south China. Two stages of protaspid development can be identified as well as all subsequent ontogenic stages for the cranidia, comprising prominent morphological changes such as the contraction of the frontal glabellar lobe, appearance of the fourth pair of glabellar furrows and migration of the facial suture from proparian to opisthoparian.

S12 - EVIDENCE OF MICROBIAL ACTIVITY IN A MIOCENE WHALE CARCASS FROM SHALLOW WATER SEDIMENTS (VOGHERA, NORTHERN ITALY)

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Whale carcasses on the sea floor host a diverse chemosynthetic community showing taxonomic affinities with those living in hydrothermal vents and cold seeps. The anaerobic decay of bone lipids is at the basis of a long lasting microbial ecosystem dominated by sulphate reducing bacteria and methanogenic archea. Reduced compounds are then exploited by chemoautotrophic bacteria, both free living and endosymbiotic, within the tissues of mussels and clams. To date, study of modern and ancient whale falls has been focused on the invertebrate component, leaving the microbial component poorly investigated. Although some studies on fossil bone material show that microbial chemosynthetic activity on marine macrovertebrates, including whales and Mesozoic plesiosaurid carcasses, can potentially leave a geologic record, some authors are more skeptical and suggest that the progressive consumption of bone lipids and diagenetic processes could obliterate its traces. Here we present a detailed study of direct and indirect evidence of a fossil microbial activity associated to the decay of a shallow water Miocene mysticaete (Voghera, Italy). Optical and scanning electron microscopes, and a Raman spectroscope were used for high spatial resolution microfacies and biosedimentological analyses of bone samples and the related cements. We recognized different (i) Ca-carbonate cements including sparry calcite, high Mg-calcite and microbial dolomite, and (ii) biofabrics and biominerals such as microborings, microbial peloids, clotted textures, pyrite and barite that are typical microbial products of chemosynthesis in cold seep systems. These new data are a further step towards understanding the record of chemosynthetic activity in fossil organic falls.

S12 - CHEMOSYMBIOTIC MOLLUSKS FROM RECENT AND FOSSIL SHALLOW WATER WHALE FALLS

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Deep water whale falls reaching the sulfophilic stage are dominated by vesicomyid clams and bathymodioline mussels, bearing endosymbiotic sulfur and methane oxidizing bacteria. These bivalves are obligate taxa of deep water reducing habitats and are shared at the family, genus and specific level between organic falls, hydrothermal vents and hydrocarbon seeps. While many studies focus on recent and fossil deep water whale falls little is known on the ecosystem response in shallow water settings, where primary production is almost always driven by phototrophy and chemosynthetic symbioses never dominate. We present a species-level study of mollusks associated with two shallow-water whale falls: a recent 5 m long minke whale artificially sunk at a depth of 125 m in the Kosterfjord (North Sea, Sweden) and a 10 m long Pliocene whale fall from outer shelf deposits of Tuscany (Italy). In both cases samples from the whale fall and background sediments have been compared in order to analyze the differences between the general and the whale fall communities. Sediments associated with the Kosterford minke whale five years after deployment at the sea floor are dominated by the thyasirid *Thyasira sarsii*. The Pliocene whale fall host many specimens of the lucinids *Megaxinus incrassatus* and very few specimens (n=2) of the bathymodioline *Idas sp.* Mollusks communities at fossil and recent shallow water whale falls are dominated by more generalist chemosynthetic bivalves than in the deep sea, in accordance with previous observations on hydrothermal vents and cold seeps faunas.

S17 - INVESTIGATING THE DIET OF EXTANT AND FOSSIL FISHES THROUGH MICROTEXTURAL ANALYSIS OF TEETH

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Hypotheses of diet and feeding in fossil fishes rely heavily on anatomical comparison and mechanical modelling. However, recent evidence indicates that in some fishes, species level dietary specializations in feeding structures correlate poorly with diet, and that diet can differ between morphologically similar populations within a species. These observations undermine the assumptions of the functional morphology approach. Here we adopt an engineering approach to quantification of tooth microwear based on micro-textural analysis of high-resolution three-dimensional data. Data were acquired with a focus variation microscope (Alicona IFM) and tooth surface roughness was quantified through several industry standard amplitude, volume and texture parameters. These data allow statistical comparison of textures developed on molariform teeth of extant herbivorous, durophagous and specialised shell-crushing populations of fishes (*Archosargus probatocephalus* and *Anarhichas lupus,* Teleostei), and comparison with teeth from fossil and modern fishes. Analysis of extant taxa reveals that dental microtextures reflect differences in diet both within- and between-species. Results were validated through blind testing of data from pharyngeal jaw teeth of cichlids (*Astatoreochromis alluaudi*) with known diets. Application of microtextural analysis to molariform teeth from fossil pycnodontid fishes, assumed to be specialised shell-crushers, shows that previous dietary hypotheses, based primarily on functional morphology, are incorrect. Microtextural analysis therefore offer a new and powerful tool to test hypotheses of the diet in both extant and fossil organisms.

S26 - FACIES AND BIOTIC EVENTS IN THE TYPE CINCINNATIAN (UPPER ORDOVICIAN): DIFFERENTIATING ENVIRONMENTAL FROM CLIMATIC-OCEANOGRAPHIC SIGNALS

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Traditional facies-based sequence stratigraphy of the type Cincinnatian portrays this succession as consisting of sequences made up of laterally time-equivalent lithostratigraphic units (i.e., lithofacies), characterizing the lithostratigraphic units as diachronous divisions of an original onshore-offshore gradient. This type of Waltherian division would be completely accurate if all components of these strata were controlled only by the local depositional environment. While many aspects of the model hold up under close scrutiny, it obscures the non-Waltherian, temporally unique nature of some of these stratigraphic units, which played a role in their original designation. Some of the time-specific components of facies in the Cincinnatian include variations in the type and concentration of authigenic minerals, unusual aspects of the faunal composition, and stratal architecture. Examples include everything from widespread open marine phosphatic beds with micromorph faunas at the base of the C4 sequence to localized, nearshore facies composed almost entirely of gastropods with unusual preservation of lamellar microstructure at the bases of the C4 and C5 sequences. Thus, some of the differences between successive stratigraphic units in the type Cincinnatian appear greater than the local to regional lateral variability within units. Time-specific components of these deposits not only provide distinctive stratigraphic signatures, which facilitate regional to intercontinental correlation, but they are keys to understanding shifting climatic and oceanic conditions of the Late Ordovician.

S27D - BIOGLYPHS IN FOSSIL CRUSTACEAN BURROWS: READING THE SIGNATURES OF ANCIENT TRACEMAKERS

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Crustaceans are among the most important burrowers in shallow and marginal marine settings today as they were throughout the Mesozoic and Cenozoic. Their burrows are well known in the fossil record, and several common ichnogenera can be confidently assigned to their activity. Some of these trace fossils bear distinctive bioglyphs (wall sculptures) preserved as ridges in burrow casts. These ornaments record the digging activity of the tracemakers' appendages in firm, fine-grained substrates. Material collected in several Neogene basins in Spain (Vallès-Penedès, Alcoi, Fortuna, Almería-Níjar, Guadalquivir) was examined and forms the basis of a general discussion on bioglyphs in crustacean burrows. Studied specimens belong to the ichnogenus *Spongeliomorpha*, which designates branching burrow systems with heavily sculptured, unlined walls. Several distinctive ornamentation patterns were recognized, which evince different behaviours and possibly also different tracemakers. Detailed analysis of bioglyph patterns, including identification of individual imprints and characterization of their arrangement upon the interior surface of the burrows, allows us to interpret the bioglyphs as the product of different operations executed in different manners. Most of the

sculptures were produced during the initial excavation of the burrow, either by scratching or plucking using the chelipeds or by the scratching action of ambulatory pereiopods. Other imprints result from activities performed by the tracemaker during occupation of the dwelling. Those include pereiopod scratch marks resulting from simple locomotion along the burrow or from wall-trimming operations, and probably also gnawing traces made by mandibular appendages when grazing upon microbial films covering the burrow wall.

S16 - MORPHOLOGICAL RATES OF CHANGE IN THE THEROPOD FORELIMB: PATTERNS AND IMPLICATIONS

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The origin of birds and that of powered flight have traditionally been seen as interconnected, with birds being one of only 3 vertebrate groups to evolve flight. To achieve and maintain active flight required a series of pectoral and forelimb modifications from the basal theropod condition. Here we examined the pattern of character change and its rate across the phylogenetic nodes bracketing this transition to examine if there was a significant increase in the rate of forelimb change at the proposed dual origin of birds and flight. Using both a specifically designed forelimb-only dataset and published total body sets, we find a consistent pattern of high rates of forelimb evolution occurring before and after the node Aves, with the node Eumaniraptora (Deinonychosauria) showing the highest peak value. This pattern is robust across multiple phylogenetic hypotheses regarding the interrelationship of Paravians. We examine possible causes for this pattern and determine that it is not merely a reflection of the whole body's pattern, nor is it due to scaling or ghost lineage length. The sharp increase in forelimb rates across multiple datasets at the node preceding Aves suggests that the morphological capacity for flight existed before birds and supports the recent suggestion of perhaps multiple origins of flight within small bodied paravians.

S27C - DIVERSITY AND ECOLOGY OF PERMIAN FLORAS FROM ANTARCTICA

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With the exception of Devonian lycopsids, the oldest well-known floras from Antarctica are dated from the Permian, after the end of the Carboniferous glaciation. In this report we present a synthesis of what is currently known about the diversity, ecology and biology of plants that composed these high latitude floras. Our analysis is based on impression/compression specimens and permineralizations from several Permian assemblages. Gymnospermous trunks, stems, roots, pollen and ovulate organs of *Noeggerathiopsis* (cordaites), *Gangamopteris* and *Glossopteris* (seed ferns) dominate these assemblages. The proportion of these taxa varies as a function of age and type of deposit, indicating the presence of several types of communities; however, the glossopterids are the most abundant and diverse group. Other taxa recognized in Late Permian permineralized peat include a fern and a moss, while compression floras indicate the presence of coniferophytes, sphenophytes, and herbaceous lycopods. Additional evidence suggests complex ecological interactions between the plants and arthropods and fungi. Wood and trunks of glossopterids, some of them in situ, indicate the presence of established forests that were well adapted to a high-latitude light regime. Permineralized specimens provide data on the development and architecture of the unusual root system (*Vertebraria*) of these trees, and also on vegetative regeneration, with the production of epicormic shoots and possible root suckers. These floras provide a unique opportunity to examine a number of factors relating to plant growth and community structure in high-latitude ecosystems that have no equivalent today.

S27B - TERTIARY ROOTS IN THE RECENT MOLLUSCAN FAUNAS OF THE SOUTHWESTERN ATLANTIC OCEAN

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The species composition of the Recent Southwestern Atlantic (SWA) molluscan biota (Argentine and Magallanic Provinces) has its roots mostly in post-Late Miocene times. Among the more than 1300 species that form the modern regional assemblage, only 37 are survivor species and 25 are long-term survivors going back to Miocene times: *Leionucula puelcha, Nucula semiornata, Adrana electa, Crassostrea rizhophorae, Felaniella villardeboaena, Tivela isabelleana, Amiantis purpurata, Mactra isabelleana, M.janeiroensis, Tellina gibber, Cyrtopleura lanceolata, Caryocorbula pulchella, C.caribaea, Tegula patagonica* and *Halystilus columna*. An additional 13 species have closely related congeneric counterparts of that age: *Lamellinucula semiornata*, *Glycymeris longior, Psychrochlamys patagonica, Aequipecten tehuelchus, Trachycardium muricatum, Anomalocardia brasiliana, Pitar rostrata, Ameghinomya antiqua, Retrotapes exalbida, Tagelus plebeius, Trophon geversianus, Adelomelon beckii* and *Pachycymbiola brasiliana*. However, when upper levels of the taxonomic hierarchy are considered, Tertiary Patagonian faunas appear to have played an important role in the genesis, composition and biogeography of the living regional faunas. Almost 80% of the Tertiary families and 42% of the genera survived in the SWA. Yet, in spite of the high percentage of surviving families, generic diversity declined considerably in many of them, as is exemplified specially by the Struthiolariidae, Muricidae, Buccinidae, Veneridae, Ostreidae and Pectinidae. Among all surviving Tertiary genera, 10% were already present in the area in Paleocene times, 31% in the Eocene, 29% in the Oligocene- Middle Miocene, and 30% in the Late Miocene. Endemic taxa such as *Trophon, Miomelon, Adelomelon, Odontocymbiola and Zygochlamys,* have been present in the area since Eocene times, and *Pachycymbiola, Retrotapes* and *Ameghinomya* since the early Miocene.

W10 - HIRNANTIAN ACRITARCHS FROM ANTICOSTI, CANADA (LAURENTIA) AND VALGA, ESTONIA (BALTICA): BIOSTRATIGRAPHIC IMPLICATIONS

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Palynological investigations of key Ordovician-Silurian boundary sections from Anticosti, Canada (Laurentia) and Valga, Estonia (Baltica) revealed several acritarch species that show high potential for local as well as long-distance biostratigraphic correlations. Due to facies differences on Anticosti, the correlations of the Hirnantian Ellis Bay Formation between the more offshore carbonate-dominated sections in the west and nearshore siliciclastic-dominated sections in the east have been problematic. However, definition of seven local acritarch biozones in the upper Vauréal, Ellis Bay and lower Becscie formations (uppermost Katian to lowermost Rhuddanian), suggests that the upper Ellis Bay Formation *sensu* Long & Copper (1987) in eastern Anticosti (Prinsta and Lousy Cove members) correlates with the upper Vauréal Formation (member 5) and the Ellis Bay Formation (members 1 to 6) sensu Petryk (1981) in western Anticosti. The acritarch-based biozonation largely confirms the recent correlations based on chitinozoans and indicates that the base of the Hirnantian as identified at the Vauréal-Ellis Bay transition in western Anticosti should be drawn in the mid-Ellis Bay Formation in eastern Anticosti. Additionally, comparative taxonomical study of the palynoflora of Anticosti and that of the Pirgu-Porkuni strata (Jelgava, Kuldiga and Saldus formations) of the Valga drill core, Estonia, revealed new acritarch species that are common to Laurentia and Baltica. This updates the potential of acritarchs for Upper Ordovician long-distance correlations between the two palaeocontinents. Noteworthy species belong to the genera *Oppilatala*, *Evittia*, *Ammonidium* and *Helosphaeridium*. Future acritarch investigations from Estonian sections should considerably improve these first observations and consequently refine low-latitude Hirnantian acritarch biostratigraphy.

S3 - PHYTOPLANKTON DYNAMICS DURING PERTURBATIONS ACROSS THE ORDOVICIAN-SILURIAN TRANSITION OF THE LOW LATITUDE CARBONATE PLATFORM FROM LAURENTIA (ANTICOSTI ISLAND, CANADA)

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Anticosti Island (Québec, Canada) exposes some of the finest sections spanning the Ordovician-Silurian boundary - a time of major paleoenvironmental perturbations (multiple Hirnantian glaciations) and global Mass Extinction Events. Refined by new sequence stratigraphy of the Anticosti Basin, detailed acritarch and carbon isotope investigations have been performed on strata of the upper Vauréal (upper Katian), Ellis Bay (Hirnantian) and lower Becscie (?uppermost Hirnantian-lowermost Rhuddanian) formations. Phytoplanktic communities display a turn-over in the lower Ellis Bay Formation with appearances of several taxa, some of which exhibit Silurian affinities (i.e., *Tylotopalla* sp., *Ammonidium* sp., *Oppilatala* sp., *Evittia* sp., *Dilatisphaera* spp.), during a glacially driven sea-level drop and a $\delta^{13}C$ positive excursion corresponding to terrestrial ice-sheet growth in northern Gondwana. At the top of the Ellis Bay Formation (Laframboise Member), phytoplanktic communities suffered a crisis, with disappearance of typical Late Ordovician taxa (i.e. *Orthosphaeridium* spp., *Peteinosphaeridium* spp., large *Baltisphaeridium* spp., *Sacculidium* sp.). The Laframboise Member crisis coincides with a second, stronger glacially driven sea-level drop and maximum $\delta^{13}C$ values, which may relate to maximal glaciation in Gondwana. Basal strata of the overlying Becscie Fm define deglaciation of the North Gondwana ice cap and sealevel rise, yielding low-diversity assemblages dominated by large acritarchs (*Hoegklintia* and other morphologically related forms), as well as few environmentally tolerant and long-ranging taxa (i.e., *Evittia remota*, *Micrhystridium* spp., *Leiosphaera* spp.). Similar phytoplankton trends are observed in northern Gondwana.

S8 - TOWARD A REFINED "HIRNANTIAN COMPOSITE STRATIGRAPHIC MODEL" FOR LAURENTIA, BALTICA AND NORTH GONDWANA

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Recent sedimentologic, palaeontologic and $\delta^{13}C$ data from the uppermost Ordovician key sections (Anticosti; Estonia; Morocco) provide new information leading to the establishment of a new "Hirnantian Composite Stratigraphic Model" for the Laurentia, Baltica and North Gondwana plates in a near future, providing a framework to improve understanding of the Hirnantian crises. The two glacial pulses recorded in Morocco, in the Lower Second Bani Formation (*elongata* Bz.), and in the Upper Second Bani Fm. (*oulebsiri* Bz.) may correspond on Anticosti, to those recorded in the lower Ellis Bay Fm. (*gamachiana* Bz.) and uppermost Ellis Bay Fm. (post-*taugourdeaui* Bz.). On Anticosti, the first regression correlates with a positive $\delta^{13}C$ excursion concomitant with faunal and floral changes (chitinozoans, acritarchs, conodonts, brachiopods, nautiloids, stromatoporoids, crinoids). The second, larger regression correlates with a stronger $\delta^{13}C$ excursion during time of impoverished diversity. The Riverside Wangjiawan Section (Hirnantian GSSP area, China) similarly exhibits two $\delta^{13}C$ excursions (in the *extraordinarius* and *persculptus* biozones). Also, compared to the subsiding Anticosti Basin, that avoided erosion associated with glacial regressions, Estonian sections show hiatuses in the Pirgu-Porkuni stages. Where the *gamachiana* Bz. is either missing or poorly represented (topmost Pirgu), only a single $\delta^{13}C$ excursion is noted in the Porkuni (*taugourdeaui*, *scabra*, post-*scabra* bzs.). In contrast, where the *gamachiana* Bz. is well represented (Kaugatuma), a first smaller $\delta^{13}C$ excursion is observed, as on Anticosti and in China. In the light of these new data, the base of the Hirnantian Stage could correlate with a horizon somewhere in the upper Pirgu, rather than the lower Porkuni.

S27B - THE LITHOSTROTIONIDAE (RUGOSE CORALS) FROM THE VISÉAN OF THE CAMPINE BASIN (BELGIUM AND THE NETHERLANDS) AND THEIR IMPLICATIONS FOR PALAEOGEOGRAPHY

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In Belgium, during the Early Carboniferous, two major basins were separated by the Caledonian Brabant Massif: the Namur-Dinant Basin in the South and the Campine Basin in the North. Differences between contemporary coral assemblages from the two basins are observed. Whereas the Namur-Dinant Basin was a relatively closed environment, the Campine Basin was an open environment with corals showing affinities with those of the British Midlands, Russia or North Africa. Viséan rugose corals of the family Lithostrotionidae have been recorded in several localities of the Campine Basin, especially in the Berneau railtrench and in the Gravenvoeren borehole. These corals show affinities with the fauna of Rhenania (Germany), which indicates coral migration between the Campine Basin and the Northwest of Germany. However, some differences exist: endemic species, such as *Happartophyllum furonensis*, have been observed in the Campine Basin. Furthermore, some species of Lithostrotionidae from this basin, such as *Siphonodendron kleffense* or *Lithostrotion araneum*, present morphometric differences from those of Rhenania; and so indicate the occurrence of geographical subspecies.

S26 - HIRNANTIAN (LATEST ORDOVICIAN) EVENT IN THE CENTRE OF NORTH AMERICA? COLOUR, CARBON ISOTOPIC EXCURSION, AND CONODONT TURNOVER

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In the carbonate succession of the Williston Basin in central North America, the Ordovician-Silurian boundary was previously equated with an abrupt change from a Late Ordovician conodont fauna to one of Early Silurian aspect including *Ozarkodina hassi*. This boundary had been located in the upper Stonewall Formation, in the vicinity of the red-coloured, argillaceous, *t*-marker bed. It was thought that latest Ordovician and earliest Silurian strata were probably absent due to a major regression caused by glaciation in Gondwana. The present study in the outcrop belt of Manitoba reveals a positive δ13Ccarb excursion beginning in the lower part of the *t*-marker bed, reaching a peak in the upper part of the bed or a short distance above it, and decreasing in the uppermost Stonewall. The *Ozarkodina* fauna appears at or near the peak of this excursion. On Anticosti Island, Quebec, the *O. hassi* zonebegins in the middle of the characteristic, latest Ordovician, Hirnantian isotopic carbon excursion(HICE). In northeastern Illinois, where the magnitude of the HICE peak is relatively low (values about +2.5‰), *O. hassi* appears in the upper part of the excursion where values are decreasing. In Manitoba, the coincidence of a positive excursion (maximum +2‰) with the appearance of the *Ozarkodina* fauna suggests that it may be the HICE. The upper Stonewall Formation may therefore represent deposition during at least part of Hirnantian time, recording the major biotic event involving conodont turnover. The Ordovician-Silurian boundary in the Williston Basin may be stratigraphically higher than previously thought.

S9 - UNUSUAL BIOLOGICAL ASSOCIATION EVENT WITHIN THE LATE FRASNIAN CRISIS

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In the northern part of the Namur-Dinant Basin (Southern Belgium), the Upper Frasnian strata show shelf facies including the carbonate unit of the upper member of the Aisemont Formation. It is mainly composed of bioclastic limestone, often dolomitized limestone with numerous oncoids, and a rich fauna of opportunistic organisms (bryozoans, brachiopods, gastropods, sponges, etc.). The massive rugose corals *Phillipsastrea* and *Frechastraea*, associated with the tabulate coral *Alveolites*, are particularly abundant and form one thin biostrome. Ragged colonies of corals, as well as multi-encrusted bodies, witness a soft sea bottom and a seasonal rate of sedimentation (Denayer & Poty, in press). These factors were unfavourable to common reef builders (stromatoporoids), thus the occurrence of one bed constructed by corals is a remarkable event that corresponds to the colonization of a hard ground defining the base of a falling stage systems tract. This fact confirms the model of the Aisemont sequence (third-order transgression-regression cycle, Poty & Chevalier, 2007) where the maximum flooding surface corresponds to the Lower Kellwasser Event. The abundant development of microbial structures in the member and in its southern lateral equivalent of the Petit-Mont Member (Les Valisettes Formation) is interpreted as an evidence of the progressive environmental deterioration corresponding to the Late Frasnian Crisis. The study of this unusual limestone and its palaeoecology permits to have a better understanding of the Late Frasnian Crisis, especially in a link with the sequence and extinction event stratigraphy.

S27B - LOWER CARBONIFEROUS RUGOSE CORALS FROM THE ZONGULDAK AREA (NORTHWESTERN TURKEY)

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Palaeozoic rocks crop out along the Black Sea coast between Istanbul and Bartin, in the northwestern part of Turkey. The Carboniferous, especially the Mississippian, is well exposed south of the coal basin of Zonguldak. Charles (1933) then Dîl (1975) gave preliminary descriptions of the macrofauna and foraminifers in which they recognized the major taxa and biozones of the European Lower Carboniferous. Sections in the Zonguldak Municipality show more or less continuously a succession from the Upper Devonian to the base of the Namurian. Lithostrotionid corals are very common in Zonguldak: “European” species such as *Siphonodendron ondulosum, S. martini, S. pauciradiale,* or *Lithostrotion araneum*, as well as more “exotic” species such as *S. asiatica* ocur. The same mix between European and Asiatic species is shown by the genus *Dorlodotia* with the very common *D. briarti* and the new species *D. euxini* evolving from the latter and giving birth to cerioid forms of *Dorlodotia* then to *Petalaxis*-like corals. Other “exotic” taxa present in northern Turkey include *Aphrophyllum* or *Kwangsiphyllum*. Palaeobiogeographic reconstructions of the Zonguladak area during the Carboniferous, based on foraminiferal distribution, have been proposed by Kalvoda (2001), who considered that the Zonguldak Terrane was close to the Ukrainian Donetz Basin. However, the corals from Zonguldak have very few affinities with those from the Lower Carboniferous of Donetz. Indeed, the Zonguldak Terrane was probably closer to the Western Europe Basin than to Donetz, and came under the influence of Asiatic provinces (South China?). During the Carboniferous, the Turkish block occupied a key position in the northern realm of the Palaeotethys.

S22 - SCHEME OF CHARACTERS IN CHONDRICHTHYANS (TEETH AND SCALES)

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The origin of teeth constitutes one of the most important unresolved questions in vertebrate evolution (Smith & Coates, 1998). Classically, teeth are considered to appear among chondrichthyans (extant rays and chimaera) from scales ('outside to inside' theory) during the Devonian, a period of innovations. But some authors considered that teeth evolved from branchial denticles ('inside to outside' theory) (Smith & Johanson, 2009). Palaeozoic chondrichthyans, show developmental schemes of teeth and scales quite different from extant chondrichthyans and contribute to our understanding of this question. The first undoubted shark teeth *Leonodus* Mader (1986) from the Lochkovian/Pragian of Spain (Turner 2004, Turner & Miller 2005) correspond to the first indication of a dental lamina (Botella 2006); placoderms are proposed not to have such a dental lamina (Smith & Johanson 2003). New material from the Emsian of Algeria, *Tassiliodus lessardi*, shows a unique assemblage of morphological and histological characters. Teeth are multicuspidate with three main cups and cusplets in an asymmetric lateral organization; the last ones are in a forward plane relative to the main cusps. Scales are characterized by meandering canals, emerging randomly at the surface and form a distinctive type of mesodentine. Furthermore, they show an unusual "onion-like" growth or "box-in-box" pattern with the earliest growth stage exposed partially at the scale surface. The type of scale growth does not correspond to any of the types defined by Karatajute-Talimaa (1998). Comparisons have been made with other scales, including *Wetteldorfia*, which is considered as an acanthodian. It is imperative that relationships between chondrichthyans and acanthodians are re-evaluated because *Tassiliodus lessardi* shows a mixture of chondrichthyan and acanthodian characters.

S3 - COEVAL MICROEVOLUTION OF TWO UPPER CENOMANIAN PLANKTONIC FORAMINIFERA GENERA IN RESPONSE TO OCEANIC ANOXIC EVENT

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Upper Cenomanian planktonic foraminifera *Rotalipora planoconvexa* and *Thalmanninella multiloculata* lack a keel or have one on only one or two chambers of the last whorl. These morphospecies are the same size as their keeled putative ancestor *Rotalipora cushmani* and *Thalmanninella greenhornensis*. It has been argued that *R. planoconvexa* and *T. multiloculata* preserve juvenile characters (i.e. the development of the keel is suppressed). Such a shift in developmental rate represents heterochrony like a neoteny *sensu* Gould. This phenomenon occurs when environmental conditions inhibit the completion of the development. Thus, the coeval persistence of juvenile traits both in *R. planoconvexa* and *T. multiloculata* would have allowed them to stay in shallower oceanic waters that would have remained more stable during the onset of the oceanic anoxic event 2.

S13 - CHANGES IN THE STYLE OF CARBONATE PRODUCTION IN THE TROPICS DURING THE END-ORDOVICIAN GLACIATION

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The latest Ordovician (Hirnantian) glacial event combines the growth of a continental-scale ice sheet, a severe two-phase mass extinction and a large carbon isotopic excursion. One of the best-exposed and most complete stratigraphic records from a paleotropical area spanning the Ordovician/Silurian boundary is on Anticosti Island in eastern Canada. High frequency glacio-eustatic fluctuations were the dominant control on the development of transgressive-regressive sequences observed in the Hirnantian Ellis Bay Formation of Anticosti Island. Two discrete glacial periods are recognized with the younger one recording large sea level changes (>50 m in magnitude) caused likely by the development of very large ice-sheets over western Gondwana. This younger glacial episode corresponds to a distinctive shallow marine limestone unit (known as the Laframboise Member) in the upper part of the Ellis Bay Formation. At the same time as a major faunal turnover (conodont, chitinozoan, acritarch, shelly faunas) and large carbon isotopic excursion, the Laframboise limestones are characterized by the sudden appearance of abundant oncolites, reefs dominated by calcimicrobes, and other microbial features. A comparison between the Laframboise succession and other coeval shallow-water tropical successions in Laurentia, Avalonia, Baltica, Siberia and South China shows that the style of global carbonate production changed from one derived largely from various carbonate-secreting organisms to one dominated by widespread microbial and/or oolitic production at a time of abrupt changes in oceanography and the global carbon cycle.

S3 - DETECTION AND CHARACTERIZATION OF EARLY EOCENE HYPERTHERMALS USING BENTHIC FORAMINIFERAL ASSOCIATIONS AND STABLE ISOTOPES

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Superimposed on the late Paleocene to early Eocene (60-50 Ma) "hothouse" was a series of transient events (<200 kyr) of extreme global warming, also known as hyperthermals. The most prominent and best-documented hyperthermal is the Paleocene-Eocene Thermal Maximum (PETM; ETM-1; ~55.5 Ma), which left a major mark on the biogeosphere evolution; the extinction of up to 50% of deep and shallow water benthic foraminifera being a prime example. In early Eocene deposits, two analog events named H1 (ETM-2; Elmo) and K (ETM-3; X-event), have primarily been recorded by means of their isotopic signature and physical properties, yet they are largely unexplored with respect to their biotic aspects. By studying these events, the sensitivity of early Eocene benthic communities towards changes in environmental conditions can be assessed. Lower Eocene deep-sea sediments from DSDP Site 401 in the Bay of Biscay (paleodepth ~2000 m) show a well-developed cyclicity in sediment color and carbonate content in calcareous nannofossil Zone NP11. In this interval, four darker, marly horizons stand out in the otherwise greyish-brown calcareous chalky lithology. Using information about lithology, calcareous nannofossil biostratigraphy, X-ray fluorescence (XRF) core scanning data and stable isotopic data, the position of H1, and the associated H2 event, has been inferred. Furthermore, the obtained quantitative benthic foraminiferal and benthic foraminiferal $\delta^{18}O$ and $\delta^{13}C$ data display the first evidence of biotic disturbance during these early Eocene hyperthermals.

S3 - PALEOCLIMATIC AND PALEOECOLOGICAL RECONSTRUCTION OF THE PLEISTOCENE-HOLOCENE SUCCESSION OF THE TYRRHENIAN MARGIN (CENTRAL ITALY): MICROPALEONTOLOGICAL RESULTS FROM THE TIBER DELTAIC AREA

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Micropaleontological studies on foraminifers, calcareous nannofossils and ostracods supported by radiometric (^{14}C dating), sedimentological and pollen analyses are carried out within the survey of the sheet 386 Fiumicino (Geological Map of Italy 1:50000 scale) in a high resolution core (Pesce Luna) drilled in the coastal plain 6 km north of the main Tiber River mouth (Central Italy). The study allows to better constrain the most important events in the Pleistocene-Holocene evolution of the Western Mediterranean area, especially during the last glacio-eustatic cycle. The studied succession (100 m depth) covers a chronostratigraphic interval ranging from the Lower Pleistocene (Calabrian stage - Emilian) to present time; the Middle-Upper Pleistocene deposits occur only for a reduced thickness. The integrated use of micropaleontological data allow us to identify assemblages corresponding to different environments covering the entire range from continental to marine environments (circalittoral, infralittoral, outer and inner lagoon). The preliminary results from pollen analysis, supported by ^{14}C dating, provide new important chronological and climatic constraints useful to a more detailed picture of Late Quaternary/Holocene succession of Tyrrhenian margin of Central Italy. In particular a late glacial phase (13140-12900 yr BP) and the onset of the Holocene (at about 11000 yr BP) coinciding with a progressive reafforestation trend were recognised. Micropaleontological data were processed by statistical analyses (multivariate analysis and cluster analyses).

S2 - INVITATION TO PALEOBIOLOGISTS TO DISSECT THE DYNAMICS OF EVOLUTIONARY STASIS WITH AN ECOLOGICAL LENS

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A topic of considerable interest and controversy concerns the dynamics of evolutionary stasis. In 1972, Niles Eldredge and Stephen Jay Gould hypothesized that most species lineages do not change their morphology appreciably—only fluctuating "mildly", with no apparent direction—during their history. Since then there have been many palaeontological studies supporting their claim. It is also now widely recognized that substantial, geologically ephemeral adaptation to unique and immediate environments can occur in local populations during a lineage's history. Here my interest is not to adjudicate the controversy over stasis (and its corollary that morphological change strongly correlates with speciation), but to invite palaeobiologists interested in the tempo and mode of evolution to view their data in a new way, that is, in light of its potential application to conservation biology. A major challenge facing conservation biology today is determining how biotic and abiotic context influences the direction and magnitude of the effects of global environmental change on species. We need to know which ecologically important traits are likely to evolve and keep species in the ecological game. Conservation biologists currently lack enough data across a broad range of traits and taxa to address this problem, which impedes the development of scenarios of the possible adaptive responses of species to future change. I propose that the data and methods palaeobiologists use to address the dynamics of evolutionary stasis are amply suited to address this challenge. We need an impassioned community effort to dissect stasis with an ecological lens.

S15 - TRACKING PALYNOLOGICAL SPECIES AS CLIMATE INDICATORS IN THE LATEST PERMIAN OF BULGARIA AND NW TURKEY

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Evolution of Phanerozoic climate change and links to biotic change can be tracked by fossil proxies. Our study focuses on the climate of the Late Palaeozoic, close to the extinction events at the P-T Boundary and recovery in Triassic. The study areas are located palaeogeographically in the tropical zone of the northern hemisphere (0° to 30°N, Laurasia): present-day Bulgaria and NW Turkey. Biostratigraphic work showed that sections of the Mirovo (Bulgaria) and Çakraz (Turkey) formations of both regions can be assigned chronostratigraphically to the latest Permian. Climate simulations for these times (Kiehler & Shields) indicate the seasonal mean surface air temperatures were approx. 20°C up to 35°C (40°C) in summer and winter. Palynomorph assemblages show pollen dominated compositions. In this study, the palynological record and vegetation patterns are relatively consistent with the reconstructions derived by the climate simulations. Our subsequent palynological work (including further locations) aims at a lateral, palaeobiogeographic comparison of species (latest Permian – climates at low and high latitudes), and on vertical comparisons of the palynological record (Permian into Triassic – tropical zone), to differentiate species dependent on climate control factors. First results show that specific pollen, such as *Alisporites tenuicorpus* Balme 1970, were present across high and low latitudes, while others may serve as climate indicators for the palaeotropical region. *Dictyophyllidites mortonii* (de Jersey 1959) Playford & Dettmann 1965 persisted in the study areas from the warm temperate latest Permian into the hotter Triassic, and hence, this species has no value as a specific 'latest Permian climate indicator'.

S20 - INK, SOFT TISSUES AND NON-MINERALIZED SKELETAL STRUCTURES IN THE FOSSIL RECORD OF CEPHALOPODS

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The oldest recorded ink sac and arm hooks belong to the Early Carboniferous coleoid *Gordoniconus* (Belemnoidea: Donovaniconida). The oldest cartilaginous tissue associated with a radula and arm hooks belongs to an unnamed Late Carboniferous coleoid from Oklahoma. Ultrastructural and chemical analyses of the last three structures reveal their different modes of fossilisation: diagenetic calcium phosphate mineralization of the walls between compartments in the first; reworking of organic material within a cavity in radula teeth and marginal plates by phosphorous-accumulating bacteria and forming internal moulds of them; calcium phosphate replacement of chitin in arm hooks. A Late Triassic ammonoid, *Austrotrachyceras*, shows a mantle in the body chamber and mandibles anterior to it. The mantle is a laminated carbon-replaced structure. Belemnite pro-ostraca and "fossil teuthids" gladia were originally chitinous; they are phosphatized and/or pyritized during diagenesis. In belemnite rostra an organic component with significantly higher content of C than in the rest of the shell was detected by EDS analyses. An organic capsule surrounding the phragmocone in the Late Cretaceous belemnite *Gonioteuthis* is preserved by replacement of organic material by sulphur-containing minerals.

S9 - EFFECTS OF LOWER/MIDDLE DEVONIAN EVENTS ON OSTRACODES FROM MOROCCO

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As regards Devonian events and their effect on ostracodes, both the Kellwasser- and Hangenberg-Event have been studied thoroughly. However, the smaller-scale events, such as the Daleje-, Choteč- or Kačák Events, have not been studied in detail so far. We present first results on the influence of these 2nd/3rd order events on the benthic ostracode faunas from six Moroccan sections (Bou Tserfine, Rich Tamelougou and Hassi Mouf in the Dra Valley; El Atrous, Jebel Amelane/Jebel Ihrs and Hamar Laghdad in the Tafilalt) which encompass the time span from the late lower Emsian to basal Givetian. Some ostracode taxa are ubiquitous, such as the long-ranging and globally widely distributed *Jenningsina planocostata*, which survives in Moroccan sections the Zlichov, Choteč and Kačak Events, re-occurring at all levels. Similarily, *Ulrichia acricula* is found at Bou Tserfine in Emsian and Eifelian limstones, but unlike *J. planocostata*, it does not reappear in the Givetian; thus, as far as we know at the present, it does not survive the Kačak Event. The globally long-ranging taxon *Bufina bicornuta* occurred in Morrocco even in strongly dysoxic black limestones. Other ostracode taxa are affected regionally by some of the events. For example, *Polyzygia kroemmelbeini* survives in the Dra Valley only the Zlichov Event, although it is known from the Eifelian in Poland. But besides, there are about 15 ostracode taxa, which are found only in Eifelian sediments so far, indicating that the Kačak Event was the most effective of the smaller-scale events as regards the ostracodes of the Dra Valley.

S27B - THE RECENT ASIAN CLAM *CORBICULA FLUMINALIS* (MÜLLER, 1774), ALSO IN THE MEDITERRANEAN PLEISTOCENE?

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Corbicula is a freshwater bivalve genus whose origins date back to the Early Jurassic. The taxonomy of the group has not yet been resolved, mainly due to the large intraspecific variability, and this is particularly remarkable in the case of the Quaternary to Recent species *C. fluminalis* and *C. fluminea*. *C. fluminalis* currently lives in Asian streams, with an origin indicated in the Euphrates River. As a result of human introduction this species is now expanding into North American and European rivers. Outcrops at Casa de Melero (Mula, Murcia, SE Spain), expose fossiliferous Pleistocene terraces formed by a succession of medium-grained sand, silty sand, sandstone and caliche. Melanopsids are the most common gastropod group, while *Corbicula* is the only bivalve genus present. The lower sandy unit contains paucispecific concentrations of molluscs, where *Corbicula* shells appear disarticulated. The upper silty sands present large numbers of specimens, mostly with articulated valves, in life position. Morphological and biometrical studies show that the populations are quite similar to the Recent *Corbicula fluminalis*, in the broadest sense of the taxon. This species lived in Europe during the Pleistocene, and being considered a thermophilic form in northern Europe, is considered to indictace interglacial conditions. The confirmation of *C. fluminalis* in southern European Pleistocene sediments will provide valuable data on the palaeogeographical distribution and migratory capabilities of the species in the past.

S27B - INTERTIDAL TO SHELF GRADIENTS ACROSS THE CENOZOIC

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Faunal gradients in intertidal to inner shelf settings at middle latitudes were reconstructed using two large quantitative data sets on mollusc assemblages. The first is from the lower-middle Eocene (Ypresian-Bartonian) of the Pyrenees and the Paris basin, the second from the Pliocene of the Mediterranean area. Both time intervals were characterized by greenhouse climates and global temperatures higher than today's. Eocene deeper subtidal communities from sandy bottoms had a very high diversity and were dominated by the same families as those of Pliocene seas, with similar abundance distributions. On the other hand, the distributions of mollusc families in intertidal and shallow subtidal settings show significant differences. For example, Eocene intertidal settings in Western Europe were dominated in abundance and diversity by the family Potamididae, a group of gastropods today thriving in mangrove-fringed coasts. Their diversity sharply decreases in the Pliocene, in favour of other families, until they disappear in the modern Mediterranean. Similarly, Eocene shallow subtidal bottoms were characterized by ampullinid gastropods, a group absent in the Pliocene and today experiencing a lowered global diversity. Diversity curves of some intertidal and shallow subtidal faunas, together with intertidal plants such as the mangroves, parallel global temperatures, suggesting a climatic control on the global shallow water biota. Whatever the controlling factors, the effect decreases at deeper shelf settings.

S19 - REGIONAL PATTERNS IN THE ALTERATION OF *CLOUDINA* IN WESTERN NORTH AMERICA

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Biomineralized skeletons of benthic organisms are first recorded in the Ediacaran period with the appearance of *Cloudina* (~548 Ma), an early metazoan with a millimeter-scale tubular, conical skeleton. *Cloudina* were examined from the Reed and Deep Spring Formations at several localities in White-Inyo region of eastern California and western Nevada. Preliminary observations indicate varying levels of diagenetic influence on the preservation of these early biomineralizers in the White-Inyo region. Qualitative analyses (thin-section petrography and cathodoluminescence) have shown significant variety in the alteration levels at the study sites, ranging from thoroughly dolomitized to completely unaltered. Additionally, there is a geographical pattern to this dolomitic alteration, with the highest levels generally found in the westernmost localities and lowest levels found in the east. Further analyses have been used to create a fully quantitative index for the levels of dolomitic alteration of the White-Inyo *Cloudina* specimens and the matrix in which they are preserved. This alteration index will be used to test the hypothesis that several previous interpretations of early biomineralizers from the White-Inyo region are incorrect and some (if not all) of the morphological characters distinguishing them from *Cloudina* are merely the result of the secondary dolomitic alteration of the shell material.

S8 - GONDWANA TO BALTICA TO AVALONIA TO LAURENTIA: *IOCRINUS* HALL (DISPARIDA), A GLOBETROTTING CRINOID IN THE ORDOVICIAN

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Arenig crinoids are rare globally, and are best known from North America and the British Isles. The first Arenig crinoid from the Arabian Peninsula is *Iocrinus* sp. cf. *I. subcrassus* (Meek and Worthen), known from two near-complete individuals, and numerous fragmentary specimens and ossicles. These specimens come from a coarse grained sandstone within the Amdeh Formation at Wadi Daiqa, south of Muscat, Oman. Faunal, ichnological and sedimentological evidence are indicative of nearshore, shallow water conditions. A latest Dapingian? to early Darriwilian age (Middle-Late Arenig) for the Wadi Daiqa exposures is supported by the evidence of palynology, trilobites and conodonts. These are the oldest *Iocrinus* specimens, and provide an unexpected extension of the palaeogeographic range of a genus known otherwise from slightly younger deposits in Laurentia (North America) and Avalonia (Wales). Although *Iocrinus* was first described and is best known from Laurentia, it appears to have originated on Gondwana and probably migrated via Avalonia. Its absence from Baltica is notable, although columnals from the Upper Ordovician of the Hadeland district of the Oslo region may be congeneric. *Iocrinus sensu stricto* has a proxistele of pentastellate section and strongly infolded cup plating. Three species from Wales and the Welsh Borders, previously placed in *Iocrinus*, each with a proxistele of pentagonal section and a smooth, conical dorsal cup, are reclassified within a new genus, type species *Iocrinus shelvensis* Ramsbottom. The new genus evolved from *Iocrinus* during the Llanvirn.

S27B - UPPER CRETACEOUS *ECHINOCORYS* LESKE (ECHINOIDEA) AS A HARD SUBSTRATE IN A MODERN SHALLOW WATER ENVIRONMENT

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The holasteroid *Echinocorys* is a common, robust echinoid of conservative morphology in the Upper Cretaceous - Danian chalks and limestones of northern Europe. It formed hard substrates that were infested by a variety of encrusters and borers during its life and after death. *Echinocorys* is also a durable fossil. Tests occur as clasts on the beach at Overstrand, Norfolk. Reworking from coastal and shallow marine sections has reintroduced Chalk *Echinocorys* into the benthic environment over 65 million years after its death and inhumation. Unsilicified *Echinocorys* tests form a taphonomic series. The oral surface is commonly not bored; this is the stable resting surface. Clean, unbored tests grade through specimens where the test calcite is perforated by *Entobia* isp. to remnants where most of the apical surface of the echinoid has been lost by boring, and the Chalk infill is perforated by *Entobia* isp. and *Gastrochaenolites* isp. Three principal lines of evidence are used to determine the time of occurrence of these borings: comparison with common Chalk borings known from *Echinocorys*; tests are invariably infilled with well lithified Chalk, but borings preserve no evidence of prior infilling; and the suite of borings are typical of modern lithoclasts on the beach. Lack of Cretaceous encrusting organisms and the absence of exotic borings like *Podichnus* indicate that all borings are recent; there is no indication of a mix of ancient and modern borings as has been noted in belemnites from Overstrand.

S27A - SEDIMENTARY PROCESSES AND PALAEOGEOGRAPHY AT THE DINOSAUR SITES, UPPER KHOK KRUAT FORMATION OF NAKHON RATCHASIMA PROVINCE, NE THAILAND

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This study aims to explain the sedimentary depositional processes and to interpret the paleogeography at the dinosaur site of the Suranaree and Khok Kruat subdistricts, Mueang District, Nakhon Ratchasima Province. Field observations at the excavation site included the collection of fossils, sedimentology, and stratigraphy. Fossil assemblages include dinosaurs (allosaurid, iguanodontid, and sauropod), pterosaurs, hybodont sharks, fish (*Lepidotes* sp.), crocodiles (*Khoratosuchus jintasakuli*), turtles (*Kizylkumemys khoratensis*), and carbonized plant compressions. The scattered deposition of the fossils suggests a fluvial environment. The sedimentary facies were subdivided into nine types as follows: Gms (matrix supported, caliche-siltstone pebble to cobble calcareous conglomerate with sandstone alternation), with all the vertebrate fossil types and plants; Gp (planar cross-bedded, caliche-siltstone pebble calcareous conglomerate), with all the vertebrate fossil types and plants; Ss (shell-bedded, caliche-siltstone granule calcareous sandstone), with shells, hybodont sharks, fish scales and plants; Sc (carbonaceous calcareous medium- to coarse-grained sandstone), with fish scales; Sm (massive calcareous sandstone); Sh (horizontally laminated fine-grained calcareous sandstone); Sr (rippled fine-grained calcareous sandstone); Fr (rippled, calcareous red siltstone, low resistance); and Fm (calcareous red mudstone, low resistance). The depositional processes were in a meandering system with crevasse splay and a shallow pond near the main river under semi-arid to arid conditions in the late Early Cretaceous.

S1 - USING REMOTE SENSING AND A GIS TO QUANTIFY ROCK EXPOSURE AREA IN THE UNITED KINGDOM: IMPLICATIONS FOR PALAEODIVERSITY STUDIES

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Rock exposure area is a better proxy for the amount of sedimentary rock available for study than the widely used measures of outcrop area or number of sedimentary formations. This is because the majority of fossil specimens are collected from exposed horizons. With the use of remote sensing and GIS it is possible to accurately quantify rock exposure area on a regional scale. Rock exposure area, at least in the UK, does not correlate well with either outcrop area or number of sedimentary formations and the proportion of rock exposed in different areas can vary considerably with proximity to the coast, bedrock age, land use and elevation. It is therefore evident that palaeodiversity studies that have used rock outcrop area or number of sedimentary formations as sampling proxies may have produced inaccurate conclusions. This novel technique offers an efficient and accurate method of quantifying regional sedimentary rock exposure and represents a significant step forward in the methodology of assessing the effects of geological bias on patterns in the fossil record.

S3 - A REVIEW OF THE PALEOCENE-EOCENE THERMAL MAXIMUM TEMPERATURE ANOMALY

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The Paleocene-Eocene Thermal Maximum (PETM; ca 55Ma) is a relatively short-lived (~200kyr) transient climatic event characterized by a prominent negative excursion in carbon isotopes, a prominent shoaling of the global carbonate compensation depth (CCD) and a widespread positive temperature anomaly. The combination of global warming and the release of large amounts of light carbon (*circa* 2000 – 6000 GtC) to the ocean-atmosphere system during the PETM have encouraged analogies to be drawn with modern anthropogenic climate change. The PETM is clearly a planetary-scale perturbation of the Earth's carbon cycle, biosphere and climate, however there remains considerable uncertainty over the size (and source) of PETM carbon release and the detailed climatic response to this release. Progress has been made in both these areas with sophisticated carbon cycle models providing new estimates of the scale of carbon release and the application of Mg/Ca and TEX_{86} temperature proxies to resolve the extent of ocean warming. There remains, however, large uncertainties in both model estimates of carbon release - and hence the associated atmospheric pCO_2 perturbation - and the magnitude and spatial pattern of PETM global warming. Here we provide a quantitative review and critical assessment of the available marine paleotemperature proxy data for the PETM. All of these proxy data are based on the chemical composition of fossilized tests or biomarkers of single celled organisms, and as such require the taxonomic, physiological and taphonomic understanding of micropalaeontologists for their reliable interpretation.

W8 - EVOLUTIONARY TREES FOR MITES

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Evolutionary trees for mites (Acari) have been constructed by plotting their known fossil record against the most recent phylogenetic classification down to superfamily level. Mites are a highly diverse assemblage which may or may not be monophyletic. Two major lineages are currently recognised – Parasitifomes and Acariformes – both with very different fossil records. The monophyly and possible sister group(s) of the mites are discussed. The oldest parasitiform mites are late Cretaceous ticks (Ixodida). Particularly noteworthy is the lack of fossils belonging to the highly diverse predatory mites (Mesostigmata), which are presently only known from the Palaeogene. Acariform mites have a considerably more extensive fossil record. They can be broadly split into the Trombdiformes and Sarcoptiformes lineages, both of which have unequivocal records from the early Devonian. Among trombidiform mites, Sphaerolichida lacks a fossil record but the diverse Prostigmata can be divided into four main groups: Labidostomatides (no fossil record), Eupodides (Devonian), Anystides and Eleutherengonides (both Cretaceous). Among sarcoptiform (or 'chewing') mites both Endostigmata and Oribatida have Devonian records. Oribatid (box or beetle) mites have the most complete palaeontological record of any mite group. Phylogeny is broadly consistent with the appearance of taxa in the fossil record; basal oribatids from the Palaeozoic predate more derived lineages known from the Mesozoic onwards. Astigmata are recognised by some workers as a subgroup of the oribatids. Their fossil record is very poor and only extends back to the Neogene.

W9 - THE CRANIAL ANATOMY OF *ROMUNDINA STELLINA* ØRVIG, 1975 (VERTEBRATA, PLACODERMI, ACANTHOTHORACI) REVEALED BY SYNCHROTRON SCANNING.

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The acanthothoracid placoderms are among the most phylogenetically basal and morphologically primitive gnathostomes. However, their endocranial anatomy is not well understood; only one genus, *Brindabellaspis,* has been described in detail. Here we present a near-complete three-dimensional skull of *Romundina stellina*, a small Early Devonian acanthothoracid from the Canadian Arctic Archipelago, scanned at the European Synchrotron Radiation Facility, Grenoble, France, at a 7.45 µm resolution. Despite some loss of material along an oblique crack, most of the internal structures are remarkably preserved. Each postethmoid cranial and craniospinal nerve can be followed between the well-preserved endocranial cavity and the walls of the perichondrally ossified neurocranium. The minute nerve canals that supplied the neuromast organs of the sensory line system are preserved and can in the postorbital area be traced directly to a branch of the facial nerve. Both inner ears are present. The vascular mesh of the dermal bones has been reconstructed in detail, rendering visible the dermal plate boundaries of the skull roof, and is shown to connect to larger internal veins that drain to the edge of the braincase or into the jugular vein canal. The curvature of the latter vessels parallels the outer surface of the inner ear and may demarcate the boundary between otic capsule proper and applied hyoid arch material. Overall, the braincase morphology appears less extreme (and less primitive?) than that of *Brindabellaspis*, in some respects more reminiscent of a primitive arthrodire such as *Kujdanowiaspis*. These differences may illuminate the earliest stages of placoderm cranial evolution.

W6 - VERTEBRATE HOMOLOGIES AND ANALOGIES IN THE CONODONT ORAL APPARATUS

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The gradation of element morphologies in the conodont apparatus is so similar to patterns observed in many other unrelated animals that its food-processing function seems rather obvious. The occlusal surface of conodont elements grew by adding layer by layer of calcium phosphate from the outside. It tended to become robust and complex in the posteriorly located elements of the apparatus. This is a close analogy (perhaps a homology) to the enamel of vertebrate teeth. However, conodont elements did not erupt, which is the main difference between them and vertebrate teeth. Regeneration of broken cusps, denticles, and whole processes provides direct evidence that conodont elements were involved in mechanical action while being permanently covered with secretory soft tissue. Imprints of secretory cells are visible on the surface of some conodont elements, mostly in areas with the fastest growth rate. By analogy with vertebrates the smooth surface of conodont elements was likely secreted under a basement membrane of the secretory epithelium, whereas in fast-growing regions, where the membrane was missing, secretory cells directly contacted with the phosphatic tissue, leaving imprints on its surface. A fundamental question that must be answered is how they were able to act mechanically while being secreted. The complex regulation of their morphogenesis, with a need of precisely addressed transport of calcium and phosphate ions, requires that there was a highly organized and thick cover of soft tissues above the secreted conodont element. It seems unavoidable to assume that the occlusal surface (perhaps keratinous) was above this tissue.

S2 - ON THE ORIGIN OF SPACES: DEVELOPMENT, MACROEVOLUTION, AND THE PLACEMENT OF THE DIVERSITY OF BIOLOGICAL SPACES, BOTH REPRESENTATIONALLY AND CAUSALLY, IN THE EMERGING NEW STRUCTURE OF EVOLUTIONARY THEORY

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The plurality of biological spaces (morphospaces, ecospaces, developmental spaces, functional spaces, etc.) is now commonplace in the representation of biological entities. The theoretical framework of state spaces, qualified and diversified, raises new questions about pattern and process in macroevolution and has rich potential to contribute to the structure of evolutionary theory, as both a central notion and as a source of distinct factual domains, and is of broad relevance to theoretical renovation across evolutionary biology. Biological space representations harbour distinct information content, dimensionality and causal status (objects and variables having a host of other meanings and interpretations in time and space and various scales and levels). Morphospace, in particular, is not a tabula rasa; it has a history and its own structure. If so, it is a natural entity in its own right, subject to change, and having perhaps unsuspected emergent properties still to be discovered. It certainly has a dynamics, a morphospace tectonics, that, whatever its causes (logically necessary or contingent, modulated by environment, development, and ecology, adaptive or self-organized), is a motor of change as substrate in the partitioning of morphological diversity into a topography that can take many forms. A plurality of morphospaces need neither be arbitrary nor simply heuristic or operational. It may be natural and necessary that different carvings of biodiversity can be justified on logical and epistemological grounds. Evolutionary theory is missing conceptual space for spaces, as empirical and theoretical units in the growth of evolutionary thought.

S6 - MORPHOLOGICAL CHANGE THROUGH TIME IN *PTEROTRIGONIA* (TRIGONIOIDA – BIVALVIA) FROM PICÚN LEUFÚ FORMATION (LOWER CRETACEOUS, NEUQUÉN BASIN)

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This contribution is part of a project applying different morphometric techniques to fossil bivalves in order to understand the relationship between shape and function (hence to environment), and to check for particular changes in form through time, seeking historical (phylogenetic) explanations. The genus *Pterotrigonia* (Trigonioida – Bivalvia) is a well-defined group, diverse and abundant in the Mendoza Group, Neuquen Basin, Argentina. The Picún Leufú Formation comprises Middle Tithonian to Early Berriasian carbonatic ramp sediments. Shell shape and ornamentation were analyzed in samples from that unit. The overall shell shape was analyzed by means of both traditional and geometric morphometrics. For the first type of analysis the ratio “height with rostrum/height” was considered, while for the second, a semilandmark analysis was performed. Both of these indicate a major change through time in the projection of the rostrum, from dorso-posterior to eminently posterior. Different models for the analysis of ornamentation were applied in order to quantify every variable. For flank costae a linear model was used to describe their distribution along the marginal carina, while the costae divergence along the flank (i.e., the progressive separation from the carina to the ventral margin) was analyzed by means of a logistic model. The arrangement of costae along the marginal carina within each species remained unchanged throughout the analyzed strata, although individuals belonging to other species are easily differentiated. As costae divergence seems to be strongly correlated with size, its change may be, in fact, linked to their ontogeny.

S3 - PLANKTONIC FORAMINIFERAL RESPONSE TO THE MIDDLE EOCENE CLIMATIC OPTIMUM

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Superimposed on the long-term Eocene cooling trend at approximately 40 million years ago (Ma) is a transient (~600 thousand year, kyr) global warming event, the Middle Eocene Climatic Optimum (MECO). Little is known about biotic turnover during the MECO because previous work has focused on documenting only the long-term Eocene faunal evolution at multi-million year resolution. In addition, the time interval in which the MECO falls has typically proven difficult to investigate because a near-global hiatus truncates many existing deep-sea records at ~40 Ma. One exception is Ocean Drilling Programme (ODP) Site 1051 (Blake Nose, western North Atlantic), from which an expanded and complete (at least to magnetochron level) sedimentary section was recovered containing well-preserved calcareous microfossils. Here we present quantitative high-resolution faunal records of the major groups of planktonic foraminifera that encompass the precursor climate state, the MECO and the aftermath, ~39.5 to 41.0 Ma. Our records reveal that these planktonic foraminiferal groups underwent marked changes in abundance, significantly above background levels, during the MECO. The overall assemblage shift suggests a response to a gradual change from relatively warm and oligotrophic surface waters to warmer, more nutrient-rich conditions, with the most abrupt changes coincident with the peak of the MECO, followed by rapid cooling of surface waters.

S2 - EVO-DEVO AND THE LIMITS OF THE SYNTHESIS

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The architects of the Modern Synthesis could not and did not predict the findings of evolutionary developmental biology (evo-devo) with respect to the conserved nature of animal body patterning at a genetic level; to the contrary, Mayr drew on Dobzhansky to suggest that such a search for deep genetic homology or a common set of rules for building distantly-related organisms was futile. Though evo-devo is readily reconciled with the core of the Synthesis in terms of “normal” within-population variation and mutation being sufficient to serve as sources for evolutionary change over deep geological time, it offers a fundamental departure in terms of understanding how phenotypes originate. Indeed, the evo-devo focus on causal links between phenotypes across broad swathes of the Tree of Life brings the discipline of morphology to the evolutionary high table (a position it did not occupy in the Synthesis). As far back as Maynard Smith’s theory on a multiplicative process of segment generation, variation in trunk segment numbers in centipedes has been a staple of a developmental (rather than selection-focused) perspective on the origin of evolutionary novelty. A phylogeny derived from combined morphological and molecular sequence data, its time dimension calibrated by fossil occurrences, informs on the evolution of developmental genetic characters for centipede segmentation. Such facts as segment numbers being consistently odd (and its implicit double-segmental periodicity of segment generation) expose a developmental bias on evolvability.

PLENARY - BIOMOLECULAR PALAEOBOTANY – MOLECULAR RECORDS OF CONTINENTAL VEGETATION IN THE QUATERNARY

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Plant lipids carry the imprint of their biosynthetic origin in their strong, carbon–carbon bonded, molecular structures, which can be preserved over millions of years buried in ancient sediments. Leaf wax molecular signals are dispersed and persist on the global scale, surviving the numerous decay and diagenetic processes involved in plant death and consumption, wild fires, soil deposition and erosion, transport over thousands of kilometers in rivers and as aeolian dust, and finally deep-sea sedimentation and burial. Although few types of biomarker lipids are species-specific, most can serve as indicators of the biosynthetic origin and physiological conditions involved in forming them, such as e.g. C_3/C_4 carbon fixation pathways and leaf water stress, and hence serve as palaeoclimate proxies. For example, the molecular abundance patterns and isotopic contents (^{13}C, ^{14}C and D) of fossil cuticular wax components, such as the homologous carbon number series of longer than C_{24}, straight-chain alkanes, alkanols and alkanoic acids, can provide valuable records of palaeovegetational change and hence past environmental conditions. This compound-specific, isotopic approach avoids the averaging effects inherent in the classical isotopic and elemental analysis of bulk organic matter, provides complementary information to that afforded from pollen analyses, and has been successfully applied to Quaternary marine sediment cores globally. Examples include sites adjacent to the African continent, northern South America, the Arabian Peninsula, and the Indian sub-continent. Continuing improvements in analytical capabilities permit high-resolution multi-molecular proxy reconstructions, and extend the approach to a broader range of paleoclimate archives, including soils, lake sediments, loess-palaeosol deposits and glacial ice.

S2 - PALAEONTOLOGY AND THE DAWN OF EVOLUTIONARY THEORY

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Much of modern evolutionary palaeobiology is centred around the notion of species as stable entities, with discrete births and deaths: punctuated equilibria, species selection/sorting, species as particles, hierarchy theory—and, of course, the “species as individuals” literature all construe species this way. While the notion of species as real, discrete and stable entities represented a novel departure in the1970s and 1980s, it turns out it had been a dominant theme at the very outset of evolutionary biology. Giambattista Brocchi’s 1814 monograph on the Tertiary fossils of the subappenines in Italy—and their relation to the living molluscan fauna—contains a transmutational perspective (“Brocchian transmutation”). Brocchi saw species as discrete and fundamentally stable entities, proposing that species have inherent longevities, eventually dying of old age unless driven to extinction by external forces. “Brocchi’s analogy” states that births and deaths of species have natural causes, analogous with those of individuals. Sequences of births and deaths of species produce genealogical lineages of descent, and faunas become increasingly modernized through time. Darwin learned of elements of Brocchian transmutation in Jameson’s 5th edition of his translation of Cuvier (1825) and Herschel’s *Preliminary Discourse* (1830). Darwin began openly flirting with Brocchian transmutation when he discovered fossils in 1832 at Bahia Blanca. Twelve years later Darwin stated that it was (Brocchi’s) analogy that first brought him to evolution.

S8 - DID STORMS HAVE A ROLE IN THE GREAT ORDOVICIAN BIODIVERSIFICATION EVENT? EVIDENCE FROM CORALS IN A LAURENTIAN STORM-SWEPT EPICONTINENTAL SEA

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Corals became a major faunal component during the Ordovician Period. The palaeocontinent Laurentia was an important centre of diversification. High diversity was attained in the Red River-Stony Mountain Province of Late Ordovician, Cincinnatian age. This biogeographic province included a vast area of the storm-swept epicontinental sea. Most of the solitary rugose corals lived unattached on soft substrates. They were susceptible to overturning during high-energy events, often resulting in fatalities. Therefore, strategies that improved stability had a selective advantage, which led to speciation and divergence of genera. Such strategies included corallum shapes that provided better support on the substrate and reduced drag due to currents, and thicker skeletal parts that increased weight, lowered the centre of gravity, and improved balance. In the case of tabulate chain-corals, the mode of colony growth provided stability under high-energy conditions and enabled recovery from influxes of sediment. This contributed to the success of genera, permitting diversification of species. The corallum of a chain coral, anchored in soft substrate, provided a broad, stable base. The arrangement of corallites in meandering ranks allowed polyps to shed sediment anywhere on the colony surface. The spaces enclosed by these ranks were effective reservoirs for rejected sediment and for shifting sediment that encroached on the coral. The colony had considerable regenerative abilities, permitting rapid recovery from partial mortality caused by influxes of sediment. Evolutionary innovations that promoted survival in storm-swept epicontinental seas seem to have been a significant factor in the success of corals during the great Ordovician biodiversification event.

S26 - GEOCHEMICAL RECORD OF MARINE ANOXIA DURING THE IREVIKEN EVENT

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The Silurian Ireviken Event near the Llandovery/Wenlock boundary is interpreted as a time of environmental, biotic and isotopic perturbations of the paleo-ocean. Eight discreet extinction datums are recognized during this event. While conditions responsible for the extinctions remain poorly understood, several researchers have proposed that water-column anoxia had a significant role. Chemical analyses of conodonts, brachiopods, and micritic carbonate from a section in Gotland, Sweden through the Ireviken Event detected systematic changes in the abundance of redox sensitive elements. Ce*, Eu*, U/Th and other element concentrations indicate conditions, outboard of this shallow platform environment, become increasingly reducing through the event. Short-lived, signatures of anoxia occur at datums 1-3. At datum 4 these signatures reach maxima that persist through the remainder of the event. Increased REE, Fe, and Mn contents during anoxic episodes are best explained by the transfer of elements released by dissolution of oxy-hydroxides in sediments to the water column. This interpretation is consistent with changes from red to green shale to gray-black pyritic shale through this event in Europe, eastern North America and elsewhere. The temporal correlation between indicators of anoxia with extinction datums at several locations and the global $\delta^{13}C$ excursion are evidence that the anoxia was global in extent.

S14 - PHYLOGENY ESTIMATION BASED ON FOSSIL PROTEIN SEQUENCES: A CASE OF EXTINCT LAND SNAILS FROM THE BONIN ISLANDS

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Fossil proteins are potentially useful for phylogeny estimation of extinct forms because they are always present in the specimens in which ancient DNA are preserved, and may also exist in vast varieties of fossils that would contain no DNA (such as shells). *Mandarina luhuana*, a land snail species that became extinct no older than 1000 years ago, provides an interesting opportunity to explore this potential because its phylogenetic position is both enigmatic and relevant to such evolutionary problems as migration to and adaption in oceanic islands. A sequence comparison of the genes encoding the shell matrix protein Dermatopontin among several living species of *Mandarina* (endemic to the Bonin Islands) and its sister group genus *Euhadra* (widely distributed in mainland Japan) demonstrated that the amino acid sequences vary considerably between *Mandarina* and *Euhadra*. This fact indicates that Dermatopontin is informative for the inference of phylogeny in this species group. Immunological assays on shell extracts using antibodies prepared against a synthetic partial sequence of Dermatopontin confirmed that the protein sequences are present in both living and fossil shells, with an estimated amount in the latter being about 1-2 % of the former. Further analysis of the shell extracts of *Mandarina luhuana* is currently underway to determine the amino acid sequence of fossil Dermatopontin using liquid chromatography and tandem mass spectrometry.

S26 - SURFACE-WATER ACIDIFICATION PRECEDES DEEP-WATER CARBONATE DISSOLUTION AND ANOXIA DURING OCEANIC ANOXIC EVENT 1A

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The Early Aptian (~120 Ma) Oceanic Anoxic Event (OAE)1a was caused by massive addition of volcanic CO2 to ocean and atmosphere that should have lowered seawater pH. Calcareous nannofossils trace early acidification of surface-water in Tethys and Pacific Oceans. The demise of heavily calcified nannoconids and reduced calcite paleofluxes marks the beginning of the pre-OAE1a calcification crisis, while ephemeral coccolith dwarfism and malformation represent remarkable species-specific adjustments to survive maximum acidity. Abundance peaks of peculiar nannoliths trace intermittent alkalinity recovery. Deepwater acidification occurs with a delay of 25-30kyr. Onset of OAE1a is preceded by a dissolution event recording 1 to 2km shallowing of the CCD not related to anoxia. After dissolution climax, nannoplankton and carbonate recovery developed over ~160 kyr, under persisting global dysoxia-anoxia.

S27A - FOSSIL FAECES FROM THE UPPER CRETACEOUS OF SOUTHERN SWEDEN

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Coprolites (fossilized faeces) are common fossil elements in the Upper Cretaceous (informal *Belemnellocamax mammillatus* belemnite zone) shallow marine strata of Åsen, southernmost Sweden. They are associated with a diverse vertebrate fauna and represent at least seven different morphotypes that suggest a variety of source animals. Their faecal origin is corroborated by several lines of evidence, including chemical composition (primarily calcium phosphate), external morphology, and nature of the inclusions. Their preservation in a fossil coquina, interpreted as a taphocoenosis, suggests early phosphogenesis promoted by rapid entombment. Such early lithification would prevent disintegration of the faecal matter and facilitate transportation and introduction to the host sediment. The sizes and morphologies of the coprolites suggest that most, if not all, were produced by vertebrates. The largest specimens (up to 6 cm in maximum diameter) infer a host animal of considerable size. Two spiralled coprolite morphotypes include bone fragments and scales of bony fish, suggesting that the producers were piscivorous sharks. Other coprolites contain inclusions interpreted as the remains of shelled invertebrates, thus indicating that they may have derived from durophagous predators and/or scavengers. The occurrence of small scrapes, tracks and traces on several specimens suggest manipulation of the faeces by other (presumably coprophagous) organisms after deposition. These data provide new insights into the trophic levels of a shallow-water Late Cretaceous marine ecosystem hitherto known solely from body fossils.

S27B - LOWER DEVONIAN (EMSIAN) CYSTOPORATE BRYOZOAN FAUNA FROM NORTHWESTERN SPAIN

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Bryozoa were abundant and diverse worldwide in the Devonian; however, their use for stratigraphical and palaeobiogeographical studies is limited due to insufficient investigations of regional faunas. Bryozoans can be reliable indicators of environmental conditions and useful for palaeobiographical analysis. A new bryozoan fauna has been identified from different localities in the Cantabrian Mountains, NW Spain. The fauna has been recorded from the La Vid and Esla formations (Lower Devonian, Emsian), which represent highly fossiliferous carbonate platform deposits. These sedimentary sequences are the result of the combined effects of sea-level tectonic changes and synsedimentary tectonics. Abundant and diverse fossils (bryozoans, brachiopods, solitary corals and echinoderms) are associated with limestones, marlstones and shales. The cystoporate bryozoan fauna from these deposits is represented by 12 species from four genera. The fauna shows possible palaeogeographical affinities with North America.

S18 - THE RISE AND FALL OF PIKERMIAN CHRONOFAUNA

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We build on previous research to integrate the evolution of Pikermian-type mammal faunas to their ecologic, climatic and paleogeographic contexts. We use similarity index comparisons to map out the spatial extent of the Pikermian fauna, and how it developed over time. We then use recently developed late Miocene palaeo-climatic and palaeogeographical reconstructions to assist in our interpretations. Our results show that at the European scale there is clear pattern in the rise and fall of the Pikermian fauna, and that this is connected to a change in community structure towards more hypsodont herbivore communities. Higher hypsodonty is interpreted as an adaptation to drier conditions. Our results confirm that this development was asynchronous regionally. Our results suggest that changes in atmospheric circulation pattern, via changes in rainfall and pressure systems, had a direct effect on the structure of the late Miocene mammal communities. There was a strong connection between paleogeographic reorganisation, changes in atmospheric circulation pattern and development of faunal provincialism. Pikermian faunas spread from Central Asia to Eastern Mediterranean during the early late Miocene, and this faunal development climaxed during the latest late Miocene, around 8-5 Million years ago as the Pikermian biome, when the associated taxa spread to much of Europe and Asia. The disappearance of Pikermian faunas happened 5 to 4 million years ago. After this time there were no longer such taxonomic associations Eurasia. The reasons for the disappearance are not clear.

S27B - MIDDLE EOCENE OSTRACODA AND BENTHIC FORAMINIFERA FAUNAS FROM THE KAZAN BASIN, CENTRAL ANATOLIA, TURKEY

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The Tertiary Kazan Basin is located in central Anatolia, northwest of Ankara city. After the closure of the northern branch of the Neotethyan Ocean in the Late Cretaceous, the basin was filled with sediments originating from continental environments. The only exception to this terrestrial deposition is the Middle Eocene Akpınar Formation, deposited under shallow marine conditions. The Akpınar Formation is located at the centre of the Tertiary Kazan Basin and is dominated by thick-bedded limestones with medium to thin marl interbeds. The marls and limestones are very rich in micro- and macrofossil faunas, including foraminifers, ostracods, molluscs (bivalvs and gastropods), echinoids, corals, algae and crabs. The foraminiferal fauna of the formation is dominated by *Alveolina* species in the lower part, but species of *Nummulites* gradually become dominant in the upper levels. *Alveolina tenuis* Hottinger, *A. orhaniyensis* Acar, *A. nuttalli* (Davies) and *A.* cf. *kieli* Sirel indicate an Early-Middle Lutetian age for the lower part of the sequence. In the upper part *Alveolina elliptica* (Sowerby) becomes dominant and a grainstone layer very rich in *Assilina exponens* (Sowerby) along with *Nummulites aturicus* Joly & Leymerie is present at the uppermost levels. In the central part of the basin the uppermost part is dominated by *Fabiana cassis* (Oppenheim), *Gyroidinella magna* (Le Calvez) and *Gypsina marianensis* Hanzawa, which indicate a Middle-Late Lutetian age. *Asterigerina rotula* (Kaufman), *Orbitolites complanatus* Lamarck, *Linderina brugesi* Schlumberger, *Sphaerogypsina carteri* Silvestri, *Sphaerogypsina globula* (Reuss), *Planorbulina brönnimanni* Bignot & Decrouez, *Neorotalia vionetti* and *Amphistegina* sp. are the other benthic foraminifers. The ostracod fauna includes *Cytherella* sp., *Bairdia (Bairdoppilata) gliberti* Keij, *Bythocypris* sp., *Cytheretta* cf. *sculpta* Ducasse,

Pokornyella sp., *Horrificiella* sp., *Hermanites alatus* Ducasse, *Krithe* sp., *Schizocythere appendiculata* Triebel, *Echinocythereis* sp., *Pterygocythereis* sp., *Xestoleberis convexa* Deltel, *Paracypris* sp., *Grignoneis* sp., *Limburgina* sp. and *Quadracythere vermiculata* Bosquet. This fauna can be correlated with the Middle Eocene of the French Basin.

S2 - MACROEVOLUTION IS NOT ONE THING: THREE STYLES OF 'MACROEVOLUTIONARY' CHANGE

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Macroevolution initially was applied to theories associated with the production of large-scale morphologic novelties in a lineage (Macroevolution I), or the generation of variation. As Simpson noted, by the 1950s palaeontologists assumed that macroevolutionary *patterns* could be explained by microevolutionary *processes*. But he recognized this was a conclusion born of ignorance, not evidence. By the 1980s macroevolution was implicitly re-defined to address differential sorting, and possibly selection, between species and clades to generate evolutionary trends and other patterns in the fossil record (Macroevolution II). Recent studies of the evolution of development are suggesting differences in the introduction of morphologic variation through changes in regulatory patterning may be important sources of macro-evolutionary change. Studies of major evolutionary transitions, spurred by Maynard Smith and Szathmary, indicate that these events may often be associated with non-uniformitarian changes in the focal point of selection. Although it has not been widely appreciated, this forms a third style of macroevolutionary change (Macroevolution III). Moreover, such non-uniformitarian processes are not necessarily limited to major evolutionary transitions. Davidson and I have argued that comparative studies of development in sea urchins and starfish suggest a non-uniform pattern of evolutionary change across the *cis*-regulatory gene networks. Specifically, the formation of small sets of recursively wired gene interactions (kernels) seem to be responsible for regional patterning of the developing embryo. After formation, these kernels appear to change the patterns of allowable morphologic evolution, underpinning morphologic discontinuities. Evolutionary theory must recognize these three different styles of macroevolution and their underlying processes.

S19 - NEW ALOKISTOCARIDAE (ALTIOCCULINAE, TRILOBITA) FROM THE MIDDLE CAMBRIAN OF SPAIN

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Although ptychopariids are abundant trilobites during Cambrian times their phylogenetic relationship is poorly known. The order represents a basal trilobite group, and some of them could belong to the stem groups of some post-Cambrian trilobite clades. A new ptychopariid with alokistocarid affinities was found in the Iberian Chains (NE Spain), representing the first evidence of the Family Alokistocaridae in west Gondwana. The new trilobite has been found in a thin layer (ca 0.5 m in thickness) of red mudstones, rich in several types of fossils: echinoderms, brachiopods, sponges and different trilobites. The trilobite *Solenopleuropsis thorali* indicates an age of lowermost Languedocian (middle Cambrian). This new find allows a renewed cladistic analysis of this family. In addition, other gondwanan trilobites with uncertain affinities were also included as *Schofaspis granulosus*, *Chelidonocephalus anatolicus*, *Derikaspis toluni* and *Kounamkites multiformis*. This analysis suggests a clear hypothesis of the relationships of the Family Alokistocaridae. As a consequence the family can be divided into two subfamilies, Alokistocarinae and Altiocculinae. The Spanish trilobite and *Schofaspis granulosus* fall in the latter subfamily. This analysis demonstrates a possible relationship between alokistocarids and those trilobites with uncertain affinities, previously assigned to different families.

S27D - THE PURUJOSA TRILOBITE ASSEMBLAGE AND ENROLMENT STRATEGIES IN CAMBRIAN TRILOBITES

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Although trilobites preserved in enrolled posture are common in post-Cambrian rocks, this condition is generally rare in the Cambrian. A newly discovered ca 50 cm thick red mudstone from the lower Languedocian (Cambrian Series 3) of Purujosa (Zaragoza, NE Spain) contains abundant enrolled trilobites. This 'Purujosa assemblage' has enrolled representatives of five genera: *Peronopsis, Eccaparadoxides, Solenopleuropsis, Conocoryphe*, and a new Alokistocaridae. The assemblage is unique in the Cambrian for the abundance and diversity of enrolled trilobites and variety of enrolment-types, and provides important insights into the enrolment capacity of phylogenetically basal trilobites. Two enrolment strategies are evident. Those trilobites with long genal-spines (e.g. *Eccaparadoxides*) enrolled by first flexing the pygidium downward, and then by flexing more anterior trunk segments downward and forward from the rear in a progressive manner so as to lap the posterior of the trunk beneath the cephalon with the outer rim of the pygidium (sphaeroidal or basket-and-lid enrolment-type). Those trilobites with short genal-spines (e.g. *Solenopleuropsis*) pulled both cephalon and posterior trunk down, slotting the pygidial doublure into a vincular furrow at the margin of the cephalic doublure or against the doublure (sphaeroidal or spiral enrolment-type). The presence of the major styles of enrolment both within and among genera in a single bed indicates that the major styles of enrolment were already present among phylogenetically basal trilobites and that individual taxa could show a variety of enrolment styles. The question of why this locality preserves such a diversity of enrolled trilobites remains open.

S9 - ASSOCIATIONS AND DIVERSITY DYNAMICS OF FRASNIAN-EARLY FAMENNIAN OSTRACODS IN THE CENTRAL PART OF THE EAST EUROPEAN PLATFORM, RUSSIA

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The area under consideration in the central part of the East European Platform, historically called the Central Devonian Field (CDF), demonstrates significant variations of sediments and habitats within a shallow-water epeiric environment. In the Frasnian and early Famennian strata of the CDF, ostracods are an important component of the fossil assemblages and occur almost ubiquitously. An analysis was made of the associations obtained from samples collected in the main reference outcrop sections and derived from a number of drill cores. The associations recovered belong to the Eifelian Mega-Assemblage and are indicative of shallow open-marine environments or protected-marine, near-shore habitats. The characteristics of ostracod associations were assessed through species diversity and abundance. The ostracod faunas demonstrate significant changes in dominance and diversity likely caused by regression-transgression couplets in the shallow-water environment. The general distribution pattern shows three remarkable changes in composition of the ostracod associations, coinciding with the onsets of the middle (*Pa. punctata*) and upper Frasnian (*Pa. semichatovae*) transgressions as well as with the Frasnian/Famennian boundary. The early/middle Frasnian boundary interval is marked by an abundant and diverse middle Frasnian ostracod association having no species in common with the early Frasnian one. The middle and upper Frasnian associations show a closer affinity. Most upper Frasnian associations are dominated by long ranging species. The Frasnian/Famennian boundary interval in the CDF is characterized by a remarkable stratigraphical gap, which is supposed to span the whole *Pa. triangularis* Zone. The early Famennian fauna is characterized by a new benthic ostracod association.

S8 - EARLY ORDOVICIAN MARINE REGIME SHIFT FROM PRECAMBRIAN-TYPE MICROBE-DOMINATED TO PHANEROZOIC-TYPE METAZOA-DOMINATED REEFS: GEOBIOLOGICAL TURNING POINT

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Reefs as a microcosm of geobiological systems underwent a marked change from Precambrian-type microbe-dominated reefs to Phanerozoic-type Metazoa-dominated ones. The Cambrian through Early Ordovician (EO) is characterised by archaic types of reefs made up of metazoans (e.g., archaeocyathids, demosponges) along with significant amounts of microbialites in a somewhat inclusive manner. In particular, the Middle-Late Cambrian was impoverished in reef-building metazoans relative to the abundance of the microbialites. However, the oldest bryozoans constructed reefs in the Tremadocian with the aid of demosponges and pelmatozoans, suggesting an incipient regime shift in reef construction. The EO greenhouse Earth was dominated by calcite-sea oceans, in which oligotrophic conditions would have been widespread. Even in such a setting, microbes would have flourished. However, it was not until the EO that many types of filter feeders and suspension feeders characteristic of the Paleozoic evolutionary fauna (PEF) began to dominate, facilitated by the fact that the marine food web, as well as trophic systems, underwent a fundamental restructuring. Masuda and Ezaki (2009) proposed a hypothesis, the *Cambrian-Ordovician Sr Termination Event* that may reflect an EO biotic invasion onto land. This terrestrial biotic colonization would have strongly modified the nutrients and their distributions in the ocean, which in turn would have facilitated the remarkable development of the PEF. The EO regime shift in reef construction had a strong influence on the establishment of basic reefal framework for the remainder of the Palaeozoic reef systems, which corresponded to a first-order turning point for Phanerozoic geobiological systems.

S4 - KEY CONTRIBUTIONS OF INTER-GROUP VARIATION FOR MACROEVOLUTIONARY INFERENCE

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Understanding how biodiversity has arisen is a fundamental challenge for evolutionary biology. Addressing it requires understanding of how speciation, extinction and character change interrelate. Approaches based purely on extant diversity attempt to reconstruct the past using only modern groups and therefore neglect extinctions in deep time. If the fossil record is sufficiently complete, paleontological approaches can provide insight into the fall and rise of clades, elucidating processes that phylogenetic reconstructions can only imply. Using our recently-compiled phylogeny of all Cenozoic macroperforate planktonic foraminifera, we will show (1) how overall diversity fluctuates due to interactions among abiotic and biotic processes and (2) that the importance of morphogroups exhibiting key innovations within the whole phylogeny waxes and wanes. In other words, parts of the tree are ‘hot’ whilst others are ‘not’. Furthermore, ‘hotness’ - the influence of particular morphogroups on overall tree structure - is not static: it fluctuates with changing ecological conditions, abrupt examples of which include the Eocene - Oligocene transition and the radiation of distinctive morphogroups, such as keeled globorotaliids or tubulospinose hantkeninids. Here, we explore how considering such inter-group variation may give a clearer picture of diversification and adaptive radiation than can be had by analysing the clade as a homogeneous whole.

S8 - EDRIOASTEROIDS ATTACHED TO *SELENOPELTIS* REVISITED

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Trilobite exoskeletons served as hard substrates on and above the soft Palaeozoic seafloors. Articulated exoskeletons and/or their disarticulated parts provided attachment sites for diverse invertebrate groups. Bryozoan colonies, brachiopod and cornulitid shells or crinoid holdfasts attached to the living trilobites, as well as to moult remains and carcasses, have been described by the following authors, Brandt (1996), Taylor and Brett (1996), Budil and Šarič (1995), Kácha and Šarič (1995, 2009). A sample of *Selenopeltis buchi* with 22 attached edrioasteroid thecae described by Prokop (1965) was interpreted as a case of commensalism. During a new extensive investigation, rich material of attached edrioasteroids on *Selenopeltis* was gathered and statistically evaluated. So far, all attached edrioasteroid specimens apparently did not restrict the host trilobites' movement. A preference to settle on adult and/or gerontic host trilobites is obvious. Very probably, the individuals of different edroasteroid taxa were able to distinguish between adult and juvenile specimens of *Selenopeltis*. In the case settlement on a young host trilobite, the attached edrioasteroid, having very restricted mobility, could lose their live host very quickly due to the next moulting event.

S19 - *IN SITU* FEEDING TRILOBITES AND HYOLITHIDS: THEIR RESPONSIBILITY FOR THE CAMBRIAN SUBSTRATE REVOLUTION

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Shallow-water sediments in the middle Cambrian Jince Formation of the Barrandia area (Czech Republic) commonly preserve untransported concentrations of skeletal fauna. Shields of the bivalved arthropod *Forfexicaris* are surrounded, covered and/or underlaid by various number of complete specimens of the small hyolith *Jincelites vogeli*. A nearly complete articulated exoskeleton of the large polymerid trilobite *Paradoxides* (*Rejkocephalus*) *rotundatus* is associated with twelve articulated specimens of the much smaller trilobite *Ellipsocephalus hoffi* with natant hypostome; eight of them are preserved under the large *Paradoxides* carapace and all are oriented upside-down. Numerous other samples show concentrations of articulated specimens of *E. hoffi* associated with complete hyoliths (conchs with opercula) on bedding planes covered by bacterial mats, commonly with organically preserved filaments. All associations are interpreted as death assemblages of primary producers of organic matter (microbial mats) and/or microbial communities which envelope decaying organic matter in aqueous environment (designated as microbial halo) consumed by the in situ preserved consumers, the hyolith *Jincelites* and the trilobite *Ellipsocephalus*.

W5 - CONFOCAL LASER SCANNING MICROSCOPY AND SPECTROSCOPY OF ORGANIC-WALLED MICROFOSSILS: 3D-IMAGING, ANALYSIS AND ONLINE PRESENTATION

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Confocal Laser Scanning Microscopy has been shown to be a most valuable tool for imaging and the morphological analysis of organic-walled microfossils. Thanks to the natural fluorescence of the wall of most palynomorphs, confocal microscopy can be carried out on standard slides, without any special preparation of the specimens. Individual specimens, e.g. holotypes or other specimens that have been identified to be important during the conventional transmitted-light microscope study, can easily be subjected to complementary confocal microscopical analysis and benefit from its different imaging capabilities, including serial optical sectioning, 3D-reconstructions and 3D-animations. Current research deals with Confocal Spectrometry, using fluorescence emission spectra for the characterization of the organic material of fossil palynomorphs, with the aim to identify potential links between wall material and the trophic mode of extinct dinoflagellates. In this contribution I will report on the techniques used in Confocal Laser Scanning Microscopy, data acquisition for imaging, analysis and 3D reconstructions. I will also report on some experiences made with Confocal Spectrometry and the presentation of confocal data on the Internet.

S27B - SCLEROBIONTS AND BIOEROSION IN A SHALLOW MARINE EQUATORIAL JURASSIC FAUNA: THE MATMOR FORMATION (CALLOVIAN) OF SOUTHERN ISRAEL

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Jurassic sclerobiont communities (organisms which live on and in hard substrates) have been well studied in what were temperate and subtropical marine environments, but they are only now being systematically described from the tropics. The Matmor Formation is a Callovian unit in southern Israel that contains abundant fossils, including many sclerobionts, and significant bioerosion. We present interpretations of these sclerobionts and bioerosion structures as part of a larger study of the latitudinal and environmental controls on hard substrate communities. Sclerobionts in the Matmor Formation include oysters, plicatulids, calcareous sponges, serpulids, sabellids, thecideides, and cyclostomes. Many of these are new. The substrates, especially platter-like corals and sponges, provided exposed and cryptic spaces, and the sclerobionts were consequently divided between them in a similar way to their subtropical and temperate equivalents. The sclerobiont community in the Matmor is bryozoan-poor as predicted by latitudinal models, but has a surprising dominance of sabellid tubes over serpulids (almost 10 to 1). The bioerosion structures on the Matmor hard substrates are moderately abundant, with eight ichnospecies. The bioeroders included bivalves, worms, barnacles, phoronids and sponges. Crinoid stems show frequent swelling associated with shallow pits that may be the results of myzostomid parasite infestations. Compared to subtropical and contemporary equivalents, this equatorial bioerosion assemblage is of average diversity. Sponge borings are surprisingly rare. This is the first tropical Middle Jurassic bioerosion ichnofauna to be documented.

S9 - FRASNIAN-FAMENNIAN DECLINE IN CALCIFIED ALGAE AND CYANOBACTERIA, SOUTH CHINA

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A total of 253 Givetian, Frasnian and Famennian reef and non-reef platform carbonate horizons were sampled at four sections from three widely spaced localities in Guangxi and southern Guizhou, South China. Of these, 61 contained calcified algae, cyanobacteria and microproblematica, among which a total of seventeen taxa were identified. All three groups show little change in relative proportions from stage to stage. As a whole, their abundance increased by 34% from Givetian to Frasnian, and declined by 63% in the Famennian. Survival of these organisms into the Famennian could be interpreted to indicate tolerance of environmental stress, independence of changes in food supply, morphological plasticity, and ability to occupy a range of habitats and depths. However, their marked decline in abundance indicates that they too were susceptible to the changes that affected other shallow marine organisms at this time. This secular pattern therefore does not fully support recognition of these microfossils as 'disaster forms' in the immediate aftermath of the late Frasnian extinction.

S20 - PRESERVATION OF THE BIOLOGICAL INFORMATION UNDER ACIDIC CONDITIONS IN THE RÍO TINTO EXTREME ENVIRONMENT

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Acidic and oxidizing environments are commonly thought to prevent preservation of the morphologies of, and organics sourced from the activity of, ancient communities. However, sampling of the Río Tinto terrace system dating back to 2.1 My has revealed an exceptional fossil association, composed of both microbial and pluricellular remains. The fossilization processes involved can be understood by comparing them with the preservation mechanisms in the modern environment, which are mediated by very acidic and oxidizing solutions (pH ~ 1-2.5, Eh ~ 500-650 mV) oversaturated in ferric and sulfate complexes. Preservation commences via a simple coating of the biological structures by these compounds which are rapidly mineralized to nanophase iron oxides (Fe-oxide or schwertmannite –like) within the first days. Such a process is followed by incipient mineral crystallization in the river to goethite and hematite after several months. Such a mineral transformation is a consequence of sulfate removal and dehydration which do not greatly affect the final preservation of the biological information in the rocks. However, as will be discussed, information from the ancient communities in the form of different microbial elements and macrostructures, and also associated organics, survives both the primary extreme conditions and subsequent diagenesis.

S26 - THE COLOUR OF THE SILURIAN: JUST BIOPAINTINGS?

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Black is the colour that characterizes sediments deposited during the Silurian along the northern Gondwana margin, either as cephalopod limestones or graptolitic shales. This dark colour indicates the presence of high contents of organic matter there preserved. However, a pink to reddish colour appears to dominate this scenario in different localities, with Silurian-Lower Devonian sediments cropping out as condensed calcareous sequences or hydrocarbon-related Ca-carbonate deposits in the Carnic Alps and Morocco. Microscopic-scale investigations of these reddish signatures in the studied deposits show that a significant role is played by different microbial communities in making these biopaintings. Here we illustrate some Silurian sequences from the Lake Wolayer area (southern Austria). Limestones there exposed from the Valentin Törl, Rauchkofel Boden and Seekopf sections keep this peculiar colour that derives from red-coloured coatings around skeletal fragments (mostly trilobites and subordinate cephalopods and echinoderms). Coatings are made of calcareous laminae alternating with micro-layers rich in iron silicates or oxides (chamosite, goethite, and magnetite). We have investigated these structures in detail using a reflected and transmitted light optical microscopy and an environmental scanning electron microscopy coupled with microanalyses. The use of confocal laser Raman spectroscopy and complementary microscopic analysis captured a clear signal of the presence of organic matter, and these analyses are critical for a comprehensive organic and inorganic compound identification.

W10 - ANIMAL AND PLANT CUTICLES FROM THE LOWER DEVONIAN OF POLAND

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Palynological investigation of Lower Devonian clastic sediments from the Dyminy IG2 and Klucze 1 boreholes (central Poland), revealed the presence of both plant and animal cuticles. The investigated intervals are dated as late Pragian and Emsian (the *polygonalis-emsiensis* and *douglastownense-eurypterota* miospore zones). Apart from abundant miospores, only a few acritarchs have been found in the samples. Among plant tracheids, long tubes classified as *Porcatitubulus* are quite frequent. In addition, the enigmatic *Nematothallus* and *Cosmochlaina* cuticles are also present, together with some unrecognised cuticles of higher plants with stomata. More complex cuticles of animal origin are also present. Fragments of very well-preserved respiratory organs (Kiemenplatten), belonging to eurypterids have been recognized. The other associated remains consist of fragments of both pitted and unpitted cuticles with wavy surfaces, possessing setation. They may belong to eurypterids and/or scorpions. Isolated spines interpreted as eurypterid in origin, are also present in the samples. Apart from the cuticles of eurypterid/scorpion origin, some single enigmatic arthropod cuticles occur as well, but their origin is problematic. This is the first report of such plant/animal cuticle assemblages in the Lower Devonian deposits of Poland. The presence of land plant and arthropod components, with a simultaneous rarity of acritarch species may point to marginal-marine or even an alluvial depositional environment.

S16 - MODELING EVOLUTIONARY RATES OF MEAN AND VARIANCE IN BODY SIZE FOR THE CANIDAE (MAMMALIA)

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Modeling evolutionary rates of continuously varying traits (e.g., body size) is one of the more intuitive aspects of studying evolutionary trends. Yet discussions of evolutionary rates often evaluate differences in absolute change per unit time, conflating the effects of changes in mean and changes in variance. For example, on such analysis of extant mammals recently concluded that rate of body size evolution increases with increasing size. Employing a generalized Brownian motion model, I modeled evolutionary rates for mean and variance in body mass data for 150 species of fossil and extant canids (jackals, wolves and foxes). AIC model-selection returns a well-constrained set of models, demonstrating fundamental differences in body size evolution across the three canid subfamilies: Hesperocyoninae, Borophaginae, and Caninae. Observed differences between sister groups within canid these subfamilies include: 1) decreased variance rate with no change in the mean rate, associated with no difference in body masses between groups (Hesperocyoninae), 2) mean and variance rate decreases coinciding with significant body mass increase between groups (Borophaginae), and 3) both rates increasing with a significant body mass increase (Caninae). These results highlight the importance of partitioning phenotypic change into changes in mean and variance, and urge caution when drawing conclusions of evolutionary rates from extant taxa alone.

S3 - NANNOFOSSIL ASSEMBLAGES AS A TOOL TO INFER ENVIRONMENTAL CONDITIONS - AN EXAMPLE FROM THE CENOMANIAN-TURONIAN BOUNDARY OAE

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Extensive work on paleoecological implications of calcareous nannofossil assemblages ended in a summary of environmental preferences for several Cretaceous nannofossil taxa. Many efforts have been devoted to identify criteria which allow to correlate fossil assemblages to different environmental conditions. Combining data with information available in the literature, a method was obtained for screening assemblage compositions in order to sort out if and how environmental parameters can be inferred. Since most of the variables cannot be measured directly and furthermore they interact with each other, eventually generating the same output for different combinations, a composite evaluation of assemblages is necessary. In order to simplify the environmental interpretation of assemblages based on their quantitative composition and on the additional information that taxa may provide, a flow diagram was created. Its application in the study of the mid-Cretaceous portion of the Oued Mellegue succession (north-western Tunisia) allowed to distinguish the effects of several parameters across the Cenomanian-Turonian boundary Oceanic Anoxic Event. The study focused particularly on productivity, sedimentary setting and diagenesis, integrating nannofossil results with planktonic foraminifera analysis.

S5 - DATABASE OF SAMPLES AND PALEONTOLOGICAL ANALYSES IN THE FRAME OF THE ITALIAN CARG PROJECT, GEOLOGICAL CARTOGRAPHY AT THE 1:50.000 SCALE

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The Italian Project of Geological Cartography at the 1:50.000 scale, goes beyond the production of the hard-copy of the geological maps, and foresees the creation of a geodatabase collecting all data supplied. Maps are georeferred and attached to a GIS application, a samples and analyses database has been developed, running in Access environment. It contains information regarding representative and/or meaningful samples of the lithostratigraphic units cropping out within each map. The database is arranged following a tree pattern: the main container is the geological sheet listed by number; then samples are grouped by sets according to different criteria; for every sample information regarding location, stratigraphic unit and lithology is required. Several analyses can be associated to any sample: for the time being, these are micro- and macro-paleontological and sedimentological. The sedimentological analyses can be further detailed in an additional window according to them belonging to calcareous, terrigenous cemented and terrigenous non-cemented categories. As for the paleontological analyses, information is subdivided into four (for the macro) or five (for the micro) windows: preparation methods and macroscopic information, assemblage recovered with indications of quantitative results and state of preservation, biostratigraphic results (when available), geochronology, palaeoenvironmental conditions. All databases are transferred by ISPRA into the central databank and will be accessible in the next future through the web by an application which is currently being elaborated. It will give the possibility to visualize information regarding each sample.

S20 - TAPHONOMIC PATHWAYS OF THE EARLY CAMBRIAN CHENGJIANG BIOTA

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An overview on taphonomic pathways of the early Cambrian Chengjiang Biota from the Yangtze Platform using material with little or no weathering influence is still missing. This work aims to propose an updated model analyzing both unweathered and weathered Chengjiang – type fossil material. Energy dispersive X-ray (EDX) analyses and elemental mapping of fresh fossil material from a variety of facies settings indicate pyrite crystals are located only surrounding the fossils. Instead of this particular type of preservation, carbon can be detected in almost all metazoan clades present in this fossil deposit. This indicates that mostly of Chengjiang fossils followed a typical preservational pathway of Burgess Shale- type fossils, rather than an Hunsrück- type preservation (early pyritization, later pseudomorfed by iron oxides), as earlier suggested. Using different geochemical proxies and as various redox indicators and DOP, besides classical geological observation, the strong influence of weathering and later diagenetic alteration in most Chengjiang- type fossil can be proven.

S13 - OSTRACODES (CRUSTACEA) WITNESSES OF PALEOENVIRONMENTAL MODIFICATIONS ASSOCIATED WITH PERMIAN-TRIASSIC BOUNDARY EVENTS IN THE PALEO-TETHYS OCEAN

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Numerous sections surrounding the Paleo-Tethys Ocean are characterized by microbialites directly above the Permian-Triassic Boundary. The conditions of their formation are still debated: between anoxia and/or supersaturation in bicarbonates in a very shallow setting. Ostracodes (Crustacea) are a very important part of faunas found in these formations, together with gastropods, a few brachiopods, as well as conodonts used for their dating. The study of these exceptional faunas is an important tool in the comprehension of microbialite formation and more globally of conditions in the earliest Triassic, leading to a delayed biotic recovery. The study of ostracode faunas from microbialites in South China, Turkey and Hungary allows several observations: (a) numbers of species and specimens are very high; (b) these faunas are made of typical outer-shelf setting ostracodes (*Bairdioidea*); and (c) they indicate that waters were not impoverished in dissolved oxygen. A scenario can be drawn from these observations, envisaging microbialites as “refuges”. Ostracodes may have migrated from poisoned waters to relatively more hospitable environments: photosynthetic cyanobacteria forming microbialites should have been important, producing oxygen in an “anoxic” ocean. According to this hypothesis, ostracode zonation in relation to depth and environments established in modern ostracodes, used for environmental and palaeobathymetrical reconstructions elsewhere in the stratigraphic record, would no longer be valid during the Early Triassic.

S17 - BIOMECHANICAL ANALYSIS IN CAPITOSAUR (AMPHIBIA: TEMNOSPONDYLI) SKULLS

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Capitosaurs were the largest Triassic temnospondyl group, being aquatic top predators with a crocodile-like outline with a dorsoventral flattened skull and body frequently displaying gigantism. A great diversity of forms are now known, characterized for the broad patterns of skull shape such as the morphology of the tabular horns; posteriorly or laterally directed and in contact with the squamosal creating otic fenestrae in some taxa. Temnospondyls displayed a large variety of sutural types (e.g. lamellae, flat bevels, butt joints, steep walls) playing a key-role in the stress distribution of the skull. To evaluate the mechanical performance in the akinetic skull of capitosaurs, Finite Element Analysis (FEA) of 2D models were used in bilateral, unilateral and lateral biting cases of the skull roof. Maximum Von Mises stress and strain energy recorded for each model reveals an evolutionary trend to reduce these values and the concentration of the stress around the orbits, especially in taxa with otic fenestrae (e.g. *Eocyclotosaurus*, *Cyclotosaurus*). Likewise, FEA results evidenced that higher patterns of strain are present in regions where cranial sutures are mainly located in the skull roof, performing absorption and dispersion functions of compressive, tensile, torsional and shear forces. Our results point to diverse different feeding behaviours within capitosaurs, being active predators including general and specialized feeders.

S22 - ANCIENT GENE NETWORKS AND THE EVOLUTION OF THE CORE TOOTH MODULE FROM OLD TO NEW JAWS

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Teeth arose with the dawn of vertebrates and their origin was instigated, in part, by the elaboration of neural crest fates that were emerging prior to and during early vertebrate evolution. Both oral and skin denticles appeared in vertebrates before jaws evolved; however, where and how they first emerged and their relationship to one another is of considerable debate. In the light of new developmental data, evolution of gene co-expression profiles that form part of a larger gene regulatory network could provide the all-important information on tooth origins. Pharyngeal teeth of jawless vertebrates utilized an ancient gene network before the origin of oral jaws, oral teeth, and ectodermal appendages. The first vertebrate dentition likely appeared in a hox-positive, endodermal environment and expressed a genetic program including ectodysplasin pathway genes. This ancient gene network was co-opted and modified for teeth in oral jaws of the first jawed vertebrate, and subsequently deployed as jaws enveloped teeth on novel pharyngeal jaws. Our data highlight an amazing modularity of jaws and teeth as they coevolved during the history of vertebrates. We exploit this diversity to describe a core tooth module, which includes the dental gene network, common to the first tooth and all of its descendants.

S16 - HEADS AND TAILS, SIZE AND SHAPE: CONTRASTING PATTERNS AND MODES OF PHENOTYPIC DIVERSIFICATION DURING THE EVOLUTIONARY RADIATION OF ACANTHOMORPH TELEOSTS

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Distinct evolutionary processes can yield similar trajectories of phenotypic radiation, limiting the precision of inferences made in the absence of phylogenetic data. Further complicating matters, some models of adaptive radiation predict that onset of diversification in different morphological systems might be disjunctive, hinting that synoptic approaches could obscure important temporal contrasts between distinct anatomical regions. Using a morphometric and phylogenetic dataset comprising over 500 extinct species of acanthomorph fishes, a group that includes nearly one in three living vertebrate species, we explore patterns of cranial, postcranial, and body-size diversification during a major evolutionary radiation. Acanthomorphs originated in the Late Cretaceous, radiated prolifically around the Cretaceous-Palaeogene boundary, and achieved modern levels of ecomorphological diversity by the mid-Eocene. Anatomical partitions show contrasting trajectories of diversification; particularly noteworthy is that morphological variety accumulates more rapidly for skulls and jaws than bodies and fins, mirroring a pattern reported for other fish groups. This might be interpreted as support for the hypothesis that divergence early in evolutionary radiations is focused along lines related to feeding ecology. Fitting models of trait evolution to these data shows that the rapid accumulation of skull diversity is unlikely due to accelerated rates of change early in acanthomorph history. Rather, this pattern is congruent with constant evolutionary rates combined with a strong central tendency, suggesting anatomical or functional constraint. This result implies that trophic divergence is important at all stages of acanthomorph history, consistent with the pattern of homoplasy in cranial biomechanics reported for some living fish radiations.

W9 - OUTGROUPS, CHARACTERS, AND POLARITY: CURRENT CHALLENGES IN INFERRING THE INTERRELATIONSHIPS OF EARLY JAWED VERTEBRATES

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Extant jawed vertebrates are represented by two reciprocally monophyletic groups: chondrichthyans (sharks, rays, chimaeras) and osteichthyans ('bony fishes', tetrapods). Debates on the origin and divergence of these modern radiations and their sub-clades have centered on two nominal groups known exclusively from Palaeozoic fossils: acanthodians and placoderms. Most work on early vertebrates has accepted, either implicitly or explicitly, the monophyly of these extinct assemblages, and few studies have queried their status as clades. In practice, members of these two groups are easily identified by a suite of characters, some of which are derived. This, however, is not evidence of monophyly; subsets of each assemblage bear apomorphies that might to link them with other radiations to the exclusion of the remaining acanthodians or placoderms with which they traditionally aligned. Here we review competing hypotheses concerning the contents of the gnathostome, chondrichthyan, and osteichthyan stems, evidence for and against the monophyly of placoderms and acanthodians, consider the limitations posed by available outgroups, and propose a roadmap for future research. We conclude that persistent typological classifications based on a gestalt, rather than explicitly phylogenetic identifications based on polarized characters, is prone to misidentifying fossils and contributes to a perception of strong evidence for spurious clades. This creates an obstacle to a more detailed understanding of the sequence of character evolution leading to the origin of modern gnathostomes. We attempt to remedy this by outlining an approach where identifying total-group placement is given primacy over sorting fossils into notional categories of uncertain monophyly.

S3 - LONG- AND SHORT-TERM BENTHIC FORAMINIFERAL RESPONSE TO OCEAN ANOXIA

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Benthic foraminifera mainly rely on two factors, food availability (organic-matter flux) and oxygen content at the sea floor. Here we will present data from a 20 Ma long Cenomanian to Campanian benthic foraminiferal assemblage record generated in the core of the tropics (Demerara Rise, ODP Leg 207, off Surinam). Cenomanian to latest Santonian sediments at Demerara Rise consist of laminated black shales, which indicate the existence of a strong oxygen minimum zone. These black shales are followed by well-oxidized, organic matter poor Campanian nannofossil ooze. The observed long-term trend indicates a stepwise increase in benthic foraminiferal abundances and diversity supposed to be related to the ongoing opening of the Equatorial Atlantic Gateway and corresponding oxygenation of the sea floor. Especially during the Cenomanian and Turonian (mid-Cretaceous supergreenhouse) benthic foraminifera are absent or rare. On shorter time scales, however, several abundance peaks and repopulation events characterize the record. The most important one of these repopulation events corresponds to OAE 2. Comparison with other localities (i.e., Wunstorf, Northern Germany; Pueblo, Western Interior Seaway) and proxy data (e.g., TEX_{86}, XRF, calcareous nannofossils, stable isotopes) indicates a common trigger mechanism for these events.

S20 - SHELL CONCENTRATIONS RECORD CLIMATIC CYCLES: THE UPPER JURASSIC TEREÑES FORMATION OF NORTHERN SPAIN

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The Kimmeridgian Tereñes Formation consists of metre- to decametre-scale coarsening-upward cycles. These cycles start with a thin shell bed of the oyster *Nanogyra virgula* and networks of *Thalassinoides*, followed by marly siltstone with numerous shell beds and pavements of the bivalve *Corbulomima*. The cycles are commonly topped by sandstones with abundant dinosaur tracks, or else by marly fine-sandy siltstone and fine-grained sandstone, bioturbated by *Rhizocorallium irregulare* and *Thalassinoides*. These deepening-shallowing cycles are best explained as resulting from the progradation of delta lobes in a protected environment (?shelf lagoon), characterised by anoxic to dysoxic conditions. The abundant shell concentrations and the intervening unfossiliferous sediments are thought to represent a lower order of cyclicity, controlled by high-frequency climatic oscillations. Three regimes appear to govern sedimentation and biological activity in the shelf lagoon. The first is characterized by low-energy conditions and dysoxic to anoxic conditions, inimical to most benthic life. With increasing oxygenation (regime 2; dysoxic conditions) the sea floor was colonised by *Corbulomima* and *Protocardia*. An increase in water energy (regime 3) led to winnowing, reworking, and local transport of shells. The shell concentrations thus record a cyclic change from equal to more extreme climate conditions. As several hundreds of these shell concentrations occur within the higher-order cycles, the time scale of these cycles is below that of the Milankovitch band. A seasonal origin can also be excluded, as the life span of the bivalves most likely was more than one year. Instead, the high frequency cycles probably record centennial climatic oscillations.

S17 - THREE-DIMENSIONAL FUNCTIONAL QUANTIFICATION OF RUMINANT OCCLUSAL PATTERNS – AN APPROACH USING INDUSTRIAL METROLOGY SYSTEMS

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The implicate difficulties using two-dimensional (2D) methods to characterize the complex three-dimensional (3D) morphology of occlusal geometries have been largely overcome by the application of newly available 3D techniques. Indeed, during the past 5 years a substantial development of the 3D engineering metrology has taken place. We implement the high precision, efficiency of automatisation and minimized levels of observer error offered by these engineering 3D tools to, strictly quantitatively, characterize functional occlusal structures of ruminant dentitions. The aims of this study are to: 1) test for the accuracy of this new method in discriminating functional traits correlated to the different physical properties of the food, and 2) expand our model to the whole post-canine tooth row in contrast to former works, which relied on the study of one tooth position only (M2). We generate digital 3D models of upper cheek teeth of nine extant species of bovids (Bovidae, Cetartiodactyla) representing well known dietary traits using a topometric digitisation system working with a fringe projection technique. An industrial 3D metrology software is subsequently employed to extract 3D linear, surface and volume parameters of the enamel and dentin components of the occlusal topography. We test the hypothesis that functional gradients should be identified along the post-canine tooth row, which in turn reflect specific traits in the chewing dynamics and efficiency linked to biomechanical properties of food items and the specific mode of digestion.

W9 - CRANIAL ANATOMY OF 400 MA JAWLESS FISH FROM CHINA THROWS NEW LIGHT ON PRECURSORS OF JAWED VERTEBRATES

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Most living vertebrates are jawed vertebrates (gnathostomes), and the only living jawless vertebrates (agnathans), hagfishes and lampreys, provide poor proxies for investigating the fundamental evolutionary changes to the vertebrate head that occurred with the rise of jaws. Like their living counterparts, most fossil jawless fishes lacked a mineralized braincase, except for the 435-380 Ma osteostracans, whose cranial anatomy was elucidated in the 1920s, and the still poorly known 435-370 Ma galeaspids from China. We utilized Synchrotron Radiation X-ray Tomographic Microscopy (SRXTM) to elucidate the cranial anatomy of galeaspids, and we show here that the latter is in many ways a better proxy than that of osteostracans for reconstructing the condition that prevailed in vertebrates just before the origin of jaws. Our data throw new light on the evolutionary changes in braincase anatomy during the emergence of jawed vertebrates. Notably, we show that, like in jawed vertebrates and contrary to living agnathans, the nasal sacs of galeaspids are paired, separate from one another, and independent from the hypophysial duct. This is precisely a prerequisite for the origin of paired nostrils and jaws which are two key innovations in the transition from jawless to jawed vertebrates.

W1 - EVOLUTION OF THE ASTEROIDEA; WHERE THE GAPS IN KNOWLEDGE LIE

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It is now widely agreed that the post-Palaeozoic Asteroidea constitutes a monophyletic group, the Neoasteroidea, which evolved from a common ancestor living around the Permian-Triassic boundary. However, a gap in the fossil record of the asteroids exists from the Late Permian and earliest Triassic (Artinskian-Late Anisian), a period of 40 my. The identity of the most crownward member of the neoasteroid stem group amongst Late Palaeozoic taxa is problematic, partly because so few taxa show ossicle details. Neoasteroids are best characterised by details of muscularisation and articulation of the ambulacrals and adambulacrals, and two known clades in the Carboniferous and Permian display ambulacral groove characters similar to those of neoasteroids. The form of the neoasteroid tree has proved controversial, with two proposed models, the "basal paxillosid" and the "basal forcipulatid" sharing little common ground. The former is preferred in this presentation, although it is largely unsupported by the fossil record. The earliest Triassic asteroids, from the Anisian-Ladinian Muschelkalk, have very unusual character combinations, and although they are clearly neoasteroids, cannot be placed confidently in any extant clade. However, new material from the Carnian of Italy includes taxa that can be assigned confidently to Jurassic-Cretaceous extant families, and shows that the numerous first appearences of families in the early Jurassic are probably a consequence of migrations associated with major transgression.

S18 - FOSSIL WHALE SKELETONS OF WADI AL-HITAN, FAYOUM AREA: STRATIGRAPHY AND PALEOECOLOGIC SIGNIFICANCE

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A preservation of rich vertebrate skeletal remains occurs in Wadi Al-Hitan (Valley of Whales) at about 80 km southwest of Cairo in Fayoum Governorate, Egypt. The Wadi contains vertebrate fossils belonging to whales, sea cows, crocodiles, turtles, and shark teeth. The most common whale species preserved in the area are *Basilosaurus isis* and *Deurodon atrox*, found in Middle-Upper Eocene shales, sandstones and carbonates which include the Gehannam, Birket Qaroun and Qasr El Sagha formations. Most of whale skeletons are concentrated at the contact between the Gehannam Formation and the Birket Qaroun Formation within a mangrove bed, some occurring below the mangrove bed while others occur above it. From the stratigraphic and sedimentologic studies it appears that the whales tended to live in small sinuous bays occupied by the mangroves. After death they were washed ashore by waves and tides. The carcases were later reoriented by fresh water stream currents flowing from the nearby terrestrial terrain. The area represents a sinuous paleoshore line during the Middle-Late Eocene time in the Western Desert of Egypt, consisting of many bays where the whales lived. The occurrence of Lake Qaroun fed by River Nile water eroded and destroyed these bays and only the bay represented by Wadi Al-Hitan is preserved. The area of Wadi Al-Hitan is the first natural world Heritage site in Egypt. It is an important protectory for whale skeletons in Egypt and represents one of the most important and interesting places for whale preservation in the world.

S2 - INTEGRATING MACRO AND MICRO: BRINGING THE MODERN SYNTHESIS INTO THE 21ST CENTURY

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The Modern Synthesis was a major advance in evolutionary thought, incorporating ideas from diverse fields including genetics (Fisher and Dobzhansky), systematics and speciation (Mayr), and palaeontology (Simpson). This approach combined natural selection with mechanisms of genetic change to explain patterns and processes at both micro- and macroevolutionary scales. In the last sixty-five years, evolutionary thinkers have expanded our knowledge and endeavoured to integrate these new ideas with those proposed by the Modern Synthesis. However, studies of both the extant and extinct have shown that changes at the genetic level alone are inadequate explanations for many macroevolutionary phenomena. As new techniques in phylogenetics, palaeobiogeography, evolutionary development, palaeoecology, and others continue to improve our understanding, it is clear that macroevolutionary studies provide significant input to our view of evolution. Despite these advancements, many scientists still ignore the importance of hierarchical theory, species as individuals, cladogenesis, biogeographic complexity in speciation, community stasis and turnover, higher levels of selection/sorting, and mass extinctions. The time is ripe to revisit and distil the lasting contributions of the Modern Synthesis and forge ahead towards a new synthesis that integrates these tenets into our broader understanding of macroevolution.

S27B - FIRST REPORT OF *CRUMILLOSPONGIA* (DEMOSPONGEA) FROM THE CAMBRIAN OF EUROPE: *CRUMILLOSPONGIA* SP. NOV. FROM MURERO (SPAIN)

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The demosponge genus *Crumillospongia* has been reported from the lower and middle Cambrian of Canada, USA and China, but is now also recorded in the uppermost lower Cambrian of south Europe (Spain), extending its range to Western Gondwana. *Crumillospongia* is a globular sponge perforated by conspicuous circular canals of at least two sizes, and the new *Crumillospongia* species is sack-shaped to elongate and consistently presents canals of three different sizes. Although the best preserved specimen is some 2 cm wide by 3 cm high, some fragmentary specimens are considerably larger, reaching more than 9 cm in height. A striking decay series is reported for this species, from fine specimens preserved as chlorite all the way to limonitic impressions only recognizable based on faint multi-sized pore edges. In the Murero fossil assemblages, this species was the dominant type of sponge in the upper Bilbilian, disappearing right before the Valdemiedes Event (lower-middle Cambrian boundary), and its niche taken by the demosponge *Leptomitus* in the lower Caesaraugustan.

S27D - A VETULICOLID-BANFFOZOAN INTERMEDIATE FROM THE EARLY CAMBRIAN EMU BAY SHALE LAGERSTÄTTE, SOUTH AUSTRALIA

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The Cambrian (Series 2) Emu Bay Shale on Kangaroo Island, South Australia, contains the only known Cambrian Burgess Shale-type biota in Australia. A new vetulicolian stands out among a number of fossil *incertae sedis*. This enigmatic group of longitudinally bipartite animals was previously known only from early and middle Cambrian strata of China and North America. The new taxon reaches 125 mm in length and is divided into subequal anterior and posterior sections. These are both about 35 mm in height, lack any type of projections and are connected by a narrow constriction showing a twist of 180º, which gives the animal an hourglass outline. The anterior portion is generally smooth and does not show a longitudinal groove, gills, pouches or annulations. There is no evidence of a mouth surrounded by a circlet of plates, as described in

other vetulicolians. The posterior section is divided into 5 segments, each about 10 mm wide, connected by intersegmental membranes, and often preserves a wide, parallel-sided, three-dimensional gut. The Phylum Vetulicolia is divided into the classes Vetulicolida and Banffozoa; the former is characterized by some degree of body torsion and few segments in the posterior section, while the latter shows strong torsion (hourglass shape) and a very densely annulated posterior section. The new Australian taxon shows intermediate characters between the two classes, yet a preliminary cladistic analysis places the new taxon in a polytomy among the Vetulicolida. The unusual set of characters shown by the phylum still defies a proper assignment into a higher ranking clade.

S5 - MUSEUM OF GEOLOGY AT THE UNIVERSITY OF VALENCIA (SPAIN): GENERAL ASPECTS

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There are two main research interests of the Museum of Geology at the University of Valencia (MGUV) in Spain, which are the historical study of their ancient finds and the scientific study of its specimens. Spanish legal regulations consider the fossil record as part of both the Historical and the Natural heritage, thus it determines the rules for paleontological activities up to the deposit of the specimens in a public scientific institution like a museum. This is essential for good management of the collections, and allows researchers of the university a great accessibility to their study materials. These collections are the basis for several scientific publications. The MGUV is the legacy of the Museum of Natural History which was created in the XIX century. The deposition of the first finds date from the beginning of the University of Valencia in the XV century, but unfortunately they were completely destroyed in 1932 by a fire. After the fire, new collections were generated, mainly as a result of donations by some international institutions, including donations from the British Museum.The MGUV is the depositary of geological and paleontological materials mainly from excavations in Valencia Province. We want to note that in Spain there are only a few universities that have their own scientific museum, and normally these museums lack a curator in their staff. In conclusion, the University of Valencia is pioneering in this aspect and its museum widely promotes the study of the regional palaeontology.

S27D - X-RAY MICROTOMOGRAPHY OF CARBONIFEROUS HARVESTMEN (ARACHNIDA: OPILIONES)

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Siderite ($FeCO_3$)-hosted fossils are central to understanding Coal Measures ecosystems. They are often preserved as three-dimensional voids within a nodule, and at some exceptional sites can preserve soft tissues of arthropods in addition to more heavily sclerotised features. Harvestmen (Arachnida: Opiliones) lack a mineralized exoskeleton; as such, their fossil record is sparse, with only eight Palaeozoic examples. This study reports two previously undescribed harvestmen specimens from the Upper Carboniferous Montceau-Les-Mines Lagerstätte, France, where nodule formation was rapid enough to preserve the soft, leathery cuticle in three dimensions. X-ray microtomography was used to produce computer reconstructions of the specimens. One belongs to the extant suborder Eupnoi. Other than the termination of several elongate walking limbs, it is resolved in its entirety, including a short and almost spherical body with an occularium, chelicerae, and pedipalps bearing a single tarsal claw. The other specimen is more heavily ornamented and shows similarities to members of another extant suborder, the Dypsnoi. Several limbs are truncated post-coxa but pre-femur; this may represent a fossil example of autospasy, whereby modern forms lose limbs at this precise line of weakness. These first ‘virtual harvestmen’ greatly expand anatomical data from the early history of the group: they are notably anatomically modern, supporting models of early (Palaeozoic) cladogenesis among the Opiliones.

S27A - THE CHACOAN PECCARY, CATAGONUS WAGNERI (MAMMALIA, TAYASSUIDAE) IN THE LATE PLEISTOCENE OF NORTHERN URUGUAY (SOUTH AMERICA)

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The Tayassuidae and Suidae split from their common ancestor during the late Eocene in Eurasia. The Tayassuidae, first expanded their range into North America from Eurasia and, then extended into South America during the “Great American Biotic Interchange”, becoming one of the first North American mammalian immigrants. Three genera are recognized in South America: Platygonus (middle Pliocene-early Pleistocene), Catagonus (late Pliocene?-Recent) and Tayassu (middle Pleistocene-Recent). Catagonus wagneri has the most restricted geographical distribution among extant Tayassuidae and inhabited semi-arid thorny forests of Dry Chaco in western Paraguay, south-eastern Bolivia and northern Argentina. Until now, C. wagneri has only been recorded in archaeological, pre-Hispanic deposits (ca. 1.000^{14} C yrs BP) from the Santiago del Estero province, Argentina. A new partially complete skull (MHD-P-9) from the Sopas Formation (Late Pleistocene, prior to the Last Glacial Maximum; Artigas Department, Uruguay), is identified as Catagonus wagneri. This is the oldest fossil record of this species; the most complete and best preserved fossil material and the first record of the species in Uruguay. The presence of this species allows us to reconstruct the palaeoenviroment at this time.

S27B - HOW DO EVOLUTION AND NATURAL SELECTION FUNCTION?

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To get something done you need a force and forces are created by the flow of energy. All forms of energy have their origin in subatomic quanta and these smallest units have the ability to detect the most economic structures around themselves and to flow there by tunnelling effects. Order and organisation in nature are rooted in the sub-atomic world and proceed according to the rules of probability. Because subatomic units construct all higher-level structures, a hierarchical and heterarchical interaction and mutual dependency structure exists between them. Each newly established higher-level system depends on its constituent components. Therefore, continuous mutual interaction systems exist between all beings. Interactions are results of energy flows to the most economic structures, obeying the minimum amplitude principle with tunnelling effect abilities. Mutual interactions are mutual communications. Communications are information exchanges. The difference between present and past lies in the degree of information potential, being reflected in the structural and textural compositions of the components, with different order-parameters, hence with different force-fields or information potentials. In the past the information level was low, consequently, the combination-styles of matters were poor; today information level is higher, consequently the combination-styles of matters are more sophisticated. It is heading towards a maximum information building, enabling the systems to use less energy and creating a more comfortable status with the aid of information. Life has its origin at the quantum domain.

W6 - CONODONTS, WERE THEY (THE FIRST?) PARASITIC ANIMALS?

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Conodonts were probably parasitic animals and their skeletal apparatuses the anchoring, sawing and rasping elements for this life style. The skeletal apparatus in animals with only coniform elements could have performed both anchoring and daggering functions, by forwards and backwards movements and/or slight rotations, whereby carinae or costae may have facilitated bleeding. In animals with ramiform and pectiniform elements, ramiform elements could have acted as anchoring devices, whereas pectiniform elements may have performed sawing (Pb) and rasping (Pa) functions. Arguments for a parasitic life include: i) V-shaped structures on conodont animals, facilitating a forward movement, but impeding pushing-out efforts by the host; ii) Microwear textures (polishing, chipping, scratching) indicating a cutting function; iii) Explosive biological diversification at the beginning of Cambrian could be explained if conodonts were parasitic animals, enabling gene transfer between host animals; iv) ^{18}O and ^{13}C ratios. The ^{18}O ratio of conodonts is enriched in ^{18}O relative to the skeletons of the other marine animals indicating a two fold physicochemical transfer of oxygen additional to the marine one. This special environment could be the host animal's body fluids, where the host tries to restore its body and continuously activates the chemical reactions, getting the ^{16}O isotopes and enriching the remaining fluids in ^{18}O, which is consumed by conodonts. v) Laminated structure of conodont elements indicates a daggering activity because the toughness of the laminated structure is suitable for hard work. vi) Co-occurrence of many conodonts with certain taxa, e.g. cephalopods, could be indicative for a parasitic relationship.

S6 - DEVELOPMENTAL MORPHOLOGICAL DISPARITY: A BRIEF OVERVIEW

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Disparity analysis comprises a suite of techniques that allow quantification and description of morphospace occupancy through space and time. Over the last two decades, disparity patterns have been documented for an increasing number of groups, resulting in a better appraisal of the morphological dynamics of clades during their diversification and extinction phases. In parallel with this, advances in morphometric techniques have facilitated quantification of more aspects of biological form over a wider range of morphologies. A major task of evolutionary paleobiology is to identify and understand the processes underlying these macro-evolutionary patterns. Are they primarily caused by intrinsic or extrinsic factors, for example? While there are many ways to quantify biotic and abiotic extrinsic forces (e.g., eustatic curves, geochemical proxies, faunal changes…) intrinsic factors – genetic/developmental s.l. – are difficult to characterize in a clade-wide perspective. For this reason, intrinsic factors have been little studied. Here, I briefly review some of the approaches that have been proposed to incorporate the developmental dynamics of taxa in disparity analyses. These include character partitioning, developmental morphospaces, juvenile disparity and allometric disparity. These recent approaches provide tools for the analysis of developmental disparity and provide the foundation for an emerging discipline of evolutionary developmental paleobiology.

S8 - MID TO LATE ORDOVICIAN BIODIVERSITY AND BIOGEOGRAPHY PATTERNS IN 'EAST' PERI-GONDWANA FROM IRAN TO CENTRAL ASIA

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During the Mid to Late Ordovician, microplates and island arcs now incorporated in the orogenic systems of Iran and Central Asia were spread widely along the Gondwanan margin from southern temperate to equatorial latitudes. Some of them (e.g., Central Iran and Zerafshan/Hissar) were probably within mainland Gondwana. Others, such as the Alborz and Alai terranes were separate microplates situated fairly close to the Gondwanan margin, whereas the Kazakhstanian cluster of microplates and intraoceanic volcanic arcs formed a huge archipelago that extended far into the ocean west of equatorial Gondwana. Temperate latitude benthic faunas of Alborz, Central Iran and Zerafshan/Hissar were sensitive to climatic changes. They preserve a record of recurring pre-Hirnantian warming and cooling episodes resulting in increased immigration and faunal turnover. The first cooling episode occurred in the mid Darriwilian (*variabilis* Biozone). It is best documented in the Alborz terrane which saw the invasion of a low diversity '*Neseuretus'* fauna, followed by the proliferation of *Echinosphaerites* forming characteristic echinoderm beds. The latest Darriwilian to Sandbian in Alborz, Central Iran and Zerafshan/Hissar was the time of increasing biodiversity of benthic faunas, which incorporated a number of brachiopod and trilobite taxa mostly characteristic of lower latitudes. The late Katian (*pacificus* Biozone) represents another distinct warming episode. In Zerafshan/Hissar a low diversity cool water fauna, dominated by the brachiopod *Eostropheodonta* and trilobite *Vietnamia*, was replaced by a new rich benthic fauna of tabulate and rugose corals, trimerellide, atrypide and pentameride brachiopods, including *Holorhynchus*, with some characteristic signatures of low latitude Gondwana.

S3 - BACKGROUND VERSUS EVENT-LEVEL BIOTIC VARIABILITY

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The early Eocene interval contains a spectrum of closely-spaced (inferred) transient warming events, or 'hyperthermals', characterized by carbon isotope excursions (CIEs), most notably the Paleocene-Eocene thermal maximum (PETM) and the ETM2. These events provide enormous potential for testing for biotic response across a range of carbon cycle perturbations that are relatively closely spaced in time. Furthermore, they provide an opportunity to test whether any biotic change accompanying the CIEs was exceptional and/or above background levels of variability. We have analysed a three million year calcareous nannofossil record from the palaeo-subequatorial Pacific, applying a novel analytical approach which combines an objective method of generating the best-smoothed fit, followed by a quantitative assessment of the magnitude of assemblage variability (summed standard deviation analysis). Results of this analysis have allowed us to differentiate intervals of biotic variability that lie significantly above background levels, with the magnitude of this biotic variability scaling to CIE size, pointing to a critical and quantifiable threshold level of environmental perturbation. We are currently investigating the applicability of this technique to other key intervals of climate change and we will present preliminary results in the talk.

S9 - AMMONOID AND FORAMINIFERAL FAUNAS FROM THE FAMENNIAN OF WESTERN KAZAKHSTAN: DEPTH CONTROL DISTRIBUTION ON A CARBONATE RAMP

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In the Famennian, the area of western Kazakhstan between the Mugodzhary Mountains in the east and the Caspian Sea in the west was occupied by an eastward-deepening carbonate ramp on the passive eastern margin of Baltica. The territory has been the subject of intensive research because of the carbonate buildups of the Tengiz and Karachaganak oil fields on the western extremity of the ramp, now deeply subsided. We examined the distributions of ammonoids and foraminifers in outcrops in the east and of foraminifers in the wells in the west of the area. The succession of middle-uppermost Famennian ammonoid zones (*Cheiloceras, Prolobites-Platyclymenia, Clymenia-Gonioclymenia* and *Kalloclymenia-Wocklumeria*) and four foraminiferal zones (*Parathurammina, Eoquasiendothyra, Eoendothyra* and *Quasiendothyra*) and their correlation allowed the dating of the Famennian carbonate sedimentation and gave insights into evolutionary pathways in both groups. We were able to date the main stages of ramp evolution, which was controlled by eustatic sea-level fluctuations and local tectonics, and examined microfacies patterns across the entire area. Three facial bands (inner ramp, mid-ramp, and outer ramp) display features of an idealized carbonate ramp complicated by regional tectonics. Famennian ammonoids are abundant and are found in association with foraminifers in the deep ramp microbioclastic wakestones-packstones, in highly condensed sections. A high diversity of ammonoids throughout the middle-upper Famennian and the presence of many endemic species suggest that this area was a center of their mainly northward distribution along the shelf of Baltica, while the relative abundances of foraminifers display a gradual eastward decrease, suggesting depth-controlled distribution.

S3 - EVOLUTION OF CONODONTS OF THE LATE PENNSYLVANIAN IN THE MOSCOW SYNECLISE (RUSSIA)

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Recently Kasimovian and Gzhelian stages of upper Carboniferous (Upper Pennsylvanian) are fixed in the International Stratigraphic Chart, but their GSSP have not been chosen yet. In the past decade research efforts increased to define markers of the lower Kasimovian boundary, to find sections where reliable phylogenetic succession can be traced, and where GSSP for this boundary can be established. Two conodont lineages *Idiognathodus nikitini*n.sp. - *I. sagittalis* from the Moscow Basin, and the *I. swadei* - *I. turbatus* from the Midcontinent have been proposed as possible biostratigraphic indices for the GSSP. We studied in detail stratigraphy and conodonts of the Kasimovian in Moscow and its nearest vicinities, as well as neostratotype of the Kasimovian – Afanasievo section. *Idiognathodus* sp. 3, the sole survivor of the late Moscovian extinction event, is the stem species for all early Kasimovian species of *Idiognathodus* in the Russian Platform. These forms persisted through the Moscovian-Kasimovian transition and gave rise to *I. trigonolobatus* in the Lower Krevyakinian, *I. nikitini* n. sp. in the Late Krevyakinian (Voskresensk Fm.), *I. sagittalis* in the Neverovo Fm. of the Khamovnikian Substage, and it probably descendent species, *I. mestcherensis* in Dorogomilovian Substage. This lineage can be considered as perspective for fixation of GSSP at the level of first appearance of *I. sagittalis*. The first appearance of *I .turbatus* is present in the Moscow Basin on the same level, but *I. sagittalis* may serve as an indicator of the base of the Kasimovian because it occurs more widely in Eurasia.

S21 - THE PHYLOGENETIC AFFINITIES OF THE ENIGMATIC MAMMAL *DECCANOLESTES* FROM THE LATE CRETACEOUS OF INDIA AND IMPLICATIONS FOR THE ORIGIN OF CROWN PLACENTAL MAMMALS

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Cretaceous mammals from India have received great attention since first reported because of their status as the only undisputed Cretaceous eutherians from a Gondwanan landmass. Furthermore, there have been suggestions that *Deccanolestes* may be a stem euarchontan (including primates and tree shrews), possibly representing the first pre-Tertiary fossil record of crown placental mammals. The few phylogenetic analyses of *Deccanolestes* noted its Laurasian affinities, but were based on poorly preserved teeth and tarsal elements. In recent years, dozens of additional and better preserved specimens have been recovered from intertrappean beds in Central and South India. Here, we report the results of a phylogenetic analysis including 83 Jurassic to Recent mammalian taxa, including new specimens representing 8 Cretaceous taxa from India, and 415 dental, cranial, and postcranial characters. In particular, Palaeogene representatives of euarchontans, adapisoriculids (possible stem euarchontans), and Afrotherian afrosoricids (including tenrecs) were also included. Results show a strong affinity between *Deccanolestes* and *Afrodon*, an adapisoriculid from the Late Palaeocene of Africa and Europe, supporting hypotheses of dispersal between India and Africa during the early Palaeocene before a subaerial connection between India and Asia existed. However, our results do not support a close affinity between either of these taxa and euarchontans. Preliminary results instead support an affinity with Afrosoricida. If this relationship is upheld by further analysis, it would represent the first strong fossil evidence for pre-Tertiary divergences of crown Placentalia and begin to close the lengthy gap between molecular and fossil divergence time estimates for the extant placental clades.

S6 - STRATIGRAPH: AN OPEN-SOURCE FRAMEWORK FOR ANALYZING STRATIGRAPHICALLY DISTRIBUTED DATA

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Data from stratigraphic paleontology and community paleoecology are scale-dependent, and in real-life situations always 'noisy'; dates or times, taxonomic identifications, and locations are often approximate or incorrect. Identifying a geological or biological signal through such statistical noise constitutes exploratory data analysis; often more art than science. Stratigraph is a framework for handling such data. It is distributed as a package in the R graphics/statistics language; it currently consists of a data structure, input/output functions, example data, and analytical functions for plotting pollen diagrams and correlating stratigraphic sections. Unlike menu-driven, compiled software which often does not provide the generality or flexibility needed to tune analyses to particular data sets, Stratigraph is intended to show the advantages of interactive data analysis via open source, community-supported scripting in a high-level programming language.

S5 - COLLECTIONS MANAGEMENT AT THE JOGGINS FOSSIL CLIFFS UNESCO WORLD HERITAGE SITE: A NEW MODEL?

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The Joggins Fossil Cliffs (Nova Scotia, Canada) contains an unrivalled fossil record, preserved in its environmental context, which represents the finest examples in the world of Carboniferous terrestrial tropical ecosystems. The Joggins Fossil Institute (JFI) is a non-profit, charitable, community-based organisation which was created to aid in the promotion, conservation, and sustainable development of the Joggins Fossil Cliffs. All fossils in Nova Scotia legally belong to the province and collecting is only allowed with a Heritage Research Permit. JFI works in partnership with the Nova Scotia Museum (NSM, Department of Tourism, Culture and Heritage) to manage the most comprehensive collection of Carboniferous fossils that is housed at the award-winning interpretive and research centre in Joggins. JFI houses a collection of Joggins fossils that is on loan from the province. JFI and the province share curatorial responsibilities for the collection and training of new staff on curatorial practices and care and handling of the collection. The province has provided a specialized, site-specific database that allows JFI staff to catalogue new material as it is collected and share these records with a central server. NSM, in partnership with JFI, has also developed an on-line searchable database of the collection housed at the Institute. This style of collection management is a new model that allows for shared responsibility and best-practices for curation between institutions. Our institutional relationship represents a critical step in achieving JFI's goal of having a co-managed site with the provincial government.

S10 - BIOMARKER DISTRIBUTIONS AND ISOTOPIC SIGNALS ASSOCIATED WITH THE PERMIAN /TRIASSIC AND TRIASSIC/JURASSIC MASS EXTINCTION EVENTS: A GLOBAL PERSPECTIVE

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Biomarker evidence for photic zone euxinic (PZE) conditions within P/Tr sections, where concentrations of sulfide are sufficient to support anoxygenic photosynthesis derive from pigments of green sulfur bacteria (GSB). Perturbations in the marine sulfur cycle and thus the redox-state of the seas are also reflected in $d^{34}S$ of pyrite supporting widespread PZE in both Palaeotethys and Panthalassa Oceans. C_{33}-*n*-alkylcyclohexane (C_{33} ACH) reported in 4 P/Tr sections has been attributed to a specific community of phytoplankton that bloomed during the marine ecosystem collapse (Late Permian) and well into the Middle Triassic. Dibenzothiophene, dibenzofuran and biphenyl have been detected in high abundances in samples prior to the marine collapse. We have proposed that lignin derived from land plants, present during the Late Permian is their source. We provide sedimentological data, biomarker abundances and compound specific $d^{13}C$/dD along with $^{34}S_{pyrite}$, $d^{13}C_{carbonate}$ & $d^{13}C_{org}$ for several Late Permian sections. At 2 localities sedimentological and geochemical data supports a marine transgression and collapse of the marine ecosystem in the Late Permian. dD of biomarkers reflects a change in microbial community structure. Further, we report biomarker and isotopic evidence for a phytoplanktonic bloom triggered by eutrophication as a consequence of the marine collapse. The Tr/J is the fourth most acute extinction event of the Phanerozoic in terms of ecological impact. Resin-derived biomarkers are abundant in the plant extinction horizon attributed to gymnosperms probably produced under extreme environmental stress. Presently a global biomarker and isotopic study is underway for the Tr/J extinction.

W1 - REVOLUTIONARY NEW UNDERSTANDING OF CRINOID ORIGINS AND EARLY HISTORY: OLD QUESTIONS ADDRESSED, NEW QUESTIONS POSED

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Previous efforts by palaeontologists directed toward understanding crinoid origins and early phylogeny have been speculative, reflecting virtual non-existence of basal taxa. Middle and Late Ordovician taxa have been viewed as primitive, but they are diverse and derived, their usefulness in phylogenetic reconstruction clouded by homoplasy. Early Ordovician finds, until recently, have been rare. *Aethocrinus*, late Tremadoc, Early Ordovician, was the oldest known crinoid, widely accepted as the most basal known taxon. Five recently discovered Early to Middle Tremadoc crinoids extend the range of camerate, cladid, and disparid clades downward, predating the Late Ordovician by 30 million years. These crinoids express plesiomorphies assignable to basal crinoid or earlier phylogenetic levels not found in later taxa. Floor plate- and brachial-bearing arms are evidence of crinoid origin from edrioasteroids (as broadly defined) rather than blastozoans, the latter trait diagnosing the class Crinoidea. Among edrioasteroids, the edrioblastoids furnish

the closest putative crinoid progenitor but supporting evidence for this relationship is tenuous. Evidence for basal crinoid morphology can be inferred from Tremadoc crinoid morphology but sister-group relationships among camerate, cladid, and disparid clades are not yet apparent. These basic questions underscore the need for additional discoveries in Tremadoc-aged and older rocks.

S27A - REVIEW OF SHARKS OF THE GENUS *HETERODONTUS* (BLAINVILLE, 1816) FROM THE LATE CRETACEOUS OF THE ANGLO-PARIS BASIN

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Modern species of the genus *Heterodontus* are relatively small, with two spined dorsal fins, prominent eye ridges and a dentition characterised by two tooth morphologies: small, pointed, clutching anterior teeth and low, blunt, crushing lateral teeth. Although fossil representatives of the genus are mainly found as isolated teeth, associated dentitions, fin spines and sub-complete specimens are also known. Isolated teeth recovered from bulk samples from localities in southern England, northern France and Northern Ireland supplement this study. The isolated teeth, recovered in association with rich selachian faunas, come from sites ranging from Cenomanian to Campanian in age, and are mainly from phosphatic chalk facies, which are typically present as concentrations immediately above hardgrounds or forming fossil-rich basal lag accumulations. Study of these new collections and archival research on museum material has revealed additional information on previously described Late Cretaceous specimens as well as identifying one new species which possesses a dentition unlike that of other Cretaceous taxa.

S26 - BLACK IS THE COLOUR – NOT JUST A SEASONAL FASHION

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In 1977 Fischer and Arthur proposed that the history of the last 200 million years can be understood in terms of cyclic changes between so-called *polytaxic* and *oligotaxic* episodes. Such simple cyclicity has a number of shortcomings, and has not been generally accepted. What is focussed on here are the supposed alternations between oxidation state, represented by laminated black and unlaminated red sediments. The type example of the former occurs in the Aptian-Albian, with deep-ocean black shales signifying one of Schlanger and Jenkyns *oceanic anoxic events*. However, in north eastern England their stratigraphic equivalent is the so-called Red Chalk. In the Lower Toarcian, widespread laminated black shales have been held to signify another oceanic anoxic event, but deposits of this age in the Italian Apennines consist of the red Ammonitico Rosso, laid down in deeper, well oxidised water. While the red-black contrast certainly signifies different facies, there is no simple cyclicity recognisable through the later Phanerozoic. For the detection of geologically significant events, black colour is much the more important. The term black shales is a useful short phrase to signify laminated organic-rich deposits signifying deposition in anoxic conditions, although the deposits in question need not recessarily be either black or shaly. Episodes of widespread marine black shale deposition appear to correlate well with episodes of widespread anoxia and mass extinction. They characteristically correlate with times of marine transgression, and in the terminology of sequence stratigraphy they tend to represent *maximum flooding surfaces*. We investigated newly discovered marine Chinese sections embracing the Permian-Triassic boundary, which marks the biggest extinction event of all. Continuing work across the globe has confirmed that marine anoxia has been a major factor in the mass extinction.

S23 - NEW ANATOMICAL DATA ON THE SELKIRKIIDS FROM THE LOWER CAMBRIAN OF CHENGJIANG, SOUTH CHINA

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The priapulid worm selkirkiids, a tubicolous benthic taxon in the Middle Cambrian Burgess Shale (Canada) and the Kaili fauna, Guizhou (China), have been a main source for investigations into the prototype for stem-group priapulids. Whereas *Paraselkirkia sinica* from the Lower Cambrian Chengjiang deposits of Yunnan, China, should have retained some primitive states crucial for the reconstruction of the early lineage of this clade. Our new observations include: 1) the proboscis consists of three spinose zones intercalated with two smooth zones, strikingly different from other stem group priapulids; 2) a terminal cover rather than one or two flaps is present at the pointed end of the tube and occasionally found detached from the tube end; 3) a bulbous gizzard anterior to the anterior gut is occasionally found inside the introvert; 4) the gut can be considerably coiled with knob-like infillings commonly seen in other stem groups; 5) the tube is probably not a cuticular layer of the trunk, differing from those of extant loricate larvae; 6) some areas of the trunk can be enlarged into a swollen structure intruding against the tube wall, and probably in this way the trunk can be withdrawn into or projected beyond the tube, dragging the tube forward. A new species, which was originally regarded as larger-sized individuals of *Paraselkirkia sinica*, is erected based on the different arrangement of the proboscis ornament.

S1 - INFERRING CAUSAL RELATIONSHIPS BETWEEN GEOLOGICAL AND FOSSIL RECORDS

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Observed correlations between geological and fossil records may involve a combination of a direct forcing and mutual response to external factors. Teasing apart the relative importance of these confounding factors remains a challenge. The relative strength of causal dependencies will, under ideal conditions, be reflected in the relative magnitude of partial correlations and/or signal frequency power spectra. However, when faced with the added complexity of mutual responses to processes potentially acting on multiple scales, standard tools may be less useful or even misleading. Here I use information-theoretic methods to detect causal interactions directly from incomplete and noisy geological time series, without recourse to modelling. For inference skill assessment, I use sedimentary basin simulations to run "what-if" experiments linking together sea level change, habitat availability, true diversity, outcrop volume, sampling intensity and fossil diversity. Hypothetical scenarios range from simple, linear responses to multiple interactions involving non-linear coupling. By combining estimates of (1) the relative strength, (2) scale variance, and (3) directionality of the interactions, a direct forcing (e.g., outcrop bias) can be distinguished from common-cause response (e.g., shelf flooding). This is possible even when the responses to an underlying forcing factor are very different and non-linear, and for sampled time series shorter than 50 data points. The ability to quantify directional asymmetry and the relative influence of forcers operating on different scales may be of particular inferential value. Finally, I apply the method to observed records and discuss the results in light of previous analyses.

S27B - HOLOCENE *MYTILUS* IN THE BARENTS SEA REGION

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Though commonly found on raised shorelines, the mussel *Mytilus edulis* has in modern time been absent from the northern part of the Barents Sea region until very recently. Because of its absence from this area in the late Holocene, specimens of subfossil *Mytilus* found here are commonly ^{14}C-dated. Some investigations have reported how the distribution of the species changed through the Holocene at Svalbard. Here we present for the first time a series of time slides showing the changing distribution of the species within the entire Barents Sea region. These include two new dates from the first finds of *Mytilus* along the northeastern coast of Spitsbergen. Though few dates are available from the southern and eastern parts of the Barents Sea, there is a strong positive correlation between the prominent sea current systems and changing oceanic climate, and the spatial and temporal distribution of *Mytilus edulis*. During the early Holocene climatic optimum, the species appears to have spread to and settled in most parts of the region within less than two thousand years, by following the strengthened flows of warm Atlantic water. During the late Holocene cooling, the species became restricted to the southernmost part of the region.

S20 - SOFT BODIES FROM THE SIRIUS PASS: COMBINING A UNIQUE ENVIRONMENT WITH AN UNUSUAL TAPHONOMIC WINDOW IN THE CAMBRIAN ROCKS OF NORTH GREENLAND

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The remote area of Sirius Passet in North Greenland exposes one of the key and earliest of the Phanerozoic lagerstätten. The geological setting of this unique Cambrian locality, the composition and taxonomy of its fauna together with its environmental setting are now well established through the pioneering expeditions of the 1980s and early 1990s, but much less is known about this biota and its taphonomy together with its role in understanding the Cambrian explosion than those of other Cambrian lagerstätten, notably Chengjiang and the Burgess Shale. New bed-by-bed investigations of the approximately 8.5 m of exposed Buen Formation at the classic locality has yielded *in situ* fossil material; field counts of taxa together with preliminary rarefaction analyses suggest more taxa are yet to be discovered. Various characteristics set the fauna apart from other Cambrian lagerstätten, including a) the relatively high abundance of taxa, dominated by the bivalved arthropod *Isoxys*, b) the mode of preservation on smooth bed surfaces with some mouldic preservation together with silicified gut contents and muscle tissue in many taxa, associated with microbial mats, c) the autochthoneity of much of the fauna and the presence of large, soft-bodied arthropods, and d) the very restricted distribution of the fauna. Together the fauna indicates not only an unusual taphonomic window but also a unique environment in deep-water, dysoxic conditions; the abundance of soft-bodied animals suggests few predators and scavengers. More typical Burgess Shale type preservation occurs within certain beds where abundant carbonized films of mostly sponges and arthropods occur.

S27D - A NEW CRUSTACEAN MICRO-LAGERSTÄTTE FROM THE MIDDLE CAMBRIAN EARLIE FORMATION OF SASKATCHEWAN, CANADA

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Like other arthropods, crustaceans experienced a dramatic Cambrian 'explosion', although their early fossil history is comparatively obscure. Exceptionally preserved carbonaceous microfossils are a crucial source of data, complementing the very different view onto Cambrian crustaceans provided by phosphatic Orsten-type preservation. Until now, however, only a single occurrence of a carbonaceous crustacean 'micro-Lagerstätte' has been reported, from the early Cambrian Mount Cap Formation of the Northwest Territories, Canada. Here we describe a new assemblage from the late middle Cambrian Earlie Formation of Saskatchewan, Canada, which likewise contains sophisticated crustacean mouthparts such as filter plates and mandibular molar surfaces, and confirms Mount Cap-type preservation as a unique window onto the fine-scale anatomy of larger-bodied Cambrian crustaceans. Corresponding body parts from the two assemblages are sometimes almost identical in anatomy and preservation, revealing the previously unseen geographic and temporal range of such crustaceans, but also implying a strong bias within this preservational mode. Other body parts, notably the mandible, exhibit important differences in shape and ornamentation. These help to constrain interpretations of phylogenetic position and ecological significance for the Mount Cap and Earlie fossils, which offer a fresh perspective on early arthropod evolution.

S19 - ARE PALAEOSCOLECIDS ANCESTRAL ECDYSOZOANS?

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Palaeoscolecids, an extinct group of introvertan worms known from the Cambrian to Silurian, have been suggested as models for the ancestor of Ecdysozoa, a major branch on the animal tree of life. However, their extinct character combination means that their precise phylogenetic position has been difficult to resolve. Here, we test between competing hypotheses of affinity by performing a review of palaeoscolecid characters, including new observations on gross anatomy and sensory organs, and a detailed description of the internal structure of the cuticle, based on sectioned specimens of isolated sclerites (*Hadimopanella*, *Milaculum*) as well as articulated material. We identify specific characters shared with scalidophorans (priapulids, loriciferans and kinorhynchs) and nematoids (nematodes and nematomorphs), but not with panarthropods. Cladistic analysis of a revised and augmented dataset for living and extinct ecdysozoans resolves palaeoscolecids as stem-group priapulids. An alternative scenario in which palaeoscolecids are positioned close to the ecdysozoan ancestor is less parsimonious, and furthermore requires the rejection of well-supported homology statements. We note that as palaeoscolecids have become better known, support has grown for a more derived phylogenetic position, cautioning against a tendency to assign poorly known and poorly preserved fossils to positions deep within the metazoan tree.

S27D - MORPHOLOGY, ONTOGENY AND EVOLUTION OF MANTIS SHRIMPS (STOMATOPODA, CRUSTACEA) IN THE LIGHT OF NEW MESOZOIC FOSSILS

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Mantis shrimps (Stomatopoda) comprise a group of large, colourful malacostracan crustaceans. The internal relationships of Stomatopoda remained difficult to understand, not least because many taxa are only known from fragmentarily preserved fossils. In particular, the appendages, a crucial character for evaluating systematic affinities, were thought not to be visible on certain Mesozoic stomatopods (e.g. Schram 2007), although Kunth (1870) had already reported the finds of raptorial appendages of such fossils. We present appendages of several stomatopods from lithographic limestones from southern Germany and Lebanon dated to the Jurassic to Cretaceous. Different ontogenetic stages of certain stomatopod species were also discovered, contributing important morphogenetic data. In our analysis we focused on the raptorial apparatus, which, for the first time, could be documented in detail for Mesozoic stomatopods. Fossil mantis shrimps exhibit four different morphologies: 1) four equally-sized raptorial appendages, 2) one large and three medium-sized limbs, 3) one large, one medium-sized and two small limbs, and 4) one large and three small appendages. This is also the condition in extant stomatopods. The morphology of the pleon (including pleopods, tail fan) provides another complex phylogenetic signal. Taking all data into account, we are now able to propose an evolutionary scenario for Stomatopoda, which includes a stepwise miniaturisation of the posterior raptorial appendages. The evolution of the raptorial apparatus may have resulted in a specialisation of the feeding habits from a more generalised system in the stomatopod ground pattern to that developed in modern taxa.

W5 - USING LIGHT MICROSCOPY FOR 3D IMAGING

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We present a rather simple method for obtaining 3D images of small-sized specimens by applying transmitted light microscopy. The data are then processed with the aid of open-access computer software. The specimens are documented as a stack of images, i.e. images are taken from several focal levels. Up to 300 images should be taken to obtain an accurate resolution in Z-axis. The resulting stack is processed further using three software packages consecutively: 1) CombineZM for eliminating small lateral offsets of the single images within the stack = aligning; 2) ImageJ for transforming sharp areas into information (white) and deleting blurred areas (they become black); and 3) OsiriX/OsiriS for projecting the processed image stacks in three dimensions. These projections can be exported either as red-blue stereo images or as QuicktimeVR files without further processing. As for other methods based on a stack approach, such as confocal Laser Scanning Microscopy (cLSM) or Depth from Defocus, resolution in lateral aspect is superior to that in Z-axis. Again, details of the microscopic method must be adjusted to specific requirements of the material. We applied dark-field microscopy to extant crustaceans as well as the fossil 'Orsten' arthropods, while Rhynie chert fossils can be illuminated best with bright field. Especially for this latter type of fossil preservation in an optically dense matrix, the method applied yields enormous potential, whereas other 3D methods tested on Rhynie chert material, such as cLSM or Synchrotron Micro Computed Tomography, did not yield sufficient results.

S18 - METABOLIC PALEOTHERMOMETRY: CLIMATIC INSIGHTS FROM THE FOSSIL RECORD OF REPTILES

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Histories of body size evolution in Cenozoic reptiles provide paleothermometric estimates from a previously unexplored dataset. Poikilothermic taxa are dependant upon a critical minimum ambient temperature to maintain maximum body size for a given metabolism, and the relationship between environmental temperature and body size in extant reptiles provides a model for inferring paleoclimate from body size in fossils. Latitudinal changes in body size within modern reptiles are consistent with a model that predicts proportionality of size with temperature. The model can be derived to calculate past temperatures by comparing body sizes in fossil reptiles with maximum sizes in extant reptiles at a given Mean Annual Temperatures (MATs), assuming similar ecologies and appropriate mass-specific metabolic rates for both modern and fossil taxa. Phylogenetic constraint minimizes such assumptions, and multi-taxon sampling increases the robustness of estimates for a given depositional environment. Cenozoic paleotemperatures were estimated by comparing maximum body sizes of extant turtles, crocodilians, and snakes from aquatic environments at known mass- specific metabolic rates for modern MATs with Paleogene and Neogene herpetofaunas from equatorial South Asia, South America, and North America. Gigantism in fossil taxa indicates high tropical MATs during the Paleogene and late Miocene, with poleward temperature gradient magnitudes similar to modern values. These results support hypotheses of hot equatorial climates during greenhouse intervals and indicate warmer equatorial regions than previously considered for the late Neogene global cooling event.

S27D – AN EXCEPTIONALLY PRESERVED STEM-GROUP STICK INSECT (HOLOPHASMATODEA: SUSUMANIIDAE) FROM THE JURASSIC OF CHINA AND THE EARLY EVOLUTION OF PHASMATODEA

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Preliminary study of a remarkably well-preserved stem-group stick insect from the mid-late Jurassic Daohugou Lagerstätte of Inner Mongolia sheds much needed light on the relationships and early evolution of the order Phasmatodea. The new genus can be unequivocally assigned to the extinct holophasmatodean family Susumaniidae, previously placed within Orthoptera. The exquisite preservation of the new specimen allows identification of important diagnostic character suites, providing unprecedented resolution of relationships and confirming the phasmatodean affinity of these Mesozoic stem exemplars. Furthermore, analysis of wing venation characters firmly establishes the relationship between Phasmatodea and the other orthopterid orders. This relationship does not support the Archaeorthoptera hypothesis, which excludes the stick insects from the clade comprising Orthoptera and its stem groups. This pivotal specimen confirms the relationship between Mesozoic phasmatodean-like taxa and the derived crown-group stick insects, allowing reassessment of higher level systematics in orthopterid Polyneoptera. Holophasmatodea is clearly nested within Orthopterida, though the radiation of true, crown-group Phasmatodea has yet to be elucidated.

S22 - MESOZOIC MICROVERTEBRATES AS WINDOWS INTO TETRAPOD TOOTH EVOLUTION AND DEVELOPMENT

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Extant archosaurs poorly represent the clade's past diversity, and provide particularly poor models for understanding the evolution of archosaurian dentitions. In spite of a rich fossil record, archosauriform teeth are under-utilized, largely because of the perception that homoplasy and convergence obscure differences between taxonomic and non-taxonomic (positional, ontogenetic, individual, taphonomic, chimaeric and pathological) variation. Mesozoic small- and micro-vertebrates demonstrate that taxonomic distinctions are possible even in ziphodont dentitions, including sympatric Cretaceous theropods (*Dromaeosaurus*, *Pectinodon*, *Richardoestesia gilmorei*, *R. isosceles, Saurornitholestes*,*Troodon*), the Jurassic theropod *Koparion*, and diverse Triassic taxa, some named (*Revueltosaurus*, *Crosbysaurus*, *Uatchitodon*) and others only identified as morphotypes. Triassic microvertebrate faunas demonstrate that simple measurements of tooth proportions and denticle density can discriminate distinct faunas from different localities. Even isolated teeth yield important information on the evolution of dental adaptations. For example, venom delivery structures vary from open to fully enclosed in a large sample (>40) of *Uatchitodon* teeth both the Tomahawk and the Moncure microvertebrate localities (Newark Supergroup), supporting the "infolding" hypothesis of venom tube formation. Similarly, *Crosbysaurus* teeth from multiple Upper Triassic localities in the south-western USA are "sub-denticled," where the few, large denticles each posses 1-3 subdivisions or smaller denticles, implying that one pathway to developing teeth with fewer, larger denticles, lies through expanding a subset of denticles, perhaps every fourth or fifth denticle. Careful description of both isolated teeth and *in situ* dentitions thus will not only resolve issues of taxonomy and diversity, but also open windows into evolutionary and developmental questions.

S20 - THE TAPHONOMY OF MODERN *NAUTILUS* (CEPHALOPODA) IN A NEARSHORE, SHALLOW WATER ENVIRONMENT, LIFOU (LOYALTY ISLANDS)

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A collection of 34 submerged *Nautilus macromphalus* shells was recovered in 2008 from a shallow lagoon on the island of Lifou, Loyalty Islands. The specimens were either on the surface or partly buried in carbonate-dominated sediment in water depths of 1–3 meters. The majority of the specimens (66%) were recovered in a horizontal position, but 34% were vertically oriented. While several specimens were clean with sharp color stripes, the majority had substantial algal and cyanobacterial overcoats with some epizoans. The *in situ* specimens were compared to 47 beached *Nautilus* shells collected in 2002 from the same locality, many of which were also encrusted. Analysis of the two populations reveals that *Nautilus* shells may or may not float directly to the beach. Shells not immediately transported to the beach sink in the shallow lagoon in a vertical position. If present long enough, weight added by attached organisms and water infiltration causes the submerged shells to fall into a horizontal position. Waves, currents, and bioturbation then flip the shells over from side to side. Eventually, submerged shells are buried, broken apart, or transported onto the beach. Beached shells that follow this taphonomic pathway have conspicuous algal coatings compared to those that simply float to shore. The Lifou *in situ* population represents the first substantial modern, externally shelled cephalopod collection from a shallow water environment to be taphonomically analyzed. The results of this analysis can be used to enhance the interpretation of ancient nearshore deposits that contain fossilized externally shelled cephalopods.

S3 - PHYTOPLANKTON SIZE: CLIMATIC ADAPTATION AND LONG-TERM EVOLUTION

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Marine phytoplankton, such as diatoms and coccolithophores, constitute the base of the marine food chain and are a fundamental component in biogeochemical cycles. The overall ecological success of marine phytoplankton, but also its taxonomic diversity and size distribution, determines the efficiency by which fixed carbon is transferred to higher trophic levels and into the deep ocean- and sedimentary carbon reservoirs. Therefore, we need a better understanding of the mechanisms and rates of adaptation within phytoplankton to evaluate marine ecosystems under present-day and future climate scenarios of rapidly rising ocean temperatures and lowering of ocean pH ('ocean acidification'). The likely response of coccolithophores, the most prominent group of calcifying algae, in particular has provoked controversy. We have hypothesized that species-specific responses to climatic perturbations within extant members of this group are due to differences in the mechanism and rate of climatic adaptation inherent to their respective evolutionary lineages (Henderiks, J. and Rickaby, R.E.M., A coccolithophore concept for constraining the Cenozoic carbon cycle, Biogeosciences 4: 323-329, 2007). The Cenozoic ancestors of all extant coccolithophores have experienced much higher levels of CO_2 and lower ocean pH than today, according to proxy reconstructions over the past 60 million years. However, we show that different lineages display different levels of variation in coccolith shape and cell size, and that this could indicate that some species are more adaptable to climatic change than others. The observed geological trends in algal cell size also have implications for long-term feedbacks in the Cenozoic carbon cycle.

W6 - THE EVOLUTION OF GONDOLELLID TOOTH MORPHOLOGY IN RELATION TO HOW THEY LIVED AND ATE

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The concentration of Na on the oral surfaces of Permian gondolellid P_1 elements comparable to that seen in modern shark teeth indicates that these elements functioned as teeth exposed to seawater. The general shape of gondolellid P_1 elements has not changed dramatically, suggesting, if this form can be related to food type, that there were few changes in diet during their evolutionary history from Pennsylvanian to Triassic. Evolutionary changes to other elements in the gondolellid apparatus have been used to define numerous genera, but it is uncertain how these modifications would have affected food processing. However, the apparent fragility of the ramiform elements may point towards an herbivorous or scavenging role. The single pair of P_1 "molars", despite the complexity in shape of these elements, may preclude herbivory. There are two repetitive changes to P_1 element morphology that may be significant. The first pattern occurs during the Late Pennsylvanian/Early Permian and Early Triassic intervals when the platform margins become reduced or lost. The second pattern is represented by the development of widely spaced discrete denticles on the carina during third-order transgressive events in the Permian and Triassic. Both patterns can be attributed to retention of juvenile characters or paedomorphic development occurring during times of unstable environments characterized by fluctuating temperature and shelf space. It is uncertain whether these changes can be related to the relative abundance and parallel evolution or extinction (at end of Triassic) of an organism representing a potential food source, but non-ammonitic ammonoids may be an example.

S7 - ADAPTIVE LIMITS: EVOLUTIONARY CONSTRAINTS FOR LINGULIFORM BRACHIOPODS

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The unique Cambrian evolutionary fauna was dominated by vagile marine benthos and the ecologic space available to suspension feeders was not extensively exploited until the advent of the Palaeozoic evolutionary fauna during the Ordovician. Evolutionary strategies adopted by the sessile epibenthos of the Cambrian fauna were of limited scope and most forms were of small size. Success was directly challenged by the mobility of level bottom substrates generally available beneath shallow shelf seas where marine productivity and biodiversity were concentrated. Linguliform brachiopods were the most common and diverse elements of Cambrian epibenthos. They were diminutive, rarely exceeding 3 mm in diameter. Acrotretids, a major branch of the group, typically possessed a conical shell with apical attachment to the substrate by means of a pedicle. Individuals lay on the seafloor like drogues, aligned with prevailing bottom currents, and feeding depended on down-current eddies generated at the lip of the cone. The second major linguliform group, the lingulellids, was also epibenthic with their shells suspended in the water column above a muscular pedicle. The feeding strategies adopted of both groups were size-limiting with respect to evolutionary pathways. The epibenthic habit of linguliforms as very small organisms inhabiting mobile substrates focuses attention on attachment strategy as a critical constraint on success of the group. Attachment is informed by linguliform occurrence in an epeiric Cambrian succession in Australia where the Mail Change Limestone is characterised by a prolific linguliform fauna. It shows compelling evidence for cryptic boundstone substrates, suggesting a relationship between the availability of attachment sites and linguliform abundance. We speculate that cryptic boundstone substrates may have been an important influence on seafloor colonization by, and evolutionary potential of, linguliform brachiopods.

S27B - BODY SIZE IN SPACE AND TIME: EXPLORING SPATIAL SIZE GRADIENTS IN THE WESTERN ATLANTIC AND EFFECTS OF THE RISE OF THE ISTHMUS OF PANAMA

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Interpretation of temporal and geographic patterns in fossil body size variation is difficult without understanding modern trends and the mechanisms that drive them. We present a new and growing database of body size for selected gastropods and bivalves of the Western Atlantic and tropical Eastern Pacific, focusing particularly on taxa that exhibit a circum-Caribbean distribution and apparent species-pairs that exist on either side of the Isthmus of Panama. The database currently includes data for more than 500 species (c. 22000 specimens; 7000 specimen lots) that represent a range of trophic life-styles taken from adult specimens reposited in malacological collections. This database will allow a wide range of questions about modern body size distribution to be addressed as well as acting as a baseline for comparison with fossil data. We present size variations along geographic clines by a number of exploratory statistical and graphical approaches. Analyses to date among species sharing distributions around the Florida Peninsula and Caribbean suggest little difference in the geographic distribution of body-size maxima. At a finer geographic scale, however, it is apparent that particular areas within both regions have a tendency towards larger sized specimens. The Panamanian Isthmus provides a natural laboratory to test the effects of vicariance and changing environmental conditions (temporally-mediated processes) in a spatial setting. Initial results suggest that many Eastern Pacific species attain larger body size than their Caribbean cogeners. It remains to be seen whether these patterns hold up following increased sampling and the incorporation of additional taxa.

S1 - JUST HOW GOOD IS THE CENOZOIC FOSSIL RECORD? APPLICATIONS OF ENVIRONMENTAL COVERAGE, GEOGRAPHIC RANGE, AND BODY SIZE DATA TO TEST SPATIAL AND TEMPORAL COMPLETENESS

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Analyses of biodiversity, origination and extinction patterns commonly assume that the quality of the fossil record is relatively homogeneous. Nevertheless, it is apparent that preservational biases can vary significantly over both long and short time scales, and across spatial gradients. The Cenozoic fossil record provides a crucial test case for the quality of the fossil record given that it's fauna is so easily compared with living biota. Modern assemblages give us baseline data on faunal composition, abundance and size distributions, knowledge of organismal construction and preservability, as well as data on taxon geographic range and environmental constraints on distribution. Here, I compare the latitudinal range, environmental distribution, and size distribution of the known Western Atlantic and New Zealand fossil records with that of their respective extant molluscan fauna. Comparison of the Western Atlantic late Neogene fauna with their extant counterparts indicate: 1) poor sampling of geographic ranges (Recent taxa have 3 to 4-fold greater mean latitudinal range; 2) poor representation of deep-water assemblages (fossil assemblages dominated by nearshore faunas; lacking in bathyal faunas); 3) poor sampling of smaller size classes (only large sizes well represented). Analyses of the New Zealand Cenozoic fossil record indicate that: 1) environmental representation is temporally variable; and 2) taphonomic biases such as lithification can radically alter the abundance structure and size distribution of original communities. These findings further highlight the need to be careful in analyses of biodiversity and ecology through time and in space, particularly comparisons between fossil and recent faunas.

S27B - FACIES RELATIONS OF MOSCOVIAN AND KASIMOVIAN (PENNSYLVANIAN) SPONGES FROM THE CANTABRIAN MOUNTAINS, NORTHERN SPAIN

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Diversity, importance and facies relations of sponges from Moscovian and Kasimovian carbonate platform sediments of the Cantabrian Mountains, northern Spain, are elucidated. Results prove surprisingly widespread occurrence and an important contribution to buildup formation.
Coralline demosponges include chaetetids and sphinctozoans. Chaetetids are widely distributed in Moscovian platform settings. They form chaetetid level-bottom communities, thin chaetetid biostromes and the capping facies of algal (beresellid)-chaetetid buildups and syringoporid-chaetetid buildups. Variable growth types appear to be mostly controlled by water-energy. Starting in the late Moscovian, chaetetids are completely replaced by sphinctozoans. Both taxa do not co-occur. Sphinctozoans are surprisingly common and diverse and the Cantabrian Mountains might be considered as a hot spot for the late Palaeozoic evolution of the group. Delicate to slender taxa, in places forming dense meadows, inhabited low-energy, eutrophic muddy lagoons. In carbonate dominated lagoonal settings they intermingled with the stick-like growing dasycladacean *Anthracoporella*. On extended carbonate platforms predominantly large sphinctozoans lived in spicular sponge-echinoderm-sphinctozoan buildups below wave base. Rare body fragments of demosponges, among those lithistids, and a few hexactinellids are known. Sponge spicules are widespread. Most seem to belong to demosponges; unequivocal hexactinellid spicules are missing. Spicules occur in spicular sponge-echinoderm-sphinctozoan buildups and in syringoporid-chaetetid buildups below wave base. Common occurrences in algal buildups formed by *Anthracoporella* or *Archaeolithophyllum* and in sphinctozoan meadows stress the importance of spicular sponges in lagoonal inner shelf environments. Spicular remains of the boring sponge *Aka* from a bryozoan-crinoid-brachiopod buildup below wave base merit special attention.

W6 - USING CONODONT PALEOECOLOGY AND ISOTOPE GEOCHEMISTRY TO ASSESS IF A VOLCANIC MEGA-ERUPTION CAUSED GLOBAL COOLING DURING THE LATE ORDOVICIAN

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We tested for a climatic perturbation associated with the Late Ordovician Deicke eruption by estimating changes in ocean temperatures from the oxygen isotope ratios of single species separates of conodont apatite from the Carimona Fm. in SE Minnesota USA. Two of these taxa, *Polyplacognathus ramosus* and *Scyphiodus primus,* are proposed to have had a neckto-benthic habit living selectively in a shallow subtidal carbonate mud-dominated, wackestone facies. *P. ramosus* is not present in the upper Mississippi valley area above the Deicke K-bentonite bed, and its disappearance is attributed to a change to a muddier seafloor and increased turbidity. A third taxon*, Oulodus serratus*, is associated with *P. ramosus* and *S. primus* in the wackestone facies but continued to be present in the area after the shift to a muddier conditions making inferences about its ecology difficult. The final taxa examined, *Drepanoistodus suberectus* and *Panderodus gracilis*, were found in all recognized facies associations suggesting pelagic lifestyle. To test the hypothesis that there was cooling associated with the Deicke eruption, we used $d^{18}O$ values of conodont apatite as it has been shown to provide a diagenetically robust, paleoenvironmental signal. In contrast to predictions of models invoking volcanic forcing, we found no obvious or consistent change in temperature at or above the Deicke, but did see evidence of cooling among presumed nekto-benthic taxa (~4°C) in the 0.7 meters of section below it. This result argues against volcanic mega-eruptions as a general trigger for initiating long-term shifts in Earth's climate state.

S3 - CALCAREOUS NANNOFOSSIL "BLACKOUT" AND SEAWATER ACIDIFICATION PRIOR TO THE EARLY JURASSIC GIANT PERTURBATIONS TO THE CARBON CYCLE

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Rapid changes in the global carbon cycle in the past are indicated by pronounced shifts of the carbon-isotope profile from the sedimentary archive. Events such as those recorded across the PETM (~55Myr ago) or during the Early Toarcian (~184Myr ago) are thought to represent extreme and abrupt greenhouse episodes. The Early Toarcian experienced two perturbations to the carbon cycle: a 6‰ negative carbon-isotope excursion, and widespread deposition of organic-rich facies related to an oceanic anoxic event. Very high-resolution techniques in sedimentology (carbonate content, calcite vs. dolomite ratio), micro-palaeontology (calcareous nannofossil abundance and preservational state), and geochemistry (carbon and oxygen isotopes), applied to a succession from the Paris Basin, demonstrate an acidification of seawater before the major disturbance to the carbon cycle. Acidification is expressed by substantially diminished carbonate deposition on the seafloor prior to the carbon-cycle perturbations expressed in either carbon-isotope signature or enhanced organic carbon content. Anoxia is recorded at this location after acidification, during the decrease in the carbon-isotope ratios, and corresponds to a crisis in pelagic sedimentation. This crisis ended the recovery from the initial perturbation of the saturation state of seawater that had mostly been achieved by the rapid (few kyr) recovery of coccolithophores. This deep-time example of acidification of seawater caused by substantial pCO_2 levels from volcanism and dissociation of methane hydrates, illustrates the dynamic of the inorganic carbon cycle, and thus provides a meaningful analogue for understanding possible feedbacks for our "Anthropogenic Earth".

S6 - MULTI-VIEW STEREO 3D RECONSTRUCTION OF THE LOWER MOLARS OF RECENT AND NORTH-WESTERN EUROPEAN PLEISTOCENE RHINOCEROSES FOR THE PURPOSE OF MESOWEAR ANALYSIS

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Reconstructing palaeodietary regimes provides important information about the habitat conditions of palaeocommunities. Since wear patterns of mammalian teeth are influenced by the diet, the dental material of fossil species has proven to be an advantageous research subject. In 2000 Fortelius and Solounias introduced mesowear analysis, which can be used to reconstruct the diets of different herbivore species. In this work a method derived from mesowear analysis is presented for the analysis of the lower molars of rhinoceroses, to which classical mesowear analysis cannot be applied. The method is based on examining the phase I facets of the buccal enamel band. Multi-view stereo reconstruction was used to generate 3D models of the teeth from ordinary digital photographs. The digitally measured angle between the surface of the phase I facet and the buccal side surface of the teeth is used to score wear patterns. A variation of the method, where the scoring is made visually, is also presented. The palaeodiet reconstruction of North-Western European Pleistocene rhinoceroses was used as a study case. The reconstructed palaeodiets were compared to the dietary regimes of the Recent species of rhinoceroses. The results suggest that the dietary regime of Stephanorhinus etruscus and Stephanorhinus kirchbergensis fall within the browsing realm, whereas the diet of Stephanorhinus hemitoechus was more abrasive, yet not as abrasive as the diet of the Recent mixed feeder Rhinoceros unicornis. The dietary regime of Coelodonta antiquitatis falls between the dietary regimes of the Recent grazer Ceratotherium simum and mixed feeder Rhinoceros unicornis.

S22 - ONTOGENY UNDERPINS THE EVOLUTION OF DWARF ELEPHANT MOLARS

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Elephant molars are highly derived, with a horizontal system of tooth replacement that is characterized by the continued growth, development and eruption of molars late into adulthood (with dental ontogeny occurring over 40+ years). This delayed dental ontogeny is linked with the protracted post-natal skeletal ontogeny of elephants, over which they achieve their great body size. Dwarf elephants evolved repeatedly, and independently, during the Pleistocene when full-size mainland species became isolated on islands. In some cases, the size reduction was dramatic – the 100kg *Palaeoloxodon falconeri* from Sicily, for example, probably descended from the 10,000kg *P. antiquus*. Evidence from post-crania and skulls in hippos and elephants has previously suggested that island dwarfs evolved small body-size through paedomorphosis, and that this can explain many dwarf 'adaptations' (such as relatively small brains and robust limbs). The mechanisms underpinning dwarf mammal molar evolution are less well studied, but the extended post-natal dental development of elephants provides a unique opportunity to investigate the importance of ontogeny. Here we present new data to show that dwarf elephant molar morphology may also result from a truncation of the ancestral ontogenetic trajectory. By considering elephant dental ontogeny within the broader framework of mammalian tooth development, a single explanation is provided for seemingly disparate evolutionary trends in *Palaeoloxodon* dwarf elephants and *Mammuthus creticus*, the dwarf descendent of *M. meridionalis.* This broader implication for the use of dental characters in elephant taxonomy and phylogeny, and provides novel insights into the developmental basis of key Proboscidean macroevolutionary trends.

S19 - THE TRACE FOSSIL RECORD OF ECOSYSTEM ENGINEERING

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Ecosystem engineering is the physical production, modification and modulation of abiotic resources by a species, leading to the development of a new ecosystem. The mechanism by which the ecosystem is engineered can be allogenic (produced by the behaviour of the engineer) or autogenic (a consequence of the engineer's physical structure). Recent studies have begun to apply the concept of ecosystem engineering to the fossil record (e.g. Parras & Casadio 2006); here we use trace fossils to assess the palaeoecological record of allogenic engineering. In marine environments of Mesozoic and younger age, examples of allogenic ecosystem engineering can be demonstrated ichnologically. In the late Cretaceous of Utah, specimens of *Chondrites* occurring in the muddy lining of *Ophiomorpha* burrows indicate the exploitation by one species of an environment engineered by another (cf. de Gibert et al. 2006). This approach becomes increasingly difficult, however, in older rocks. Studies of the profound changes in bioturbation across the Ediacaran-Cambrian boundary at the Fortune Head GSSP, Newfoundland, for example, do not provide direct evidence of ecosystem engineering at that time. Though vertically burrowing organisms were critical to the evolution of benthic ecosystems, many of the commonest early Phanerozoic ichnotaxa (e.g. *Planolites*, *Skolithos*) cannot be linked demonstrably to an engineered palaeo-ecosystem. The environmental changes these tracemakers brought about were probably mostly non-local; they may be better termed biosphere engineers.

W5 - TRACING THE TRACES: THE ICHNOLOGICAL APPLICATIONS OF 3D VISUALIZATION TECHNIQUES

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Though now used widely in the fields of vertebrate and invertebrate palaeontology, the application of 3D visualization techniques to the study of trace fossils has been very limited. The recent work of Naruse & Nifuku (2008) and Bednarz & McIlroy (2009), however, has demonstrated the sedimentological, palaeoecological, palaeobiological and petroleum geological potential of such approaches. Using examples from Palaeozoic and Cainozoic mudstones, Mesozoic sandstones, and experimental sedimentary microcosms, we discuss here some of the techniques that can be used to visualize burrows in 3D. These include using CT scanning to visualize burrow networks produced by organisms in experimental aquaria, and using high resolution serial grinding and composite digital photography to reconstruct large trace fossils. These techniques provide a wealth of new information on the constructional morphology, behaviour and sedimentological impact of bioturbating organisms.

S12 - IDENTIFYING *OSEDAX* TRACES ON FOSSIL WHALE FALLS

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In 2004 a new genus of worms, *Osedax*, was described from whale skeletons on the deep-sea floor. These worms were found to be actively boring into the whale bones for nutritional benefit. On some whale remains they have been found at high densities, causing rapid degradation of the skeletal material. The taphonomic consequences of this boring have not yet been fully resolved. *Osedax* worms are very important members of whale fall communities. Their destructive activities decrease the longevity of skeletons on the seabed and may also regulate sulphide flux from the bones by increasing their porosity. Thus, *Osedax* directly affect the ability of whale skeletons to host chemosynthetic communities and act as dispersal stepping-stones for sulphophilic organisms over long periods of time. Since the initial reports at least 17 species of *Osedax* have been identified, with more awaiting description. The group appear to be cosmopolitan in the deep-sea, living at depths from 30m to over 3000m. They have been found from both sides of the Pacific and the NE Atlantic. With such a large potential taphonomic footprint it is important to consider how *Osedax* may have shaped past whale fall communities. Yet it is unclear how, or if, *Osedax* could be recognised in the fossil record. Using micro computed-tomography we have determined the morphology of *Osedax* borings in recent whale bone, documenting the changes over time. With this information it is now possible to identify potential *Osedax* traces, allowing their past taphonomic and ecological significance to be assessed.

S5 - PALAEONTOLOGICAL COLLECTIONS IN ESTONIA: AN EXAMPLE OF DEVELOPMENT OF NATIONAL COLLECTION MANAGEMENT SOFTWARE

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Large palaeontological collections in Estonia are owned by three institutions: Tallinn University of Technology (GIT), University of Tartu (TUG) and Estonian Museum of Natural History (ELM). Altogether the number of fossil specimens is close to 0.5 million; most of them are Ordovician and Silurian invertebrates and Devonian vertebrates from the Baltica palaeocontinent. Some early Paleozoic microfossil collections (chitinozoans, scolecodonts, conodonts, ostracods) are among the largest in the world for this time interval. The electronic management of palaeontological collections started in late 1990s when an in-house MS Access database was developed at GIT. Since then the system has continuously grown, both in functionality and the amount of data. ELM and TUG deployed the same data model and software in 2005 and 2008, respectively, making up a virtual “national geological collection” together with GIT. Now the system contains over a hundred related tables served by open source MySQL database server. The front-end for regular collection management procedures (accessioning, keeping track of the specimens, printing labels and loan invoices etc) is still largely based on MS Access. However, with the emergence of new standards and technologies, the focus is switching to web-based solutions, which will eventually replace the desktop software. As of 2010, about 20% of Estonian fossil collections are electronically catalogued. Most of these data, including specimen records, digital images, information on geological localities, literature and so on, are publicly available through a common web portal at http://geokogud.info. The Estonian palaeontological collections are also accessible via BioCASE and GBIF specimen-level data networks.

S8 - METAZOAN EGG CAPSULES FROM THE BALTIC DARRIWILIAN (MIDDLE ORDOVICIAN)

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Enigmatic organic-walled microfossils were recovered from limestones in the Kunda Regional Stage, lower Darriwilian, in the Viki (western Estonia), Rapla (central Estonia) and File Hajdar (Gotland, Sweden) drill cores. The collection contains several hundred specimens co-occurring with chitinozoans, acritarchs, prasinophytes, scolecodonts and microscopic gastropods. These fossils are spherical hollow shells, 90-130 microns in diameter, composed of black organic material, with no openings. They have shiny laevigate to verrucate, sometimes undulating outer surfaces. Characteristic of all specimens is an equatorial groove that visually divides the shell into two hemispheres. Two parallel small ridges commonly occur in the bottom of this groove. The shell wall varies in thickness and structure, being 3-25 microns thick and usually composed of opaque inner and outer layers, with porous material in between. The groove does not penetrate the wall and is not reflected on the smooth inner surface. Broken specimens were not split along the groove. To our knowledge similar fossils have not been reported from the Baltic Ordovician, or elsewhere, so far. Thickness and structure of the capsule wall is notably different from that of prasinophytes, acritarchs and spores. Although different in size and shape, the wall structure is similar to that of egg shells of some molluscs and echinoderms. We therefore suggest that the reported fossils most likely represent metazoan egg capsules, but the egg-producing organism itself remains unknown. Fossil eggs are rarely reported in the Palaeozoic, except for the chitinozoans, which, too, are interpreted as eggs of a yet unknown group of metazoans.

S27A - A BURROWING, LACERTID-LIKE SQUAMATE FROM THE EOCENE OF MESSEL, GERMANY, REVEALS AMPHISBAENIAN ORIGINS

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Recent molecular investigations have dramatically challenged the traditional view of squamate relationships. Among the many shifts in paradigm, the hypothesis of a sister relationship between amphisbaenians and lacertids figures among the most prominent, as it has significant implications for the evolution of limblessness in squamates. However, so far there has been no morphological or fossil support for this relationship. Here we report on the discovery of a new lacertid-like lizard from the early Eocene Messel locality of Germany, consisting of a completely articulated specimen of which only parts of the tail and the shoulder girdle are missing. The new taxon is characterized by a spatula-like snout with a modified premaxilla and maxilla, notably small and anteriorly positioned orbits, lack of a tympanic crest, low tooth count, and reduced manus and pes. In a phylogenetic analysis including both morphological and molecular characters from extant and fossil taxa, the new taxon groups consistently with amphisbaenians and lacertids, showing the tendency to fall in a sister position to Amphisbaenia. Morphometric analysis of body shape and ecology among squamates places the taxon in cryptic or opportunistically burrowing habitats. The combination of cranial kinesis with a more generalized postcranium indicates that head-first burrowing evolved prior to body elongation, and may have been a crucial first step in the evolution of fossoriality in Amphisbaenia.

S27B - TAXONOMIC REVISION OF THE LATE CRETACEOUS AMMONITE *POLYPTYCHOCERAS* YABE, 1927, BASED ON AN ONTOGENETIC STUDY

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Six species from the Upper Cretaceous of Japan have been referred to the genus *Polyptychoceras*, Yabe, 1902. The type species of the genus is *Ptychoceras pseudogaultinum* Yokoyama, 1890 and the other five species are: *Anisoceras subquadratum* Yokoyama, 1890, *A. haradanum* Yokoyama, 1890. *A. subundulatum* Yokoyama, 1890. *Hamites* (*Polyptuchoceras*) *yubarensis* Yabe, 1927, *H. obstrictum* Jimbo, 1894. The original descriptions of these six species were based on fragmentary specimens. Since the original description by Yokohama 120 years passed, and during this long time better specimens and information have been accumulated. As a result, it becomes clear that these six nominal species were discriminated by different morphology of different ontogenetic stages of some species. The morphology of ribbing and cross section were the traditional criteria used for discrimination. We studied ontogenetic changes in the morphology of 128 specimens obtained from the Upper Cretaceous Yezo Group in Hokkaido, Japan, with a focus on the ribbing and cross section. The ribbing is divided into six forms and the cross section is into two forms. We clarified that the combination of these six ribbing and two cross section forms changes with growth. As a result it appears that the six nominal species were based on different ontogenetic stage of three species, *P. pseudogaultinum*, *P. obstrictum* and *P. yubarense*.

S26 - THE SILURIAN NAUTILOID FAUNAS OF THE CELLON SECTION (CARNIC ALPS, AUSTRIA): COLOUR VARIATION RELATED TO EVENTS

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The rich abundance and variety of the Silurian nautiloid faunas of the “Orthoceras Limestones” of the Carnic Alps (Austria) were first documented over a century ago and are now being redescribed in detail. A range of multidisciplinary studies have been carried out on the Silurian successions of the Cellon section in recent years so that a comprehensive data set with regard to documenting microfacies, eustatic changes, oxygen and carbon isotope excursions and palaeoenvironmental settings using pelagic and benthic faunas and taphonomic signals is now available within a biostratigraphically well constrained framework based on conodonts, chitinozoans and graptolites. Nautiloid communities found within the Silurian Cephalopod Limestone Biofacies along the North Gondwana margin have been identified in Sardinia and central Bohemia and representative elements of these also occur in the Carnic Alps. Concentrations of rare juvenile faunas occur at certain intervals. The various nautiloid-bearing levels from the Cellon section (Wenlock-Pridoli), their nautiloid faunal composition and the particular taphonomic features presented will be compared with co-eval nautiloid faunas described from other palaeobiogeographical settings in order to identify the prevailing features of their occurrence at precise stratigraphic intervals. Particular attention will be given to the colours of these levels as seen in the Cellon section and those seen elsewhere. What do they indicate? Do particular levels of juvenile faunas reflect biotic events caused by changes in eustatic or climatic conditions? Can we correlate these levels using the overall data set available for these successions to global biotic events or do they reflect local phenomena?

S26 - THE VARIED COLOURS OF PALAEOZOIC ORTHOCONIC NAUTILOID CEPHALOPOD ACCUMULATIONS

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Accumulations of orthoconic nautiloid cephalopods form distinctive colourful strata which are often singled out for use as ornamental stone in building facades, floors or indeed as pavement slabs in some cities. The most common occurrences are known from the Ordovician, Silurian and Devonian but tend to become rare from the Carboniferous onwards. They display a variety of colours ranging from dark to light red, brown, black and various shades of grey. Most appear to represent shallow water facies with the orthoconic shells often being oriented either by current or wave action on the bedding plane. Various studies have been carried out with regard to their depositional environments, their taphonomy, their use as current indicators and many theories and models have been proposed for their peculiar formation. But are there common criteria that we have missed? Are they all shallow water deposits? oriented? are they time-rich taphonomic accumulations? winnowed beds? Do they represent biotic events? Does their stratigraphic occurrence correlate with other biotic events? Why do we not find similar accumulations of coiled nautiloid cephalopods comparable with those of the Ammonites in the Jurassic for example? This presentation will compare some examples of these accumulations across diverse time intervals and palaeogeographical settings with particular emphasis on the colour of the rock strata in an attempt to identify common factors which may shed light on their enigmatic character.

S13 - DYNAMIC RECOVERY PATTERNS OF BENTHIC ECOSYSTEMS IN THE AFTERMATH OF THE END-PERMIAN MASS EXTINCTION

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The recovery of benthic ecosystems from the end-Permian mass extinction is generally assumed to have been severely protracted, not starting before the Spathian, approximately 2 Ma. after the crisis. However, the precise succession of fossil communities and their ecological significance has not been studied in detail so far. Bed by bed sampling at previously unstudied localities of the Werfen Formation (Alps, Italy) provided new insights into recovery patterns of benthic biota. Ecological parameters (guild diversity, species richness, dominance, etc.) suggest that the most advanced recovery stages in the investigated time interval (Pre-Spathian Early Triassic) were present during the middle and late Griesbachian. Robust ichnoassemblages in uppermost Griesbachian rocks reflect a significant recovery signal that has not been recognized before. The benthic diversity drastically declines towards the Dienerian/Smithian-boundary possibly as a result of local environmental stress. Our data show that the recovery does not reflect a gradual increase of diversity and ecological complexity throughout the Early Triassic but out-of-phase fluctuations of numerous parameters. For instance, the increase of average body size among bivalves is not contemporaneous with diverse or ecological complex communities. Furthermore, the integration of our new trace fossil data with those from the literature shows that advanced recovery stages were reached quite early after the mass extinction on a global scale. The Early Triassic was possibly a time of volatile environmental conditions that allowed at least local ecological amelioration punctuated by smaller crises that repeatedly replaced faunal association at various stages of recovery.

S27B - GARDENERS AND ARCHITECTS OF GLASSHOUSES IN THE OCEANIC MICROCOSM

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An important function of symbiont-bearing benthic foraminifera is to provide their endosymbiotic microalgae with light. At the same time, these foraminifera have to resist hydrodynamic forces. Foraminifera match these demands by constructing shells (tests) functioning as glasshouses. In the shallowest regions of oligotrophic tropical seas, at one end of the scale, foraminifera with spherical and thick lenticular tests develop special fixing mechanisms to resist extreme water motion. To provide the central parts of the tests with light, they develop transparent structures called piles or plugs. In the deepest euphotic zone, at the other end of the scale, with extremely weak light and quiet water, foraminifera with flat discoid and blade-shaped tests possessing a high surface/volume-ratio position their symbionts just beneath the transparent test walls, intensifying the weak light through elevated test surface structures. Between these two extremes, foraminifera react to decreasing light intensity and water motion by a transition in shell form from spherical to extremely flat tests. A second spectrum of test form from high energetic shallow water to less, but still energetic water is the transition from spherical to spindle shaped (fusiform) tests, again raising the surface/volume-ratio but not to the same degree as accomplished by test flattening.

S7 - BRACHIOPOD PHYLOGENY IN THE CAMBRIAN

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Brachiopods are abundantly represented in the rock record, and show an impressive diversity of form and shell mineralogy already in the Cambrian. Although they are presently rather firmly rooted within the lophotrochozoan branch of the bilaterian tree based on molecular data, both their in-group relationships to other phyla on this branch and the origin of the characteristic enclosed bivalve brachiopod body plan remain highly controversial. Our recent research has identified members of the enigmatic Early Cambrian tommotiids as belonging to the brachiopod stem and some tommotiids preserve traces of their earliest ontogeny, including bivalved larval shells with evidence of the earliest larval attachment. The conjoined bivalved shell of adult living brachiopods may represent a plesiomorphic character retained from planktonic tommotiid larvae; the crown group body plan may have evolved independently in living linguliform and rhynchonelliforms. Other important potential brachiopod stem groups have also been described from the Cambrian Lagerstätten, most importantly the Chinese Chengjiang Fauna, and some of these indicate that a lingulid-like pedicle and spirolophous lophophore may be plesiomorphic characters at least for the linguliforms. However, the phylogeny and radiation of the Brachiopoda in the Cambrian remains a problematic and controversial issue and presently only two of the three major brachiopod clades, the Linguliformea and the Rhynchonelliformea have known Cambrian representatives. The origin and phylogeny of the Craniiformea remains problematic, but it is possible that the rhynchonelliform chileate brachiopods are involved.

S18 - PLIO-PLEISTOCENE CLIMATE CHANGE IN AFRICA AND MODELING FAUNAL RESPONSE

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Our understanding of the links between climate change and mammalian evolution has been limited by low-resolution palaeoclimate proxies or geographic separation of the climatic and faunal evidence. We present new high-resolution stable isotope records of Plio-Pleistocene climate change from speleothems associated with mammalian assemblages from the “Cradle of Humankind”, South Africa. These long and continuous records of rainfall and vegetation are dominated by ENSO and orbital cycles; stepwise climatic shifts are also observed in relation to changes in ocean circulation. We compare these records with contemporaneous faunal assemblages and discuss the effects of time averaging on the isotope palaeoecology of the mammal assemblages. Implications for the reconstruction of hominin habitats and diet are discussed. We conclude by highlighting the potential of these high-resolution palaeoclimate archives for modeling mammalian evolution in response to stepwise and cyclical climatic changes at a range of timescales.

S5 - FIRST IMPRESSIONS – CASTING THE ENIGMATIC EDIACARANS OF CHARNWOOD FOREST

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Ediacaran biotas are preserved at several localities in the Neoproterozoic strata of Charnwood Forest, Leicestershire (UK). However, access problems have restricted their study in the past, while vandalism is threatening their future study. Since 2007, the British Geological Survey, Natural England and GeoEd have been collaborating in a major project to reproduce the fossils, together with their spatial and temporal locations, by replicating over 175 m^2 of bedding planes from three key localities. Moulds were made in silicone rubber and these are being archived as plaster of paris casts, typically up to 1 m square, with overlap. A special technique ensures that the casts are strong, yet light enough to study. This is the largest operation of its kind ever undertaken and has produced a key remote resource for future study that will reduce the need to re-expose the fossils at these key sites. Working with the casts under controlled lighting in the laboratory has increased the number of individual fossils recognised by two orders of magnitude. This would have not been possible in the field. Detailed comparison of the casts with ones made in the 1980s should provide information that will help in the future conservation of the sites. The outcrops have been scanned with lidar and it is intended to link high resolution scans of the moulds to the resulting DTMs (digital terrain models).

S21 - HOMOPLASY, CHARACTER VARIABILITY, AND THE SIZE OF THE MORPHOLOGICAL STATE SPACE: AN INCREASE IN EVOLUTIONARY FLEXIBILITY THROUGH TIME AND SIGNIFICANT PHYLOGENETIC EFFECTS

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If the frequency of homoplasy reflects evolutionary flexibility, we might expect phylogenies based on inflexible characters to exhibit few states and high levels of homoplasy. Using computer simulations of evolutionary trees, I show that the relationship between the homoplasy excess ratio (HER) and the number of states per character can be used to infer whether new states were acquired within an expanding or limited character state space. Levels of morphological variability and homoplasy are compared between 100 phylogenies of bilaterian animal taxa using average character states per taxon, ratio of HER to states per character, and HER. The results suggest that the size of the morphological state space and amount of homoplasy observed within a phylogeny differ according to the age of origination of the taxonomic group considered and the identity of the higher taxonomic group to which it belongs. Partial least squares regressions (taking into account the age range of each taxonomic group) indicate general increases in states per taxon, ratio of the HER to states per character, and HER, from the Cambrian to the Neogene. These results are evident in the minimum and maximum levels for each period as well as the mean, suggesting a driven trend towards increasing morphological variability and decreasing homoplasy through time. Partitioning the data set by taxonomic group suggests that deuterostome phylogenies tend to encompass a larger state space and less homoplasy than protostomes phylogenies. This suggests that the most ancient bilaterian branching event has left marked differences in morphological evolutionary flexibility. Morphological evolution during the Phanerozoic was characterised by increasing flexibility through time and significant phylogenetic effects.

S23 - A NEW EXCEPTIONALLY PRESERVED BIOTA FROM THE MIDDLE TRIASSIC OF SW CHINA

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A new fossil Lagerstätte, named the Luoping Biota, was discovered recently in Luoping County, Yunnan Province, SW China. A conodont-based age determination indicates that this biota lies within the Nicoraella kockeli conodont Zone, which is assigned to the Pelsonian Substage of the Anisian Stage, Middle Triassic. Primary excavations show that the Luoping biota is a mixture of marine animals, terrestrial plants and some terrestrial animals. Lightly sclerotized arthropods are the most dominant animal group, associated with fishes, marine reptiles, bivalves, gastropods, belemnites, ammonites, echinoderms, brachiopods, conodonts, foraminiferans, as well as plants. Anoxia of bottom water and microbial sealing might have been responsible for the exceptional fossil preservation. The Luoping Biota is one of the most diverse Triassic marine fossil Lagerstätten known in SW China, providing a new window on the early recovery and radiation of Triassic marine ecosystems after the end-Permian mass extinction.

S27D - AQUATIC INSECT COMMUNITY SUCCESSION AND ENVIRONMENTAL CHANGES IN THE LATE MESOZOIC OF NORTHERN CHINA

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Aquatic insects, representing 9 Orders, 28 families, 52 genera, and 70 species from the Jiulongshan Formation (Middle Jurassic), and 9 Orders, 31 families, 47 genera, and 53 species from the Yixian Formation (Late Jurassic-Early Cretaceous) in Northern China, and their associated plants and other animals are enumerated here. These aquatic insects were buried in situ and may have died due to environmental changes or to another natural disaster. Preliminary hypothetical structures of ecosystems are based on the fossil lists, and their environmental settings are reconstructed. The Jiulongshan Formation has a richer species diversity than the Yixian Formation. The Jiulongshan Formation may represent an early stage of the community when the aquatic ecosystem was relatively unstable. However the Yixian Formation may represent a stable stage of the community when the aquatic ecosystem was stable. Overall, the climate was warm and humid, while there were seasonal arid and semi-arid climates in micro-environments during the two times. There were lakes and swamps in both periods, and all of them were low-energy. In addition there were mountains. But the water environments were not the same in the two formations. The water body was relatively shallow and small in the Jiulongshan Formation compared with that of the Yixian Formation in Northern Hebei and Western Liaoning.

S10 - MICROBIALLY-MEDIATED DIAGENESIS OF PLANT TRITERPENOIDS IN PEATLAND

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Aliphatic *des*-A-triterpenoids were identified in the Dajiuhu Peatland in central China (Huang et al., 2008). Here we present the high-resolution records of the relative abundance of aromatic triterpenoids in a peat core from the Dajiuhu Peatland. Aromatic triterpenoids contain compounds of the following four groups, i.e., aromatic *des*-A-triterpenoids, aromatic pentacyclic triterpenoids, and aromatic C-ring cleaved triterpenoids and *des*-A-triterpenoids. Both aliphatic and aromatic triterpenoid derivatives are thought to be intermediate products of plant 3-oxy triterpenoids (oleanoids, ursanoids or lupanoids). In comparison with the common occurrence of aromatic *des*-A-triterpenoids and aromatic pentacyclic triterpenoids in immature coals, ancient and recent sediments, the appearance of aromatic C-ring cleaved triterpenoids and *des*-A-triterpenoids in peat sediments of such a young age is of importance. This suggests the quite quick aromatization of plant triterpenoids. The high diversity of aliphatic and aromatic oleanoids provides a good record to support the formerly proposed transformation pathways. Dehydration and further aromatization from A- to E-ring is the predominant pathway. Of significance is that the microbially-mediated aromatization processes are affected by climate changes, and these resultant compounds can be used as tools for palaeoenvironmental reconstruction.

S16 - TRENDS IN MORPHOLOGICAL DISPARITY THROUGH THE PHANEROZOIC

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Morphological disparity refers to the range or spread of anatomical design displayed by a sample of organisms. It is distinct from diversity, which is a direct function of the number of species sampled. The pattern of morphological disparity through time was once assumed to uniformly mirror trends in taxonomic diversity (i.e., an expanding cone starting at some point prior to Cambrian). However many modern phyla have body plans with a fossil record extending back to the Cambrian: a time when diversity was low. Disparity and diversity therefore appear to be decoupled. A limited number of case studies have compared patterns of diversity and disparity in the radiations of large clades from which three categories of trend can be noted. Some clades like blastozoans, crinoids, and carnivorous mammals explore morphospacial extremes prior to a peak in diversity, early in the clade's history, while others show early high diversity accompanying low disparity (e.g. trilobites, pterosaurs), or in which diversity and disparity increase in tandem (e.g. acritarchs). Is the pattern of early high disparity seen in the majority of published studies the prevalent trend, or is it a function of the groups so far investigated? And does the precise pattern depend upon the taxonomic level of the analysis and the time of the radiation? To answer these questions, a much larger sample size was needed. We therefore applied a variety of established disparity indices to published matrices of discrete character data. We present results for a broad sampling of taxa throughout the Phanerozoic.

S6 - LANDMARK ANALYSIS OF THE LOWER JAW IN SPHENODON (REPTILIA: DIAPSIDA: RHYNCHOCEPHALIA) FROM HOLOCENE ASSEMBLAGES

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The New Zealand tuatara, Sphenodon, is a terrestrial reptile which is now mainly restricted to small offshore islands, but was formerly widespread across the North and South Islands as demonstrated by an extensive Holocene record. Sphenodon is frequently described as a 'living fossil' or 'unchanged for over 150 million years'. If correct, we might expect there to be no difference between fossil bones recovered from different localities and different time periods. However, this has never been tested. We landmarked c. 150 Holocene dentaries from seven different localities (North Island: 3, South Island: 4) and following Procrustes fitting performed a geometric morphometric analysis. Aspects of shape variation include differences in the depth of the dentary, length of the tooth row and posterior process, and shape of the ventral margin and coronoid process. Multivariate analysis of variance demonstrates that there are significant shape differences between localities on the same island as well as those last connected by land c. 450,000 years ago. The portion of total shape variation that can be accounted for by location is more than double that of latitude and over ten times that of longitude. We do not advocate that the different morphotypes represent different species, but geographic variation is clearly apparent. A separate comparison between the dentaries in the Holocene sample and those of Mesozoic Rhynchocephalia (e.g., Clevosaurus, Cynosphenodon, Gephyrosaurus, and Homoeosaurus) show that there are no Mesozoic taxa that possess a dentary of equivalent shape to that of Sphenodon.

PLENARY - THE FOSSIL RECORD OF MICROEVOLUTION

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Since Darwin, scientists have used patterns of phenotypic evolution in fossil lineages to shed light on evolutionary processes. In the first part of this talk, I will review some of these attempts, starting with Darwin's expectation of geologically gradual change, ranging through the Punctuated Equilibrium debates of the 1970s and 1980s, and finishing with more recent efforts that use modern statistical methods to determine the relative frequencies of gradual change, stasis, and other evolutionary patterns. I will argue that the empirical fossil record is mostly consistent with the tenets of Punctuated Equilibrium: phenotypic traits seldom trend gradually over geological time, and instead show meandering or fluctuating trajectories. The second part of this talk will discuss the more difficult, and largely unrealized, goal of relating paleontological patterns of stasis and change to microevolutionary processes such as natural selection and drift.

W1 - RESOLVING ASTEROZOAN ORIGINS: MOVING TOWARDS A BETTER WORKING MODEL FOR SKELETAL HOMOLOGIES AND PHYLOGENY FOR THE ASTEROIDEA AND OPHIUROIDEA

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Starfish and brittle stars (Asteroidea and Ophiuroidea) and the extinct order Somasteroidea represent an important component of the Lower Palaeozoic benthic fauna. These groups are often subject to separate phylogenetic treatment. However, it is clear that to understand the evolution of this group we must form an integrated model of homology. Until recently, it was thought that the asteroids possessed a relatively poor fossil record, which has made determining their phylogenetic relationships problematic. Although it is now established that taxa appearing as early as the Lower Ordovician already possessed key established synapomorphies. Although Spencer established a good basis for study, a comprehensive phylogeny was not attempted until that of Dean Shackleton. This phylogeny has a bias towards Laurentian/Avalonian faunas with much data coming from just a single locality the Upper Ordovician Lady Burn Starfish Beds, Scotland. Furthermore, these studies have largely overlooked those ideas put forward by Mooi and David using the Extra-Axial theory (EAT) of echinoderm homologies. In recent years there have been a flurry of discoveries in the Ordovician, Silurian and Devonian that have the potential to reveal much about the origins of this group. The working modal of Dean Shackleton will be discussed in the light of these new discoveries, along with the usefulness of the EAT and similar models in an attempt to further resolve the interrelationship between these early asterozoans.

S27B - STABLE CARBON ISOTOPIC COMPOSITION OF MARINE NATICID SNAILS FOR DIETARY ANALYSIS

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Stable carbon and nitrogen isotopic compositions of animal tissue depend mainly on their diet. The specific signatures of carbon isotope compositions in autotrophs are transferred to the heterotrophs conservatively, which provides a useful method in tracing food webs. Here, we analyzed stable isotope compositions in two modern marine snails, ampullospirine *Cernina fluctuata* and naticid *Polinices mammilla*, to further unearth the history of naticid predation. We also performed analyses of *Enhalus acoroide* (abundant seagrass at the collecting site) and *Padina australis* (macroalga frequently found in the stomach of *C. fluctuata*) as potential primary food sources. The isotopic signatures of the soft parts of ampullospirine and naticids were clearly distinguished; the $\delta^{13}C$ and $\delta^{15}N$ of *C. fluctuata* were 4.5 and 1.4‰ higher than those of sea macroalgae *Padina australis*, respectively. This suggests that *C. fluctuata* mainly consume the macroalgae. In contrast, $\delta^{13}C$ and $\delta^{15}N$ of *P. mammilla* were 2.8–3.0‰ and 1.5–2.7‰ higher than those of filter-feeder bivalves or gastropods, suggesting that *P. mammilla* feeds on such benthic molluscs. The $\delta^{13}C$ of *C. fluctuata* soft tissue was 2.5‰ higher than that of *P. mammilla*, suggesting that the primary food sources of *C. fluctuata* have higher $\delta^{13}C$ than those of *P. mammilla*. The $\delta^{13}C$ of *C. fluctuata* shell organic matrix was also 3.6‰ higher than that of *P. mammilla*. The method may thus be applicable to fossil shells and may become a powerful tool to understand the history of naticid predation in ancient food webs.

S9 - UPPER DEVONIAN CONODONTS OF WEST SIBERIA, RUSSIA

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The Upper Devonian of West Siberia is represented by marine sediments with abundant benthic and pelagic fauna. Late Devonian conodont associations were recovered from the NW and central parts of the West-Siberia Geosyncline (WSG), Rudny and Gorny Altai, and NW Kuznetsk Basin. At the Shchuchiy Ledge (NW of WSG) Frasnian conodonts include few *Polygnathus* and *Palmatolepis*. Famennian conodonts were recovered from limestone olistoliths. The first association characterises the *triangularis* Zone, the second belongs to the *marginifera* - Early *trachytera* zones. In the central part of the WSG, lower and middle Frasnian conodonts include common *Polygnathus*, rare *Ancyrodella, Palmatolepis*, and *Icriodus*; the upper Frasnian mainly has *Palmatolepis,* rare *Polygnathus,* and *Ancyrognathus*. Famennian associations are dominated by *Palmatolepis.* Lowermost Famennian beds lack conodonts. Most diverse Frasnian associations that characterize complete zonal successions (*falsiovalis - linguiformis* zones) were found in the Rudny Altai. Lower and middle Frasnian carbonates yielded abundant *Polygnathus*, *Ancyrodella, Mesotaxis,* rarely *Icriodus* and *Palmatolepis.* Late Frasnian siliceous-terrigenous sequences contain rare *Palmatolepis* and *Polygnathus.* Frasnian conodonts from the SE Altai are different: common *Polygnathus, Ancyrognathus*, *Icriodus,* few *Pelekysgnathus* and *Ancyrodella*. In the NW Kuznetsk Basin, the Frasnian and lower Famennian contain shallow-water biofacies conodonts, mainly *Polygnathus* and *Icriodus*, single *Ancyrodella, Ancyrognathus,* and *Polylophodonta*. The conodont diversity increased sharply at the base of the lower Famennian *crepida* Zone: abundant *Polygnathus* and *Palmatolepis,* rare *Icriodus* and single *Ancyrolepis.* Most of the recovered taxa belong to widely distributed species but very rare taxa (*Ancyrolepis*) were found, too.

S2 - THREE MODES OF DIVERSIFICATION: ECOLOGICAL CONTEXT AND HIERARCHICAL LEVEL AS DETERMINANTS OF CLADE DYNAMICS

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Macroevolution can be measured in many currencies – e.g. taxonomic, morphologic, functional – but relationships among these different aspects of diversity over a clade's history are poorly understood. Palaeontologists have detected a variety of clade behaviours but recent neontological approaches, often fuelled by molecular phylogenies, have emphasized a single model, with rapid early diversification and later diversity dependent quiescence. A new approach to comparative analysis of diversifications in the fossil record re affirms that diversifications can follow a variety of trajectories: Type 1, where morphological or functional diversity outstrips taxonomic diversity; Type 2, where morphological and taxonomic diversity are concordant, once the exponential expectation for taxonomic diversification is incorporated; and Type 3, where morphological diversity lags taxonomic diversity. As expected from previous work, Type 1 patterns are most frequent in the early (marine) and mid (terrestrial) Palaeozoic. These dynamics are hierarchical: diversification by a more inclusive set of clades or occupants of an adaptive zone can collectively show Type 1 patterns while individual subclades show Type 2s or 3s (e.g. Blastozoa vs Blastoidea, Mollusca vs Bivalvia, ecological carnivores vs Carnivoramorpha, perhaps Arthropoda vs Trilobita), suggesting that open ecospace is a crucial promoter of evolutionary bursts, even though present day archipelagos and rift valley lakes do not provide appropriate analogues to the major diversifications of the geologic past. The failure of diversity to be a simple function of time since origin does not guarantee diversity dependent dynamics, owing to extinction pulses and clade specific rates, and new analyses of marine bivalves shows that clades can shift diversification mode over time.

W10 - NEW MIDDLE CAMBRIAN ACRITARCHS FROM UPPER SILESIA, SOUTHERN POLAND

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In the Upper Silesian Block, the Sosnowiec IG 1 borehole drilled 195 m of Lower Palaeozoic deposits beneath the Lower Devonian. The rocks, cut by an igneous intrusion, have been assigned to the Middle Cambrian on the basis of acritarchs and named as the Sosnowiec Formation. This formation is composed by clastic rocks which consist of alternating layers of sandstone and claystone. The Sosnowiec IG borehole did not reach the base of Sosnowiec Formation. According to Moczydłowska (1998) there is a transition from the Middle to Upper Cambrian and even Ordovician (Tremadoc) rocks are present. The recent palynological study resulted in the discovery of typical Mid Cambrian acritarch assemblages. In three samples taken from rocks overlying the gabbro diabase intrusions (3212 - 3204,5 m), new acritarch associations were documented. They are dominated by a new taxon which differs from typical Middle Cambrian genera such as *Celtiberium* or *Adara*. Acritarch assemblages from samples both underlying and overlying the previously mentioned depths are dominated by *Adara alea*, *Cristallinium .cambriense*, *Heliosphaeridium notatum*, *Eliasum llanisum* and *Comasphaeridium longispinosum*. Therefore Upper Cambrian sediments have not been recognized, although their presence is very likely in the northern part of the Upper Silesian Block.

S3 - THE NORTH SEA RECORD OF VEGETATION CHANGE DURING THE PALAEOCENE/EOCENE THERMAL MAXIMUM (PETM)

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The Palaeocene/Eocene Thermal Maximum (PETM) was a period of extreme global warming that occurred ~55Ma ago. It is characterised by an excursion in the carbon isotope record and a distinctive turnover of biota. Due to its enclosed nature, proximity to large landmasses and availability of high-resolution borehole records, the subsurface sedimentary record beneath the North Sea is an ideal natural laboratory in which to investigate the changes in vegetation brought about by this event. Biostratigraphic data covering an area from the Vøring Basin to the Central Graben is utilised to present a temporal analysis of the effect of the PETM on the ecosystem which will aid in understanding the pattern and timing of environmental changes at the PETM. Such a broad areal analysis is unprecedented and the results show distinct changes in floral composition and diversity in both the terrestrial and marine realms over the PETM. Stress tolerant dinoflagellates such as *Apectodinium* increase at the expense of *Spiriferites* and a coeval increase in the freshwater dinocyst *Bosedinia* indicates that low salinity as well as extreme temperatures may have brought about the compositional changes. The appearance of *Botrycoccus* and other species of Prasinopycean algae also point to freshening and stratification in the North Sea basin due to increased run-off from the hinterland. A fungal spike is also identified, indicating that the increased humidity and temperatures during the PETM allowed swamp communities to expand and the enhanced run-off rates transported the organic matter and fungal debris into the basin.

W10 - AGE AND REGIONAL CONTEXT OF THE CARBONIFEROUS-PERMIAN GLACIGENIC TOBRA FORMATION (SALT RANGE, PAKISTAN)

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Until now the precise age and nature of the glacigene Tobra Formation (Salt Range, Pakistan), and its relationship to palaeogeographically nearby sequences in Arabia and the Middle East have been uncertain. However a new detailed survey of samples from a 125 metre thick interval of the Tobra Formation at Zaluch Nala, western Salt Range, yielded 37 palynomorph taxa including the stratigraphically important spores *Converrucosisporites confluens*, *Microbaculispora tentula* and *Horriditriletes* spp., abundant monosaccate pollen, including *Plicatipollenites malabarensis*, *Barakarites* cf. *rotatus* and *Cannanoropollis janakii*, and rare taeniate and non-taeniate bisaccate pollen. Taxa representative of the *Converrucosisporites confluens* Oppel zone occur in the upper part of Tobra Formation suggesting a probable Gzhelian to Asselian age (see Stephenson 2009; Palynology vol. 33). This upper part of the Tobra is also correlated to the 2165B to 2141A biozones of south Oman based on the presence of *Converrucosisporites confluens*, *Microbaculispora tentula* and *Horriditriletes* spp. This indicates that the Tobra Formation in Zaluch Nala is equivalent to the middle part of the Al Khlata Formation of Oman (PDO production units lower P1 and P5), and that the upper parts of the Arabian and Middle Eastern deglaciation sequence are absent in Zaluch Nala. The Tobra Formation is unconformably overlain by the 'Speckled Sandstone' of the Warchha Formation in Zaluch Nala, whereas in the eastern Salt Range the Tobra Formation is succeeded conformably by the Dandot Formation. This suggests that the Dandot Formation may represent a deglaciation sequence, though until now it is has proved to be palynologically barren.

S17 - FUNCTIONAL MORPHOLOGY OF SWIMMING CRINOIDS

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Modern crinoids are dominated in species richness by the stalkless comatulids, notable for their rapid crawling and elegant swimming, abilities which are believed to allow escape from predators. This diversity pattern is in contrast to crinoids in the fossil record, which are stalked, and traditionally thought to be sessile. These observations have led to the conclusion that the success of comatulids is due to their mobility. Recently, rapid crawling has been observed in stalked crinoids, an ability that allows them to escape from benthic predators. Crawling may have evolutionary roots as far back as the Paleozoic. If crawling is plesiomorphic for stalked and stalkless crinoids, the success of comatulids may be due to their ability to swim. In order to determine the traits that allow comatulids to swim, a biomechanical model of swimming was developed. This model demonstrates that thrust generation in comatulids is low: A crinoid's stalk is an anchor that hinders swimming, and stalk loss is likely a prerequisite for swimming. Biometric data was collected on extant comatulid specimens. In combination with the model, these data demonstrate that in addition to stalklessness, swimming crinoids often have relatively few arms. The arms of swimming crinoids are generally gracile, and the musculature of arms is increased. These observations allow us to infer from a fossil crinoid's functional morphology whether it likely swam. It may now be possible to determine when swimming arose, and its potential role in crinoid diversification.

S6 - A LIKELIHOOD APPROACH TO DETECTING EXTINCTION SELECTIVITY

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Extinction selectivity is usually detected by testing for correlation of taxon traits with extinction rate or survivorship, but this can be hampered for fossil taxa as the trait on which selectivity operated may not have been preserved or observed. However, even in the absence of knowledge of organismic or species-level traits, detecting extinction selectivity is possible. Based on the stochastic expectation that the extinction of a genus is determined by the number of species it contains, it is possible to test whether extinctions of genera were selective with respect to species richness. Here, I employ a Likelihood Ratio (LR) test to detect extinction selectivity among genera of marine invertebrates at the Permian/Triassic and Cretaceous/Paleogene extinction events. Likelihood methods have become commonplace in palaeontological studies, most frequently as part of model selection methods like Akaike's information criterion ("AIC") or Bayesian information criterion ("BIC"). The LR test is a straightforward example of a model selection algorithm. In this case the LR determines the support for one of two extinction models: stochastic (H_1) or selective (H_2). The application of the LR test to the two most well-studied mass extinctions of the Phanerozoic shows strong support for the selective extinction model.

S18 - PATTERNS OF HYPSODONTY IN UNGULATES SHOW THAT NEOGENE ARIDITY IN NORTH AMERICA PRECEDED THAT IN EURASIA

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The mean hypsodonty of the large herbivorous mammals in palaeocommunities can serve as a proxy for palaeoprecipitation, and thus may illustrate changing climatic patterns. Mean hypsodonty explains 65% of Recent global precipitation, but it performs relatively better for areas that have retained their megafauna (e.g., Africa). Mean hypsodonty maps for Eurasia show much greater humidity than today prior to 11 Mya; progressively modern rainfall distributions developed around 7 to 5 Mya. Here we compare mean hypsodonty patterns of Eurasia with newly derived ones for North America, and show that modern patterns of aridity appeared much earlier on the North American continent. The two continents appear similar in the early Miocene, with estimates of palaeoprecipitation much greater than those of today. By the middle Miocene, aridity had spread across the Great Plains of North America, but Eurasia remained relatively humid. More general continental aridity was apparent in North America by the early late Miocene; this time central Asia and southern Europe were relatively arid, but other Eurasian areas remained humid. North America retained this pattern throughout the rest of the Neogene, but Eurasia did not come to match North American aridity until the Pliocene. These differences in predicted palaeoprecipitation from hypsodonty levels probably reflect differences in patterns of uplift and tectonics on the two continental masses, which in turn affected the local climate and vegetation and hence the diets of the herbivorous mammals.

S5 - THE HUNSRUECK SLATE AND BRACHIOPOD COLLECTIONS OF THE SENCKENBERG MUSEUM: NEW INITIATIVES

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As a result of a German Research Foundation Grant (DFG-LIS), the Hunsrueck Slate and fossil brachiopod collections of the Senckenberg Museum are undergoing a curatorial upgrade, including electronic cataloging and imaging in the web-based Senckenberg Collection Management System (“SeSam”). The main objective is to make object data and images available to researchers worldwide. The famous Hunsrueck Slate collection comprises more than 1,000 specimens from the Lower Devonian of Germany with excellent preservation, for example echinoderms, arthropods with appendages and even soft-bodied animals. In addition, an X-ray collection of 10,000 photographs mainly of Hunsrueck Slate fossils is housed at the Senckenberg. All object data, images of the Hunsrueck fossils and x-ray photographs are now made available on the internet. With about 900,000 fossil brachiopod specimens the Senckenberg brachiopod collection is one of the largest of its kind in Europe. Older, mainly Devonian voucher specimens are recorded in SeSam as there is a prolific research on these at the Senckenberg. SeSam manages all Senckenberg collections of animals and plants, both fossil and recent. All collections are stored in a central database and use a joint data-pool for systematics, geographical and stratigraphical data, persons and literature, so that collection spanning searches are possible. The system allows to record new data very quickly. Data retrieval is possible with combinations of various queries what is useful in different kinds of palaeontological studies.

S9 - BIOHISTORY OF PRIDOLIAN THROUGH EIFELIAN BRACHIOPODS

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Pridolian through Eifelian faunas of the Rhenish Massif (Germany) document the brachiopod evolution during this time interval. The faunal succession reflects environmental fluctuations in a tropic epeiric sea, driven by local, regional and global forces, such as climate and sea-level fluctuations.
In connection with detailed taxonomical studies based on material from different museums and institutional collections, a high-resolution brachiopod stratigraphy applicable to different facies types is developed. 24 brachiopod zones and 16 faunal intervals are proposed for the studied interval. A series of bio-events with more or less strong faunal turnover could be recognized. The distribution patterns are very different: Whereas several species or genera just appear during a short geological interval, other taxa exhibit a long evolutionary history characterized by gradual phylomorphogenetical change. The Rhenish shelf was located at the southern margin of Laurussia. Comparisons of Rhenish faunas with faunas from other parts of the world allow to draw palaebiogeographical conclusions. The relationships to Peri-Gondwana (e.g. Armorican Massif, Iberian Chains, Cantabrian Mountains, Anti-Atlas) turned out to be very close. Therefore, the “Rheic Ocean” was rather a narrow sea-way, not a barrier for the migration of brachiopod larvae. On the other hand, southern Chinese faunas represent a completely separate development. The major stratigraphical units can be recognized in Europe and North Africa. A future combination with other biozonations or sequence stratigraphic studies, hardly investigated in the Rhenish Massif so far, is promising. A “holostratigraphy” approach could improve the integration of the Rhenish Devonian with global stratigraphical schemes and ecological-evolutionary units.

S3 - HOW SIGNIFICANT WAS THE PETM FOR DRIVING PARATROPICAL FLORAL TURNOVER IN THE EARLY PALAEOGENE?

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The sporomorph (pollen and spore) record of the U.S. Gulf Coast documents the response of a paratropical vegetation type to early Palaeogene climate change. Of particular interest is the impact of the rapid, greenhouse-induced global warming event at 55.8 Ma, termed the PETM (Paleocene-Eocene Thermal Maximum). ~20% extinction of sporomorph taxa has previously been demonstrated across the P-E boundary on the U.S. Gulf Coast, but the significance of this event has yet to be considered in the context of a longer timescale. This is particularly important, as the early Palaeogene is associated with extensive climate change over various timescales. We present sporomorph data from Mississippi and Alabama, extending from 62 to 45 Ma. The lack of a robust chronostratigraphic framework means that traditional approaches for calculating turnover rates are problematic. We therefore use additive diversity partitioning compared against a randomised null model. We show that heterogeneity among samples and formations is smaller than expected by chance, whereas heterogeneity between epochs (Paleocene versus Eocene) is significantly greater than expected. Community composition was therefore relative stable over several million years within each epoch, but changed rapidly across the Paleocene-Eocene boundary. Our results demonstrate that while vegetational response to background climate change was slight, the abrupt event at the Paleocene-Eocene boundary was sufficient to push the Gulf Coast paratropical biome to a new compositional state. This has clear implications for the response of modern tropical floras to predicted climate change, and the magnitude of disturbances needed to shift ecological systems to alternative states.

S19 - LARGE ORGANIC-WALLED MICROFOSSILS IN MESOARCHEAN SHALLOW-MARINE SILICICLASTIC DEPOSITS

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Possible traces of life reported in Archean sediments suggest a diverse microbial community in a range of habitats from evaporitic lakes and open-marine shallow-water settings to deep hydrothermal systems. However, ambiguities and controversies persist regarding the biogenicity, endogenicity and syngeneity of the record older than the Late Archean. We report the discovery of a population of large (up to 298 µm in diameter) carbonaceous spheroidal microstructures in 3.2 Ga shales and siltstones of the Moodies Group, South Africa, the Earth's oldest siliciclastic alluvial to tidal-estuarine deposits (Javaux et al, 2010, Nature 463, 934-938). These microstructures are interpreted as organic-walled microfossils based on petrographic and geochemical evidence for their endogenicity and syngeneity, their carbonaceous composition, cellular morphology and ultrastructure, occurrence in populations, taphonomic features of soft wall deformation, and the geological context plausible for life, as well as lack of abiotic explanation falsifying a biological origin. The cell size of the microfossils population is larger than any other reported Archean sphaeromorphs, but comparable in size to the oldest unambiguous organic-walled microfossils (acritarchs) reported from the late Paleoproterozoic, extending their record in fine-grained siliciclastic sediments by more than 1 billion years. The Moodies Group provides an unusual window into ecology of Mesoarchean ocean, demonstrating the early evolution of a moderately diverse ecosystem in the photic zone of 3.2 Ga marginal marine siliciclastic environments, where large recalcitrant organic-walled unicells or colonial envelopes lived contemporaneously with earlier reported benthic microbial mats.

S12 - CASPICONCHIID BIVALVES: WIDESPREAD OCCURRENCES IN LATE MESOZOIC COLD-SEEPS

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Since Cretaceous vesicomyid, mytilid, thyasirid, lucinid, solemyid, and caspiconchiid bivalves are the most characteristic animals living in a cold seep environment. The vesicomyids and mytilids are the most common bivalves in the Recent cold-seep environments. It seems that these bivalves entered the cold-seep environment in the late Eocene while solemyid and lucinid bivalves can be traced back at least to the Jurassic. Thyasirid bivalves appeared at the cold-seeps in the Early Cretaceous. Caspiconchiid bivalves belong to an extinct lineage. These large bivalves were found in Late Jurassic to Early Cretaceous seep deposits in Greenland, California, Ukraine, and Japan, and they are also known from a single record from Japanese Late Cretaceous (Campanian) seep deposits. This suggests that *Caspiconcha* occurred widely in the Early Cretaceous world's oceans and some its descendants survived at least until Campanian in Japan. It is noteworthy that the locality which yields last caspiconchiid bivalves is also known from the youngest occurrence of a large number of brachiopods from a methane-seep environment (Kaim et al., 2010). Through Early Cretaceous the caspiconchid bivalves have been competing or coexisting with peregrinellid brachiopods in the cold seep environment, both having basically the same sessile behavior. At the end of Early Cretaceous both groups almost completely disappeared from cold-seeps. Such a coincidence strongly suggests that the caspiconchiid bivalves and the brachiopods were outcompeted during mid-Cretaceous by other bivalves which started to flourish at that time. It especially concerns lucinids which gained both large individual and population sizes in the Late Cretaceous cold seeps.

27D - REVISED AGE OF TRILOBITES FROM THE LOWER CAMBRIAN PUSA FORMATION, CENTRAL IBERIAN ZONE, SPAIN

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The occurrence of trilobites in the upper part of the Pusa Formation in south-central Spain has been known since the mid-1990s but the material has never been figured, and published documentation is limited to tentative identifications of the genera *Hupetina* and *Bigotinops*. According to a widely used correlation schemes, the Pusa Formation trilobites occur in strata assigned to the Corduban regional stage (roughly corresponding to the basal Cambrian Terreneuvian Series). Therefore they would substantially antedate other Iberian trilobites, and would arguably be among the earliest trilobites globally. A re-study of the Pusa Formation shows that these trilobites, which we tentatively compare with *Abadiella bourgini*, are associated with small shelly fossils, including *Pelagiella* sp., orthothecids, hyolithids, chancellorid spicules, *Cupitheca* sp., and unidentified archaeocyathans. This biostratigraphical context is readily comparable to that of trilobite-bearing Ovetian strata in the Ossa Morena Zone in the Córdoba area, and demonstrates that the upper part of the Pusa Formation is younger than had traditionally been thought. Therefore, these trilobites can no longer be considered among the earliest globally.

S4 - THE MICROPALAEONTOLOGY OF TERRESTRIAL ARTHROPODS – PROGRESS AND PROSPECTS

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Disarticulated and fragmentary remains of terrestrial arthropods are commonly incorporated into sediments as a minor component of the organic detritus. Quaternary and archaeological studies routinely exploit this material due to its proven value in environmental and climatic reconstruction, but despite this, relatively little work has focussed on earlier cuticle assemblages. The prime motivation for studying Palaeozoic cuticle assemblages arose from the need to augment a poor body fossil record of arachnids and myriapods that was largely restricted to a few Lagerstätten. Assemblages from the Silurian, Devonian and Carboniferous have reshaped our perception of the composition and development of early terrestrial ecosystems. Analysis of these assemblages concentrated on descriptive taxonomy, but the results are now being used to polarise character states in phylogenetic studies, and to provide fossil calibration points for molecular phylogenetics. Until now, the Mesozoic has been entirely neglected, but the recent discovery of terrestrial arthropod cuticle in marine mudrocks spanning the Triassic-Jurassic boundary in Northern Ireland offers a unique opportunity to explore other potential applications. Assemblages from eight levels have been collected. Beetle remains dominate, with smaller contributions from other groups. The fate of approximately 200 beetle morphospecies can be tracked through the boundary interval, revealing for the first time the response of an ecologically diverse terrestrial arthropod clade to an environmentally induced biotic crisis. A complex pattern of extinction, probable *in situ* speciation, and recolonisation of the Irish Landmass is emerging that contradicts the evolutionary ‘stasis’ model derived from Quaternary beetles.

S10 - VARIATIONS IN ALGAE AND BACTERIA DURING THE END-PERMIAN BIOTIC CRISIS IN THE BULLA SECTION, ITALY

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Molecular geochemical data of samples from the Permian –Triassic parastratotype section in Bulla, Italy, were investigated using gas chromatography-mass spectrometry (GC-MS). Enrichment of dibenzofuran (OF) provides molecular evidence that the terrestrial ecosystem collapsed prior to the main oceanic mass extinction, which delivered the enhanced influx of nutrition beneficial for subsequent algae and cyanobacteria expansion. The 2-MHP index (2-methylhopanes/hopanes) increased immediately after the main oceanic mass extinction, indicating cyanobacterial blooms, with the second episode found in the conodont zone of *Isarcicella isarcica*, consistent with Meishan sections in China (Xie et al., 2005, 2007). The variation of the C_{28}/C_{29}-sterane ratios, displaying a parallel pattern to the 2-MHP index, reveals the expansion of C_{28}-steranes producing green algae, probably prasinophyte algae, after the faunal mass extinction. Cyanobacteria and prasinophyte algae, well adapted to these aquatic environments could be the messengers recording the danger all the marine plankton community faced. The total abundance of pristane and phytane relative to the lower-chained *n*-alkanes suggests that the photosynthetic autotrophs were suppressed prior to the faunal mass extinction but expanded thereafter. The mass extinction knocked the oceanic world into a new configuration of microbial ecosystems.

S23 - A CALDERA-LAKE ORIGIN FOR THE FAMOUS EARLY CRETACEOUS FOSSILLAGERSTÄTTEN IN SIHETUN, WESTERN LIAONING, NE CHINA

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The Jehol Biota is one of the most important Mesozoic fossil lagerstätten. However, the palaeoenvironmental conditions under which the famous biota was preserved have not been yet sufficiently elucidated. In this study, the features of an Early Cretaceous lake in the Sihetun area of western Liaoning, NE China, including its size and shape, depositional patterns and their succession, are described based on intensive field investigations and systematic excavations. A caldera model is tentatively put forward to interpret the origin and evolution of the lake, based on some exposures of major structural and morphologic elements of caldera, such as the topographic rim, inner topographic wall, bounding faults and intra-caldera fills. The succession of volcanic eruptions, pyroclastic distribution and their influence on the preservation of the Jehol Biota are discussed.

S23 - DIVERSITY AND PALAEOCLIMATE OF THE FLORAL ASSEMBLAGES FORM THE TIAOJISHAN

AND TUCHENGZI FORMATIONS OF JURASSIC IN WESTERN LIAONING, CHINA

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The Jurassic system is well developed and exposed in western Liaoning, China. The Middle Jurassic Tiaojishan Formation is represented by intermediate extrusive and pyroclastic rocks, with intercalations of basic volcanic and sedimentary rocks. The Upper Jurassic Tuchengzi Formation consists of grey purple, purple-red shales, sandstones with large-scale crossing-bedding. In the Tiaojishan Formation fossil wood specimens are well preserved with distinct growth rings and xylem structures. The flora in this formation is characterized by the dominance of cycads and ferns, followed by ginkgophytes; conifers and sphenopsids are less frequent. Abundant permineralized rhizome materials show anatomically preserved and diverse taxa belonging to fern families. In the Tuchengzi Formation plant fossils are rare, except for some fossil wood associated with megafossils and dinosaur footprints. The floral aspects of the Tiaojishan Formation indicate that subtropical to temperate warm and humid climate prevailed during the late Middle Jurassic. Growth ring pattern analysis of fossil conifer wood suggests a temperate climatic condition with distinct seasonal variation. The mean sensitivity index of growth rings shows the varying conditions of the environment and their climate tolerance. It was a different palaeoclimate in the Tuchengzi Formation, which reflects a dry climate with small desert forests during Late Jurassic, an important factor for interpreting and understanding evolutionary processes in the terrestrial ecosystem across the Middle-Upper Jurassic boundary, linked with red-bed floras.

S26 - THE LATE ORDOVICIAN *THALASSINOIDES* ICHNOFACIES ALONG THE PALAEOEQUATOR OF LAURENTIA

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The Børglum River Formation in North Greenland and the Red River Formation of central Canada contain a similar *Thalassinoides* ichnofacies, formed in the palaeoequatorial epeiric seas of Laurentia during the Late Ordovician. The upper Børglum River Formation contains a thick (130 m) unit of thick-bedded carbonate with pervasive *Thalassinoides* ichnofacies, which is also typical of the Selkirk Member (c. 40 m) of the Red River Formation. In their size, shape, overall density, and dark-grey dolomitic mottling contrasting with a light-grey limestone matrix, the *Thalassinoides* traces are virtually identical, pervasively and evenly distributed in both the Selkirk Member and the upper Børglum River Formation. The traces have the typical Y-shaped tunnel junctions, with individual tunnels ranging from 10 mm to 25 mm in diameter. In addition to the ichnofossils, the shelly faunas are also similar, as indicated by the dominance of giant nautiloids, relatively abundant stromatoporoids and receptaculitids, and large gastropods. The *Thalassinoides* ichnofacies points to a remarkable palaeogeographic extension from an intracratonic basin to a pericratonic shelf over a distance of 11,000 km. This facies consistency implies a homogeneous and stable depositional environment along the palaeoequator of Laurentia during the Late Ordovician.

W4 - FOSSIL RECORD IN TARU TAO ISLAND AND COASTAL AREAS, SATUN PROVINCE, SOUTHERN THAILAND

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Taru Tao Island and coastal areas (Thung Wa and La Ngu districts) Satun Province, in southern Thailand have extensive outcrops of Paleozoic marine karst. Over 35 taxa of Paleozoic fauna have been recorded including the stromatolites (late Ordovician to middle Devonian age), 9 species of trilobites (late Permian age), 13 species of brachiopods (Odovician to early Devonian age), 6 species of graptolites (late Ordovician to early Silurian age), 5 genera of nautiloids (Ordovician to late Permian age), ammonoids (Carboniferous age), algae, fusulinids, and crinoids (Ordovician to Permian age). In limestone caves, several mammalian fossils of the Cenozoic were recovered at Wang Kluay cave, consisting of 2 genera of the proboscideans, *Stegodon* (first record in Malay Peninsula) and *Elephas*, 2 genera of rhinoceros *Gaindatherium* and *Rhinoceros,* including bovid, and cervid. The abundance of fossil assemblages of both Paleozoic and Cenozoic eras, along with of archeological sites, and tourism attraction, demonstrate the potential to be Geopark or important geological area.

W9 - EVOLUTION OF PAIRED FINS AND THE LATERAL SOMITIC FRONTIER

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Recent research on the evolutionary origins of the paired fins (pectoral and pelvic, evolving into the four tetrapod limbs) has focused on genetic, developmental, and fossil evidence. However, a combined synthesis of this evidence has largely been lacking. In living animals, identification of dorsal and ventrolateral zones of fin-producing competence, the distinction between primaxial and abaxial regions separated by the lateral somitic frontier, and the recognition that fin developmental mechanisms could have been co-opted from unpaired to paired fins can be used to evaluate vertebrate fin evolution, including fossil forms. These fossil taxa dominate early vertebrate history and possess an unusually wide variety of fin or fin-like structures; establishing homologies with the paired fins of jawed vertebrates has been challenging, in part owing to the absence of supporting girdles in most jawless vertebrates. An evolutionary scenario is proposed where these fin-like structures develop from somites, in the same manner as dorsal, unpaired fins. Girdles and the paired fins of osteostracans and jawed vertebrates develop from lateral plate mesoderm when the lateral somitic frontier and the abaxial region of the body evolve.

S17 - FUNCTIONAL MORPHOLOGY OF THE EARLIEST VERTEBRATE FEEDING STRUCTURES

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Teeth constitute the majority of the vertebrate fossil record and are typically the first site of direct interaction between an animal and its food; this makes them obvious targets for the application of engineering approaches to understanding their functional morphology. Such work is well advanced for mammals, together with many reptile and fish groups. However, one major vertebrate group, conodonts, have yet to reach the intersection between biology and engineering, despite possessing an excellent fossil record, which preserves a variety of tooth forms rivalling or surpassing that of other vertebrate groups. To address this shortcoming, we have conducted the first rigorous analysis of conodont tooth function based upon engineering principles. We have concentrated on the food processing (P1) teeth and focussed for simplicity on those with a flattened, blade-like morphology. Following a similar methodology to that previously applied to mammals, our approach treats conodont teeth as serrated tools. Analysis of the geometry of function - relating to the most efficient shape for food fracture – reveals that the diversity and disparity of conodont tooth forms reflects a diversity of function and occlusal mechanics. In particular, changes in the shape and orientation of denticles strongly influence functional mode. This work will ultimately help place evolutionary changes in conodont tooth morphology within a functional context and allow investigation of the extent to which functional mechanics of serrated blades can be generalised, thereby permitting an assessment of functional convergence in feeding structures across vertebrates.

S17 - MODELLING MUSCLE STRUCTURE AND ACTIVITY IN VERTEBRATE SKULLS: IMPLICATIONS FOR THE ANALYSIS OF EXTINCT TAXA

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Analysis of skull structure and potential feeding behavior in vertebrate taxa increasingly involves computer based models and simulations such as Finite Element Analysis. Computed tomography (CT) can be used to provide geometrically accurate models but appropriate representation of muscle activity and the associated loading is more problematic particularly in extinct taxa. As the only living rhynchocephalian, *Sphenodon* (New Zealand tuatara) is an important reference taxon for use in a phylogenetic bracket. Using data from CT and dissections we have built a complex three-dimensional multibody model of the head and associated jaw muscles. The latter are represented by groups of linear "springs" spanning sites of origin and insertion. To simulate feeding the lower jaws of the model are directed to follow a path that corresponds to that observed in the living animal. When resistance (e.g. a virtual food item) is encountered the amount of work carried out by each "spring" (muscle activity) is dictated by its orientation relative to the outlever (Dynamic Geometric Optimization, DGO). In general, predictions of muscle activity provided by the computer model resemble those previously recorded from live *Sphenodon* using electromyography. Differences can be explained by variations in food material properties, food position and lower jaw motion. Therefore, provided muscle arrangement can be reasonably inferred from living analogues and muscle scars, DGO provides a means of simulating muscle activity in taxa known only from fossil material. Moreover, comparisons can be made between alternative hypotheses of muscle arrangement to explore the different implications of each.

S18 - CLIMATE CHANGE VERSUS COMPETITION AS THE CAUSE OF UNGULATE EXTINCTION AT THE GRANDE COUPURE (EARLY OLIGOCENE, EUROPE)

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It has been assumed that the extinction of most members of the main endemic European Eocene ungulate families Palaeotheriidae (Perissodactyla) and Anoplotheriidae (Artiodactyla) in the earliest Oligocene was caused by competition with newcomers dispersing from Asia via newly formed land bridges. This turnover event, known as the Grande Coupure (GC), also coincided with the onset of permanent glaciation of Antarctica (Oi-1). In terms of timing therefore, competition and climate change are apparently equal candidates for agents of the extinctions. Incoming ungulates in earliest post-GC faunas are restricted to tapiroids, pecorans, rhinos and an entelodont. Tapiroids and pecorans only occur in southern Germany, whilst the others are rare. It is not until c.0.5 million years after the GC that anthracotheres appeared (diverse and abundant) and pecorans became widespread. They thus arrived too late to have competed with palaeotheres and anoplotheres and cannot have caused their extinction at the GC. Integrated study of dental mesowear and microwear in key palaeothere and anoplothere taxa provides evidence of two phases of dietary shift across the Eocene-Oligocene transition. The first is gradual during the 2 million-year countdown to Oi-1, the second is more rapid across the GC itself, affecting the survivors *Plagiolophus minor* and *Diplobune* spp. Both shifts mark progressive increases in abrasiveness of a basically browsing herbivorous diet in palaeotheres. Anoplotheres show more complicated changes. Climate change in the form of cooling and increased seasonality, influencing vegetation and therefore availability of plant food, is judged the most likely cause of GC ungulate extinction.

S6 - MODAN: A NEW COMPREHENSIVE MORPHOMETRIC SOFTWARE PACKAGE

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Since the introduction of geometric morphometrics more than twenty years ago, research using morphometrics has been conducted in various fields including paleontology, biology, and anthropology. The process consists of several steps: data acquisition, data processing, statistical analysis, interpretation and visualization. In most of these steps, various computer software programs are used by researchers. Some of these programs are specialized for a specific task (e.g., data acquisition, statistical analysis), while others are designed to perform more than one task. However, in many cases no single program provides all the features that are required. Thus, researchers are forced to edit data files manually, to jump from software application to software application. Furthermore, different software programs developed by different people tend to have inconsistent user interfaces which hinders smooth workflow. Modan is a new, comprehensive and open source morphometric software package that focuses on 2D and 3D landmark-based morphometrics. Landmark-based morphometric studies can be accomplished in Modan ranging from 2D/3D data acquisition, data management, and statistical analysis, to final visualization, with a consistent and easy-to-use interface. It also supports importing and exporting data using various formats such as TPS, IMP and Morphologika2, minimizing the need to edit data manually. The ultimate aim of Modan is to provide the most comprehensive and feature-rich software for morphometricians that will enhance our understanding of biological shapes and encourage morphometric research.

S9 - EFFECT OF THE KAČAK EVENT (MIDDLE DEVONIAN) IN THE CENTRAL BARRANDIAN AREA ON THE DEVELOPMENT OF THE HIGHEST PLANTS

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The Kačak Event is one of the major Devonian biocrises. It is characterized by a decline of taxonomic diversity of marine fauna. The Kačak Event is reflected by black Kačak shales of the Srbsko Formation in the Czech Republic (Hlubočepy-section). We have analyzed this section in detail. It includes the Choteč, Kačak and Roblin layers, with six levels with flora and seven with miospores. The character of plants and miospore changes at Kačak and Roblin times has been determined. Plants from Kačak layers are represented by seven species belonging to five genera and four major clades (Rhyniophyta, Lycopodiophyta, cladoxylaleen fern and Progymnospermopsida). The extinction phenomenon in Kačak time has been registered while the one in Choteč and in earlier times has not been fixed. On the contrary, the systematic composition has become more complex from the point of view of genus and higher categories composition. The Roblin flora is similar to the Kačak flora and practically does not differ from it. The development of the highest plants occurred both in Kačak time and after it. Miospores in the Kačak layers are represented by 19 species belonging to 12 genera from the *Densosporites devonicus – Grandispora naumovae* Zone (late Eifelian). The miospore assemblage from Roblin layers is represented by 20 species belonging to 13 genera from the *Geminospora lemurata – Cymbosporites magnificus* Zone (Givetian). The Kačak Event did not affect the development of the highest plants and miospores. It influenced only the degree of plants and miospores preservation when they entered Kačak environments.

S13 - DEAD BELLEROPHONTIDS WALKING – THE SHORT MESOZOIC HISTORY OF THE BELLEROPHONTOIDEA (GASTROPODA)

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The bilaterally symmetrical gastropods grouped in the extinct superfamily Bellerophontoidea are considered as a typical Early Triassic example of the Dead Clade Walking taxon. They survived the Permian-Triassic extinction but disappeared in the Early Triassic. We analysed all Triassic occurrences of bellerophontoideans known from the literature and revised their taxonomic assignment and stratigraphic occurrence. We could confirm eight Early Triassic species of Bellerophontoidea representing three genera (*Dicellonema*, *Retispira*, and *Warthia*) from two families (Bellerophontidae and Euphemitidae). Bellerophontoideans were globally distributed in the Griesbachian, Dienerian, and Smithian (early-to-mid-Early Triassic) and at some localities they formed mass accumulations. Apparently they started to recover from the Permian-Triassic extinction but finally became extinct at the Smithian/Spathian boundary. We could not confirm any bellerophontoidean occurrence from Spathian and younger strata. The end-Smithian extinction event was previously found for conodonts and ammonoids. Thus, a double blade extinction in the Late Permian and end-Smithian finally removed the important Palaeozoic group Bellerophontoidea from the fossil record.

S9 - THE GLOBAL HANGENBERG CRISIS AT THE DEVONIAN-CARBONIFEROUS BOUNDARY - A REVIEW OF THE 6TH FIRST ORDER MASS EXTINCTION

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The Devonian-Carboniferous (D/C) boundary marks one of the major extinction events of the Phanerozoic. The generic extinction rate exceeds 45%, and ~20% of the families were affected. Black shale and sandstone deposits in different palaeogeographical settings, related to climatic and oceanographic changes, are reflected in the global Hangenberg Crisis, which has a magnitude and evolutionary significance comparable with the 1st order mass extinction at the Frasnian-Famennian boundary. The Hangenberg Crisis was a multiphase event, which affected numerous fossil groups of different environmental realms at different times. Recent studies indicate a short-termed but drastic climate cooling at the end of the Devonian, which is preceded by enhanced organic carbon burial rates during changing seawater temperatures. This has been considered as a trigger for the Late Devonian mass extinctions and the first glaciation pulse after 80 m.y. of greenhouse conditions. However, stratigraphical gaps, changes in litho- and biofacies, the lack of index fossils, and an imprecise correlation of different regions comprising neritic or pelagic faunas lead to misinterpretations of data on palaeoenvironmental changes and mass extinctions at the D/C boundary. Therefore, future studies will have to focus on interdisciplinary approaches to different palaeogeographical settings, involving isotope, chemo- and sequence stratigraphy as important addition to biostratigraphy.

S8 - KATIAN BIODIVERSITY – A PRELUDE TO THE HIRNANTIAN (ORDOVICIAN) MASS EXTINCTION AS SEEN FROM BALTIC DATA

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The Baltic data on macro- and microfossil diversity and distribution, published through IGCP projects 216, 410, 503, and complemented with new observations and carbon isotope data, serve as the basis for this study. We present different diversity curves (number of species and genera, total rates of appearances and disappearances) for nine groups of organisms (corals, stromatoporoids, brachiopods, trilobites, ostracodes, conodonts, scolecodonts, chitinozoans, acritarchs). These are correlated with the latest Baltica $\delta^{13}C$ trend in order to link biodiversity with environmental changes. The diversity of several groups (but not conodonts) increases significantly in the earliest Katian (= upper Keila Regional Stage) and decreases in the following Oandu Stage. This diversity peak coincides with the Guttenberg $\delta^{13}C$ peak. The faunal diversity fluctuates in the mid-Katian, reaching the highest values in the late Katian (Pirgu Stage) despite the step by step increase in the disappearance rate in some groups. Biodiversity in the Hirnantian is much lower than in the Katian, but several taxa manifesting morphological innovations occur also in the Hirnantian (Porkuni Stage). Middle-Porkuni rocks show the Hirnantian $\delta^{13}C$ peak. The lowest diversity episode occurs during the late Porkuni, partly due to global extinctions and partly due to local geological conditions. Two diversity peaks noted in the Katian are followed by low-diversity episodes. This suggests that corresponding disappearances occurred within comparable time intervals in the Katian and only the “second strike” of mass extinction took place in the Hirnantian.

W5 - DEPTH OF FIELD – A LIMITING FACTOR AS AN ADVANTAGE FOR 3D

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A method to reconstruct fine structural details of fossils, which avoids the need for any destructive intervention, is introduced. Though it requires fairly translucent fossils this simple and powerful technique can be applied to, e.g. Rhynie Chert material, in order to reveal a visually more sophisticated, and aesthetic presentation, which can further recognize details hidden in the 3rd dimension. The methodology is essentially adopted from the so-called '4D Microscopy', but of course lacks the 4th (time) dimension. Disadvantages of what is actually a limited depth of field are in fact advantageous for generating image stacks for 3D reconstructions.

W8 - SCORPION STERNITES AND THEIR HOMOLOGUES

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The question of how sternal plates and plate-like appendages differ, and how they supposedly evolved, are addressed with respect to scorpion fossils. In addition to previous comparisons of Recent arachnid lungs and merostome gills, and to fine structural observations even of fossil arachnids, this study can now define the sternite more precisely than ever before. Direct and serial homologues of scorpion sternites were examined and the data was placed into a modified context. Phylogenetic consequences, including a new perspective on the stemline of Arachnida, are discussed and a revised nomenclature for gill and/or lung associated structures is proposed.

S3 - THE EOCENE-OLIGOCENE EXTINCTION OF DEEP-WATER AGGLUTINATED FORAMINIFERA AT ODP SITE 647, SOUTHERN LABRADOR SEA

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The Eocene/Oligocene boundary represents an interval of rapid climatic change connected with global cooling, Antarctic glaciation, and concurrent changes in the composition of deep waters in the world ocean. Site 647 in the southern Labrador Sea is the only site in the western North Atlantic that recovered a complete Eocene/Oligocene boundary interval directly calibrated to standard chronology by means of a well-constrained age model. Our high-resolution study of the faunal record at Site 647 confirms earlier findings (e.g., Van Couvering et al. 1981, Kaminski et al., 1989) that the E/O transition was an interval of significant faunal change among benthic foraminifera. The E/O transition in Hole 647A is characterised by an extinction of deep-water agglutinated foraminiferal species (DWAF), especially among taxa that used organic cement to constrict their tests. In total, 90 DWAF species and generic groupings are observed. Species diversity falls from ca. 25 species/sample in the uppermost Eocene to 3 – 5 species across the E/O boundary interval. The extinction is preceded by an acme in large suspension-feeding tubular forms such as *Psammatodendron* and *Bathysiphon*, suggesting increased bottom water activity. The boundary interval in Core 647A-30R is nearly devoid of DWAF, with only the calcareous-cemented DWAF surviving. Several organically-cemented DWAF species reappear as Lazarus taxa in the lowermost Oligocene, but diversity never recovered to Eocene values. The decline in DWAF suggests improved ventilation of the bottom water in the Labrador Sea across the E/O boundary interval, possibly due to the appearance of a southern-source bottom water mass.

S3 - A CATALOGUE OF AGGLUTINATED FORAMINIFERAL GENERA

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The descriptions of foraminiferal genera are in need of revision and updating. The compilation of Loeblich & Tappan (1987), is now 25 years out of date, and advances in the the suprageneric classification of the foraminifera (including changes in rank of the group), have now made the Loeblich & Tappan classification obsolete. At latest count, over 140 new genera of agglutinated foraminifera have been described since 1987 (Kaminski, 2000, 2004, 2008); and many others have been subsequently emended. In 2002, we convened a working group to address the problem of updating the systematics of the Foraminifera. As a first step towards the task of updating the foraminiferal classification, we are preparing a compendium of all agglutinated foraminiferal genera considered valid (>760 genera). We have compiled a database using a file format that follows the general format of the Ellis & Messina Catalog of Foraminifera, containing the name of the genus, the type species, type reference, synonymy, description and remarks, stratigraphic range, and illustrations. We have added new illustrations, re-scanned original figures, and included information on the locations of type specimens. As part of this work, we have lectotypified over 50 type species of genera housed in the collections of the NHM in London. Our goal is to produce a revised catalogue of the valid genera of agglutinated foraminifera that can be accessed in electronic form, and updated on a regular basis. We envision this will be the first stage in the revision of the foraminiferal genera as a whole.

S8 - RESOLVING WHITEROCK TRILOBITE FAUNA "CRYPTOGENESIS" WITH DEVELOPMENTAL DATA: STYGINIDS ARE PAEDOMORPHIC DERIVATIVES OF LEIOSTEGIIDS

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It is now well understood that a major group of trilobite families, termed the Whiterock Fauna, diversified during the Ordovician radiation alongside members of Sepkoski's Paleozoic Fauna. A hallmark of the Whiterock Fauna taxa is the phenomenon of "cryptogenesis" - their sudden Ordovician appearance in the absence of obvious earlier relatives. In fact, very few hypotheses of sister taxa for major post-Cambrian clades exist, and as a result higher trilobite phylogeny remains essentially unresolved. One result is that it is impossible to map the origin of Whiterock Fauna groups and to test the extent of phylogenetic or ancestral geographic cohesion of the overall evolutionary fauna. A relatively untapped source of information is developmental data, which is now becoming available for many Late Cambrian and Early to Middle Ordovician taxa via a targeted field program focusing on silicified faunas, which can yield well preserved early ontogenetic stages. Here, we use developmental data to definitively root a major, heretofore cryptogenetic, Ordovician clade, the Styginida. Early ontogenetic stages of a new species of the leiostegioidean *Brackebuschia* are virtually identical with adults of phillipsinellid styginids. Hence, Styginida likely arose via paedomorphosis and should be regarded as an ingroup component of a broader leiostegiid clade.

S6 - GISWEAR; 3D AND GIS DIET ANALYSIS METHOD FOR BUNODONT OMNIVORE GROUPS SUINA AND HOMINIDAE

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The method presented here, GISWear, uses automated three-dimensional surface scanning and GIS (geographical information systems) methods for occlusal surface analyses in order to perform quantitative and objective diet analysis. GISWear uses characters similar to the traditional mesowear, but in three dimensions by looking at the sharpness and relief of the whole occlusal surface resulting from both attrition and abrasion. GISWear is introduced to extract dietary information from animals with bunodont tooth form. Suoids (pigs and peccaries) and hominids (great apes) were the main groups analysed. Dietary categories were classified within the omnivore group to distinguish the tendency to favour certain foods. The material examined consists of extant and extinct species. Recent species were used to generate a method and palaeo-species were then classified to diet categories using the generated method. Factors used were mean slope and surface sharpness (proportion of steep parts on the tooth surface). A decision tree was selected as the analytical tool. It divides large groups into smaller subgroups with absolute values. These groups are defined by their diet classification. The decision tree was made both manually and automatically. The manual decision tree divides specimens into four groups using mean slope. This is the same number of groups that mesowear has, even though diet categories are not the same. The automated decision tree divides specimens into eight groups using mean slope and surface sharpness. GISWear is ready to use for independently acquired 3D dental data by simple conditional sentences with two clear factors, relief and sharpness.

S24 - LAND PLANT ORIGINS: PHYLOGENETIC AND TEMPORAL CONTEXT

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Sometime during the late Neoproterozoic or early Palaeozoic terrestrial ecosystems changed fundamentally with the colonization of the land by plants. Evidence comes from a variety of sources, but currently these present a conflicting and very incomplete picture in terms of the relative timing of events, the organisms involved, and the pattern of diversification of various groups. The record of dispersed spores indicates that land plants originated during the mid Ordovician, and that there was an initial diversification of groups related to bryophytes (i.e., early relatives of mosses, liverworts). Evidence from body fossils (i.e., stems, leaves, roots, etc.) appears much later, during the latter part of the Silurian Period, and documents a well known and widely analysed radiation of simple vascular plants (i.e., early relatives of lycopods, ferns, horsetails, conifers) in the apparent absence of bryophytes. The topology of molecular phylogenetic trees is consistent with the evidence from fossil spores supporting a bryophyte-first hypothesis, but calibrations of these phylogenies produce results that fall into two categories: those that are broadly consistent with the picture derived from spores and those that are very much older. These inconsistencies are attributable to biases operating in the early fossil record and to assumptions underpinning tree calibration. Circumventing these biases to obtain a clearer perspective on the plant colonization of the land requires a better understanding of the nature of the early Palaeozoic terrestrial rock record and would benefit from additional geochemical and sedimentological indicators.

S13 - PERMIAN-TRIASSIC BOUNDARY MICROBIALITES IN SOUTHERN TURKEY: A HIGH-RESOLUTION ANALYSIS

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Earliest Triassic microbialites in southern Turkey are probably the thickest and most complex worldwide, formed directly after the end-Permian mass extinction during rising sea level. At Çürük Dağ, near Antalya, the 15-m microbialite has small-scale erosion and 3 distinct microbialite types, interbedded: 1) stromatolites, 2) thrombolites, 3) planar limestones (a complex hybrid of stromatolitic, thrombolitic and peloidal fabrics, and precipitated crystal fans). The Çürük Dağ microbialite shows repetition of microbialite; the lower part has abundant stromatolites and hybrid microbialites. Stromatolites are missing higher up in the sequence, which consists of thrombolites with tabular then domal forms, with domes directly below small breaks in microbialite growth, where very thin shelly micrites and grainstones/packstones are deposited. Repetition of facies may be controlled by sea-level change; a deepening-up model is consistent with the evidence, with stromatolites (with abundant crystal fans) in shallower water, deepening through hybrid microbialite and interlayered sediments to thrombolite, probably no more than a few tens of metres deep, followed by breaks and renewal of microbialite growth. Parallel work on ostracods shows that the microbialites were open marine, because of abundance of the Bairdioidea group, consistent with a deepening-up model. Bairdioidea grew in normal oxygen conditions, but other published ostracod work in China is not conclusive, so debate continues about the oxygenation of water in which microbialites grew. The principal driver of post-extinction microbialites is likely to be carbonate supersaturation of the oceans. The microbialite sequence is overlain by a 25 m of grainstone/packstone (without microbialite), then Early Triassic shales.

S27B - PALAEOECOLOGY OF COMMENSAL EPISKELETOZOANS FOULING *FLEXICALYMENE* (TRILOBITA) FROM THE LATE ORDOVICIAN CINCINNATI ARCH REGION

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Commensal epizoozoans and episkeletozoans are rarely preserved attached to the external exoskeleton of the Late Ordovician trilobite *Flexicalymene.* Large collections from two separate trilobite shales from the Cincinnati Arch region indicate that less than 2% of *Flexicalymene* specimens contain epizoozoans or episkeletozoans. Factors limiting *Flexicalymene* fouling include a shallow burrowing life style, frequent moulting of the host, larval preference for other substrates, observational bias caused by overlooking small fouling organisms, and the loss of the non-calcified, outermost cuticle prior to fossilization or as the trilobite weathers from the encasing sediment. Articulate and inarticulate brachiopods, trepostrome bryozoans, cornulitids, and an unknown tube-dwelling soft-bodied organism represent the preserved members of the Late Ordovician marine hard substrate community fouling *Flexicalymene*. This assemblage of organisms is less diverse than the hard substrate community fouling Late Ordovician sessile epifaunal organisms. Fouling is not restricted to only large *Flexicalymene* specimens as observed in previous studies but occurs in

medium to large individuals interpreted as early to late adult specimens. Epizoozoans fouling the carcasses or moult ensembles of 16 *Flexicalymene* specimens provide insight into the life habits of the host and these fouling organisms. Articulate and inarticulate brachiopods, trepostrome bryozoans, and cornulitids preferentially attached to elevated portions of the dorsal exoskeleton, and preferentially aligned in either the direct line or lee side of currents generated by *Flexicalymene* walking on the sea floor or swimming through the water column.

S27B - EVOLUTION OF THE LATE PENNSYLVANIAN LINEAGE *FUSULINA - QUASIFUSULINIODES - QUASIFUSULINA* WITHIN THE MOSCOVIAN - KASIMOVIAN TRANSITION

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The Moscovian - Kasimovian boundary in the Tethyan and Boreal provinces is marked by the extinction and origination of many fusulinid genera. The Kasimovian *Protriticites* and *Quasifusulinoides* displaced the Moscovian *Fusulinella* and *Fusulina* genera respectively. The evolution of the lineages *Fusulinella - Protriticites - Montiparus* and *Fusulina - Quasifusulinoides - Quasifusulina,* reflected in their wall structure, is well preserved in the the continuous Pennsylvanian succession in the Donets Basin. Few stages can be recognized in the wall evolution of intermediate *Quasifusulinoides.* The changes affected mainly the diaphanotheca and the inner tectorium. The species of this genus from the limestone N_3 possess thick walls with a massive inner tectorium. In the limestone N_5 the inner tectorium is still thick but becomes discontinuous, and in O_1 it transforms into a thin band, underlying a wide light diaphanotheca.The overall thickness of the wall is gradually decreased. The transition from *Fusulina* with a four-layered wall to *Quasifusulina* with a two-layered wall occurs over approximately 1 Myr. A rapid tempo in evolution is also observed in the lineage *Fusulinella - Protriticites - Montiparus,* which is successfully used in biostratigraphy. The main evolutionary stages, reflected in the wall structure, are synchronized in both lineages, probably in response to dramatic climatic changes within the Moscovian - Kasimovian transition.

S20 - CONSERVATION PALEOBIOLOGY – AN EMERGING APPLICATION OF MODERN DEATH ASSEMBLAGES AND TAPHONOMIC ANALYSIS

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Death assemblages (DAs) constitute the taxonomically identifiable dead remains of organisms that accumulate on and within the uppermost mixed layer of modern landscapes and seafloors, and are regularly encountered – and discarded – by biologists because of concerns with postmortem bias and prolonged time averaging. However, a new generation of actualistic studies dedicated to quantifying and understanding these effects among animals – focusing most strongly on mollusks but broadening to corals and mammals - is finding strong survival of such ecologically important information as species relative abundance and environmental gradients in regions, despite decadal to centennial scales of time-averaging that coarsen both spatial and temporal resolution. In settings that have not been strongly modified by humans, DAs generally match local living assemblages (LAs) quite well, not because postmortem bias is nil but because bias is largely swamped by the continued input of newly dead individuals from the LA, which refreshes the composition of the DA. In settings modified by human activities (eutrophication, animal exploitation, habitat change by trawling or grazing), “live-dead agreement” tends to be poorer because the DA includes relictual specimens from pre-impact community states. Thus, although the original aims of actualistic taphonomy were to evaluate the fidelity of *fossil* records (and many insights have been gained), a new field relevant to conservation and management of biodiversity is emerging. Time-averaged DAs encountered during conventional biological surveys represent an important under-exploited resource for inventory of regional diversity, and live-dead analysis permits a retrospective evaluation of the magnitude and nature of anthropogenic community change.

S15 - SIMULATING ICEHOUSE AND GREENHOUSE CLIMATES OF THE PALAEOZOIC

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Simulating climate of Earth's deep past provides a unique opportunity to evaluate the robustness of coupled climate system models that are currently used to look at Earth's future. Climate simulations of the icehouse state of the latest Ordovician (445 Ma) will be presented and compared with palaeoclimate proxy data. Implications of the climate simulation for the first mass extinction will be discussed. Simulations of the greenhouse climate of the latest Permian (251 Ma) will be presented and compared with palaeoclimate proxy data, again the implications of this warm greenhouse world in explaining the largest mass extinction in Earth's history will be explored. Finally, deep past climate forcing will be shown to be similar in magnitude to that which is expected to occur over the next one hundred years. Thus, understanding deep time climates and their affects on life are an essential component for understanding Earth's future.

PLENARY - EVOLUTIONARY REGULATION OF BIODIVERSITY IN THE OCEANS

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The last decade saw many exciting developments in deep-time biodiversity studies. These advances have been made possible by the Paleobiology Database. We now know that the early view of unbridled diversity rise in the oceans of the last 100 million years is probably incorrect. The "Pull of the Recent" and sampling biases have distorted the outcome of earlier compilations of taxonomic ranges. We also have a much better idea on the diversity dynamics that underlie the large scale patterns. First, diversity appears to be regulated at global scales: Declines of global diversity lead to subsequent declines in extinction rates and increases in extinctions are followed by increases in originations. Second, diversification was not governed by extinction in the Palaeozoic but by origination in Mesozoic and Cenozoic. The discovery that marine level-bottom community structure has changed substantially at the Permian-Triassic boundary, offers an elegant explanation for this observation. The ecologically complex communities that dominated Mesozoic and Cenozoic oceans created opportunities for speciation, whereas the simple Palaeozoic communities required extinction for new species to become established. Third, both origination and extinction rates vary systematically among habitats and over time. Rates are significantly larger in tropical, shallow water, calcium carbonate and reef habitats than in extra-tropical, deep water, terrigenous clastic and non-reef habitats. Reefs appear to be especially important in regulating marine biodiversity. The evolutionary cradle effect of reefs was higher in the Palaeozoic than later on, probably because community structure in reefs was always complex, whereas level-bottom communities gained complexity after the Palaeozoic. These examples demonstrate once again how much the fossil record can contribute to understanding macroevolutionary dynamics and how much insight can be gained by community-wide efforts in palaeontology. We are getting close to a holistic and reliable picture on biodiversity dynamics in the oceans. What is yet needed is a rigorous theoretical framework for these patterns.

S9 - EARLY DEVONIAN (PRAGIAN-EMSIAN) BIODIVERSITY PATTERN IN ZINZILBAN AND KHODZHA-KURGAN SECTIONS, ZERAFSHAN RANGE, SOUTH TIEN SHAN

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In the Zerafshan-Hissar Region of South Tien Shan, characters of Lower Devonian sedimentology and biodiversity changes are best documented in the Zinzilban and Khodzha-Kurgan sections situated in the Zerafshan Range within the area of the Kitab Natural Reserve. Within the Pragian-Emsian interval two major horizons can be recognised, which are characterised by an increased faunal turnover, extinction and immigration of a new fauna. It includes the base of the Emsian Stage (*Polygnathus kitabicus* Biozone), and the base of *Polygnathus costatus partitus* Biozone, which corresponds to the base of the Middle Devonian. The beginning of the Emsian coincided with significant changes in pelagic communities and in particular with a proliferation of polygnathid conodonts. There is also significant change in taxonomical composition of dacryoconarids, including the extinction of characteristic Pragian genera, such as *Homoctenowakia* and *Paranowakia*, which are replaced by *Nowakia*. The character of biofacies changes in shallow water benthic communities suggests a moderate sea level rise in the early Emsian. The base of the *Polygnathus costatus partitus* Biozone marks the beginning of significant transformations in the taxonomic composition of various groups of benthic fauna. The interval of the *Polygnathus nothoperbonus* Biozone coincides with marine transgression and resulted in the deposition of pelagic sediments. It was the time of proliferation of ammonoids (e.g., *Anetoceras, Gyroceratites, Erbenoceras*, *Mimosphinctes, Mimagoniatites* and *Convoluticeras*) and dacryoconarids, including *Nowakia barrandei*, *Nowakia elegans* and *Nowakia cancellata*, which occur in Bohemia and Germany within the interval from the *Polygnathus inversus* to *Polygnathus serotinus* conodont biozones.

S27C - A LATE PALAEOZOIC JIGSAW PUZZLE: HOW AND WHEN DID THE WETLAND PLANT COMMUNITY TEMPLATE MIGRATE?

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Ancient wetland plant communities (peat-forming swamps) persisted from the mid-Carboniferous Period in North America and Europe through to the end of the Permian Period in South China. Recent palaeobotanical findings have suggested significant taxonomic and systematic similarities between these two temporal and geographic end members, indicating a united Amerosinian phytogeographic realm which linked the North China block to Euramerica before the end of Carboniferous times, and a Euramerican origin for the wetland communities in China. This study is the first to test this theory empirically, by analysing a vast database created from over 120,000 plant macrofossil specimens from the UK, USA and China. There are definite linking species and species-associations between the regions, and results confirm that wetland plant communities were highly dynamic and locally heterogeneous. Also emphasised is the interplay of a multitude of factors in the development and migrations of these complex plant communities across huge tracts of space and time. These results give powerful insights into not only palaeofloristics and palaeogeography, but also plant evolution and palaeoclimatology, and this unique and expansive data resource will continue to be exploited to these ends.

S9 - KONZENTRAT LÄGERSTATTE OF THE GONIATITE *NAPLESITES* MARKING A GLOBAL TRANSGRESSSION EVENT (UPPER DEVONIAN, *MESOBELOCERAS* GENOZONE) IN THE RHINESTREET SHALE, WESTERN NEW YORK

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A bedding-surface “graveyard” of the beloceratid goniatite *Naplesites* caps a thin dacryoconarid-fish bone-conodont lag horizon in the basinal black Rhinestreet Shale (mid Frasnian) at Lake Erie near Buffalo, New York. The evolute coils (of calcite or pyrite) are clearly outlined against the background of dacryoconarid molds and otherwise barren black shale with as many twenty-five specimens (clustered or overlapping) per 100 cm^2. All ontogenetic stages, from juveniles in the size ranges of euro-coins to adults with diameters exceeding 10 cm, are represented in this record of a short-term anoxic event. Some pyrite replacements show the chevron-pattern of pointed lobes and saddles of *Naplesites* heretofore known in New York only by the few poorly preserved types reported by J. M. Clarke in 1898 from Naples, NY, 140 km east of Lake Erie. The ancestral genus, *Probeloceras*, occurs in New York in the gray Cashaqua Shale, which underlies the transgressive Rhinestreet succession. The bed with *Naplesites* at Lake Erie is in the band of black shale immediately above a recurrence of gray shales (“false Cashaqua” division) in the lower Rhinestreet. Conodonts from the *Naplesites* horizon and from a lag at the base of the “false Cashaqua” interval indicate Montagne Noire Conodont Zone 7. The beloceratid goniatites have a worldwide distribution. Tracking this *Naplesites* epibole across New York and internationally should help constrain the timing of the early pulses of the Rhinestreet deepening event.

S27A - A NEW DISCOSAURISCID (SEYMOURIAMORPHA) FROM THE LOWER PERMIAN DEPOSITS OF THE CZECH REPUBLIC

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A skeleton of a new specimen of discosauriscid tetrapod has been recorded in the lake deposits of the Boskovice Basin in Moravia (Czech Republic). The specimen exhibits the following features that place it into the family Discosauriscidae: short preorbital region; rounded to oval orbits positioned mainly in the anterior half of the skull; and otic notch dorsoventrally broad and anteroposteriorly deep. The skull of is about 45 mm long and is massive in comparison with the similarly sized specimens of other discosauriscids. The skull is distinguished from all other members of Discosauriscidae by a very distinct ornamentation of the skull roofing bones. This ornamentation consists of high and mostly sharp ridges joined together forming a net. Such distinct ornamentation is not developed in the largest known specimens of *Discosauriscus austriacus* with a skull length about 52 mm. In contrast to other seymouriamorphs, the intertemporal is larger than the supratemporal and a small process of the parietal fitting between the postfrontal and intertemporal is absent. In other features, the anatomy of the skull of this discosauriscid is similar to that of *D. austriacus*. The marginal teeth are conical, slightly posteriorly curved and their basal portions bear dorsoventral grooves. The tooth crowns have medial and distal cutting edges. The grade of ossification of the cranial endochondral elements and the postcranial skeleton corresponds to that of similarly sized specimens of *D. austriacus*.

S19 - THE MAJOR TRANSITIONS IN EVOLUTION: A PHYSIOLOGICAL PERSPECTIVE

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As told by Maynard Smith and Szathmáry, life's major transitions involve information and individuality. With equal justification, however, one can mark evolutionary milestones in terms of physiological innovation. A physiological complement to Maynard Smith and Szathmáry's list might include three major innovations associated with primary production (photosynthesis, oxygenic photosynthesis, and nitrogen fixation) and four that changed the face of heterotrophy (respiration, aerobic respiration, bulk oxygen transport, and technology). Such a physiological perspective highlights interrelationships between evolving life and a physically dynamic planet. Geochemical data suggest that for much of the Proterozoic Eon, oxygen minimum zones of Earth's oceans tended toward euxinia. Under these conditions, nitrogen limitation would have favored primary producers capable of nitrogen fixation, as the geobiological record suggests. Despite the presence of oxygenic photoautotrophs, continuing anoxygenic photosynthesis likely played an important role in sustaining the redox structure of Proterozoic oceans. Late in the Neoproterozoic Eon, however, tectonic events appear to have nudged the biosphere toward a new state. Widespread rifting correlates with a switch from sulfidic to ferruginous waters in the OMZ; broadly coeval expansion of eukaryotes is consistent with the low sulfide tolerance exhibited by most eukaryotic clades. Four independent geochemical proxies suggest further redox transition 580–550 Ma, a time when rates of sediment accumulation increased markedly. Higher oxygen tensions and a receding challenge of anoxia likely facilitated animal diversification, but it was the evolution of anatomical mechanisms for bulk transfer that freed animals from the constraints of diffusion – ushering in the age of bilaterians.

S20 - IMPORTANCE OF ANALYZING *IN-SITU* BIVALVES IN THE RECONSTRUCTION OF BRACKISH-WATER BENTHIC ASSOCIATIONS

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Infaunal bivalves preserved in life position are one of the most reliable information in environmental and palaeoecological reconstruction of estuaries, which harbour brackish-water communities. Estuaries are characterized by extensive post-mortem transportation and community mixing due to high environmental heterogeneity, being in contrast with most marine environments where post-mortem transportation is limited and it is generally not necessary to assume serious mixing. A case study is presented for the brackish facies of the Early Cretaceous Hanoura Formation in Tokushima, Japan. Sedimentary facies and mode of fossil occurrence were analyzed for the Tatsugatani section in Kamikatsu-cho, Tokushima. In the black mudstone deposited in the innermost part of estuary, the fossil association is dominated by a corbiculid bivalve, *Tetoria sanchuensis,* one of the early heterodonts possessing long siphons. Most of the specimens are articulated, but no specimens are preserved in normal life position; they are embedded parallel to bedding or found with their beaks down. In contrast, *T. sanchuensis* are found in normal life position in sandy facies with other brackish-water bivalves, such as *Costocyrena radiatostriata, Isodomela* sp. and *Pharella* sp. This difference suggests that *T. sanchuensis* occurred in a wide variety of habitats, but the innermost part of the estuary could have been colonized only by *T. sanchuensis.* Therefore, the long siphon of *Tetoria sanchuensis* may have evolved to cope with rapid deposition occurred frequently in the innermost part of estuaries, rather than evolved to avoid predation by burrowing deeply in the substrates, or to avoid drastic changes in temperature or salinity.

S27B - NEW DINOSAUR FOSSILS FROM THE MIDDLE JURASSIC IRHAZER SITE OF NORTHERN NIGER

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New dinosaur sites from Middle Jurassic sediments of the Irhazer Group in the plains of Agadez (Rep. Niger, NW Africa) have yielded the basal sauropod *Spinophorosaurus nigerensis* Remes *et al*. 2009 and extraordinarily well preserved didactyl tracks of a medium-sized theropod. *Spinophorosaurus nigerensis* is the most complete basal sauropod currently known. It was discovered during several excavation trips made by a team from the Staatliches Naturhistorisches Museum Braunschweig, Germany, between 2005 and 2008. The new taxon is a middle sized and spike bearing sauropod that shares anatomical characters with Middle Jurassic East Asian sauropods. Only two specimens are known to science. A reconstruction of the complete skeleton produced by using Rapid Prototyping was recently presented to the public in an exhibition at the Braunschweig museum. The 120 tracks in the vicinity of the bone site are assigned to five individual trackways. The distinct morphology of the footprints indicates a digitigrade bipedal trackmaker from the bird-related group of paravian maniraptorans. The early age and the morphological traits of the tracks allow for description of a new ichnotaxon. The new ichnotaxon takes a unique position in the ichnological fossil record of Gondwana and the mid-Jurassic biota worldwide as it is the earliest record of a possible paravian maniraptoran and the first record of didactyl theropod tracks from Africa.

S13 - EVENT PATTERNS OF PENNSYLVANIAN – CISURALIAN RUGOSE EVOLUTION

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The Pennsylvanian - Cisuralian interval shows four main levels of substantial lowering of taxonomic diversity emphasized by partial extinction of some genera or families: mid-Carboniferous, mid-Pennsylvanian, late-Pennsylvanian, and mid-Artinskian. The extinction of the massive colonial Rugosa indicates the event levels, with one exception: the diminishing of diversity at the end of the Late Pennsylvanian is ongoing within the “caninoid morphotype”. In general, recovery succession includes replacement of several morphoecotypes: (i) solitary forms, (ii) fasciculate forms, (iii) cerioid colonies, (iv) astreoid colonies. The post mid-Carboniferous (Bashkirian) recovery in shallow-water facies started from small *Caninia* (i) to ?*Prolytvophyllum* - *Heintzella* (ii) and ended with the *Petalaxis* I assemblage. The Moscovian colonisation of the East-European platform shelves is illustrated by a gradual change within the complete ecological succession: *Alekseeviella* (i) - *Fomichevella* (ii) - *Petalaxis*-II (iii) - *Ivanovia* (iv). The latter is displaced by the *Bothrophyllum* crisis assemblage. The next complete succession includes an initial assemblage with ‘*Cyathaxonia’* or *Timania* fauna (i) which is replaced by *Heintzella* fasciculate colonies (ii), and then during the late Asselian - early Artinskian succeeded by widespread cerioid *Kleopatrina* (iii) - astreoid *Protolonsdaleastraea* (iv) assemblages. There are a few more simultaneous parallel evolutionary lineages widespread along the Pangaean shelves, for example *Tschussovskeni*a (i) - *Protowentzelella* (ii) - *Permastraea* (iii). The adaptive radiation of colonial forms is interrupted by ecological crises marked by the diverse ‘*Cyathaxonia’* fauna. Stable isotope data from studied sections (Russian Platform, the Urals, and northern Timan) allows connection of the biotic events to multiple cooling effects developed during the Pennsylvanian - Cisuralian interval.

S27B - PERMIAN REEFS OF THE EAST-EUROPEAN PLATFORM (CRISIS, BIOTA, MICROFACIES)

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Two main periods of reef development in the East European Platform (EEP) correspond to the Mid-Asselian – early Artinskian and the Mid-Artinskian – early Kazanian (Roadian). The abundance and variety of the early Permian buildups were triggered by long-term climatic and tectonic stabilization which favoured widespread diversification of the chlorozoan biota. They are situated along the eastern margin of the EEP, in the southern part of the Barents Sea and on Kolguev Island. *Tubiphyites- Archaeolithoporella*, *Palaeoaplysina*, and rugose corals (Family Kleopatrinidae) are among the main reef-builders of the isolated frame reefs and coral patch-reefs. The gradual restriction of their area is typical for the Early Artinskian and a *Palaeoaplysina* reef is reported from northern Timan (western EEP). The predominance of skeletal reefs or mud-mounds after the Mid-Artinskian biotic event reflects climatic cooling. This followed a long-term comparatively warm period according to new stable isotope data from the key sections along the Kos'va River (Central Urals) and northern Timan. Bioclasts studied from the Late Artinskian buildup (Divia Mountain) include a fauna of heterozoan association such as fenestellid bryozoans and silicisponges encrusted by *Microcodium* (Early Kungurian). The microfacies succession reflects a transgressive–regressive cycle corresponding to the Late Artinskian and Early Kungurian, respectively. The terminal Early Kazanian mud-mounds are developed in the central part of the EEP. They are surrounded by oncoid shoals consisting of micritized oncoid-foraminiferal rudstone, with *Parachaetetes* (red-algae) fragments. Mud-mound microfacies include bryozoan boundstone, *Tubiphytes –Palaeonubecularia* floatstone, foraminiferal wackstone. The appearance of *Microcodium* in the uppermost part of the mud-mound corresponds to subaerial exposure.

S21 - PHYLOGENETICALLY STRUCTURED EXTINCTION AND THE EVOLUTION OF POLAR MARINE FAUNAS

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The low taxonomic diversity of polar marine faunas reflects both the failure of clades to colonize high latitudes and the local extinction of clades that had once been there. The composition and community structures of the two poles differ strongly, with the Antarctic generally more species rich but exhibiting archaic community structures more reminiscent of Paleozoic than modern communities. Here, combining fossil data from the Arctic and Antarctic Paleogene with a family-level molecular phylogeny of living marine bivalves, we show that differences between the polar faunas arose via contrasting phylogenetic patterns of extinction through the Cenozoic. Phylogenetic clumping in extinction was tested statistically using two measures of the phylogenetic relatedness of taxa, mean pairwise distance and mean nearest taxon distance. Both metrics verify that Arctic losses are randomly distributed across the phylogenetic tree, whereas Antarctic losses are significantly clumped in the more derived portion of the tree. As a result, phylogenetic diversity (PD, equal to the sum of the branch lengths in a regional phylogenetic tree) in the Arctic has remained stable through the Cenozoic, while up to 35% of PD has been lost from the Antarctic, leaving a fauna dominated by basal lineages. These results show that the direction of climate change alone cannot predict its phylogenetic consequences, and provide the first phylogenetic support for the "retrograde" hypothesis of Antarctic faunal evolution. Climatic, oceanographic, and ecological differences between the two poles may all have contributed to the contrast in extinction patterns.

S3 - ORIGIN OF MODERN PLANKTONIC FORAMINIFERA AND THEIR RESILIENCE TO CLIMATE CHANGE

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Modern planktonic foraminifera are highly unusual in comparison to their earlier evolutionary history. The extant fauna is composed of unusually few and unusually old species, which inhabit an oceanic habitat characterized by lack of low latitude seaways and dominated by large-magnitude orbitally paced glacial cycles. Such configuration has never previously occurred during the evolutionary history of the group. In particular the unusually old age (almost twice the Cenozoic average) of the extant species has led to hypotheses that the extant species of planktonic foraminifera are a robust relict resulting from additive extinction of susceptible species accompanied by a suppression of speciation due to rapid glacial-interglacial scale climate change. This hypothesis has potentially significant implications for the assessment of the reaction of the pelagic ecosystem to future climate change and for the applicability of observations of plankton response to climate change in the geological past. Here I test the “relict” hypothesis on three independent datasets. First, the NEPTUNE database of species occurrence in deep-sea cores is analysed to estimate the rate of speciation and extinction throughout the last 5 Myr. Second, existing data on assemblage composition for the same period are analysed to determine when the modern community structure evolved and whether ecological preferences of species remained constant since their first appearance. Third, the distribution of molecular clock estimates of divergence ages among cryptic species in modern planktonic foraminifera is tested for deviations from a constant diversification null model.

S3C - ON THE FORAMINIFERAL SUPERFAMILY LASIODISCOIDEA FROM THE LATE MISSISSIPPIAN OF THE SOUTH URALS

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Lasiodiscoidea species are found in limestones deposited in a shallow open sea with normal salinity. The first diversification event in this superfamily was in the Serpukhovian and resulted from global events leading to the shallowing of the Mississippian basins. In the South Urals, the arachaeodiscid superfamily Lasiodiscoidea first appeared in the Late Visean. *Vissariotaxis* (family Vissariotaxidae) and *Howchinia* (family Howchiniidae) have a two-chambered shell. The second tubular chamber is spiral-conical, with an umbilical cavity. In *Vissariotaxis* the shell wall is microgranular, single-layered, less commonly inconsistently bilayered. The shell wall of *Howchinia* consists of two layers – microgranular and clear vitreous-radial; the umbilical cavity is filled with vitreous-radial matrix with pillar fracturing. The supplementary fissure-like apertures are inconsistently observed on the upper surface. *Eolasiodiscus* and *Monotaxinoides* (family Howchiniidae) appeared at the beginning of the Serpukhovian and had a discoidal or weakly convex shell. *Monotaxinoides* differs in the bilayered shell wall, well-developed vitreous-radial matrix in the umbilical region on the lower surface, and inconsistently present supplementary fissure-like apertures. It had been previously thought that *Monotaxinoides* with its more flattened shell evolved from *Howchinia*, and gave rise to *Eolasiodiscus* with vitreous-radial layer faintly developed only in the umbilical cavity, and with well developed supplementary fissure-like apertures. However, we showed that *Monotaxinoides* and *Eolasiodiscus* appear simultaneously in the Lower Serpukhovian in the South Urals, suggesting that *Monotaxinoides* evolved from *Howchinia*, and *Eolasiodiscus* - from *Vissariotaxis*. Further evolution of *Eolasiodiscus* in the Pennsylvanian led to the appearance of *Mesolasiodiscus* with different morphology of supplementary apertures.

S13 - A NEWLY DISCOVERED EARLY TRIASSIC CHERT AT GAIMAO SECTION, GUZHOU, SOUTH-WESTERN CHINA

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The Gaimao Permian-Triassic boundary section is located at Gaimao, Huaxi District,Guizhou Province, Southwestern China. From the bottom to top, this section continuously displays Changxing Formation bioclastic limestone, Dalong Formation siliceous rock and siliceous mudstone with ash interbeds, and Shabaowan Formation mudstone with limestone interbeds. Conodont samples were collected along 20 marked beds at this section. Well-preserved conodont elements obtained from 7 samples are useful for conodont biostratigraphy and zonations. The occurrences of *Hindeodus julfensis* and *H. typicalis* in the Changxing Formation bioclastic limestone indicate a Late Permian age. Furthermore, four conodont zones have been established in the Dalong Fm. and Shabaowan Fm. In ascending order, those conodont zones are as follows: *Isarcicella isarcica* zone, *Neogondolella planata* zone, *Neogondolella krystyni* zone and *Neospathodus dieneri* zone. Due to the appearance of typical Griesbachian conodonts *Isarcicella isarcica* and *I. staeschei* in the upper Dalong Formation, we consider that the age of the upper Dalong Formation at Gaimao section should be assigned to the Early Triassic. Thin section analysis also indicates that the siliceous mudstone of the upper Dalong Fm. contains rich radiolarians. The new data prove that there is no "Early Triassic Chert Gap" at Gaimao section.

W8 - CHARACTER ACQUISITION AND RELATIONSHIPS OF THE BASAL EURYPTERIDA

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Restudy of the Silurian Pentland Hills eurypterid fauna helps to resolve the poorly understood early phase of eurypterid evolution. '*Drepanopterus*' *bembycoides* and '*D*'*. lobatus* are not stylonurines, but identified as synonyms of '*Nanahughmilleria' conica*, representing a distinct new genus with an intriguing set of characters; an epistoma, appendages II-IV with poorly-expressed paired spines, and a pediform appendage VI with a modified podomere 7a (as in Eurypterina; swimming forms). It is assigned to the superfamily Moselopteroidea, along with *Moselopterus* and *Vinetopterus*, that share an oval metastoma with anterior notch, anterior 'ears' on the coxa of appendage VI, a pediform appendage VI with a podomere 7a, and serrate posterior margins of the postabdominal segments. This new genus and *Vinetopterus* are the most primitive Eurypterina known, and show that both basal Eurypterina and Stylonurina possess a three-segmented genital operculum and a pediform appendage VI. Eurypterina are distinguished by the presence of a podomere 7a and the lack of transverse sutures on the prosoma. Furthermore, some 'derived' characters, such as genital spatulae and epistomal sutures are now found in the most basal Eurypterina. This also suggests that one of the earliest (Ordovician) eurypterids, *Megalograptus*, considered by some workers as a basal member of the Eurypterina, actually belongs within the Mixopteroidea.

S20 - PHOSPHATIZED ORGANIC NANOFIBRILS IN CAMBRIAN LINGULATE BRACHIOPODS

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Observation of the results of taphonomic processes at the microscale and nanoscale is a clue to the interpretation of microstructures in phosphatic fossils. We consider an example, where fibril-like structures thinner than 100 nm have been preserved in 500 Ma old fossils. The use of non-destructive ESEM studies of fracture surfaces of Cambrian lingulate brachiopod valves has allowed fragile nanoscale structures - phosphatized nanofibrils – to be observed. The studied shells were untreated and uncoated, and the low-vacuum regime and back-scattered electron detector were used. The nanofibrils were interpreted as compounds of early stages of baculi – rod-like elements of the trellised baculate sets characteristic of a certain type of shell structure in lingulates – the baculate structure. The nanofibrils observed in *Obolus ruchini* Khazanovitch and Popov from the Cambrian of the Leningrad district, NW Russia are flexible strands, 70-100 nm in diameter, and resemble the structures observed by Schmahl et al. (2008) in the modern linguloid *Discradisca stella* (Gould). The observed nanostructures are instructive for understanding biomineralisation and taphonomic processes shaping the structures in different levels of structural hierarchy of the shell.

S16 - CLOCKING MORPHOLOGY: ESTIMATING ANCIENT DIVERGENCE TIMES AND ABSOLUTE RATES OF MORPHOLOGICAL EVOLUTION

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Evolutionary rates vary across populations, lineages, clades, and time. Such variation has been well documented at all these levels and for molecular and morphological data. Aspects of neutrally evolving molecular data have been used to construct molecular clocks to estimate ancient divergences between living taxa. Morphology, on the other hand, is generally implied to be under selection and is not expected to yield neutral rates of change. This discordance is likely one of many causes for the often contradicting phylogenetic hypotheses derived from molecular and morphological data. We review available methods to measure morphology and assess morphological changes over phylogenies with the express purpose of measuring rates of morphological evolution. We present a general method of measuring morphological evolutionary rates and demonstrate how large enough data sets begin to yield linear rates of change. These rates are comparable across all large tetrapod data sets examined and reveal r^2 values similar to neutral molecular data. We demonstrate how these morphological clock models can be used much like molecular clock models to estimate ancient divergence times. We elaborate using Bayesian methods to estimate internodal rate variations and present evolutionary rate data for Mesozoic mammals and archosaurs. In spite of these results, static evolutionary rates of morphological evolution is counterintuitive to the notion that morphology is always under selection. We present an explanation for this that is founded on the Law of Large Numbers and discuss how this explanation likely pertains to supposedly neutral molecular data as well.

S5 - CLOSING THE CIRCLE – CONSERVING FOSSILS AT SOURCE

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Linking site-based conservation of fossils to site manager, site owner, collector, researcher and museum is critical to the success of fossil conservation. Communication across these interests has always been central to the principles of 'responsible collecting' that have been widely applied across England since the 1990's. These are simple principles linking the scale and nature of collecting to vulnerability of fossil resource that, if followed, should ensure that fossil collecting is sustainable. Guidance is now being developed and adopted by Natural England that helps palaeontological site managers make clearer and consistent decisions about the degree and nature of site-based management that is required. Taking the approach of 'responsible collecting' as a common standard there are three broad approaches to site management: 1) Open collecting - where there is a significant and renewed fossil resource, typically a rapidly eroding coast, and the need for management intervention is minimal.; 2) Open-managed - collecting where elements of the fossil resource are more restricted, threatened or vulnerable, in a disused quarry, for example, and some degree of more careful management is required; 3) Controlled collecting **-** where there is clearly a finite resource where unmanaged collecting would rapidly remove or destroy the resource, a cave bone deposit is a typical example. A series of guiding questions to help site managers arrive at the most appropriate collecting option will be outlined as part of this presentation as well as a small number of case studies to help illustrate each collecting management situation.

S5 - UTILIZING CT-SCAN TECHNOLOGY TO DISSECT RARE PALAEOZOIC SHARK TEETH

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Isolated shark teeth are found worldwide in both marine and continental deposits dating as far back as the lower Devonian. These fossils represent important palaeoenvironmental proxies, providing valuable biostratigraphic and stratigraphical correlation data. Most shark teeth are basically made up of enameloid and ortho- and/or osteodentine. The presence, structure and distribution of these tissues, together with the vascularization system are taxonomically relevant. Fossil teeth are often found isolated and are too rare to justify the use of destructive techniques leading to a potential conflict between collections management best practice and research need. In this study the dental morphology and internal structures were reconstructed and rendered in 3D using micro-computed tomography. Three Palaeozoic shark teeth were investigated: *Diplodoselache parvulus* (Traquair) (Carboniferous of Scotland); *Cladodus* sp. (Carboniferous of Russia) and an Euselachian tooth (late Permian of Brazil). The specimens have been prepared out of the rock matrix, except the *Diplodoselache parvulus*. It is partially embedded in the rock, but was virtually separated from matrix, in order to access the external morphology. The study of the complete teeth set shows that micro-CT is effective to distinguish the type (ortho/osteo) of the dentine tissue and to determine the distribution of the enameloid cover, representing a non-destructive alternative to serial histological studies. However, the resolution of this particular CT scanning system was low to determine the crystallite organization of the enameloid and the distribution of cells and processes in the dentine matrix.

S18 - TESTABLE PALEOPHYLOGEOGRAPHIC MODELS AND SPECIES' RESPONSE TO CLIMATE CHANGE

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The global climate is changing rapidly, arguably at a more rapid rate than has ever been experienced by evolving organisms. Understanding how species respond to rapidly changing global climate is crucial to inform conservation decisions, to predict changes in biodiversity in the near future, and to understand fundamental ecological and evolutionary processes. The history of species' distributions through geologically recent climate cycles, where the climate fluctuated drastically between glacial and interglacial periods, provides clues to what may happen in the near future. Here we show that the combination of paleoclimate models and ancestor niche reconstructions is particularly insightful to visualize and measure species' response to climate change. We generated a near-continuous prediction of how the geographic distributions of North American rattlesnakes (Genus *Crotalus*) changed through the last three glacial-interglacial cycles, taking into account both geographic tracking with the changing climate and the evolutionary specialization to new climates. The resulting paleophylogeographic models can be used to predict ancestral geographic distributions of species or where to find their fossils. In turn, geographic distributions of fossil taxa can provide an independent test of the fit and predictive power of our model. These results provide insight into how niche evolution and environment influence a species' geographic distribution and quantitatively illustrate the dramatic effects that climate change has on the geographic distribution of species over geological time.

S7 - OCCURRENCE OF THE ENIGMATIC BRACHIOPOD *PEREGRINELLA* FROM HYDROCARBON-SEEP SUSPECT SITES IN THE SINAIA FORMATION, LATEST HAUTERIVIAN, EASTERN CARPATHIAN MOUNTAINS, ROMANIA

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Peregrinella is the largest-sized Mesozoic rhynchonellid and has attracted much attention due to this fact and its typical occurrence *en masse* in "*Peregrinella*" beds. This fascination has appeared warranted as it is now considered an associate of chemosynthesis-based communities (e.g., Campbell & Bottjer 1995; Kiel & Peckmann, 2008). *Peregrinella* has been mentioned in the Romanian literature in over a dozen works, Herbich (1878) being the first. All of these refer to a total of four localities that have yielded *Peregrinella*. The material investigated here is a rediscovery of the outcrop mentioned by Bancila (1958). In addition we have investigated samples from neighbouring localities. *Peregrinella* occurs in turbidites of the Neocomian flysch deposits of the Sinaia Formation. These deposits belong to the sedimentary cover of the Baraolt and Ceahlau nappes of the External Dacides – Carpathian Orogen, corresponding to an external rift (extensional basin). The brachiopods occur at three levels, predominantly in a muddy facies. They represent biocoenoses developed during intervals of quiescence, subsequently transported downslope; they are suspected to be associated with hydrocarbon seeps. A benthonic foraminiferal assemblage similar to that recorded by Neagu (1972) has been recovered from the turbiditic sequence just below the *Peregrinella* levels and is therefore considered latest Hauterivian in age. This macrofaunal/microfaunal association is biostratigraphically significant. *Peregrinella* is restricted to the southern part of the Eastern Carpathians in Romania. This is significant as the first integrated study (macro- and micropalaeontology, taphonomy, microfacies and sedimentology) concerning *Peregrinella (P.) multicarinata* (Lamarck, 1819) from the Eastern Carpathians.

S1 - THE DEEP-SEA MICROFOSSIL RECORD: POTENTIAL AND CURRENT DATA QUALITY

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Ocean plankton (morpho)species are distributed among a small number of large biogeographic provinces, rapidly mixed by ocean currents, and complete recovery of diversity from a small number of sample locations is possible. Only a few groups of plankton fossilize; only a small fraction of shells are preserved in sediments; and differential preservation alters relative species abundance. Nonetheless, for planktonic Foraminifera and Polycystina (radiolaria) most known living species are preserved in sediments. Lesser fractions of phytoplankton species diversity (diatoms, coccolithophores and dinoflagellates) are preserved. Sedimentation is continuous on annual scales but bioturbation blurs resolution to ca 1 kyr. Erosion is vastly less common than in shallow water environments but reworking frequently displaces small numbers of shells into younger sediments. Most sediment is lost only by subduction, limiting the usable record to late Cretaceous and Cenozoic times. Our documentation of this generally excellent record of species-level evolution however is still very incomplete. Most occurrence data is only for biostratigraphic or palaeoceanographic subsets of species. For radiolarians, the majority of species recovered have not even been described. Although the potential accuracy and precision of deep-sea geochronology is superb, the majority of all recovered drilled sections have poor age models (errors often >>1 my). Taxonomic catalogues for coccolithophores and planktonic foraminifera currently offer the most accurate record of these two groups; no comprehensive catalogues exist yet for other groups. New, complete fauna/flora surveys and new age models of sections are needed to document this record for studies of evolution at the occurrence level.

S3 - CALCAREOUS NANNOPLANKTON DURING OCEANIC ANOXIC EVENT 2 (CENOMANIAN/ TURONIAN BOUNDARY) – EXCEPTIONALLY-PRESERVED RECORDS FROM THE TANZANIA DRILLING PROJECT

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Between 2007 and 2009, the Tanzania Drilling Project (TDP) recovered a total of five coreholes from the south-eastern coastal region, around the village of Lindi, that contain the isotope excursion (based on bulk $\delta^{13}C_{org}$) associated with Oceanic Anoxic Event 2 (OAE2) at the Cenomanian/Turonian boundary. These holes provide expanded successions of a shallowly-buried, predominantly claystone facies that have preserved the calcite component exceptionally well. Calcareous nannoplankton (primary-producers at the base of the oceanic food-chain) preservation in the TDP holes is exceptional, with continuous representation of small and delicate nannofossil taxa, thus affording us the opportunity to shed more light onto the evolutionary record and environmental conditions across this interval of carbon-cycle perturbation that included warming, sea-level rise and extinction. This borehole material allows us to overcome the difficulties faced by previous attempts to document changes in the nannofossil assemblages through OAE2 that were hindered by insufficient temporal resolution, and the poor preservation of fossils due to widespread occurrences of chalk and non-calcareous black shales. Here, we will present currently unpublished calcareous nannoplankton data from this material. Our data show overall species richnesses that approach global compilation values for this interval, and that are much higher than in any previously published section. We record extinctions leading up to the first isotope peak, but with new taxa appearing from the base of the peak. Additionally, there is a marked shift in assemblage composition and diversity accompanying the excursion peak. This suggests an onset/increase in oligotrophic marine conditions.

S19 - THE CAMBRIAN SUBSTRATE REVOLUTION AND ITS IMPACT ON THE DIVERSIFICATION OF ECHINODERMS

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The latest Precambrian – early Cambrian time interval corresponds to one of the most critical ecological transitions in the history of Life, with the progressive replacement of microbially bound, firm sea-floors, by highly bioturbated, soft substrates. This Cambrian Substrate Revolution had a profound effect on the morphologies and diversification of benthic organisms. In Early Cambrian times, echinoderms exhibit a wide range of morphologies, all of them being radially symmetrical, and adapted to life on matgrounds, with two main strategies: mat encrusters (e.g., *Stromatocystites*), and mat stickers (e.g., helicoplacoids). In Middle Cambrian times, the replacement of matgrounds by mixgrounds coincides with a dramatic turn-over in echinoderm communities, and the development of new strategies: hard-surface attachers (e.g., edrioasteroids), kite strategists (haplozoans are here reinterpreted as distal anchoring stem structures), and snowshoe strategists (e.g., 'carpoids'). As in modern flatfish, the asymmetrical, flattened morphologies of 'carpoids' are here interpreted as resulting from an adaptation for the life on soft substrates. This is supported by (1) the radial symmetry of all Early Cambrian taxa ; (2) the absence of 'carpoids' in Proterozoic-like sediments and strata older than Middle Cambrian; (3) their constant association with soft substrates; and (4) the observation that similar-looking flatfish morphologies appeared several times, independently in various echinoderm lineages in Palaeozoic times (e.g., pleurocystitids), and each time, as adaptations to a free-living, unattached mode of life on soft substrates. As in all other, younger flatfish echinoderms, the reduced number of ambulacra in carpoids is a consequence of their mode of life.

W1 - THE CAMBRO-ORDOVICIAN DIVERSIFICATION OF ECHINODERMS: A PERI-GONDWANAN PERSPECTIVE

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Historically, our knowledge of Cambro-Ordovician peri-Gondwanan echinoderm faunas appears as strongly biased towards assemblages from Western and Central Europe. However, recent discoveries of several new echinoderm Lagerstätten have yielded abundant new data on the Early Palaeozoic diversification of echinoderms in a larger array of peri-Gondwanan regions. Early Cambrian peri-Gondwanan echinoderm assemblages are apparently exclusively made of cosmopolitan eocrinoids (e.g., gogiids), and thus less diverse than coeval Laurentian faunas (comprising not only gogiids, but also camptostromatoids,

helicoplacoids, and lepidocystids). In contrast, Middle Cambrian peri-Gondwanan assemblages are more diverse, and dominated by soft-bottom communities. They comprise cosmopolitan elements (ctenocystoids, *Stromatocystites*), and share several taxa with Baltica (e.g., *Ceratocystis*, *Cigara*). Some other echinoderm groups have a more restricted distribution (e.g., cinctans, *Lichenoides*), with no counterpart in both Baltica and Laurentia. Conversely, some taxa known in Laurentia (e.g., light-framed cornutes, solutes) are absent in peri-Gondwanan regions. In the Late Cambrian-Early Ordovician time interval, peri-Gondwanan regions are characterised by the strong diversification of various groups (glyptocystitid rhombiferans, stylophorans, and then asterozoans) on soft substrates. Contrary to the situation in Laurentia, crinoids and edrioasteroids contribute little to the biodiversity. In the Middle Ordovician-early Katian time interval, peri-Gondwanan faunas are dominated by aristocystitid diploporans, associated either with caryocystitids, hemicosmitids, and sphaeronitids (intermediate latitudes), or with asterozoans and stylophorans (high latitudes). The situation is different in Laurentia, where diploporans are practically absent, and assemblages are dominated by crinoids, edrioasteroids, paracrinoids, and pleurocystitids. In late Katian times, 'temperate' peri-Gondwanan assemblages extend southwards to high latitudes (Boda event).

S15 - CLIMATE AND ENVIRONMENTAL CHANGES AT THE FRASNIAN-FAMENNIAN BOUNDARY: A GLOBAL CARBON CYCLE MODELLING APPROACH

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The Late Devonian is a period of significant climatic and environmental changes exemplified by a severe biotic crisis of marine and tropical faunas and by the onset of an episod of glaciation on Southern Gondwana at some time in the Famennian. This time is marked by two carbon-organic rich levels (the Kellwasser horizons) deposited under disoxic to anoxic conditions. These two levels have been recognized in many places around the Prototethysian realm and are characterized by a positive carbon isotopic shift from 2‰ to 3‰ reflecting a period of enhanced organic carbon burial. Our research group proposed these episodes to be linked to a large scale fertilization and stratification of sea waters (especially that from the Proto-tethysian realm) as the result of the incipient uplift of a large sub-equatorial mountain belt, i.e. Appalachian-Eo-variscan-Ouralian cordillera. The climatic impact of this Frasnian-Famennian carbon cycle perturbation might have led to a global cooling at the beginning of the Famennian as documented in the geological record by a significant sea-level drop and an associated hiatus expressed in numerous localities as well as $\delta^{18}O$ and palynological data. On the other hand, the large amount of organic carbon buried could have led to a rise in dioxygen concentration in the atmosphere. To test this interpretation, we have used a global carbon cycle numerical model coupled with an Energy Balanced Climate Model (EBM).

S9 - ECOLOGICAL AND BEHAVIOURAL CHANGES ASSOCIATED TO THE EVOLUTION OF TAGMOSIS IN SCUTELLUID TRILOBITES

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As a defence strategy, enrolment has likely played a major role in the evolutionary success of trilobites, but it has also strongly constrained the organization of their body. This latter has thus remained virtually unchanged during the 275 million years of trilobite history, except in few clades, such as scutelluids. In the latter, the pygidium was not simply a set of unarticulated trunk segments, but an extended structure with notable morphological particularities representing a distinct posterior tagma. Morpho-functional analyses reveal that this unique morphological evolution was accompanied by major ecological changes. Most scutelluids were likely epibenthic organisms benefiting from their flat body and extreme thoracic flexibility to hide in crevices or superficially burrowed depending on the substrate. Like most trilobites, they could crawl on the sea floor but in addition they were probably able to swim, their body turned upside-down. Microstructural studies of the hypostome suggest that many scutelluids were provided with rudimentary ventral eyes, the function of which was essential while swimming. Enrolment was rare and incomplete - it had probably been supplanted as the main defensive strategy by rapid escape involving the large paddle-like tail. Another ecological type within scutelluids is exemplified by the Paralejurinae. These latter have apparently developed, though secondarily, a strongly vaulted body recalling scutelluid ancestral morphology. This and other morphological traits point towards a largely endobenthic life style. It can also be demonstrated that, unlike typical scutelluids, paralejurines were able of complete enrolment, the efficiency of which was sometimes improved by coaptative devices.

S27D - THE CEPHALIC MEDIAN ORGAN OF TRILOBITES: A SINGLE THROW OR MULTIPLE THROWS OF THE EVOLUTIONARY DICE

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Trilobites possess numerous cuticular structures, the functions of which remain almost completely unknown. This is particularly true for the cephalic median organ (CMO), a small complex of structures present on the cephalon of some trilobites, usually on their occipital ring. Typically composed of four pits arranged like the corners of a square, it is common in odontopleurids and corynexochids. Our investigations on the CMO reveal that in fact it occurs in all but one order of trilobites. The earliest record is in the Middle Cambrian, where it is found in three orders. Its existence can be documented until the Late Carboniferous. The CMO appears extremely conservative in terms of organization, morphology, and position despite a great variability of CMO-bearing trilobites. This suggests a particularly early origin for this organ and that it was an essential structure in trilobites. The CMO strikingly resembles a group of crustacean sensory organs, especially the Sensory Dorsal Organ (SDO) of malacostracans. This raises the question of the kind of relationship (analogy/homology?) existing between them. The SDO is known to be widely distributed within the Malacostraca but its function is still debated, which makes it difficult to ascertain whether the CMO functioned in a similar way. However, the variability and distribution of these two organs already provide critical evidence for arguments concerning their possible function(s) and relationships. These suggest that a unique origin of these two organs is credible, with profound effects on reconstructions of the phylogenetic relationships between major arthropod clades.

S14 - CONTINENTAL ASIA OR MALESIAN ARCHIPELAGO: MOLECULAR DATES TO TRACE THE ORIGIN OF FERN PHYMATOPTERIS (POLYPODIACEAE)

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Phymatopteris, a derived Polypodiaceae fern, is one of the few fern genera which still suffers from nomenclatural confusion; both its generic description and classification together with its phylogenetic relationships to other selligueoid ferns have been controversial. Ching (1964; 1979) considered that the selligueoid ferns originated in the Himalayan region of continental Asia while Malesian and Polynesian species in this group were the result of later migrations and speciation events, which contrasts with the opinion that SE Asia is the putative ancestral area for all selligueoid fens (Schneider et al., 2008). The current study traces the origin of modern fern *Phymatopteris* based on its phytogeographic patterns and molecular time estimates for its divergence. The phylogeny of all selligueoid ferns based on four cpDNA regions indicates that all basal species with simple blades are from the tropical Malesian archipelago, while the remaining Continental Asian species form a recent group, which is largely unresolved as a polytomy, most likely the results of an explosive radiation. Our divergence time estimation shows that the first diversification of selligueoid ferns might have occurred at about 26.75 Ma in the Malesian archipelago, and they migrated into the Himalayan region around 20 Ma, followed by a relatively recent and extensive *in situ* radiation. The explosive radiation of the Continental Asian species occurred mostly within the last 20 million years, which falls well within the interval of recent major uplift of the Qinghai-Tibetan Plateau between the early Miocene to the Pleistocene associated with late Cenozoic global cooling.

S23 - CAMBRIAN *MONGOLITUBULUS*-LIKE SCLERITES: SPINES OF DIFFERENT ARTHROPOD FOSSILS

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The apparent abundance of sclerite-bearing metazoans is a conspicuous aspect of the early Cambrian small shelly fossil faunas, and many SSFs represent only disarticulated sclerites. The difficulties in studying isolated sclerite fossils are exemplified by the *Mongolitubulus*-like sclerites. The genus *Mongolitubulus* Missarzhevsky, 1977 was originally established on the basis of isolated tube-like sclerites with prominent scale-like external ornamentation, and was described as a protoconodont. Until now *Mongolitubulus* has been known mainly from isolated sclerites, hence its scleritome and affinities remain unresolved; it has been assigned to protoconodonts, interpreted as carapace spines of bivalved arthropods or suggested to be lobopodian spines. Here we report the delicately phosphatized eodiscoid *Hupeidiscus orientalis* from South China. Of particular importance are its spines ornamented with distinctive scaly sculpture, which resembles that of the enigmatic sclerite taxon *Mongolitubulus*. The genal and axial (including occipital) spines of the eodiscoids may correspond to two kinds of *Mongolitubulus* spines examined from the Lower Cambrian of Kazakhstan. Like trilobite spines, the *Mongolitubulus* sclerites show no evidence of incremental growth but exhibit exuviating growth. This discovery shows that some *Mongolitubulus*-like sclerites can be matched with the eodiscoid spines, though these sclerites may be of multiple panarthropod origins (bradoriids, eodiscoids, lobopodians or even other trilobites).

S10 - PYRITE FRAMBOIDS IN MICROBIALITES ACROSS THE PERMO-TRIASSIC BOUNDARY: EVIDENCE FOR THE PRESENCE OF ABUNDANT SULFATE REDUCING BACTERIA

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Microbialites formed immediately above the end-Permian mass extinction boundary are found to occur widely on the shallow carbonate platform in South China. These special carbonate rocks are known as microbialites because, excepting the presence of quite monotonous ostracods, microgastropods and foraminiferans (*Earlandia* sp. and *Rectocornuspira* sp.), abundant fossil cyanobacteria are preserved in these rocks. As the primary producer, cyanobacteria played an important role in the formation of microbialites. However, they were not the only microbial population. Excepting the cyanobacteria, large quantities of sulfate reducing bacteria and other bacteria have been reported in modern microbialites (Baumgartner et al., 2006; Bosak et al., 2007; Franks and Stolz, 2009; Martínez-Alonso et al., 2006; Minz et al., 1999). Therefore, microbialites could be the products of both the primary producer (i.e., cyanobacteria) and the decomposer (i.e., anaerobic bacteria). Cyanobacteria are the only known calcified bacteria, while other bacteria are not fossilized. Significantly, along with calcite and dolomite are the numerous pyrite particles in the microbialites. Many pyrites, ranging from 2mm to 8mm in diameter, can easily be seen in outcrop, while the smaller ones <1mm can only be found under the microscope and scanning electron microscope. These pyrites provide the records of heterotrophic bacteria. Many previous studies suggested that the formation of early diagenetic pyrites including pyrite framboids could be related to the activity of sulfate reducing bacteria (Berner,1985; Raiswell and Berner, 1985). Large quantities of pyrite framboids and other types of pyrites in the microbialites formed after the end-Permian mass extinction in South China may offer evidence of the activities of sulfate reducing bacteria. Abundant pyrite framboids found in the microbialites of Guangxi, Guizhou and Chongqing in South China indicate that, not only sulfate reducing bacteria widely existed during the formation of microbialites, but also anoxic conditions expanded to shallow marine environments during the Permian-Triassic transition interval.

S2 - MACROEVOLUTION: ON THE BIRTH, DEATH, AND PERSISTENCE OF SPECIES

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One of the grand challenges of macroevolutionary theory is to successfully integrate the hierarchical view of nature with the Neo-Darwinian synthesis and consider the resultant expansion in evolutionary biology this entails. Another crucial challenge is to identify mechanisms that influence the birth, death, and persistence of species. Here, the focus is on considering case studies from the fossil record spanning the Palaeozoic to the Pleistocene and at both the species and clade levels that document how geography provides a common mechanistic thread to macroevolution – the birth, death, and persistence of species. This is especially viewed through the context of how species and population geography is modified through the overarching influences of environmental and geological change. Such environmental and geological changes are cyclical, broadly construed, and hierarchically arrayed in terms of their magnitude and scope. Biological entities are buffeted by such changes, yet they only show an evolutionary response when a critical threshold is reached. Quantifying what these thresholds are, how they vary among the different hierarchical entities (populations, species, and possibly clades), and across different taxa/time periods will be challenging but extremely beneficial.

S23 - BIOTURBATION AND BURGESS SHALE-TYPE PRESERVATION: CASE STUDY OF TRACE FOSSIL-BODY FOSSIL ASSOCIATION FROM THE KAILI BIOTA (CAMBRIAN SERIES 3), GUIZHOU, CHINA

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Bioturbation-induced effects on soft-part preservation include: 1) consumption of nutrient-rich carcasses by scavengers and/or deposit feeders and 2) introduction of oxygen in deeper sediment allowing a more expansive period of decomposition. However, there is growing evidence indicating the presence of trace fossils in Burgess Shale-type (BST) deposits worldwide. New discoveries based on the examination of 323 specimens from the Kaili Biota include eldoniids, echinoderms, trilobites, monoplacophorans, and non-biomineralizing arthropods that are associated with trace fossils. Based on the observed effects of bioturbation on the preservation of five different animal groups, it is clear that infaunal scavengers/deposit feeders were periodically active on the Kaili sea floor and were able to reach historic layers yielding exceptionally preserved fossils. Some Kaili infaunal animals could bore through the biomineralized echinoderms, but they did not appear to have scavenged upon these echinoderms. Therefore, bioturbation-induced oxygenation in deeper sediment was a more important limiting factor than scavenging for BST preservation. The relative scarcity of soft part preservation in the Kaili Biota compared to the older Chengjiang Biota and the younger Burgess Shale Biota may be the result of post-burial bio-disturbance due to the relatively high intensity of local bioturbation.

W4 - PALEOPARKS: THE PROTECTION AND CONSERVATION OF PALEONTOLOGIC FIELD SITES WORLDWIDE

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Development, construction, collecting, and vandalism endanger paleontological field sites across the world. Field data, among the most important to science, should be preserved as new techniques, discoveries and interpretation commonly require more field information. Many outstanding field sites have been protected in World Heritage Sites, national parks, reserves, and state, provincial and local parks, and by private individuals and non-profit organizations. The International Palaeontological Association (IPA), recognizing the scientific, educational and recreational values of fossil field sites, established a PaleoParks Initiative to protect endangered sites and to catalog and make public information about established parks of any nature that protect fossils in the ground, as well as key places protecting “living fossils”. At this workshop, fifteen aims and goals and a web site for documenting both established and proposed sites will be considered at this workshop. Examples of successful PaleoParks are Peking Man (China), Whale Valley (Egypt) and Miguasha (Canada) World Heritage Sites, Le Géopark de Haute-Provence (France), Death Valley and John Day National Parks (USA), Guanling Fossil Group Park (China) and other sites and field museums in New Zealand and Thailand; these are documented along with endangered sites in Lipps, Jere H., and Granier, Bruno (eds.). 2009. *PaleoParks—the Preservation and Conservation of Fossil Sites Worldwide.* Carnets du Geologie E-book *http://paleopolis.rediris.es/cg/CG2009 BOOK 03/*. These examples show how fossil sites aid science, education and recreation through their value to the public and vested interests. Promotion and protection of sites and their values should be an on-going activity in every country.

S18 - MAMMALIAN RESPONSES TO ENVIRONMENTAL CHANGE: THE QUATERNARY LINK BETWEEN ANCIENT AND MODERN

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The principal categories of mammalian response to environmental change are distributional and evolutionary – with additional, under-explored roles for behavioural and phenotypic accommodation. Major changes in the adaptive profile of land-mammal faunas on timescales of 10^6-10^7 yr have provided persuasive proxies for palaeoenvironmental shifts in the Tertiary. At the other end of the scale, there is concern for the fate of mammals in the face of ongoing, anthropogenic environmental change in the interval 10^1-10^3 yr. Quaternary mammals form a bridge between the two, with detailed palaeoenvironmental backdrop and high stratigraphic resolution on timescales of 10^2-10^6 yr. This provides particular opportunities to examine response to environmental change, which can then inform both the use of mammals as proxies in deeper time, and the likely fate of species in the future. Studies based on radiocarbon dating show that distributional response can be extremely rapid, of the order of 10^1-10^3 years, but may lag behind one environmental factor (e.g. temperature) because the mammals are dependent on another (e.g. vegetation) that responds more slowly. Quaternary mammals also illustrate the importance of refugia, and the tendency for shifting assemblage composition, when faunas re-form after environmental change. Adaptive evolutionary responses can occur on many timescales, but are likely to be synergistic with, rather than obviated by, distributional change. Circularity in the use of fossil mammals as both predictor and response variable in relation to environmental change is a hazard to be avoided.

S19 - FILAMENTOUS MICROFOSSILS IN 1.74 GA JASPERS FROM ARIZONA: IMPLICATIONS FOR PROTEROZOIC OCEAN OXYGENATION

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One of the fundamental events in Earth history was the Great Oxidation Event in the Palaeoproterozoic Era, between 2.47 and 2.32 Ga, during which atmospheric oxygen concentrations rose above 10^{-5} times the present atmospheric level, crossing the threshold from a reducing to an oxidizing redox state. Despite widespread acceptance of the GOE, there is continuing debate as to when this atmospheric oxygen increase was translated into the contemporary deep ocean. The 'Canfield Ocean' model has it that from ca. 1.8 Ga until the start of the Neoproterozoic (1.0 Ga), deep seawater was sulphidic and had high H_2S contents, which resulted in the removal of dissolved iron in precipitated iron sulphide minerals, thus also explaining the end of BIF deposition ca. 1.8 Ga. This model has received support from S and Mo isotope and biomarker analyses of contemporary sedimentary rocks. However, recent study of 1.74-1.71 Ga seafloor-hydrothermal Fe-oxide deposits in Arizona in contrast suggests that late Palaeoproterozoic deep seawater was not sulphidic and lacked abundant H_2S, and was at a transitional, suboxic state. Here we provide additional data from these Arizona hydrothermal deposits, focusing on small iron oxide filaments that are interpreted as fossil remains of microaerobic Fe-oxidizing bacteria (FeOB). These filaments represent the oldest known evidence for this biogeochemical process, and support the idea that at least some ocean basins in the late Palaeoproterozoic contained mildly oxygenated, suboxic deep waters.

S20 - RAPID FOSSILIZATION PROCESSES AT HYDROTHERMAL VENTS

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Apart from a few well-known, special occurrences (e.g. Burgess Shale) fossilization is generally thought to be a slow process that leads to the preservation of hard parts only. An exception to this is at deep-sea hydrothermal vent sites where, because of rapid mineralization, fossilization can be very rapid and traces of organic structures, such as worm tubes and bivalve periostracum, are often preserved in silica and/or sulphides (particularly pyrite). Here I show data from fossilization experiments at hydrothermal vent sites on the East Pacific Rise conducted from 2005 to 2008. The fossilization experimental devices consisted of titanium mesh cages into which were wired vestimentiferan tubes, various mollusc shells and prawn carapaces. Two sets of cages were deployed at two vent sites for 373 days and 319 days in three micro-environments: high temperature (~370 °C) black smoker fluid, diffuse flow and a control away from active venting. Preliminary results show 1) shrimp carapaces do not last a year in the vent environment, 2) vestimentiferan tubes are extremely robust, 3) molluscan periostracum protects against shell dissolution to some extent, 4) rapid mineralization leads to the preservation of a range of mollusc groups, although only as sulphide replacements, and 5) *Alvinella* tubes growing on the cages are rapidly replaced by silica and/or sulphides at a microstructural level of detail. These results are entirely consistent with the fossil record of vent organisms and shed new light on how and why animals get mineralized at vents and then potentially get preserved into the geological record.

S20 - DECAY ON THE EDIACARAN SEAFLOOR; EXPERIMENTAL TESTING OF THE EFFACED PRESERVATION TAPHONOMIC MODEL

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The Ediacara biota of the Avalon region includes a group of irregular, high-relief, asymmetrical and rounded impressions known as ivesheadiomorphs. We propose that some forms, previously considered as Ediacaran body fossils, may be the products of microbial decay on the seafloor prior to burial by the casting medium. The ivesheadiomorphs themselves are thus considered to be low fidelity (decayed) forms of other Ediacaran organisms. To determine whether microbial decay of organic tissue is a feasible explanation for the formation of ivesheadiomorphs, laboratory experiments designed to replicate conditions on the Ediacaran seafloor have been constructed. CT scanning of these experimental microcosms reveals that the actions of autolysis and microbial decay can effectively remove surface detail of an organism, over timescales of weeks to months. Importantly, this altered morphology is capable of being preserved in the rock record. Variation in the timing of burial of organic material (i.e. the temporal extent of microbial activity upon a deceased organism) is found to affect sediment properties immediately surrounding the decomposed soft tissues that may have some role in preservation, comparable to processes that may have affected Ediacaran bedding planes in Avalonia.

S23 - LATE CARBONIFEROUS–PERMIAN PALYNOLOGY AND BIOSTRATIGRAPHY OF BAODE IN SHANXI PROVINCE, NORTH CHINA

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The Late Carboniferous to Late Permian (Moscovian to Wuchiapingian) dispersed miospores are described from Baode, NW Shanxi, North China (the Cathaysian Palaeofloristic Province) including miospores of 167 species belonging to 67 genera. Using the first appearances of selected species and the changes in palynological abundance within the succession, eight miospore assemblage zones are recognized, which are, in ascending order, the *Torispora securis-Torispora laevigata* (SL) Assemblage Zone (Moscovian), the *Reticulatisporites polygonalis-Endosporites globiformis* (PG) Assemblage Zone (Kasimovian), the *Torispora verrucosa-Pachetisporites kaipingensis* (VK) Assemblage Zone (Gzhelian), the *Thymospora thiessenii-Striatosporites heyleri* (TH) Assemblage Zone (Asselian-Sakmarian), the *Radiizonates solaris-Platysaccus minus* (SM) Assemblage Zone (Artinskian), the *Indospora cingulata-Sinulatisporites shansiensis* (CS) Assemblage Zone (Kungurian-Roadian), the *Playfordiaspora crenulata-Schopfites convolutus* (CC) Assemblage Zone (Wordian), and the *Patellisporites meishanensis-Brialatisporites iucundus* (MI) Assemblage Zone (Capitanian-Wuchiapingian). The quantitative data of spore and pollen from the Late Carboniferous to Late Permian indicate that arid climates appeared at the basal boundary of CC Zone. The high proportion of monosaccate pollen (mainly *Florinites*) in the Penchi and Taiyuan formations most likely contributed to the Neves effect which was caused by marine transgression and regression.

S23 - SPATIAL AND TEMPORAL DISTRIBUTIONS OF THE EARLY ORDOVICIAN REEF SYSTEMS IN SOUTH CHINA: GEOBIOLOGICAL PROCESS DURING THE EARLY STAGE OF THE GREAT ORDOVICIAN BIODIVERSIFICATION EVENT

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The Great Ordovician Biodiversification Event (GOBE) resulted in dramatic increases in both taxonomic diversity and complexity of community structures in the marine ecological system. Detailed investigations have clarified the distinct spatial and temporal distributions of the Early Ordovician reefs of South China. The reef construction dramatically changed from microbe- to metazoan-dominated in early Ordovician of South China, which was much earlier than that of Laurentia and western Argentinian terranes. The metazoan-dominated reefs were incipiently developed and well diversified in mid-shelf areas, and then expanded to both near shore and offshore areas. The reefs in near-shore area during the late Tremadocian and earliest Floian are rare and small in scale; whereas in offshore area the microbe-dominated reefs flourished with subordinate microbe-Calathium-sponge reefs. Thus, microbial components in reefs of South China declined temporally during the ongoing GOBE, but continued to bloom in offshore areas before the first taxonomic acme of the GOBE. The temporal decline of microbial sediments in the early Ordovician reef systems of South China was possibly related to the onset of the GOBE, as suggested by roughly concomitant changes in the sedimentary systems and replacement of the Cambrian-type shell beds by the Palaeozoic-type. The continued construction of microbe-dominated reefs up until the earliest Floian in shelf-marginal areas benefited from both a delayed offshore expansion of marine benthic fauna and enhanced nutrient-rich water flux derived by upwelling. This suggests that the interplay of biological and geological factors may have controlled the tempo-spatial changes in the Early Ordovician reef systems of South China.

S23 - NEW INSIGHTS INTO THE LOBOPODS FROM THE CAMBRIAN CHENGJIANG LAGERSTÄTTE

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The Lower Cambrian Chengjiang Lagerstätte is famous for the remarkably preserved soft-parts of animals. Lobopods, with a worm-like body design and lobe-like limbs, are one of the soft-part preserved groups which diversified and flourished in the Cambrian seas, indicating that not only their extant relatives, the onychophorans and tardigrades, but euarthropods (Chelicerata, Myriapoda, Crustacea, and Hexapoda) may have been deeply rooted in the stem-group lobopods. Based on data from a new genus, together with Miraluolishania (a rare lobopod with well-preserved paired eyes and paired antennae) and Jianshanopodia (a large lobopod bearing distinct complex appendages with tree-like or lamellate branches), we suggest that the Cambrian lobopods are already well on the way to primary arthropodation and arthropodization.

S23 - PALAEOZOIC NON-LITHISTID SPONGES FROM CHINA: REVIEW AND RECENT PROGRESS

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Well-preserved non-lithistid Cambrian sponges have been widely documented in South China, including those from the early Cambrian Niutitang fauna from Guizhou Province, the Hetang Formation sponge fauna from Anhui Province, the Chengjiang Fauna from Yunnan Province, and the Middle Cambrian Kaili Biota from Guizhou Province. Except for the sponge assemblage from Hetang Formation, the faunas are dominated by demosponges and a few hexactinellids.Our recent field excavations have led to a series of significant new discoveries of Palaeozoic sponges. Particularly, several genera of demosponges have been found in the early Cambrian Guanshan Fauna in Yunnan. In North China, some well preserved *Protospongia* have been recognized in the Zhangxia Formation of Shandong Province. Well-preserved non-Cambrian sponges were recovered for the first time from the lowermost Longmaxi Formation of central Hubei, consisting of mainly hexactiellids (such as *Protospongia* and *Ratcliffespongia*). Those sponge faunas show an extraordinary diversity of the deep sea environment during late Ordovician and early Silurian. Similar sponge faunas have also been reported from North American. In addition, we also found some well-preserved non-lithistid hexactiellid sponges from the Early Devonian in Guangxi, South China, and a few deep sea hexactiellid sponge asemblages from the Permian Longtanshan Formation in Hubei and Zhejiang. The new discoveries extend the geographical and stratigraphical distribution of non-lithistid sponges in China, providing new information on the biodiversity and evolution of Palaeozoic sponges.

S23 - THE PERMO-TRIASSIC BOUNDARY AND MICROBIALITE IN THE NORTH-EAST OF SICHUAN PROVINCE

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The Hongyudongbei, Longhudong and Yudongzi sections (northeast Sichuan Province), within the upper Yangzi Region have been studied, with strictly screened samples from measured sections analyzed for carbon and oxygen isotopes. Carbon isotopic excursions in the sections show typical excursions correlated with other widely reported Permo-Triassic boundary sections, displaying a dramatic negative shift at the boundary, from typical positive values in the Upper Permian Changxing Formation to negative values in the Lower Triassic Feixianguan Formation. As the dramatic excursion around Permo-Triassic boundary is sudden and unique, the Permo-Triassic boundary in the study area is considered to be located at the lithologic boundary between the Changxing and Feixianguan formations. The base of the microbialite unit in the lowermost part of the Feixianguan Formation, directly overlying the Changxing Limestone, is also regarded as the base of Lower Triassic. The microbialite samples were treated with HCl, HAc, EDTA and NaOH of different concentrations for surface examination. Special biological structures were discovered, such as micrometer-scale strawberry pyrite, suggesting reducing environments after extinction.

S23 - NEW MATERIAL OF *CHALICOTHERIUM BREVIROSTRIS* (PERISSODACTYLA, CHALICOTHERIIDAE) FROM THE TUNGGUR FORMATION, INNER MONGOLIA

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Chalicotherium brevirostris was named by Colbert based on a skull from the upper Middle Miocene Tunggur Formation, Tunggur, Inner Mongolia, China, without mandibles. Here we describe new mandibular material collected from the area. The new material is different from *C. cf. brevirostris* from Cixian County, Hebei Province, and more likely to be the same species as C. brevirostris from Tunggur. Morphologic characters based on the new material and the old collection show sexual dimorphism and intraspecific variation. This species differs from *C. goldfussi* in having the angulus mandibulae ventrally expanded, short diastema, the mental foramen located at the front or the middle part of diastema, the metastylid on lower molars weak and just recognizable, a lingual cingulum at the opening of talonid. To date, five genera are assigned to Chalicotheriinae, e.g. Anisodon, Chalicotherium, Butleria, Kalimantsia, and Hesperotherium. The diagnosis of Chalicotherium is also revised herein. The characters of Chalicotherium and Anisodon are very close, possibly belonging to a sister group or to a single genus, which requires more new material and further study.

S1 - COMPARING ROCK AND FOSSIL RECORDS IN THE DEEP SEA

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The fossil record provides the only empirical evidence of the diversification of life, but analyses of the land-based record indicate a worrying correlation between sampled fossil diversity and the rock record. To discover whether the same applies in the deep sea we have applied similar tests to a novel database of fossil calcareous nannoplankton (coccolithophores). Currently the database contains some 50,000 species-level occurrences from both ODP/DSDP site records (from the North Atlantic, Caribbean and Mediterranean) as well as land-based localities (from Western Europe and North America) placed in c. 3 m.y. time bins. As a measure of the quality of the deep-sea rock record we have counted the number of ODP/DSDP sites sampling fossiliferous sediments. Although this curve follows a more exponential trajectory correlations between this and the species-level curve are both significant and strong (Spearman rho > 0.9). Furthermore, modelling shows that the rock record is a good predictor of sampled species-level diversity. Sampled-in-bin diversity curves derived from land and deep-sea based records contrast markedly, with deep-sea species diversity following a near linear rise over time compared to the bell-shaped diversity curve derived from land-based records and from a expert's synoptic summary. Because the effects of rock record biasing are pervasive in both environments, the true diversity curve for coccolithophorids is difficult decipher.

S7 - A DIAGNOSTIC KEY TO THE RECENT BRACHIOPODS

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The Natural History Museum, Department of Palaeontology houses a collection of approximately 4600 Recent brachiopods comprising both dry and preserved specimens. Estimates for the extant Brachiopoda indicate there are 370 species, in 116 genera representing 26 families. The collection has representative material from all the families and 83 genera. Collected as products of expeditions, including the Challenger and Discovery Expeditions, a high proportion of specimens are rich in point data, including dates, precise locations and depths of collection. Moreover, the collection includes voucher specimens contributed to GenBank. We have initiated a project to digitize the collection with the objective of capturing and making accessible the associated data, including digital images. The data document their biogeography, with disjunct distributions and links to sea mounts. Other data could have high value for conservation, research, historic studies and analogue data. As data become available it will be accessible via the collections area of the museum website. Ultimately we intend to produce an on-line key to living brachiopods. This resource will be based, but not exclusively on hard part morphology. In the first instance the key will be for genera, subsequently species. However, to achieve the wider ambition of making all living taxa available via the web we are looking to establish links with other institutions which hold collections and will be willing to partner us; we invite approaches from potential collaborators to this project.

S14 - INSIGHTS ON THE SENSORY CAPABILITIES OF EXTINCT LINEAGES IN A NODE-DATED FRAMEWORK

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The rich record contains valuable clues about how ancient extinct taxa interacted with each other and their environment. Sensory systems of living animals, show tremendous diversity, especially in arthropods, with innovative adaptation for both vision and odorant reception. This innovation is both at the phenotypic level and the underlying molecular basis. Genetic adaptation in sensory systems typically arises from gene-duplication, modification of gene-products, and altered signal transmission. Inferences from extant taxa on a robust phylogeny can be used to make predictions about ancestral states and capabilities of extinct lineages. Here, I discuss the molecular evolution of the animal visual system in a temporal (node-dated) framework, to infer the ancestral visual capabilities of extinct stem-lineages. Such insights allow us to generate hypotheses of their abilities to exploit to ancient environments, and even how extinct taxa could have interacted and competed in their struggle for life.

W8 - MOLECULAR PERSPECTIVE ON EXTANT CHELICERATES, INFERENCES FROM RIBOSOMAL RNA, PHYLOGENOMICS, MITOGENOMICS AND MIRNAS

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The phylogeny of extant Chelicerata and their sister-group has proved difficult to resolve in modern molecular analyses. Until recently, only rRNA sequences and a select few mitochondrial genes were used for molecular insights. Now, recent advances in laboratory methods and sequencing technology make it possible to gather huge datasets for massive-scale analyses, such as combined nuclear genes (shallow genomics or phylogenomics), complete mitochondrial genomes (mitogenomics), and regulatory RNA elements (miRNAs). Here, we combine insights from these cutting-edge data sources to provide an overview of the current molecular perspective on Chelicerata (inc. pycnogonids) and their closest allies. Recent molecular analyses generally favor a sister-relationship of Chelicerata to mandibulate arthropods rather than myriapods alone, a hypothesis consistent with both morphology and fossils. The placement of Pycnogonida is less clear from molecular data, but plausibly the closest allies of Euchelicerata. Yet, molecular data remains ambiguous on about how and when terrestrial arachnids separated from marine ancestors, and the inter-relationships of the traditional arachnid orders. In particular the monophyly of the ‘Acari’ remains doubtful, and the scorpions remain difficult to place. Regardless of questions, we suggest that only a synthesis of new molecular conclusions with inferences from morphologists and paleontologists will lead to robust resolution of the outstanding problems surrounding chelicerate phylogeny.

S6 - QUANTITATIVE APPROACHES IN PALAEOSYNECOLOGY: CORRELATING COMMUNITY STRUCTURE WITH HABITATS

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Understanding the structure of fossil communities (palaeosynecology) requires the use of multivariate methods. These are essential for predicting habitats and other environmental variables of past ecosystems on the basis of community structure. Such predictions often require determining which elements of modern faunal communities characterise particular habitat types, such that, if these elements are present as fossils, then palaeohabitats can be inferred. In order to facilitate comparisons between modern and extinct environments, taxonomical or ecological variables can be quantified from the fossil record. Several types of multivariate analyses are currently used to explore faunal community structure, including principal components analysis and principal coordinates analysis. Habitat types can be calculated on the basis of faunal community variables through discriminant function analysis. However this produces only qualitative predictions (e.g., 'closed forest', 'grassland'). On the other hand, habitats can be described in more detail by looking at quantifiable environmental (biotic and/or abiotic) variables. If this is done, a number of additional multivariate analyses can be applied to examine the datasets, including redundancy analysis and canonical correlation analysis. The use of these methods allows direct comparisons between faunal communities and environmental variables, facilitating more quantitative, and arguably more precise, palaeoenvironmental reconstructions. We present an example of this approach using a large-bodied mammal community to examine vegetation heterogeneity of Bed I, Olduvai Gorge (ca. 1.9 Ma).

S17 - THE ROLE OF FRACTURE MECHANICS FOR ANALYSING DENTAL FUNCTION AND ADAPTATION

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Many mechanical analyses of vertebrate fossil skulls wish to establish the magnitude and direction of forces that they endured. However, an approach using jaw mechanics is limiting in that the number of relatively complete crania is small. Our approach concentrates solely on the dentition, the contact organ in a bite, to show how forces during use can be estimated from design, dimensions and damage. To this end, fracture mechanics experiments have been conducted on fresh teeth of two living mammalian species - humans and sea otters – using relatively simple loading regimes in a universal testing machine while monitoring closely the development of fracture within tissues. These experiments indicate that the structure, properties and thickness of dental enamel, and also tooth size, are very important in gauging bite force resistance. Simple formulae have been devised to relate bite forces to these variables, which allow the relationships to be applied broadly. In addition, antemortem macro-damage, such as chipping and spalling, can provide an estimate of whether such forces were actually used during the animal's lifetime.

S20 - TAPHONOMY OF A LATE DEVONIAN VERTEBRATE ASSEMBLAGE FROM IZHMA RIVER SITE, SOSNOGORSK FORMATION, SOUTH TIMAN, RUSSIA

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The taphonomy of Palaeozoic vertebrate assemblages is not well studied but is important for understanding the ecological preferences of early tetrapods. Here we present a taphonomic analysis of a fish and tetrapod assemblage from the Izhma River locality, early Famennian Sosnogorsk Formation, South Timan, Russia. The assemblage is restricted to a relatively thin horizon of limestone yielding algal remains and a vertebrate fauna including *Bothriolepis*, *Holoptychius*, lungfishes, a new porolepiform and an undescribed tetrapod. Marine invertebrates are absent. The placoderm *Bothriolepis jeremejevi* dominates the assemblage, forming more than 90% of all macroremains. *Bothriolepis* is represented principally by disarticulated skeletal elements, but some articulated head shields, ventral walls of the trunk armour and complete armours of the pectoral fin have been found; the fragmentation index is 36.7% and the disarticulation index 4.6%. Two almost complete skeletons of *Holoptychius* have been unearthed along with disarticulated scales and skull bones. Disarticulated heads of at least two individuals represent an undescribed tetrapod. The low disarticulation index, moderately high fragmentation index, reorientation, and sorting, and almost complete absence of corrosion and abrasion, all suggest the taphocoenosis formed under conditions of moderate turbulence, rather high or periodically high rates of carbonate sedimentation, and an dysoxic environment. Sedimentary structures and textures indicate a rather high rate of sedimentation of algal remains within the wave-dominated environment and dysoxic conditions characteristic for lagoons or large lakes in humid climate conditions. The vertebrates thus most probably inhabited a lagoon subject to dysoxia associated with algal blooms.

S27B - LOWER AND MIDDLE TRIASSIC FORAMINIFERA FROM ZUNYI GUIZHOU PROVINCE, CHINA

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Ten genera and 26 species of foraminifera from the Lower and Middle Triassic section at Xiangkou, Zunyi, Guizhou, China have been identified. They include *Ammodiscus multivolutus, Ammodiscus parapriscus, Ammodiscus planus, Ammodiscus* sp., *Arenovidalina amylovoluta, Arenovidalina chialingchiangensis, Aulotortus* sp., *Dentalina* sp., *Glomospira articulosa, Glomospira regularis, Glomospira simplex, Glomospira sinensis, Glomospira* sp., *Glomospirella densa, Glomospirella elbursorum, Glomospirella irregulariformis, Glomospirella shengi, Glomospirella* sp., *Glomospirella spirillinoides, Glomospirella vulgaris, Krikoumbilica* sp., *Meandrospira cheni, Meandrospira immature, Meandrospira pusilla, Turritellella mesotriasica,* and *Valvulina* sp. Four foraminiferal zones can be recognized in ascending order: 1) *Ammodiscus parapriscus* Zone: dominated by *Ammodiscus parapriscus* and *Ammodiscus* sp.; found in the lower Lower Triassic Yelang Formation; 2) *Glomospirella spirillinoides* Zone: characterized by the first appearance of *Meandrospira cheni* with abundant *Glomospirella spirillinoides*, *Glomospira regularis* and *Ammodiscus multivolutus*, as well as some *Glomospirella irregulariformis*, *Glomospira articulosa* and *Glomospira sinensis*; found in the upper Lower Triassic Maocaopu Formation; 3) *Glomospira sinensis* Zone**:** characterized by the first appearance of *Arenovidalina chialingchiangensis*, with abundant *Glomospira sinensis*, *Arenovidalina amylovoluta* and a few *Meandrospira pusilla*, *Ammodiscus multivolutus*. This zone lies at the top of the Maocaopu Formation to the lower part of the Middle Triassic Songzikan Formation; 4) *Glomospira densa* Zone: characterized by the first appearance of *Glomospira densa*, a typical Anisian element, with some *Glomospira sinensis*, *Glomospira simplex, Krikoumbilica* sp., *Turritellella mesotriasica* and *Aulotortus* sp. This zone lies in the lower and middle part of the Shizishan Formation. These foraminiferal zones correlate well with those found in Sichuan, China, South-Eastern Asia and Europe.

S10 - CHANGE IN MICROBIAL ECOSYSTEMS AFTER THE END-PERMIAN MASS EXTINCTION: EVIDENCE FROM BIOMARKERS OF MICROBIALITE IN SOUTH CHINA

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The most severe mass extinction since the appearance of animal life on Earth occurred at the end Permian, about 252 Ma, was directly followed by the wide distribution of microbialite in shallow marine environments. The microbialite was formed by microbial communities/mats that trap and bind sediments, a critical record of the microbial ecosystems after the faunal mass extinction. However the microbial components of the microbialites remain largely unknown due to difficulties associated with microbial preservation and morphological identification. Lipid biomarkers in samples collected from the Permian-Triassic transition intervals in the Cili and the Laolongdong sections, two microbialite sections in South China, were analyzed using gas chromatography-mass spectrometry (GC-MS) to investigate specific microbial compositions in shallow marine environments directly after the end-Permian mass extinction. A series of long-chained monomethylalkanes (MMAs), accompanied by some hackneyed compounds, were present in the microbialite layer in both sections. These MMAs, ranging in carbon numbers from C_{23} to C_{32}, are indicated by the presence of the methyl group at carbon number 21. It is interesting to note that these compounds are below detection in the samples collected from the intervals below and above the microbialite layers in the two sections. This shows a close relationship between the appearance of the microbialite and this series of MMAs. A specific microbial ecosystem, which can produce these MMAs, flourished in shallow marine environments directly after the end-Permian mass extinction. These MMAs appear to be superimposed on another series of MMAs which are less abundant but commonly found in geological samples such as oils and sedimentary extracts. This indicates the presence of two distinct microbial sources for MMAs at this time.

S14 - MOLECULAR DATING SUGGESTS BIOMINERALIZATION OF SPONGES IN LATE NEOPROTEROZOIC

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On the basis of rDNA sequence data including those of 7 sponge species from South China Sea and 19 species from GeneBank, with calcarean sponges and eumetazoans as outgroups, we show that Demospongiae and Hexactinellida together are monophyletic, and Demospongiae comprise 4 major groups (G1-4), confirming recent phylogenetic studies. The phylogeny indicates that the sponging-type demosponges without siliceous spicules are the most ancient type, and the siliceous spicules are derived traits, congruent with the fact that in the fossil record, biomarkers of demosponges appeared in the Cryogenian (mid Neoproterozoic) while definite siliceous demosponges did not appear until Cambrian. Using the tree constructed here and the same dataset, with foissl calibration points of the Tetractinellida (minimum, 520 Ma), Agelasida (minimum, 270 Ma) and the earliest spicular sponges (maximum, 635 Ma), we estimated the major divergence times for the sponges and related groups using MULTIDIVTIME and MCMCTREE in the sense of relaxed molecular clock. Our phylochronological results suggest that the metazoans and demosponges appeared about 799±90 and 729±100 Ma respectively, the latter being in congruence with recent finds of sponge biomarkers, and the siliceous sponges appeared in 676±80 Ma, during Neoproterozoic.

S23 - EVIDENCE OF POSSIBLE PARASITIC WORMS FROM THE LOWER CAMBRIAN CHENGJIANG LAGERSTÄTTE

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Three new vermiform genera and species have been recognized in the Chengjiang Lagerstätte, southwest China. They possess morphological features distinct from other reported fossil worms and comparison with extant vermiform animals reveals similarities to three separate phyla of parasitic worms. One species has a cylindrical body divided into a spiny proboscis, smooth neck, a collar with long spines and a trunk. Comparative morphological study indicates that this animal may be a stem representative of Acanthocephala, which would be the first fossil record of this phylum. The second species possesses a hook-shaped body divided into an irregular-shaped trunk and a cylindrical, tapering tail. This enigmatic worm shows some similarities to the larvae of nematomorphs. The third species is distinguished by an anterior oral sucker and a wide alimentary tract posteriorly split into a pair of intestines. These distinct features are comparable with Platyhelminthes, which do not otherwise have a fossil record. The morphological evidence, such as the anterior pointed proboscis or oral sucker, suggests that each of these new vermiform taxa may have led a parasitic lifestyle, extending both the biodiversity and ecological diversity of known Early Cambrian ecosystems.

S9 - MIDDLE AND LATE DEVONIAN BRACHIOPOD ASSEMBLAGES, SEA LEVEL CHANGE, AND PALEOGEOGRAPHY OF HUNAN, CHINA

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Givetian through middle Famennian brachiopods of Hunan can be grouped into five biozones in ascending order: *Stringocephalus* Abundance Zone, Ambocoeliid-Leiorhynchid Assemblage Zone, Cyrtospiriferid Assemblage Zone, *Yunnanellina-Sinospirifer* Assemblage Zone, and *Yunnanella-Hunanospirifer* Assemblage Zone. They correspond approximately to the *Po. hemiansatus* to *Po. varcus* Zone, *S. hermanni* to *Pa. punctata* Zone, *Pa. hassi* to *Pa. linguiformis* Zone, *Pa. triangularis* to Upper *Pa. crepida* Zone, Uppermost *Pa. crepida* to *Pa. marginifera* Zone, respectively. Strengthened rifting activity in the Devonian of South China began in the middle of the Lower *Po. varcus* Zone (a level approximately at the first appearance of *Po. rhenanus*). This supposed Lower *Po. varcus* Zone rifting activity is consistent with the Lower-Middle Givetian substage boundary suggested by the SDS. A sea level rise in the early part of the *S. hermanni* Zone can be identified not only in the trough areas but also in platform areas. Similarly this level is consistent with the Middle-Upper Givetian substage boundary suggested by the SDS. Although the sea level rise may occur in the deeper water trough areas of South China towards the end of the Givetian, platform areas experienced an uplifting at various degrees, especially in the central and northern Hunan area, where Early Frasnian deposits may be absent in many places. Similarly, the end-Frasnian regression led to the exposure of many places and an absence of Early Famennian deposits, which probably is the reason why the distribution of the *Yunnanellina* brachiopod fauna is so restricted.

S20 - CEMENTATION OF OYSTERS TO NATURAL SUBSTRATA BY BIOGENIC AND DIAGENETIC PROCESSES

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Oysters live permanently immobilised by cementation of the left valve to a hard substrate. The contact zone between oysters and natural substrates has been analysed using SEM imaging, electron dispersive X-ray microanalysis, electron backscatter diffraction and Raman spectroscopy. The results reveal the influence of both biogenic and diagenetic processes on oyster cementation. Original adhesion is brought about by secretion of an organic component that acts as a nucleating surface onto which crystals precipitate. These crystals have a random orientation and are composed of high Mg calcite, suggesting that the crystals nucleating on the glue substrate are not affected by the biological control exhibited during shell bio-mineralisation. Chemical analysis indicates that these crystals are in fact formed by inorganic precipitation from seawater. There is a strong correlation between the amount of organic glue and the volume of crystalline cement present. The oldest parts of the contact are entirely composed of crystalline cement, whereas the younger parts are predominantly organic with some microcrystalline cement. This relationship suggests that cementation is occurring as the oyster grows and is therefore an example of diagenetic alteration of biomolecules in a living organism.

S6 - DISCRIMINATION BETWEEN THREE PLEISTOCENE *ASTARTE* SPECIES (BIVALVIA, ASTARTIDAE): TAXONOMIC AND MORPHOMETRIC IMPLICATIONS

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Accurate, consistent, and speedy species identification are the primary tasks of taxonomy. Classically, identification has been approached via visual inspection of morphology. However, recent blind-test experiments have revealed a disturbing lack of accuracy and consistency in qualitative identifications. The speed with which such identifications are made has also long been an issue. These remain the primary factors limiting delivery of many large-scale evolutionary and ecological investigations. While it has been argued that morphometrics can address these deficiencies, performance of morphometric-based systems in such contexts to date has been far from ideal. This can be explained by the fact that most morphometric approaches result in severe abstraction of species' morphologies with a consequent loss of inter-species discrimination power. Newly developed 3D surface-based morphometric and computer-vision approaches to morphological identification hold the promise of delivering automated systems with the required levels of identification accuracy and speed. These methods are compared with traditional and standard geometric morphometric approaches to inter-species discrimination for a set of three astartid bivalve species. Results indicate that either of these approaches can deliver scalable, automated systems of high accuracy, perfect consistency, and impressive speed. Moreover, comparison of these results illustrates important, and often neglected, problems with regard to the principles and practices of morphological disparity analyses. If supported by the palaeontological community, the use and development of such systems can overcome the taxonomic impediments to large-scale investigations and drive much-needed re-evaluations of many taxonomic concepts and morphometric approaches.

S27B - PALAEOBIOGEOGRAPHIC CHALLENGES IN THE MIDDLE OF THE ATLANTIC - MPB WORKING GROUP

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The Azores is one of the most remote island systems of the North-eastern Atlantic. Located midway between North America and Europe, at almost 2000 km from the nearest continental shores (Portugal mainland), this natural laboratory has attracted attention on account of its apparent low rate of endemism. This ‘paradox’ led to several theories, with the most popular assuming some kind of devastating phenomenon, causing a local ‘tabula rasa’ due to the drop in sea temperatures during the Pleistocene. The oldest island, Santa Maria (about 8 M.y.) has particular significance, for this small island is the only one with fossiliferous outcrops, dated from the Miocene-Pleistocene and Pleistocene in age. In spite of their existence being known since the nineteen century, the importance of the fossil record in aiding the understanding of the biogeographical history of this area stayed largely underestimated. Since 2002, the Marine PalaeoBiogeography Working Group (University of the Azores) has organized annual international expeditions/workshops aiming to rediscover Santa Maria fossils, and attempting to better understand the evolutionary history of the Azores. The work developed by MPB in the island has led to several international collaborations, which have helped to reduce the gap between fossil and extant biogeographical studies in the archipelago. As a result, the biogeographical interpretation on this archipelago now has a set of paleontological data that goes beyond the Pleistocene glaciations. Nevertheless, paleontological work in Santa Maria is far from being exhausted.

S18 - DRIFT IN MIOCENE MAMMALIAN HOTSPOTS

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In 2005, the question ‘What determines species diversity?’ was selected as one of the 25 most important fundamental but unanswered questions in science. For paleontologists the challenge is now to reconstruct biodiversity patterns of the past. Historical data can show how hotspots came to be, and, more importantly in these days of crisis, how they came to their demise. The difficulty lies in that no single locality gives a complete overview of the biodiversity in a particular period. On the generic level, we have combined data from mammal localities within squares of 2x2 degrees, and plotted the number of taxa per square. This has been done for localities in Europe and Asia Minor up to 40°E longitude, one of the most intensively studied areas in mammal palaeontology. The procedure was followed for each mammal zone in the Miocene and beginning of the Pliocene. The maps clearly testify of the patchiness of the fossil record. However, when comparing the data from different zones, there is initially a distinct trend of a southward movement of the hotspots. This leads to a climax in MN 9 in the area around Barcelona. This so-called Vallesian Climax is followed by a period in which the diversity is more evenly distributed. Making separate analyses for small and large mammals show that the pattern is much better observable in rodents and insectivores that in the ungulates and carnivores. Presumably, this is due to the higher completeness of the fossil record of micromammals.

S7 - EARLY ONTOGENY OF *CREMNORTHIS* (BRACHIOPODA, ORTHIDA) FROM THE MIDDLE ORDOVICIAN OF RUSSIA

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The genus *Cremnorthis* is known from the Ordovician of Wales, Ireland, and Estonia. Its main characterizing feature is “massive cardinal process having trilobate myophore with high median crest”. We obtained several specimens of *Cremnorthis* sp. from the Uhaku Regional Stage of the Pskov Region, Mishina Gora Quarry. The development of the cardinal process was observed in series of nine specimens from two adjacent beds. The size of specimens varies from 1.5 to 4 mm. The earliest developmental stage is represented by a specimen with an approximately 80-µm-high trifid cardinal process consisting of a massive base with two small, rounded, and separated outgrowths on the top. The base looks like a single structure with a visible groove of accretion in the middle. The myophore lobes often grow together asymmetrically or one lobe may be considerably smaller than the other. The largest specimen has, typical for the genus, an approximately 0.5-mm-high cardinal process consisting of a large base with a long linguiform, curved median extension and bounding ridges on the top. Though the median lobes of trilobate myophore are accreted in adult specimens, they are separate at the earliest developmental stages.

S19 - PROBABLE ANIMAL BODY-FOSSILS FROM PRE-MARINOAN LIMESTONES, SOUTH AUSTRALIA

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In the Neoproterozoic of South Australia, two glacial successions are separated by a thick package of non-glacial sediments. The interglacial stratigraphy includes salt diapir-fringing stromatolite-oolite shoals, black shales, and an impressive 18‰ negative shift in the $\delta^{13}C$ of carbonate preceding the younger (Marinoan) glacial unit that was deposited at equatorial latitudes. Within pre-Marinoan stromatolitic limestones are bioclastic packstones containing distinctive weakly calcified fossils. These objects are the oldest cm-scale calcified fossils ever reported by ~90 Myr. The fossils cannot be physically released from the calcite matrix by conventional techniques, nor are the density contrasts between fossil and matrix significant enough to be imaged with traditional X-ray based CT-scanning methods. We construct 3D digital models of the fossils from automated tracing of individual specimen cross-sections obtained by serially grinding and scanning the sample 50.8 µm at a time. Through this process, we image a population of ellipsoidal organisms without symmetry and with a network of interior canals opening to circular apertures. We suggest that these reef-dwelling organisms share ecological and morphological similarities with sponge-grade animals.

S3 - RESPONSE OF TERRESTRIAL VEGETATION TO TRIASSIC-JURASSIC CLIMATE CHANGE IN EAST GREENLAND

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The Triassic-Jurassic (Tr-J; 200Ma) transition coincides with the eruption of flood basalts associated with the opening of the Atlantic Ocean. This is thought to have lead to a fourfold increase in palaeoatmospheric CO_2 and a consequent rise in global temperatures of 3-6°C. Detailed investigations of macrofossils (mostly leaves) at Astartekløft, East Greenland, have shown a genus- level extinction rate of ~17%, clear compositional changes and a catastrophic richness decline of 85% in the Late Triassic in response to this episode of major environmental change. These results are in sharp contrast to records of Tr-J vegetation in Europe based on sporomorphs (pollen and spores), in which evidence for compositional change is pervasive, but evidence for geologically abrupt richness loss is lacking. In order to explore this discrepancy, we present an assessment of compositional change, and a quantitative analysis of terrestrial plant richness using sporomorph assemblages from Astartekløft, East Greenland. Compositional differences between sporomorph samples were assessed using non-metric multidimensional scaling, and sporomorph richness was estimated using individual and sample-based rarefaction. These analyses reveal that sporomorph assemblages from the Tr-J boundary interval at Astartekløft are characterized by significant compositional change that is independent of facies changes. Emigration and/or extirpation of plants apparently played a greater role in this compositional change than immigration and/or origination. Among-sample richness is 10-12% lower in the Tr-J boundary interval than in the Late Triassic, indicating that richness loss across the Tr-J in East Greenland is apparently greater in the macrofossil record than the sporomorph record.

W10 - TERRIGENOUS DEVONIAN ZONAL MIOSPORE STRATIGRAPHY OF THE WESTERN PART OF THE PRECASPIAN DEPRESSION AND ITS FRAME (RUSSIA)

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The terrigenous Devonian includes all the pre-Frasnian deposits. Stratigraphic study of these deposits is difficult because conodonts have not found here. Therefore, the zonal miospore assemblages are very important for their subdivision and correlation. These deposits have been attributed to several miospore zones (Avkhimovich et al., 1993, with modifications). The Eifelian deposits are characterized by miospores of the *Periplecotriletes tortus - Calyptosporites velatus* zone (Klintsov Horizon). The overlying *Rhabdosporites langii - Cirratriradites monogrammos* zone confirms to Mosolov and Chernoyar horizons. The most distinct changes in the palynocomplexes are recognised at the *R. langii - C. monogrammos* and *Geminospora extensa* (Ex) zone boundary. This level corresponds to the boundary between the Eifelian and Givetian stages. This boundary is one of the most precise in the whole Devonian section. The Ex zone has been divided into three subzones. The uppermost part of the Ex zone is palynologically less distinct than the lower ones. The dominant changes in the miospore assemblages are mainly seen at species level. In upper part of Ex zone miospores appear which are characteristic species for the palynocomplex of the overlying *Contagisporites optivus - Spelaeotriletes krestovnikovii* zone (Pashiya and Timan horizons). This zone is subdivided into the lower *Ancyrospora incisa - G.micromanifesta* and the upper *Acanthosporites bucerus - Archaezonotriletes variabilis insignis* subzones. By palynological data the upper boundary of Givetian stage should be defined on the *A. bucerus - A. variabilis insignis* subzone (the basis of Upper Timan subhorizon).

S19 - A BIOTURBATION-INDUCED ECOLOGICAL TRANSITION: QUANTITATIVE EVIDENCE FROM THE LOWER CAMBRIAN OF CALIFORNIA AND NEVADA, USA

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Bioturbation became more plentiful, complex, and physically disruptive as a direct consequence of the Cambrian radiation of marine invertebrates. This increase in sediment disruption by metazoans transformed substrates and dramatically expanded available ecospace. In particular, microbial mats, which were ubiquitous on Proterozoic seafloors, virtually disappeared from open marine environments by the end of the Cambrian Period. Seilacher and Pflüger (1994) termed this early example of metazoan ecosystem engineering the agronomic revolution, and Bottjer and colleagues (2000) recognized the significant ecological and evolutionary effects of this transition as the Cambrian substrate revolution. In order to better understand the initial phase of the agronomic revolution as it occurred in different shallow marine environments, field studies were conducted at Lower Cambrian localities in California and Nevada that fall along an onshore-offshore transect. Because bioturbation is concentrated along bedding planes in the Lower Cambrian, particular attention was paid to bedding plane exposures and associated strata. In addition to field paleoecological methods, including visual scoring of bioturbation, the intersection grid method (Marenco and Bottjer, in press), a quantitative technique for estimating bioturbation intensity, was applied to digital photographs of the studied bedding planes. Results indicate low average bioturbation intensities on bedding planes at all localities, with a subtle trend toward higher maximum bioturbation intensities up-section. This grid-based dataset provides a new, quantitative perspective on the ecological impact of metazoan behavior during the Cambrian radiation.

S6 - THE PHANEROZOIC HISTORY OF THE LATITUDINAL DIVERSITY GRADIENT IN THE MARINE REALM

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Taxonomic diversity tends to decrease from the tropics to the poles. This major biogeographical pattern, known as the latitudinal diversity gradient (LDG), was present in the geological past, although little is known about its historical development. The combined analysis of Sepkoski's compendium and the Paleobiology Database shows that LDG persisted in the marine realm throughout the Phanerozoic. Within any time interval, diversity peaked in one latitudinal zone, and declined away from this peak toward the poles. Peak diversity was not always near the equator, but shifted continuously northward through time. This trend is related to the northward shift of continental shelf area, as demonstrated by Powell (2009), who found the same pattern in brachiopods. The results are robust to the latitudinal sampling bias and to the fact that most data came from the USA and Western Europe, the regions that were shifting northward in parallel with the major portions of continental shelf. The LDG, measured as difference in diversity levels between higher and lower latitudes, was steeper during the major 'icehouse' intervals, when peak diversity was near the equator, and gentler during the major 'greenhouse' epochs, when peak diversity was in mid-latitudes. This trend is detectable at the two levels of biodiversity: total genus richness within and beyond the tropics and alpha diversity of tropical and extratropical palaeocommunities. These results imply that, in addition to the major impact of plate tectonics, the long-term climatic trends may have played a role in shaping the LDG through the Phanerozic.

S6 - THE BARE BONES OF IT: DOES MORPHOMETRIC ANALYSIS OF OSTEOLOGICAL VARIATION IN THE SKULLS OF EXTANT CROCODILIANS GIVE BIOLOGICALLY CONGRUENT DEFINITIONS OF INTER AND INTRASPECIFIC VARIATION?

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Many factors can influence the morphology of bones; such as age, sex, geographic isolation and taphonomy, not to mention true species distinctions. But when dealing with fossils none of this information may be known. Despite this, these explanations are often invoked to explain variation among specimens that does not seem to represent specific differences. In reality it is very difficult to tell where interspecific and intraspecific variations begin and end. To help disentangle these, palaeontologists often utilise morphometric methods to visualise these differences. However, better knowledge of the scale and location of variation does not necessarily tell us its cause. One way to resolve some of these problems is to use extant animals where we can account for species, age, sex, location and taphonomy and treat them in the same way as fossils. This enables us to show what variation is independent of these factors (true individual variation) and give better indicators as to how sexual, ontogenetic and specific variations manifest themselves. Larger sample sizes than might be possible in a palaeontological study also allow us to investigate how consistent these variations are, since smaller samples may make individual variations appear more significant than they are in the general population. Skulls of Caiman crocodilians and geometric morphometrics have been used to investigate some of these issues. Emphasis was placed on using specimens of known sex and species down to sub-specific level. This degree of resolution allows a better understanding of the patterns and causes of variation within and between species.

S9 - THE LATE DEVONIAN AND EARLY CARBONIFEROUS TERRESTRIAL CLIMATIC RECORD

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The East Greenland Devonian Basin contains sections in terrestrial sediments that cross the Devonian-Carboniferous boundary. These contain a record of climatic events that can be matched to the marine record. The zonal spore *Retispora lepidophyta* has a first occurrence in the upper part of the Britta Dal Formation, some 10 m above the last occurrence of the tetrapod *Acanthostega*. The occurrence of *R. lepidophyta* marks a change from sustained mid and late Famennian aridity to climates that are both successively both more arid and wet. The overlying Stensiö Bjerg Formation had wet intervals that can be matched to the base of the Strunian in Belgium and includes a lake that can be correlated with the Etroeungt Limestone. At the D-C boundary the most intense calcrete within the sequence is followed by the deepest lake that is a composite of 2 ?precessional cycles. This is a far field record of the terminal Devonian glacial and deglaciation. New D-C boundary sections have been identified in the southern part of the basin that include the earliest Carboniferous Harderbjerg Formation. These sections shows a change to a generally seasonally wet climate within which there is another calcrete/lake couple that may represent the high latitude Miller Diamictite and Soutkloof Shale couplet or at low latitudes the Alum Shale. This terrestrial climatic record demonstrates the complexity of events at the D-C boundary that are either unrecognized or unrepresented within correlative marine sections. It therefore provides a template to both understand and stratigraphically sub-divide the interval.

W10 - SPORES, LIFE, DEATH AND THE DEVONIAN EARTH SYSTEM

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When trying to understand the Earth System a crucial linkage is that between the marine and terrestrial environments. Perturbations in the Earth System are generally recognized within marine sequences through major changes in both sedimentary environment and biota. However, the terrestrial environment can give much more direct and easily interpretable changes in the climate system and how it interacts with the terrestrial biota. In reality, terrestrial biota means the spores of land plants as these are the only group present in both a sufficient abundance and through long stratigraphic sequences. An example is given from a thick (>1 km) terrestrial Frasnian/Famennian section from Ymer Ø, East Greenland. This gives a high resolution integrated record of spores and palaeoclimate. Productive palynological samples are quite rare but contain similar spore assemblages to those recorded from the Timan in Russia where they occur in well studied sections that also contain conodonts and goniatites thus enabling marine/terrestrial correlation. The East Greenland section shows a number of distinctive climatic events with successive intervals of seasonally much wetter climate followed by episodes of intense aridity. In the latest Frasnian there was a progressive and significant down-step in the diversity of terrestrial vegetation that matches these aridity episodes. The F/F boundary can be linked to sustained aridity driven by a particular combination of orbital cycles that can be interpreted as an increased sensitivity of the Devonian Earth System to particular climatic thresholds.

S13 - PALAEOECOLOGY OF UPPER TRIASSIC REEFS

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Following the end-Permian extinction, metazoan reef ecosystems all but disappeared from the rock record for the entire Early Triassic. In the Middle Triassic, scleractinian corals (modern stony corals) evolved and became minor players in Palaeozoic-style reefs. By the Late Triassic, these corals, as well as calcifying sponges, were building large, diverse reef ecosystems in both Panthalassa and Tethys. Despite significant interest in these ecosystems from the 1970s to the 1990s, a rigorous understanding of the micro-environments, framework builders, and fossil assemblages from many localities is not known. Without this baseline, it is difficult to determine how these reefs recovered from the end-Permian extinction and how they were influenced by the end-Triassic extinction, which caused an analogous reef collapse. The three main objectives of this work are to: (1) establish what framework builders were important in the construction of Upper Triassic reefs; (2) quantitatively determine what fossil assemblages are present, with a particular interest in the microbial component; and (3) resolve what changes can be observed in reef ecology through the Late Triassic. Six key sites in Canada (Pardonnet Hill, BC; Lime Peak, YT), the United States (Mina, NV; Summit Point, OR), and Austria (Gosausee; Werfen's Eisreisenvelt) were studied using rigorous mapping, sampling, and microfacies analysis. Additionally, several other classic localities from the Northern Calcareous Alps were examined for comparative purposes. This investigation suggests very unique reef palaeoecologies ranging from microbial and/or algal reefs to sponge and coral reefs analogous to the shallow water, tropical patch reefs of today.

S27B - *OICHNUS* IN PLEISTOCENE *MELANOPSIS*: EVIDENCE FOR PREDATION OR PARASITISM

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Casa de Melero locality (Mula, Murcia Region, SE Spain) represents a Pleistocene fluvial terrace, composed of a succession of medium-grained sands, silty sands, sandstones and caliche. The lower sandy unit contains pauciespecific concentrations of freshwater molluscs, with thickness and lateral extent highly variable. Twenty-eight samples weighing 3.5 kg each were collected from this unit and yielded 43,116 specimens. All samples show associations dominated by the gastropods *Melanopsis dufori* (49%) and *Theodoxus fluviatilis* (44%), with subsiduary *Melanoides tuberculata* (3%) and the bivalve *Corbicula* sp. Very similar species associations are known in sub-Recent and Recent swamp (palaeo)environments. 3.2% of shells (1393 specimens) bear *Oichnus*, represented by circular holes with smooth or slightly irregular margins. In general, the one boring per shell is located on the last whorl. Almost all drilled specimens (1379:1393) belong to *M. dufori*. In addition, only 14 *M. tuberculata* shells are bored, and no traces are detected on *T. fluviatilis* or *Corbicula* sp. The hole characteristics and the nonrandom distribution among species, suggest that they represent biotic interactions between an unknown freshwater borer and gastropod prey/host. Numerous predator or parasitic invertebrate taxa bore into organic skeletons, this behaviour is well known in Recent marine ecosystems, and is also widely documented in the fossil record. We present the first record of boring into a freshwater species.

S27B - MOLLUSC FOSSIL CONCENTRATIONS AND QUATERNARY RELATIVE SEA LEVELS IN URUGUAY

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Radiocarbon dated shell concentrations from Uruguay provide evidence for sea level rise during the Quaternary. Two periods are identified in which a sea level was higher than at present: 1) during the Late Pleistocene, dated as 35000 ^{14}C years (minumum age), but estimated to be ca. 126000 years and considered to be equivalent to Mi5e and, 2) during the Holocene, beginning around 6500-6000 calendar years and continuing to near the present. The faunal content of the shell beds, primarily infaunal bivalves preserved *in situ* and ichnofossils can help constrain absolute sea levels, relative to present day, at these times. The intertidal bivalve *Tagelus plebeius* occurs in both Pleistocene and Holocene deposits, whilst the ichnofossil *Gastrochaenolites* is only found in the Pleistocene deposits. At the present day in Uruguay, similar borings to *Gastrochaenolites* are made by pholadids, which are also found as body fossils in Quaternary deposits. We have evaluated the depth at which modern *T. plebeius* and pholadid species live, and how deep they burrow. The Uruguayan coast is situated in a passive margin, and is considered to be neo-tectonically quiescent. Taking these data and the present altitude of the shell beds into account, an approximation to past sea levels can be calculated. Our preliminary data indicate that the Late Pleistocene transgression reached up to 5m above the present sea level, and during the Holocene up to 1.8m.

S27B - TEMPORAL AND GEOGRAPHICAL DISTRIBUTION OF TERTIARY SOUTH AMERICAN SAND DOLLARS (ECHINODERMATA: ECHINOIDEA: CLYPEASTEROIDA)

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During the Tertiary, South American scutelline sand dollars were represented by at least three families (Monophorasteridae, Mellitidae, Abertellidae), plus a genus with uncertain affinities (*Iheringiella*). The aim of this survey is to reevaluate stratigraphical data concerning these taxa. The Monophorasteridae is an extinct clade restricted to southern South America. *Monophoraster* is represented by *M. darwini* (Argentina, Middle Miocene-early Late Miocene) and *M. duboisi* (Argentina, Uruguay, early Late Miocene). *M. darwini* apparently also occurred in Chile, where its age remains unclear, although undoubtedly not Eocene as originally stated. The other genus in the family, *Amplaster,* contains three species: *A. alatus* (Argentina, Early Miocene-early Late Miocene; Uruguay, early Late Miocene), *A. coloniensis* (Uruguay, early Late Miocene), and *A. ellipticus* (Uruguay, early Late Miocene). The family Mellitidae is represented by *Leodia divinata* from the Early Pliocene of Venezuela, and *Encope* species from the Pliocene of Chile. The Abertellidae is represented in South America by two species: *Abertella pirabensis* (Brazil, Early Miocene), and *A. gualichensis* (Argentina, early Middle Miocene). *Iheringiella patagoniensis* is limited to the Late Oligocene of southern Argentina. The early Late Miocene was the time when the maximum diversity of sand dollars was reached. The absence of Pliocene deposits along the southwestern coast of South America prevents us from knowing how these faunas changed during that period. Pleistocene fossils represent a modern fauna.

S6 – LARGE SCALE PALAEONTOLOGIAL DATA ANALYSIS OF CONODONT FOSSIL HISTORY

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Conodonts are an extinct group of marine vertebrates with an exceptionally abundant and continuous fossil record from the Upper Cambrian to the Upper Triassic. This makes them an specially useful group to estimate large-scale evolutionary patterns from palaeontological dates. Previous studies have estimated conodont palaeodiversity using several analytical techniques. Nevertheless, due to the incompleteness of the fossil record, new inference techniques are being applied in order to obtain better information from the conodont fossil record. In the global analysis attempted here we apply classic methods of palaeobiological inference (e.g., estimation of evolutionary rates, abundance and richness analyses, taxonomic survivorship curves), together with multivariate analyses; in particular, clustering and ordination methods. An analysis based on probably of extinction was also employed. The overall pattern shows that conodonts reached their greatest diversity at the early Ordovician. This peak is followed by an interrupted decline in the familial palaeodiversity during the late Ordovician and Silurian, with a new radiation in the Devonian and early Carboniferous. During the Permian a general decline began that continued until the extinction of the group by the end of the Triassic. Our results not only reveal that the major extinction represent deep loss of diversity, but also significant discontinuities in the conodont record. These results illustrate a partial decoupling between the probability of extinction, the extinction rate and the loss of diversity, emphasizing the important role of the origination process in the evolutionary history of the group.

W6 - FINITE ELEMENTS ANALYSIS OF CONODONT ELEMENT FUNCTION

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Conodonts constitute the first clade of jawless vertebrates that explore the biomineralization of their skeletons, characterized by an oropharyngeal feeding apparatus. For decades there has been a controversy concerning conodont element function, *viz*. whether it performed a filter support or tooth-like function to process prey. Several authors have contributed to this debate with new evidences (mainly microwear, occlusion and histological data) that are in agreement with an efficient food processing function of conodont elements. We sought to test these hypotheses of function using Finite Element Analysis, together with other evidences from histology, occlusion, microwear and functional morphological analysis. Our preliminary results, based on the P_1 elements of the Carboniferous conodont *Gnathodus bilineatus*, allow us to conclude that geometry has an important impact on its mechanical performance. The pattern of stress distribution coincides precisely with microstructural adaptations in the element crown tissue.

W4 - DINOSAUR TRACKSITES UNEARTHED BY TEN YEARS OF PALAEONTOLOGICAL EXCAVATIONS ON THE HIGHWAY A16 (JURA MOUNTAINS, NW SWITZERLAND): RESULTS, FUTURE RESEARCH DIRECTIONS, AND IMPLICATIONS FOR GEOCONVERSATION

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In the Canton Jura (NW Switzerland), the Palaeontology A16 since ten years systematically excavates body fossils and dinosaur tracksites prior to the construction of the highway A16. Four Late Jurassic (Kimmeridgian) intervals, each with several superimposed track-bearing levels, were excavated level-by-level on six tracksites situated on the future course of the highway. This revealed over 40 ichnoassemblages with 8'930 tracks including 222 sauropod trackways and 244 trackways of tridactyl bipedal dinosaurs, mainly attributed to theropods. The tracks were documented with standard ichnological and state-of-the-art 3D imaging technologies (laserscanning, photogrammetry). Sauropod and tridactyl tracks both vary from very small (10 cm pes length for sauropods; 6 cm for tridactyl tracks) to huge (115 cm for sauropods; 75 cm for tridactyl tracks), and different size classes and morphotypes are commonly associated on single ichnoassemblages. Trackways are up to 115 m long exhibiting different patterns and configurations, also along single trackways. These rich dinosaur ichnoassemblages give important insights into the otherwise poorly-known Late Jurassic dinosaur fauna of the Jura carbonate platform. This talk focuses on recent discoveries and results regarding ichnotaxonomy, palaeobiology and palaeoecology, and discusses future research directions. Furthermore outlined are the importance of the tracksites as natural, palaeontological heritage and implications for geoconservation and construction of the highway. So far, one tracksite was protected by the construction of an additional highway bridge. Discussions concerning the future (covering-up or protection by an additional highway bridge) of two other sites (one over 4000m^2 in size) are currently under way at federal level.

S4 - MULTI-STAGED DINOFLAGELLATES WITH GAMETES FUSION IN CRETACEOUS AMBER: PERIDINIACEAE EVOLUTION

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The dinoflagellates are an important group of phytoplankton (Alveolata) in marine and fresh water ecosystems. This group of biflagellate unicellular eukaryotes arose in marine waters earlier than the mid-Triassic paleontological record according molecular phylogeny and subsequently colonized fresh waters. Rare fresh water dinoflagellates are reported in the fossil record; the first appearance is observed during Eocene up to Recent. Fossilized dinoflagellates are the resistant dinosporin walls of the hypnozygotes, the dormant cysts. Motile free-living haploid cellulosic thecae (schizonts) are destroyed during fossilization processes. Multistaged dinoflagellates with exceptional preservation are trapped in amber embedded in paralic mid-Cretaceous sediment from Archingeay (S-W France). For the first time with dinoflagellates, motile cellulosic thecae, ecdysial openings and gamete fusion are reported from the fossil record. Cells reached the sticky resin blown by the wind inside spray droplets. Ecological affinity of the amber species with fresh or marine waters can be suggested by determining the number of cingular plates and by the opening type of the thecae before division. Fossilized cellulosic dinoflagellates from paralic ecosystems will provide new insights on the marine-freshwater transition and on Peridiniaceae evolution complimenting the data from molecular phylogeny.

S9 - DEVONIAN – CARBONIFEROUS BOUNDARY IN POLAND: CONODONT AND MIOSPORE SUCCESSIONS AND EVENT STRATIGRAPHY

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The studies focused on the transition from the uppermost Famennian to the lowermost Tournaisian within an offshore shale and carbonate, condensed succession in NW Poland. This transgressive-regressive succession consists of dark clayey deposits, in which faunal remains are rare (0.80 m) passing upwards into marly, arenaceous calcarenites (4,6 m) with relatively rare crinoids, Palaeosiphonocladales algae and encrusting foraminifers Three miospore zones of Streel were recognized within this succession, i.e. *Retispora lepidophyta-Indotriradites explanatus* (LE), *R. lepidophyta-Verrucosisporites nitidus* (LN), *Vallatisporites vallatus-Tetusotriletes incohatus* (VI), as well as some conodont and entomozoid ostracode species. A biostratigraphic analysis resulted in a high-resolution record of the oxygen isotopic composition of micrites (delta 18 O) and of carbon sedimentary organic matter (delta 13 C), as well as of the magnetic susceptibility signal. A significant positive carbon isotope excursion is reported from the LN miospore Zone (~Middle *praesulcata* conodont Zone), which coincides with a decrease of the delta18 O value and the magnetic susceptibility signal. The marly shale horizon is identified as an equivalent to the Rhenish Hangenberg Black Shale, whereas carbonates can be correlated with the Hangenberg Sandstone and Shale. They are equivalent to the multiphase Hangenberg Event.

W5 - HOLOTOMOGRAPHY IN EXCEPTIONALLY PRESERVED CRETACEOUS OSTRACODS

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We have applied a sub-micrometer-resolution inline quantitative phase X-ray synchrotron tomography (holotomography) to show possible internal traces of exceptionally well 3D-preserved Cretaceous ostracods. The non-marine *Harbinia micropapillosa* (Cyprididae) of the Brazilian Santana Formation (100 Myr) in previous SEM analyses has shown very well preserved appendages, enabling a taxonomic identification. The new imaging tool of holotomography allowed non-invasive investigation of the preserved soft bodies of these rare ostracod fossils. Beside strongly sclerotized internal structures such as the oesophagus, remnants of the males' sperm pumps as well as traces of the inflated sperm receptacles in the females were identified. These structures were directly compared with holotomographic images of living representatives of the same family. Since sperm pumps and large receptacles occur only in groups with males producing giant sperm (up to ten times longer than the animal itself) our findings indicate that this costly way of reproduction persisted for at least the past 100 million years in ostracods from the family Cyprididae.

S21 - USING PHYLOGENIES TO UNDERSTAND GLOBAL INSECT RICHNESS

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Today, the insects comprise over half of described species. Understanding the macroevolutionary causes of this richness is therefore central to our understanding of global biodiversity. Phylogenies provide both alternative and complementary approaches to the fossil record addressing this question. Here we present analyses based on supertrees of living and extint higher taxa of insects. At order level, taxonomic richness of insects peaks at the present day based on fossils alone, but, incorporating ghost ranges based on phylogenies, phylogenies combined with fossils suggest that richness peaked much earlier, in the Permian. Consequently, survival of taxa through the end-Permian was higher than fossils alone suggest. Sister-clade richness comparisons also suggest that a significant radiation has occurred in termites, but not their cockroach ancestors, suggesting that eusociality is not a barrier to clade richness, as suggested elsewhere. In the Hymenoptera, numerous increases and decreases in net diversification rate are identified, suggesting that many ultimate factors have contributed to the current richness of diverse clades.

S4 - REVISION OF THE CARNIAN/NORIAN CONODONTS THROUGH THE APPLICATION OF CLADISTIC ANALYSIS

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The taxonomy of Upper Carnian/Lower Norian conodont platform elements is problematic due to the large number of forms occurring in this relatively short stratigraphic interval and the high intraspecific variability affecting many species. The abundance of synonyms per species and the absence of an established phylogenetic model contributes to increase this systematic confusion. In an attempt to solve the taxonomic and phylogenetic problems of the Upper Triassic P1 conodont elements, we applied numerical cladistic analysis to the species belonging to the five most widespread genera (*Paragondolella, Carnepigondolella, Metapolygnathus, Epigondolella* and *Norigondolella*) from the Pizzo Mondello section (Sicani Mountains, Western Sicily, Italy), GSSP candidate for the Norian. These analyses confirmed the validity of a series of evolutionary trends among the platform elements, evidenced the most important morphological characters for their classification and allowed us to make order in the systematic position of the analyzed taxa. The analysis indicated that *Metapolygnathus, Epigondolella* and *Norigondolella* are monophyletic groups and, thus, true phylogenetic genera. *Paragondolella* and *Carnepigondolella* by contrast are paraphyletic grades including basal members of, respectively, the whole clade and a less inclusive group containing *Metapolygnathus* and *Epigondonella*, and thus early evolutionary stages of the other three taxa and not true phylogenetic genera. These results show the potential of applying cladistic methods also to parataxonomic taxa. Parsimonious grouping by synapomorphies (shared derived character states) provides in fact always a more informative and natural classification than using simple similarities (phenetics).

W6 - POSSIBLE INFLUENCE OF THE $\delta^{13}C$ VARIATIONS ON THE CARNIAN/NORIAN CONODONTS DIFFUSION

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Quantitative analyses of the absolute abundances of the species belonging to the five most widespread Upper Carnian/Lower Norian conodont genera (*Paragondolella*, *Carnepigondolella*, *Metapolygnathus*, *Epigondolella*, and *Norigondolella*) from the Pizzo Mondello section (Monti Sicani, Western Sicily, Italy), GSSP candidate for the Norian stage (Balini et al., 2008), show potential ecological competition between these genera. Cross checks of the quantitative curves evidence the presence of three major assemblage changes, named T events: at T1 *Carnepigondolella* is replaced by its descendant *Epigondolella* in an evolutionary step; at T2 *Epigondolella* is substituted by the mass occurrence of *Metapolygnathus* and at T3 *Metapolygnathus* is succeeded by advanced Epigondolellae and by *Norigondolella*. A comparison between these quantitative curves and coeval $\delta^{18}O$ and $\delta^{13}C$ isotopic curves, obtained from the carbonate bulk of the section, shows a correspondence between higher $^{13}C/^{12}C$ ratios and event T2 (and partially event T3), but not with T1. Thus, while the shifts in the C isotopic composition of seawater do not affect conodont evolution, they have an influence on the diffusion of the studied genera, which react differently to the $\delta^{13}C$ variations. *Epigondolella* and *Carnepigondolella* proliferate in fact when seawater $\delta^{13}C$ is lower than 2.5‰, *Metapolygnathus* is instead limited to environmental conditions related to $\delta^{13}C$ values higher than 2.5‰ (Mazza et al., 2009). The rapid expansion of photosynthetically active organisms in the Upper Carnian may explain these perturbations in the carbon cycle and have influenced the trophic chain of the different conodont animal genera, thus producing mutual local migrations.

S3 - HYPERHALINE ASSOCIATIONS IN THE CONTINENTAL LATE MIOCENE OF THE ÇANKIRI BASIN (CENTRAL ANATOLIA, TURKEY): IMPLICATIONS FOR PALAEOENVIRONMENTAL RECONSTRUCTIONS

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The Çankiri Basin, located in the Northern Part of the Central Anatolian Plateau, is a large Tertiary basin where thick Miocene to Quaternary continental sediments overlain the Mesozoic to Tertiary units. The current investigation focuses on the Tuģlu formation, a late Miocene succession mainly composed of dark gray shales and organic rich mudstones. The section of Tuģlu, located around 200 km from the Black Sea coast, has been sampled for micropaleontological and micromammal analyses. During the sampling, fragmentary paleontological remains of molluscs, freshwater crabs, turtles, fishes and leaves have been found. A detailed palaeoenvironmental reconstruction of the whole section has been achieved through the analyses of several paleontological proxies: ostracod, foraminifers, nannoplankton, pollen, molluscs, charophytes and micromammals. The high-resolution sampling of the lower part has led to the recognition of several polyhaline events. Such events are recorded by miliolide foraminifera (*Quinqueloculina*, *Miliolina, Trisegmentina* and *Varidentella*) and by brackish water ostracods (smooth *Cyprideis*). Nannofossil assemblage, with abundant *Perfocalcinella fusiformis*, documents high-mineralized shallow water masses. To explain such a peculiar ssemblage in continental setting, two hypotheses have been advanced: leaching of middle Eocene-Oligocene evaporites or contiguity with the Parathetys. The first hypothesis poses several questions related to paleoclimatic issues whereas the second one is linked to the palaeogeographical setting of the Central Anatolia during late Miocene and to the timing of the uplift of the Western Pontides.

S8 - BEYOND BIOSTRATIGRAPHICAL CORRELATION: *CAROLINITES*, CALIBRATING THE WHITEROCK TRILOBITE FAUNA DIVERSIFICATION, AND PHYLOGENETIC TESTS OF PROPOSED ANCESTRY

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Species of the pelagic telephinid trilobite *Carolinites* have been regarded as distributed both across and between widely separated palaeocontinents during the Early and Middle Ordovician. Hence, with a temporal range spanning the period of diversification of the Whiterock Fauna (a group of post-Cambrian families which radiated alongside elements of the Palaeozoic Evolutionary Fauna), *Carolinites* provides a rare means to globally calibrate the diversification. A sequence of *Carolinites* species from western Laurentia is one of the most stratigraphically comprehensive yet discovered, with 12 stratigraphically successive taxa. Many of these species - all from the Great Basin - are new, which indicates that global sampling of *Carolinites* is likely far from complete. These discoveries greatly extend the early history of the group, with species now known from the lower Tulean Stage (upper Tremadocian) which reveal surprising details of the clade's plesiomorphic morphology. It has been suggested that stratigraphic series of *Carolinites* species indicate ancestor-descendent lineages. While no positive evidence for ancestry can exist, such hypotheses may nevertheless be tested in a cladistic context, yet no quantitative hypothesis of relationship has ever been presented for any member of Telephinidae. We demonstrate on the basis of extensive new data that while the inferred phylogeny of *Carolinites* is largely stratigraphically consistent, several significant ghost lineages confirm that more diversity awaits discovery.

S27D - A BATHYURID BIOFACIES (TRILOBITA) FROM THE LOWER ORDOVICIAN (IBEX, TULEAN) SEPTEMBERSØ FORMATION, NORTH-EAST GREENLAND

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The newly identified Septembersø Formation comprises 83 m of predominantly microbial limestones. It includes part of the 'Lower Limestones' (Albert Heim Bjerge) and 'Banded Limestones' (Ella Ø) of Cowie & Adams's (1957) 'Kap Weber Formation'. The Septembersø Formation is separated from the underlying (Skullrockian, *R. manitouensis* Zone) Antiklinalbugt Formation by a disconformity. The Tulean to Blackhillsian age Septembersø and Cape Weber Formations lie above the disconformity, indicating a significant hiatus, encompassing the Stairsian Stage. This poster describes the trilobites from the Septembersø formation, based on Cowie & Adams's (1957) collection and fossils collected by WDB/IK/SS during 2000/2001 GEUS-led mapping and logging of the Cambro-Ordovician of North-east Greenland (Stouge *et al*., 2001, 2002). The trilobites comprise members of the Family Bathyuridae, including *Peltabellia*, *Bolbocephalus*, *Punka* and *Chapmania*, a 'bathyurid biofacies' (Fortey, 1980) typical of shallow water, near-shore, carbonate settings. Bathyurid-dominated faunas have been recorded from other parts of Laurentia, including the Catoche Formation, western Newfoundland (Fortey, 1979), Kindblade Formation, Oklahoma (Loch, 2007) and Poulsen Cliff Formation, North-west Greenland (Fortey and Peel, 1988). The fauna also includes gastropods, straight cephalopods, ostracodes, crinoids, brachiopods and sponges. The trilobites present suggest an early-Late Canadian, late Jeffersonian (Tulean) age, which is supported by a sparse conodont fauna recorded by Smith (1991), assigned here to the Septembersø Formation. It includes *Glyptoconus quadriplicatus, Eucharodus parallelus* and *Drepanodus concavus*, indicating a Fauna D (Ethington & Clark, 1971) assemblage similar to the late Tulean fauna found in the Barbace Cove Member and Catoche Formation of western Newfoundland.

S5 - PALAEOSAURUS: FEEDING THE BIG BEAST

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Since 2001 the British Geological Survey has been undertaking an ambitious project to build a publicly accessible digital index to its biostratigraphy collections. With an estimated three million specimens, the BGS collections comprise the most comprehensive resource relating to the biostratigraphy of the UK and its continental shelf available anywhere, as well as being the second largest palaeontological collection in the country. 'Palaeosaurus' (*www.bgs.ac.uk/palaeosaurus/home.cfm*) currently holds data on specimens ranging in age from Neoproterozoic to Quaternary, from all parts of the British Isles as well as significant numbers from further afield, and is a formidable curatorial and research resource. Such an undertaking requires tackling many issues, some of which are clear at the outset, while others only become apparent as the work progresses. Technical issues to be addressed include whether to develop the cataloguing system in-house or purchase a third party product, what data to store, how to handle incomplete data, designing a workflow, how best to deliver the data to various stakeholders, and how to make the data most widely discoverable. Resource issues include availability and continuity of staff and funding, and staff skills and development. This talk will present some lessons learned.

S21 - PHYLOMORPHOSPACES: INFORMATIVE MASH-UPS OR PULPING THE TREES?

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One key task of evolutionary biology is to construct models of biodiversity change, both to explain the history of biodiversity as recorded in the fossil record and to predict future changes. This means more than just the enumeration of taxa, which has become a favoured, but incomplete, measure of biodiversity. Morphological diversity (disparity) has also proved an important complementary measure of biodiversity. By combining richness and disparity data, more nuanced hypotheses about the diversification of clades in space and time can be formulated and tested with broader suites of data. Studies of both of these aspects in isolation have been important in establishing evolutionary patterns, which have provided the impetus for considerable theoretical work. Many theoretical models posit particular evolutionary processes that should leave distinctive signatures when phylogenetic and morphometric data are analyzed in tandem. We compared three methods available for combining cladograms and morphospaces. Stone proposed a geometric method for reconstructing the position, and hence the morphology, of common ancestor in morphospaces. Harmon and colleagues developed a method that traces the distribution of disparity among clades and subclades through time. Sidlauskas produced the phylomorphospace approach. Each method makes different claims about the additional insights into the evolutionary process they can provide. Sensitivity and robustness analyses with real and simulated datasets allow fresh insights into the relative performance of the three methods. From this evidence base we can determine which techniques are most apt for particular macroevolutionary questions.

S1 - DISENTANGLING SIGNALS OF REGIONAL BIODIVERSITY CHANGE FROM GEOLOGICAL AND SAMPLING BIASES

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All parties in the current debate about the extent to which palaeontological diversity curves reflect genuine biological processes are seeking the same answer: what is the signal:noise ratio? Palaeontologists have cursed the vagaries of the fossil record, but their problems are not so different from those of ecologists. However, ecologists have been bullish about their ability to generate accurate richness estimates from their incomplete samples using statistical models. We propose that two other approaches developed by ecologists can also offer solutions to approportioning observed changes in richness among geological biases, sampling biases and genuine fluctuations in richness. The key to applying these methods lies in combining spatially explicit dinosaur and palynological datasets. Cam *et al.* (2002) exploited the properties of nested species-area relationships to determine whether greater sampling effort alone can explain observed increases in richness as larger areas are sampled, or whether habitat effects also need to be invoked. Estimates of richness based on count data are compared to estimates based on a model that tests whether significant differences exist in the chance of encountering different taxa, offering a new means of estimating sampling probabilities of fossil taxa. We also adapt landscape ecological analysis of the effect upon richness

differences in habitat complexity among areas of equal size for palaeontological problems. Geoprocessing of geological maps in GIS allows testing of whether more 'geocomplex' areas contain more fossil taxa. Through the application of these methods we provide fresh, quantitative evidence for the relative roles of geological and sampling biases.

S26 - A MID SILURIAN RED-GREEN TO GRAY-BLACK SHALE TRANSITION: A CASE STUDY IN TIME SPECIFIC COLOR FACIES

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Early Silurian rocks in the Appalachian Basin of eastern North America display a long-lived red-green shale color regime (late Rhuddanian-late Telychian) that shifts abruptly to a gray-black shale color regime (early to mid-Wenlock) coincident with the Ireviken positive carbon isotope excursion. The distribution of storm-generated sedimentary structures, macrofossils, and bioturbation suggest that during the early part of the Silurian down-ramp environments were characterized by red shales and ironstones, while up-ramp green shales and a combination of hematitic and glauconitic limestones were being deposited. Most sections show an abrupt shift to gray and black shales with pyrite-rich carbonates in down-ramp sections and gray shales with associated phosphate-rich carbonates in up-ramp settings. In all sections the shift from relatively low to high carbon isotope values is abrupt, paralleling the pattern shown in the authigenic minerals and organic concentrations, indicative of a minor stratigraphic break. Only in some of the basinal sections in central Pennsylvania can a transitional series in both the color facies and carbon isotopes be observed without indication of a depositional hiatus. The Upper Visby interval on Gotland shows a similar transitional position within the lithologic and carbon isotope trends. The consistency of these patterns regionally within eastern North America and between eastern North America and Gotland suggests a strong extrabasinal control on ocean chemistry that is not the direct result of base level fluctuations or basin geometry, which controlled many other aspects of facies distribution.

S20 - EXPERIMENTAL DEGRADATION OF MICE AND BIRDS: IMPLICATIONS FOR THE FOSSIL RECORD

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Laboratory-based degradation experiments are an invaluable tool for understanding decay processes but have rarely been undertaken for higher vertebrates, most notably birds and mammals, which are common elements of lacustrine-hosted exceptional biotas. In order to elucidate the factors that control the taphonomy of these vertebrates, specimens of the zebra finch *Poephila guttata* and the mouse *Mus mus musculus* x. *domesticus* were degraded under controlled conditions for 18 months. Experimental programmes simulated freshwater, marine, (collectively 'aqueous') and speluncar ('dry') settings. The results reveal that the pattern, and rate, of physical degradation differ significantly between aqueous and dry settings and, more surprisingly, between birds and mice. In particular, decay is markedly slower in mice than birds; skeletons of the former remain articulated, and retain soft tissues, for considerably longer during decay. These variations can be attributed, at least in part, to differences in internal anatomy and tissue composition, e.g. the better articulation of the pelvic girdle in mice is enhanced by its proximity to extensive fat deposits. In all experiments, the impact of biological and environmental controls on decay patterns is overprinted strongly by variations in the location, and extent, of the microbial biofilms that developed on the decaying carcasses. These experimental data thus provide a basis for interpreting taphonomic patterns in birds and mammals in lacustrine-hosted exceptional biotas such as the Middle Eocene Grube Messel biota. We hypothesise that, given a robust dataset, the fidelity of preservation will be consistently higher in mammals than birds in this, and similar, biotas.

S20 - A NEW INTEGRATED APPROACH TO TAPHONOMIC ANALYSIS OF EXCEPTIONALLY PRESERVED TAXA

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Quantitative statistical techniques are used infrequently in investigations of the taphonomy of exceptionally preserved taxa. This compromises our attempts to elucidate the biological and environmental factors that control the fidelity of physical and soft tissue preservation. In this study we present a new, integrated approach to taphonomic analysis of exceptionally preserved taxa using a combination of quantitative and qualitative data for exceptionally preserved frogs (*Rana pueyoi*) from the lacustrine-hosted Late Miocene Libros biota (NE Spain). The frogs occur within a series of laminated mudstone facies and vary in their degree of completeness, degree of articulation, limb positions, and the extent, type, and fidelity of preserved soft tissues. For each specimen, we coded its physical- and soft tissue taphonomy using twelve indices, and its lithological context. Statistical analysis reveals no correlation between any of the taphonomic indices and lithological context: variations in the taphonomy of the frogs are independent of cm-scale variations in lithology and, by inference, short-term fluctuations in environmental conditions. The consistently high fidelity of skeletal preservation and the preservation of soft tissue as organic remains reflect the general nature of the sedimentary environment, i.e., burial within laminated organic-rich muds below anoxic, monimolimnetic waters of a deep, stratified lake. Superimposed upon this environmental control are a suite of factors related to the biology of the frogs; the most important of these is the original biochemistry of specific tissues.

S8 - BIOGEOGRAPHY OF ORDOVICIAN OSTRACODS: PALAEO-CONTINENTAL OR CLIMATIC CONTROLS?

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We present a pilot study of the global biogeography of shelf marine ostracod genera for two Ordovician time-slabs, thought to reflect greenhouse and glacial climate states respectively. These correspond to the earliest Late Ordovician (*Nemagraptus gracilis* interval) and to the latest Ordovician (Hirnantian Stage). At present, the palaeolatitudinal range of the material includes equatorial to high latitude (> 60°S) for the *gracilis*-interval assemblages, but is mainly limited to low latitudes for the Hirnantian. Cluster and correspondence analyses of ostracod datasets from the *gracilis*-interval reveal five distinct biogeographical provinces: Baltican, Laurentian, Gondwanan, Siberian and Kazakhstanian. The biogeographical affinities of the Argentine Precordillera ostracod assemblage are poorly determined. Ostracod biogeography appears

dominantly controlled by palaeocontinental affinities and less influenced by the latitudinal surface temperature gradient. Thus, Laurentia and Siberia may have been positioned in the tropics during the Ordovician, but have taxonomically distinct ostracod faunas. The situation with the benthic ostracod fauna contrasts with that determined for planktonic 'mixed-layer' organisms (chitinozoans, graptolites), where palaeolatitude has been a more significant control. The Hirnantian interval contains ostracod data from a limited number of localities, mainly in Baltica. Two groups revealed by cluster analysis could be tentatively interpreted as tropical faunas (upper-middle ramp localities of Baltica, together with Yukon) and calm water faunas (lower ramp localities of Baltica, and Carnic Alps from Peri-Gondwana). An overall decrease of ostracod provincialism is suggested for the Hirnantian but a response to global cooling is not clear from the distribution pattern, mainly because of the scarcity of high-latitude data.

S27D - NEW DATA ON THE MIOCENE MARINE OSTRACODES FROM THE AZORES

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The Azorean archipelago is located in the middle of the northern Atlantic Ocean (36°55' to 39°45' N, 24°45' to 31°17' W). It comprises nine islands, about 1,500 km west of Portugal. The Miocene outcrops of Malbusca, located on Santa Maria Island, have been investigated and a preliminary identification of fossil marine Ostracoda undertaken. Eight taxa, most probably new species, are reported from the Azores: *Neonesidea* sp., *Xestoleberis* sp., *Pontocythere* sp., *Caudites* sp., *Callistocythere* sp., *Mutilus* sp., *Loxoconcha* sp. and *Hermanites* sp. The depositional palaeoenvironment is interpreted as epi-neritic (~30–40 m depth) and probably in warmer water conditions.

S3 - STRATIGRAPHIC DISTRIBUTION OF *SPHENOLITHUS* IN THE COLOMBIAN CARIBBEAN SEA FROM LATE EOCENE TO LATE MIOCENE

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Specimens of the genus *Sphenolithus* (calcareous nannofossils) were studied in order to improve biostratigraphic patterns as well as insights into the changes in paleoceanographic and environmental conditions from late Eocene to late Miocene in the Caribbean region. Three sequences were analyzed: two recovered in onshore Colombian (Arroyo Alférez and Carmen de Bolívar, Estratigráfico 4) and the offshore (ODP 999A). In all sequences the record is generally continuous and preservation of nannoliths good. The genus *Sphenolithus* is present within the fossiliferous samples of the entire sections with different abundances. Differences among patterns of distribution, abundance and morphological aspects of *Sphenolithus* were analyzed. Exceptional abundances in *S. heteromorphus* were registered both in ODP 999 and Carmen de Bolívar, Estratigráfico 4 sections. Also very high abundance of *S. abies* was identified in the ODP 999. *S. heteromorphus* and *S. abies* become the dominant taxa in the nannofossil assemblage. It also was proposed that *Sphenolithus* could produce blooms in temporarily available nutrients and strong stratification of surficial water masses, hypothesizing they would be like r-selected species adapted to a deeper nutricline position.

S3 - CALCAREOUS NANNOFOSSIL FLUCTUATION IN THE TETHYAN REALM DURING THE OCEANIC ANOXIC EVENT 2 (OAE2)

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A significant biotic turnover accompanied the deposition of the Oceanic Anoxic Event 2 (OAE2), mirrored in the diversity and composition of the marine planktonic faunas and floras, especially of calcareous nannofossils that are very sensitive to biogeographical and environmental fluctuations, being affected both by oceanic and atmosphere modifications. This paper focussed on the fluctuation pattern of calcareous nannofossils recorded in sections from Romania and Spain, throughout the OAE2 (within the Cenomanian-Turonian boundary interval). The blooms of the nannofossil fertility proxies such as *Biscutum constans* and *Zeugrhabdotus erectus* reflect changes in primary productivity of the surface waters, from a mesotrophic setting (prior OAE2) towards a eutrophic setting (at the debut of OAE2), preceding the instauration of an anoxic regime. The maximum abundance of *Biscutum constans* is situated, in the studied sections, towards the lower part of OAE2. This trend presumably indicates high fertility episodes, but also cooling intervals, as the nannofossil *Biscutum constans* seems to be more related to cooler-surface waters. The record, in Spain, of the Penrich faunal components (i.e., *Hepteris septemsulcata*) in the intervals of high-fertility nannofossil blooms supports this assumption. The blooms of the calcareous dinoflagellate *Thoracosphaera* genus, during the OAE2, indicate the establishment of stressful marine conditions together with high nutrient supply.

W9 - *IOWADIPTERUS HALLI* REVISITED

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Iowadipterus halli is a Middle Devonian (Givetian) long-headed lungfish known from one specimen found in Vinton Quarry, Vinton, Iowa, USA. It comprises a three-dimensionally preserved complete head plus the anteriormost part of the body. The external dermal skeleton of the skull was described by Schultze in 1992: it shows a number of apparently primitive characters such as narrow rectangular submandibulars and absence of E bones. This suggests that *Iowadipterus* may occupy a deep position in lungfish phylogeny, but unfortunately there is limited data overlap with other primitive genera such as *Dipnorhynchus*, *Uranolophus* and *Stomiahykus* that are represented principally by braincase, dental and skull roof material. This specimen was CT scanned at University of Texas, Austin, and a 3D model of the skull and its internal features is being created. A complete neurocranium is present in the specimen, although certain parts are only faintly visible, and major parts of the endocranial cavity including the inner ears are visible. Palatoquadrate, lower jaw, dentition and ceratohyals are also well preserved. The dentition consists of tooth plates with well-defined tooth rows, comparable to those of *Stomiahykus* or *Jessenia*. *Iowadipterus* also has a dorsal process on the palatoquadrate, previously known from primitive lungfishes such as *Diabolepis* and *Dipnorhynchus.* A cranial rib appears to be preserved in articulation with the occiput. Together with the well-preserved dermal skeleton, which is more complete than in other basal lungfishes (where only the skull roof is adequately known), these features will contribute greatly to the resolution of basal lungfish phylogeny.

S26 - FAUNAL CHANGES AND HI-RES BIOSTRATIGRAPHY THROUGH A COLOUR-SHIFTING LIMESTONE SEQUENCE: THE UNRAVELLING OF A MIDDLE ORDOVICIAN ECO-EVENT IN BALTOSCANDIA

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The fossil fauna through the grey 'Täljsten' sequence in the otherwise red orthoceratite limestone at Kinnekulle, Sweden, have been studied. Adding to the anomaly of this interval are findings of fossil meteorites in and in close proximity to it, attesting to the increased influx of extraterrestrial material to Earth approximately 470 Ma. The Täljsten is slightly more coarse-grained than enclosing strata, whereupon previously suggested to reflect a regression. Furthermore, it is traceable via Öland to southern Estonia, indicating that this event affected the greater part of Baltica. The initial study objective was the conodont fauna and potential changes related to shifting environmental conditions. Hence, a 2.5 m succession at Kinnekulle was sampled bed-by-bed, comprising the 1.3 m grey interval and enclosing red strata. Observed changes in conodont abundance and occurrences of depth-indicating taxa confirm a sea-level drop, resulting in faunal re-organizations that progressively can be followed throughout the sequence and correlated to a changing environment. The returning to pre-event conditions is also observable amongst conodonts, which suffered both temporary and long term effects. The precise correlation between lithological changes and responding conodont fauna demonstrate that conodonts have potential as fine-scaled palaeoecological indicators, rather than only as relative depth-indicators. The driving mechanism(s) behind this sea-level fluctuation is undetermined; however, because of the extraterrestrial material associated with these layers, the notion that their formation is impact-related cannot be rejected. The high-resolution conodont bio-stratigraphy rendered is applicable in identifying contemporaneous Baltoscandian strata, allowing for additional studies that hopefully will further elucidate this interval.

S6 - WHAT'S ON THE CARNIVORES' MENU 2 MILLION YEARS AGO? MULTIPLE EVIDENCE FROM MANDIBULAR FORM

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Mammalian predators are important components of terrestrial ecosystems. Predation can have a profound effect on wild herbivore community, and it is important to understand prey preference of carnivorous taxa to better identify trophic chain also in the past. I present a geometric morphometric survey of the mandible in extant mammalian carnivores in order to predict potential prey preferences of an extinct carnivore community from Europe, 2 million year ago. The mandible is an ideal skull element to investigate because it is primary devoted to feeding. Geometric morphometrics facilitates quantification of both size and shape components of the mandible which, in turn, are intimately correlated with broad prey size class (small, medium and large). Extinct large predators such as long canine cats, wolf-like canids and the giant hyena were all capable to hunt relatively large prey, while the Plio-Pleistocene cheetah was focusing on medium/small size herbivores. A ratio of each predator body mass relative to its potential prey suggests that the large carnivore community of 2 million years ago was supported by ungulates whose estimated body weight ranged between 60 and 250 kg (mostly ancestors of modern deer and wild boar). Megaherbivores represented a difficult target for Plio-Pleistocene predators while small gazzelline bovid exhibited a high predation pressure. This conclusion is validated by the relative abundance of each prey in the European fossil record.

S6 - WHAT TO DO WITH FRAGMENTARY FOSSILS? AN EXAMPLE BASED ON A FOSSIL DOG FROM OLDUVAI BED II

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The interpretation of fossil material to reconstruct ancient environments is a key issue in palaeontological research. Although skeletal elements of vertebrates tend to have a relatively high rates of preservation, fragmentary postcrania are rarely incorporated in palaeoecological data. However, even partial elements preserve meaningful biological signals.

Here, we present a complete morphometric analysis based on a radius fragment belonging to a fossil dog from Olduvai Bed II (Tanzania, Africa). Fourteen linear measurements were used in a multivariate statistical analyses to predict first taxonomic affiliation (i.e., genus) and potential adaptation to open or closed environments. Extant canids are ascribed to open or closed categories according to the commonest biome occurring in their geographical range. Six relevant measurements were selected by linear discriminant analysis to predict genera at a discrete rate of success (65% in total, but 50% if cross-validated). On the other hand, habitat adaptation can be predicted by all measurements through a binomial logistic regression model with a good success rate (open 84%, closed 77%). These statistical models indicate with a high degree of accuracy that the radius fragment from Olduvai Bed II belongs to a medium size member of the genus Canis with a preference for relatively closed environments.

S23 - NEW INSIGHTS AND EVOLUTIONARY SIGNIFICANCE OF A STROBILAR LYCOPSID PLANT FROM THE UPPER DEVONIAN OF SOUTH CHINA

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Numerous specimens of the Late Devonian *Minostrobus chaohuensis* Wang were collected from the Wutong Formation of Chaohu City, Anhui Province, China. Our restudy of this lycopsid plant provides new insights into its morphological and anatomical characters and its phylogenetic significance. Sporophylls are spirally arranged, long triangular in shape and have an abaxial keel containing vein. With a decurrent base, each sporophyll consists of a short V-shaped pedicel and an entire lamina. The lamina is divided into three parts, i.e., a laterally extended part, upturned distal part and a downturned heel. One spherical to ellipsoidal sessile sporangium is attached to the adaxial surface of the sporophyll by a subarchesporial pad. Each sporangium contains four megaspores producing a tetrad and is partly packed by the lateral lamina. The solid exarch primary xylem bears several peripheral protoxylem strands and occurs at the stelar centre of strobilus. The observation of the adaxial surface and serial sections of the sporophylls indicates that ligules are absent. Lycopsids include two groups, the eligulate homosporous primitive group and the ligulate heterosporous advanced group. In *Minostrobus*, the lack of ligules appears primitive, while other characters (heterospores, sporangia partly packed by porophylls, only four megaspores in one sporangium) are derived. *Minostrobus* thus displays a typical mosaic evolution and suggests the basis for a new plant group, i.e., the eligulate heterosporous lycopsid.

S3 - QUANTIFYING THE IMPACT OF ANTHROPOGENIC CARBON DIOXIDE ON PLANKTIC FORAMINIFERA

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Anthropogenic emissions of carbon dioxide (CO_2) from the burning of fossils fuels are taken up by a number of sinks, including the ocean. As the concentration of CO_2 increases seawater becomes less basic, a process referred to as 'ocean acidification'. A consequence of this is lowering of the carbonate ion concentration [CO^{2-}_3] which impacts upon the calcification rates of marine calcifying organisms including corals, coccolithophores and planktic foraminifera. The shell weight of planktic foraminifera can be used as a proxy for the thickness of the test, itself a measure of the rate of calcification; thin shelled individuals are likely to be lighter than thicker forms. Recent studies have shown that ocean acidification is already influencing the calcification of planktic foraminifera in the surface ocean and is documented in the youngest part of the marine geological record, the surface sediments of the ocean floor. Presented here are the results of a study on a range of planktic foraminifera, including symbiotic and asymbiotic species, along a N-S transect of the North Atlantic. The importance of planktic foraminifera in the transport of organic carbon to the deep ocean and marine ecosystems is likely to be affected with increasing anthropogenic emissions.

S24 - NUMERICAL MODELING OF *PSEUDOSPOROCHNUS* (CLADOXYLOPSIDA), A TREE OF MIDDLE DEVONIAN AGE

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The earliest plants to have reached the tree habit belong to the Pseudosporochnales, a Middle Devonian order of Cladoxylopsida. Several divergent reconstructions of arborescent pseudosporochnaleans have been presented in the 20th century literature. The recent reassessment of Belgian remains of *Pseudosporochnus* together with the discovery of well-preserved specimens of *Wattieza* borne on *Eospermatopteris* stumps at Gilboa (New York) have provided a wealth of information on the morphology of these trees, and suggested a high level of consistency in the architecture of the Pseudosporochnales. These leafless plants comprise a main stem, or trunk, bearing closely spaced determinate branches. The branches are digitate and covered with small lateral branching systems of various morphologies, that eventually bear pairs of sporangia. The root system appears entirely adventitious and borne on the swollen base of the stem. The 3-D numerical plant model we propose for *Pseudosporochnus* incorporates this information supplemented by that derived from the quantitative analysis of 55 specimens of *Pseudosporochnus nodosus* from the collections of Université de Liège (ULg). The data are processed with the AmapSim software in order to construct and simulate a 3-D growing numerical plant model and an attempt is made to use this model to estimate the amount of carbon that *Pseudosporochnus* may have accumulated during its growth. Despite their large size and wide paleogeographical distribution, the impact of such trees on the carbon cycle may have been moderate.

S5 - MANAGEMENT OF MICROPALAEONTOLOGICAL COLLECTIONS - SCIENCE OR TRADITION?

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Some techniques used in the management of micropalaeontological collections have seemingly been passed down through the generations rather than based on solid studies to elucidate best practise. The use of adhesives on micropalaeontological slides is one such issue. Studies of microfossil slides from the collections at the Natural History Museum and the adhesives used to attach individual specimens have potential for suggesting adhesives that are long lasting and do not damage specimens by cracking, encouraging mould growth or pests. Traditionally used mounting glues such as gum tragacanth and gum arabic may not be ideal for the long term storage of specimens while some cellulose water based adhesives may be better solutions. The viability of long term storage of individual microfossil specimens on SEM stubs has not previously been investigated and storage of this nature is often a matter of policy depending on the institution where the material is stored. SEM stubs from within the NHM collections have been re-photographed and results compared with original publications to enable suggestions for suitable stub storage to be made. While studies confined to one museum can help towards suggestions of best practise, ultimately inter-museum and preferably inter-continental studies are needed to thoroughly address these issues.

S23 - FIRST TETRAPOD TRACKS FROM THE CARBONIFEROUS OF CHINA

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We report the discovery of the first tetrapod tracks from the Carboniferous of the Baode district, north of Shanxi Province, China. The discovery area is located north of the Ordos basin which is famous for its richly fossiliferous “Hipparion clay” of late Miocene age. Almost all the valleys in the discovery area dissect the coal-bearing clastic Carboniferous bedrock, which is quarried in several areas. The track-bearing slab was found in the vicinity of a semi-abandoned coal mine. The slab consists of a white to grey, coarse to medium-grained sandstone (sublitharenite), apparently derived from thick bedded sandstone layers close to the mining area. There are parts of three footprints on this slab pointing in the same direction. These footprints belong to a relatively large trackmaker. The manus of this trackmaker apparently was at least tetradactyl, and the pes was at least tridactyl. The only late Palaeozoic tetrapod footprint ichnogenera that are similar in size and morphology to these footprints are Alabamisauripus, Attenosaurus and Dimetropus. The greatest similarity is to Dimetropus; however, the sole impressions that are characteristic of Dimetropus are missing in the Chinese specimen. We thus assign the Chinese tracks to aff. Dimetropus. This means the trackmaker may have been a pelycosaur, though an anthracosaur origin for such large Carboniferous tracks (as has been posited for Attenosaurus and Alabamisauripus) cannot be excluded. The global Carboniferous record of tetrapods is mostly from North America and Western Europe (Pangea’s Euramerican sector). Thus, the footprints documented here are the first record of tetrapods from the Asian Carboniferous.

S27A - FIRST REPORT OF *EQUUS* (MAMMALIA, EQUIDAE) FROM THE PLIOCENE OF THE ZAGROS BASIN, IRAN

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The Agha Jari Formation is the youngest (Late Miocene-Pliocene) member of the Fars Group in the Zagros basin of southwest Iran, which also crops out in neighbouring countries, including Iraq and Syria. The Lahbari Member, also known as Bad Land Beds and Lower Bakhtyari, forms the upper member (Pliocene) of the Agha Jari Formation. It is mainly composed of buff-weathering, soft, gypsum-veined siltstone and silty marl with interbeds of sandstone and gypsum. This member overlies the more prominent feature-forming sandstones and red marls of Agha Jari Formation and is unconformably overlain by the coarse clastics (conglomerates) of the Bakhtyari Formation, of Pleistocene age. Lithostratigraphic equivalents of the Lahbari Member, although much older (Late Miocene), in the Jebel Hamrin (Injana) area of Iraq contain fossil vertebrates. However, to date, the only vertebrate fossil found in this unit in Iran was an isolated tooth of the horse *Hipparion* recorded by Harrison from the Lahbari of Khuzestan. Here we report the discovery of horse upper molar teeth from the Lahbari member west of Masjid Soleiman, Khuzestan Province of Iran, which possess unequivocal features of *Equus* (protocone connected to protoloph). This confirms the Pliocene age of the Lahbari Member. Furthermore, the co-existence of this genus with *Hipparion* in the Pliocene of Iran, which is plausible according to earlier discoveries of the latter taxon, is remarkable. The mainly Late Miocene equid genus *Hipparion* still occurred in the Early and Middle Pliocene of Eurasia and this discovery is concordant with this range.

S6 - A METHOD FOR VISUALIZATION OF SIMILARITY/DISPARITY ANALYSIS

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Quantitative analyses of similarity and disparity of faunas by means of presence/absence data and resemblance indices have a long tradition of use in palaeontology. Several indexes for measurement of distance between localities and their associated faunas exist, but all have problems with representing patterns. In particular, traditional ways of comparing results of these studies are poorly designed for displaying the spatial information of large data sets comparing many localities. In order to solve this problem we have developed a computational equivalent of chronofauna concept (sensu Olson) in terms of faunal resemblance. A chronofauna in this sense is a set of localities united by faunal similarity to an arbitrarily selected type or standard locality. Using GIS techniques to plot the value of the faunal resemblance index of individual localities belonging to a chronofauna allows us to map the rise and fall of these entities over a series of time slices. We applied the method to Neogene mammal data from the NOW database (www.helsinki.fi/science/now). Several Eurasian chronofaunas were defined based on major fossil localities (e.g., Pikermian, Baodean and Tunggurian) and show how the patterns of endemism and cosmopolitanism of chronofaunas can be mapped and traced in space and time. Like individual species and genera, chronofaunas typically appear to have unimodal histories including buildup, climax, and decline. In contrast to the individual genera and species where rise and fall appear symmetrical, the decline of the chronofaunas studied so far appears significantly more abrupt than their gradual buildup.

S27B - PHYLOGENY OF THE TUBE-BUILDING HEMICHORDATA REVEALS THAT *RHABDOPLEURA* IS AN EXTANT GRAPTOLITE

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Graptolites are an important component of early-middle Paleozoic biotas and they are widely recognized as being related to pterobranch hemichordates. Hemichordates provide data critical to our understanding of deuterostome phylogeny. However, there have been very few attempts to resolve the relationships among both fossil graptolites and extant pterobranch hemichordates. In order to test previous hypotheses concerning their evolutionary relationships, we have undertaken a phylogenetic analysis incorporating data from extant species of *Cephalodiscus* and *Rhabdopleura* and representatives of each of the major graptolite orders. Our results reveal two well supported clades within the Pterobranchia: the cephalodiscids, and *Rhabdopleura* plus all graptolites. *Rhabdopleura* nests among the benthic, encrusting graptolite taxa and shares all of the important synapomorphies that unite the graptolites. Therefore, rhabdopleurids can be regarded as extant members of the Subclass Graptolithina, a sister taxon to the Subclass Cephalodiscida. The nesting of *Rhabdopleura* within the graptolites is significant because it allows us to infer the zooid morphology, mechanics of colony growth, and paleobiology of extinct graptolites, in direct relation to living members of the clade. It is not possible to resolve clear relationships within and between most of the previously recognized graptolite orders in our analysis, although tuboids and dendroids appear to be paraphyletic groups. A clade consisting of dendroids+graptoloids (here named the Division Pan-Graptoloidea) is well-supported in this analysis, as is a crown-like group, the Subdivision Graptoloidea, which encompasses the abundant and widespread planktic graptoloids.

S19 - FEEDING STRATEGY MODELS OF EDIACARAN COMMUNITIES

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The Ediacara biota contain the first documented complex, macroscopic organisms on Earth. They have few similarities with modern organisms, making the ecology very difficult to assess. In order to investigate possible feeding strategies, nutrient requirements and autecologies for these organisms, I present an ecological network model for a middle Ediacaran (575–560 Ma) Avalon-type biota. The model consists of the 12 most dominant Ediacaran species from the Avalon assemblage, microbial mats, planktonic microbes and nutrients. Fossil abundance, body size data and life history data for planktonic microbes was input into Lotka–Volterra type differential equations to describe the ecosystem dynamics. Stability of the ecosystem was derived using eigenvalues of the Jacobian community matrix and analysed in terms of feedback loops. Osmotrophy, suspension feeding, chemosynthetic and photosynthetic strategies for the 12 Ediacaran species were considered, with each strategy having different life history traits and interspecies interactions. The ecological feasibility of different affinities of *Aspidella* and other problematica were investigated along with the amount of nutrients required for the 12 species. An alternative model, with species grouped by different morphologies, was used to investigate different autecologies. It was found that the majority of non-microbe biomass must feed osmotrophically, because there is not enough energy in the system to support a large biomass of suspension feeders. Metazoans have never exhibited large-scale multicellular osmotrophy, supporting the theory that Ediacaran organisms were not the precursors to modern life.

S6 - MEASURING MODULARITY AND MORPHOLOGICAL INTEGRATION: EXAMPLES FROM HOMINOID CRANIAL MORPHOLOGY

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Studying the evolution and development of correlated characters has a long history in palaeontology and evolutionary biology. Groups of correlated characters (variational modules) often are considered to be the result of dissociated local developmental or genetic factors. Such characters would tend to evolve in a coordinated fashion, but relatively independent from other less correlated traits. I demonstrate that this common assumption does not hold in the presence of overlapping pleiotropic factors and allometric growth processes, and further ignores the spatial configuration of measurements. For example, certain sets of pleiotropic factors can equally well induce modular phenotypic variation—no local developmental factors are necessary for a modular covariance structure. It is thus not possible to infer genetic or developmental modularity from standing phenotypic variation alone. In spite of these difficulties it is possible to estimate pleiotropic and local (modular) patters of phenotypic variation in a morphometric data set and to model underlying developmental interactions. I demonstrate a statistical approach, based on partial least squares analysis, and apply it to the evolution of hominoid cranial morphology. I show that factors with wide pleiotropic effects on the cranium account for a large amount of shape variation, but mainly by extension or truncation of otherwise conserved developmental pathways. Local factors (modular shape characteristics) have more degrees of freedom for evolutionary change than mere ontogenetic scaling. Cranial shape is similarly integrated during development in all three species, but human evolution involves dissociation among several characteristics.

S19 - RAPID DIVERSIFICATION OF ICHNOFOSSILS IN THE EARLIEST CAMBRIAN

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In order to reveal whether the biological evolution represented by benthic animals in the Early Cambrian was explosive or not, trace fossils were comparatively investigated in the Early Cambrian Chapel Island Formation in the Burin Peninsula, Newfoundland, Canada and the Middle Cambrian strata in the Clarks Fork Canyon, northern Wyoming, the United States. Special attention was paid to the diversity of trace fossils and their sizes, densities and their stratigraphic changes. Among various trace fossils, *Planolites* was used. In the Earliest Cambrian (Treptichnus pedum zone), increase of trace fossils seems to have occurred twice, one immediately after the PC/C boundary and the other in the uppermost part of the T. pedum zone. On the other hands, ichnofossil assemblages in the lower to middle part of the T. pedum zone are almost uniform even in two different sedimentary facies. This common occurrence of the ichnofossil assemblage in the different facies indicates that trace fossil assemblages unique to one sedimentary environment have not developed in the earliest Cambrian. Diameters of *Planolites* are mainly small and their range of distribution is narrow in the T. pedum zone. However, variously sized *Planolites* occur in the next Rusophycus avalonensis zone. Such variously sized *Planolites* is also seen in the Middle Cambrian Wolsey Shale in Wyoming. It indicates that variously sized *Planolites* producers appeared in the R. avalonensis zone. In addition, bedding planes are more intensely bioturbated in the R. avalonensis zone than in the T. pedum zone. The levels of bioturbations are almost comparable with that of Middle Cambrian. Although intense bioturbation is observed in the Early and Middle Cambrian, microbial mat structures frequently occur in the Chapel Island and Wolsey Shale formations. Therefore, heavy bioturbation did not always occur in the Early and Middle Cambrian but such benthic biological activity frequently weakened during this age interval.

S15 - RESPONSE OF THE LAURENTIAN OSTRACOD FAUNA TO GLOBAL CLIMATE CHANGE DURING THE EARLY PALAEOZOIC ICEHOUSE

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Ostracods first appear in the Tremadocian at about 488 Ma and were globally diverse by the Darriwilian (460 Ma), represented by thousands of species belonging to hundreds of genera. Ostracods were present in both high (Gondwanan) and low (e.g. Laurentia) latitude regions, reaching peak diversity in the carbonate platforms of equatorial palaeocontinents. The wide distribution of ostracods makes them potential tools for tracking changes in latitudinal temperature gradient as global climate cooled through the Late Ordovician. Ostracod biodiversity remained high through the Late Ordovician but suffered major decline during the Hirnantian glacial maximum at 445 Ma. Here we examine the Laurentian ostracod fauna prior to, during, and after this interval of major global cooling. We find that (1) Laurentian ostracod biodiversity declined rapidly into the Hirnantian; and (2) biodiversity took much time to recover, only reaching 'Darriwilian-levels' by the Wenlockian at ca 425 Ma. Instability in the Early Silurian climate caused by a persistent high latitude Gondwanan ice sheet is a plausible factor influencing the slow recovery of faunas.

S16 - RATES OF SPECIATION, EXTINCTION AND PHENOTYPIC EVOLUTION IN BIRDS AND MAMMALS

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Birds and mammals are similar in many ways: both groups of species dominate higher trophic levels of most biota; both originated somewhere during the late Jurassic, while most of the extant diversity originated during the early Tertiary; and physiologically both groups share many properties, most notably homeothermy, which has resulted in comparable ecology and life history. Given these similarities, it is interesting that mammals appear to have substantially higher rates of evolution than birds. For years palaeontologists have argued that high rates of morphological evolution in mammals are due to high speciation and extinction rates. On the contrary, the majority of evolutionary biologists continue to lean towards a model of purely gradual evolution, and differences in rates of evolution are poorly understood: mammals are hypothesized to have high rates of nucleotide sequence evolution because of high homeothermic metabolic rates, while evolution in birds is thought to be slower –despite their higher metabolic rates- due to constraints imposed by flight ability. We used neontological methods to compare rates of morphological evolution in birds and mammals, analyzing measurements of present-day species on molecular phylogenies, while paying special attention to flightless birds and flying mammals. We find that when the assumption of purely gradual evolution is released, character evolution appears concentrated in speciation events, and instantaneous rates of evolution appear comparable between birds and mammals; the apparent difference in rate of evolution can be explained by differences in rates of speciation and extinction between the groups, as has long been suggested by palaeontologists.

S10 - RELAXATION OF CARBON CONCENTRATING MECHANISM PHYSIOLOGY IN THE COCCOLITHOPHORE *GEPHYROCAPSA OCEANICA* WITH RAISED DISSOLVED INORGANIC CARBON LEVELS

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Although there have been some dramatic past changes in atmospheric CO_2 (pCO_2) the rapidity of the present and human-driven increase is unprecedented. A major current question is how will the chalk-forming coccolithophores respond to this rapidly changing environment; rising pCO_2 will increase the availability of dissolved inorganic carbon (DIC) for photosynthesis and calcification but will also acidify the oceans. Photosynthesis involves carbon concentrating mechanisms (CCMs) to achieve sufficient intracellular levels of DIC for the inefficient carbon-fixing Rubisco enzyme. Whether this means that coccolithophore photosynthesis is not carbon limited at present-day pCO_2 levels is debatable and the phenotypic flexibility of CCM physiology unknown. Because CO_2 reacts with H_2O to form carbonic acid, greater pCO_2 means both more bicarbonate ions to form calcite and more acidity to dissolve it, and so whether rising pCO_2 will affect coccolithophore calcification efficiency is also debatable. Investigating these questions is important for forecasts of how coccolithophores might respond during this critical interval in Earth history. In this study, we demonstrate that the ocean-dominating coccolithophore *Gephyrocapsa oceanica* responds to quadrupled DIC levels with a compensatory decrease in carbon concentrating mechanism activity, maintaining an optimum intracellular DIC environment; it is not carbon limited for photosynthesis at present day CO_2 levels. Scanning electron micrographs also show maintained calcification with raised DIC and no signs of coccolith malformation or dissolution effects. Ongoing experimental work is investigating which genes underlie the change in CCM activity and if analysis of their evolution can give insights into past changes in pCO_2.

S17 - EXPERIMENTAL CONFIRMATION ON CENTER OF BUOYANCY AND GRAVITY IN *NAUTILUS*; RELATIONSHIP WITH STATOCYST POSITION

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One of the requirements of palaeobiology is an understanding of the relationship between skeletal morphology and animal behavioural or movement patterns. Time by time perception of this information, body inclinations, turns, and accelerations, is due mainly to statocysts. The trade-off relationship between the structural complexity of statocysts and the speed of behaviour or locomotion has been repeatedly mentioned in nektonic cephalopods. The simplest category of statocyst form and structure is an egg-like profile possessed by *Nautilus*. The simple form and structure means limited detection of locomotory patterns, whilst the receptor cells per area increases, which results in specialization in the perception of slow movements. This relationship indicates that the sharp monitoring of slow movement patterns requires a lateral pair of statocysts in neighbouring position of the centre of the animal movements. This should be, in the case of *Nautilus*, the centre of buoyancy and gravity, where the unique pitching locomotion originates. This study experimentally specifies the centre of buoyancy and gravity against chambered coiling shells in the *Nautilus* animal. The centres are specified through the ontogeny of *Nautilus pompilius* and the morphocline of the four *Nautilus* morphospecies. The topographical relationship between centres and statocysts will be clarified, and its functional influence on the unique locomotion will be discussed. The future aim is to understand locomotion–shell morphology interaction of extinct ammonoid animals with chambered coiling shells, which is based on this study as a cornerstone.

S27B - ISOTOPIC SIGNATURES FOR THE HABITAT AND GROWTH OF THE MIDDLE JURASSIC AMMONOID QUENSTEDTOCERAS

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Oxygen and carbon isotopic compositions are presented for extremely well preserved shells of the Callovian (Middle Jurassic) ammonoid *Quenstedtoceras* recovered from Lukow, western Poland. Averaged oxygen isotopic temperatures of two individuals analyzed (39 and 31 mm in maximum diameter, respectively) provide palaeotemperatures of 15 and 17 °C. Considering that the oxygen isotopic temperatures of *Gryphaea* (bivalve) and nektonic vertebrate remains recovered from the Callovian Oxford Clay of the UK show 11 and 24°C, respectively (Anderson et al, 1994; Price and Page, 2008), these two *Quenstedtoceras* individuals seem to have been nektonic swimmers within the Jurassic water column. While the oxygen isotopic compositions of these two individuals do not show a distinct systematic trend, carbon isotopic compositions ($\delta^{13}C$) display a sigmoidal fluctuation in both individuals. Although the amplitude of $\delta^{13}C$ variation is different, one period of isotopic fluctuation corresponds to three quarters to one whorl of growth in each individual. If we assume that the $\delta^{13}C$ of the specimens analyzed reflects the $\delta^{13}C$ of dissolved inorganic carbon (DIC) in the water column where these specimens lived, and that the fluctuation in $\delta^{13}C$ of DIC is annual, we can estimate the growth rate of *Quenstedtoceras* as three quarters to one whorl a year.

S7 - PLICATHYRIDINE BRACHIOPODS FROM THE FRASNIAN (UPPER DEVONIAN) OF THE MIDDLE EAST AND BELGIUM

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Plicathyridines (Athyridida), which disappeared during the Late Frasnian biological crisis, are well-known in the Frasnian of the Russian Platform and the Altai-Sayan Province, but these distinctive brachiopods also occur in Frasnian-aged rocks of the Middle East (Iran and Afghanistan) and Western Europe (e.g. Belgium). In Iran (Esfahan Province), specimens tentatively assigned to *Plicathyris* are present in a biostromal horizon apparently located just below the *Palmatolepis jamieae* conodont Zone whereas similar specimens occur in east-central Afghanistan (western part of the Dacht-e-Nawar). In this area, they are associated with an unidentified species of *Cariniferella* probably belonging to the *C. tioga* group. These orthides may indicate the *P. punctata* Zone in comparison with their occurrence in the Frasnian succession of the Boulonnais (northern France), but further research is needed. In southern Belgium (Dinant Synclinorium), plicathyridines are present only in the shaly La Prée (Nismes Formation) and Ermitage (Moulin Liénaux Formation) members (*P. falsiovalis* to *P. punctata* conodont zones) and belong to the genus *Anathyris* (*A. helmerseni* group); they are thus absent in the Upper Frasnian of the Namur-Dinant Basin. The plicathyridines constitute only a minor part of the Frasnian brachiopod assemblages recognized in the three studied areas.

S21 - PATTERNS AND RATES OF DIVERSIFICATION IN AMNIOTE VERTEBRATES

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The molecular revolution has significantly shaped our understanding of the history of life, and the molecular clock has become a widely used tool for dating the origins of organisms. However, the fossil record still remains important because it provides the empirical basis against which results from molecular studies can be compared. The fossil record is also crucial for calibrating the clock, and therefore has a primary influence on divergence estimates. At the same time, molecular clocks are not only a means to date the divergence of a clade, but can also be used to test for patterns and rates of diversification. Here I present a molecular divergence estimate of amniote vertebrates, the most diverse clade of tetrapods, using a nuclear gene data set including lissamphibians and personally selected fossil calibration dates within a Bayesian framework. I test for increases and decreases in diversification rates for pre-defined time intervals under constant and variable evolutionary rate models and compare amniotes against lissamphibians, in order to test if and when amniotes experienced diversification rates significantly different from those of other tetrapods, and to what extent amniote diversification patterns were affected by mass exctinctions. The obtained results are compared with what is currently known from the amniote fossil record. A more in-depth comparison, however, is currently hampered by the lack of a comprehensive database comprising all known occurrences of fossil tetrapods, the construction of which should be a major endeavour for the future.

S20 - TAPHONOMY OF A NEW UPPER TRIASSIC RHYNCHOSAUR (REPTILIA; ARCHOSAUROMORPHA) ACCUMULATION FROM INDIA

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We report here a new rhynchosaur assemblage from the Upper Triassic Tiki Formation of the Rewa Basin, India. Nine new fossil sites were discovered within an area of about 250x217 sq m. About 600 skeletal specimens (complete and partial elements) consisting of 30% ribs and gastralia, 23% skull bones, 20% vertebrae and 16% limb bones were collected. The specimens show varying degree of weathering, breakage and deformation. These bones were found in association with paleosol profiles suggesting that they were mainly autochthonous-attritional accumulations on non-deposition surfaces. However, 52% of the collected skeletal specimens belonged to Voorhies Group I, whereas Group II and III have almost equal proportions of about 25% and 23% respectively. 43% show abrasion stage V where the bone specimens had high degree of sphericity and roundness. The specimens had experienced short distance transport. Spatial distribution shows different susceptibility of the skeletal elements to fluvial transport. The skull fragments were least transported and constituted the lag deposits whereas the ribs and vertebrae were winnowed out by shallow competent flow. The sites had also yielded varied vertebrate fossils suggesting that the accumulation was a graveyard of mass mortality. It may be hypothesized that the animals became entrapped in the thick Tiki mud after a major flood event. Subsequently, the soft tissues decomposed and the skeletons suffered prolonged sub-aerial exposure. These were later partially dispersed by low velocity water currents resulting in segregation of skeletal specimens and were buried beneath mud deposited during later flooding events.

S27B - PALABIOGEOGRAPHY OF THE TRIGONIOIDIDS OF EUROPE

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Recently new evidence for the distribution of trigonioidids (non marine bivalves) from the early Cretaceous of Europe has come to light. The first discovery of *Nippononaia (Subnippononaia) fordi* from the alluvial Wessex Formation (Barremian) of the Wessex sub-basin, southern England, has now been augmented by new discoveries from different basins in Spain. This has changed the belief that this peculiar group is restricted to Asia. The new Spanish finds are from the Enciso Group (Aptian) of Cornago (Cameros basin, La Rioja province, northesatern Spain), from the Calizas de la Huérguina Formation (Upper Barremian) of Las Hoyas (Cuenca Province, central Iberia) and from the Lower Cretaceous (Albian) of the Escucha Formation at Utrillas (Teruel Province, southeastern Spain). The English specimens and those from the Cameros Basin are associated with the geographically more widespread and common unionoid species *Margaritifera valdensis*, also found in France and North Africa. *Nippononaia (Subnippononaia) fordi* is now also recorded from Las Hoyas (Cuenca Province, central Iberia), from strata of the same age as the English specimens. The other new taxa at the moment are in open nomenclature.

THE ORIGIN OF THE CONODONT SKELETON

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Euconodonts had a biomineralised skeleton, consisting of elements with two parts, the basal body and crown. Bengtson (1976) proposed a model for the evolution of the conodont skeleton, from protoconodonts via paraconodonts, through the acquisition of this euconodont crown. Protoconodonts are now allied with chaetognaths (arrow worms), but the affinities of the paraconodonts are unresolved, and their elements remain candidates for the precursors of the conodont skeleton. Crucially, it is histological features that are used to demonstrate the relationship between these groups. Our experiments with Synchrotron Radiation and Phase Contrast X-Ray Tomographic Microscopy (SR/PCXTM) show that these features can be fully resolved in three dimensions, without the need for traditional invasive histological sectioning. Coeval euconodont and paraconodont faunas from the Middle Cambrian to Lower Ordovician have been examined, alongside elements with well-investigated histological characters, *Ozarkodina* and *Panderodus.* By directly comparing the complete internal structure of the some of the earliest euconodonts, including *Proconodontus, Eoconodontus* and *Cordylodus,* with that of paraconodonts, it is possible to resolve the relationship between the euconodont basal body and the paracondont element, as well as the origin of the euconodont crown. In addition, by using Finite Element Analysis, the functional implications of the evolution of euconodont crown tissue can be decoded. This research has implications not only for the biological affinity of paraconodonts, but also the origin of the conodont (and therefore earliest vertebrate) skeleton. It also represents a break-through in the available techniques for the examination of the structure of conodont elements.

S2 - TESTING THE RELEVANCE OF COMPETITION IN A HIERARCHICAL FRAMEWORK

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From de Candolle's notion that "all organisms are at war," to Darwinian natural selection and the Modern Synthesis, inter- and intraspecific competitive interactions have significantly shaped the development of evolutionary theory. While modern thinking has moved away from focusing on competition, biologists and palaeontologists continue to ascribe a considerable role to 'biotic interactions' in shaping patterns at both micro- and macroevolutionary scales (e.g. trends, escalation). Explicit and quantitative tests within a hierarchical framework are necessary to elucidate the accuracy of this claim (and others that invoke biotic interactions). We tested for evidence of competitive exclusion in ten vertebrate taxa from the Late Cretaceous Western Interior Seaway of North America (WIS) using Geographic Information Systems (GIS) and paleoGIS reconstructions. Traditionally, palaeoecological studies have focused on diversity, abundance, and functional morphological data. However, one way the effects of ecology and environment on species can be observed in the fossil record is as changes in distribution and range size. Thus, significant additional insight may be gleaned from quantitative analyses of palaeobiogeographic patterns. Our investigation found that at macroevolutionary scales, competitive replacement, though not entirely absent, occurred in a minority of pairwise comparisons in the WIS. This raises additional questions, such as: (a) what is the role of phylogenetic proximity in predicting episodes of competitive exclusion? (b) to what degree are ecological niches conserved within clades, and what may be controlling such conservation? and (c) how does the influence of biotic interactions on species distributions and range size reflect and/or illuminate possible mechanisms of speciation?

S10 - CHANGES IN MG RATIOS OF SILICATE MINERALS RELATED TO INTERACTIONS WITH PURPLE NONSULFUR BACTERIA

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One approach to studying ancient biomarkers is laboratory modelling of the interactions between bacteria and solid substrates. To replicate reducing conditions similar to those inferred for the ancient biosphere silicate substrates (volcanic ash, kaolinite, montmorillonite, phlogopite, biotite, and muscovite) were experimentally transformed through anaerobic bacteria. We used purple nonsulfur bacteria, which are representatives of photosynthetic proteobacteria, and studied the chemical composition of the substrate and supernatant liquid before and after interaction. We found that bacterial growth increases the ratio of exchangeable Mg cations in solid substrates. Depending on substrate, the exchangeable Mg-quota increased by a factor of 4.16, 4.09, 3.56, 4.43, 1.37, or 14.8 compared to the equivalent sterile substrates. Experiments with volcanic ash demonstrate that an increased exchangeable Mg ratio parallels a decreased exchangeable Ca ratio. This result remained invariable in four experiments and was independent of the initial concentrations of Mg and Ca in the media. It is well known that proteobacteria, including purple bacteria, use Mg extensively and variously. Proteobacteria have different and more specialized Mg-transport channels compared to those of cyanobacteria. Taking all these observations into account we suggest that: 1) bacterial activity transforms substrates and increases the concentration of exchangeable Mg; and 2) some minerals and rocks with high Mg concentrations may have formed by the mediation of anaerobic microflora.

S12 - A HYDROCARBON SEEP FAUNA FROM THE UPPERMOST JURASSIC OF SPITSBERGEN, SVALBARD

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Fourteen Upper Jurassic carbonate seep mounds have been mapped in Spitsbergen, Svalbard. The largest being 3-4 m high and 5-6 m wide. Analyzed material includes yellow to brown coloured zoned (botryoidal) carbonate, fissure-infilling sparite, and various fossils. The macrofauna consists mainly of small to medium sized bivalves, rare brachiopods as well as worm tubes. Bivalves include at least nine species, including *uculana*, *Nucinella* (the largest known specimens of this genus), *Oxytoma*, *Pseudolimea*, *Entolium*, a solemyid, a large lucinid, arcticids and a possible thyasirid, which, if correctly identified, is the oldest representative of this family. Large accumulations of *Buchia* are present in all mounds as well as in the dark surrounding shale. Gastropods are not common, but a species of *Amberleya* has tentatively been identified. Brachiopods are represented by terebratulid, rhynchonellid, and lingulid species. Vestimentiferan and serpulid worms tubes are also present. The microfauna consists mainly of uncompacted agglutinated and calcareous foraminiferans. Embedded ammonites and large wood pieces are considered not to be related to hydrocarbon seepage. Stable isotope analyses show highly negative $\delta^{13}C$ values (~ -43‰ VPDB) in the zoned carbonate whereas the sparite, ammonite and bivalve samples have $\delta^{13}C$ ~ -22‰. The ^{13}C depletions indicate a methanogenic carbonate origin, in the range typical of thermogenic, rather than biogenic methane. $\delta^{18}O$ ~ -18‰ in the sparite, ammonite and bivalve material indicates precipitation and recrystallization involving hydrothermal fluids, either synsedimentary, or in connection with sill emplacements in the Cretaceous. The carbonate data will be compared with data from surrounding shale samples.

S15 - LINKS BETWEEN CLIMATE, BIOPRODUCTIVITY AND BIODIVERSIFICATION DURING THE EARLY PALAEOZOIC

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Diversification of the marine biosphere is intimately linked to the evolution of the biogeochemical cycles of carbon, nutrients, and primary productivity. Evolving food quantity and quality was primarily a function of broad tectonic cycles that influenced not just carbon burial, but also nutrient availability and primary productivity. Primary production (PP) and phytoplankton in the surface ocean are the base for almost all marine food webs. PP is influenced by the intensity of light, the pCO_2 atmospheric, and the availability of the most important nutrients, i.e. nitrogen and phosphorus. The Early Palaeozoic biodiversification could have been provoked by a sudden increase of nutrient supply and of primary productivity. At that time, excluding changes in ocean dynamics, the nutrient cycling was probably only influenced by the geodynamics events such as volcanicity and orogeneses, because of the quasi-absence of land plants. The goals of this work are to reconstruct the Early Palaeozoic climate and to test the hypothesis of the impact of the primary productivity on the diversity increase of benthic fauna during the most important biodiversification event of the Phanerozoic. Preliminary results show a net decrease of the atmospheric pCO_2 during the Ordovician, to reach a relatively low level in the Late Ordovician-Early Silurian. This decrease is linked to the increase of volcanic rock weathering and to the palaeogeographical changes. PP increases during the Cambrian-Middle Ordovician times, following the increase of volcanic rock weathering. This PP rise coincides with the general increase of taxonomic diversity.

W1 - MORPHOLOGICAL DIVERSITY OF THE CAMBRIAN ECHINODERMS AND ITS CONTRIBUTION TO THE UNDERSTANDING OF THE PRIMITIVE ECHINODERMS

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Echinoderms underwent a major diversification in the Early-Middle Cambrian time interval. They are represented by blastozoans, cyclocystoids, edrioasteroids, helicoplacoids, and stylophorans. Unequivocal remains of the other main echinoderm groups (asterozoans, crinoids, echinoids, holothurians) are not known before the Ordovician. The wide morphological disparity exhibited by Early Paleozoic echinoderms has lead to the multiplication of high level taxonomic entities (classes, orders), and to a very confusing profusion of descriptive terms for each of these high level taxa. As a result, putative homologies between members of different classes are frequently obscured by distinct terminologies, and conversely, structures given the same name in different classes may not necessarily be homologous. This study focuses on the morphological features of the Cambrian echinoderms body wall and their significance in the evolutionary trend of the echinoderms. Calyx could be the plesiomorphic modality, occurring in *Camptostroma*, *Stromatocystites,* crinoids, some edrioasteroids, and the lepidocystid blastozoans. One-piece theca has probably been acquired independently in some edrioasteroids, stylophorans, and some blastozoans. Observations in expected more derived forms suggest an independent evolution of thecae from calyces in several groups. Another morphological trend is based on the body wall plating. Many primitive forms are characterized by imbricate plating, such as in lepidocystid blastozoans, *Camptostroma* or some edrioasteroids. The presence of tesselate or adjacent plating in the more derived forms suggests that this condition could be derived from the imbricate condition.

S20 - RESOLVING TAXONOMIC RESOLUTION ALONG TAPHONOMIC GRADIENTS: COMPARING MACROFAUNA AND CARBONATE MICROFACIES

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Determining the degree to which taphonomic processes affect shell morphologies is fundamental for ecological and diversity studies which rely on high resolution taxonomic identifications. Taphonomic effects on taxonomic resolution vary greatly according to the shell morphologies of the organisms involved, the ambient taphonomic processes in the respective environment of deposition as well as state of shell preservation along taphonomic gradients. A case study is presented for clypeasteroid echinoids for which detailed analysis are present with respect to both environmental distribution and the effects of taphonomic processes on characters. In general, increasing taphonomic impact on the preservation of surface characters leads to an expected poorer resolution of taxonomic identification. This is, however, not straightforward and highly dependent on the specific taxa involved and the distinct taphonomic pathways affecting the shells. A further example concerns components encountered in thin section analysis of Cenozoic limestones. Taxonomic resolution is again highly variable depending on the environment of deposition and the taxa involved. Specific examples are given with respect to coralline algae which are conducive for such a study as species identification is based on characters encountered in thin section. In both cases, variations of preservation as well as presence of taxonomically distinguishing characters affect the respective assignment of the taxa within the hierarchy of classification ranks.

S2 - ADAPTIVE RADIATIONS AND THE FOSSIL RECORD: A CASE STUDY USING JURASSIC AMMONITES

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The burst of lineages during a short span of time is a macroevolutionary pattern observed in the fossil record[1]. This burst in diversity may be triggered by key innovations, even if the exact causes are difficult to detect. Using ecological terminology, and provided, among other criteria, that the rapid increase in number of lineages is due to adaptation, this phenomenon is referred to as an adaptive radiation: the evolution of ecological and phenotypic diversity within a rapidly multiplying lineage (*sensu* Schluter). In the fossil record, this pattern is frequently observed after a biological crisis (i.e., post-crisis recovery). Before discussing the initiators of adaptive radiations, we must be able to accurately detect them. Schluter, for example, proposes four criteria: common ancestry, phenotype-environment correlation, trait utility, and rapid speciation. Here, we examine the Hammatoceratids, a clade of Jurassic ammonites that are the putative root group of nearly all post-Middle Jurassic ammonites (with the exception of the Lytoceratids and Phylloceratids, two conservative taxa, and potentially the Ancyloceratids, Upper Cretaceous ammonites with frequent heteromorph shapes). We focus on the beginning of the Hammatoceratids during the Toarcian and the Aalenian stages (Lower-Middle Jurassic), and we compare this clade to other contemporaneous monophyletic lineages.

W6 - VARIETY IN CONODONT ELEMENT MORPHOLOGY AND APPARATUS STRUCTURE, CAMBRIAN TO TRIASSIC, A REFLECTION OF DIFFERENT PREY AND FEEDING STRATEGIES

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The apparatus structure of the conodont animal was numerically conservative through time, with 7 or 8 element types and 15 elements being represented in most species and genera. The M and S elements, while morphologically variable, also remained generally “simple” with most species having discrete coniform shapes or denticulate ramiform bars in the apparatus. Individual coniform or ramiform S elements range from simple coniform shapes to morphologically complex ramiform units with as many as 4 processes. P elements, usually 4 in number, of 2 types, are highly variable through time. Early (Cambrian) forms are most often represented by coniform shapes. Ordovician forms probably displayed the greatest morphologic diversity, with coniform, ramiform and pectiniform shapes with an extremely wide ranging from interactive or non-interactive shapes. These are the Likmas apparatuses type elements that had elongate denticles that could not have been designed to intermesh and must have operated pointing in the same direction. Hyalion apparatuses type elements were similarly oriented, but worked across the axial plane of the apparatus with a morphologically similar element. Peraios apparatus type elements were designed to work laterally across the axial plane of the apparatus with another element of similar morphology that may have had morphological accommodation. Most conodont animals of Permian and Triassic age had Peraios type apparatuses.

S5 - HISTORICAL COLLECTIONS OF CARBONIFEROUS AMMONOIDS AT THE NATURAL HISTORY MUSEUM: AMATEUR COLLECTING AND PROFESSIONAL EXPERTISE

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Over the last 200 years the British Museum (subsequently NHM) has acquired a significant proportion of the Palaeozoic cephalopod material collected in the UK, including important historical collections described by James Sowerby, John Phillips among others, largely contributed by amateur geologists. Much of this material has not been critically revised since its original acquisition, and while some work remains to be done, there are still considerable discoveries to be made in the major Palaeozoic cephalopod holdings. An important Carboniferous ammonoid collection from the North of England, assembled by the amateur geologist William Gilbertson, was largely the basis for John Phillips' ammonoid descriptions in his seminal work "*Illustrations of the Geology of Yorkshire*" (1836). The collection, purchased by the Zoology Department of the British Museum in 1841 and presently housed in the Palaeontology Department of the Natural History Museum, stands out as the largest extant assemblage of Phillips' type specimens (despite rumours that many of the fossils were stolen or lost during Phillips' lifetime). Comparison of Phillips' original drawings and notes in the Oxford University Museum of Natural History Library with the Gilbertson Collection at the NHM, has shown that some illustrations were omitted from the final publication. This allowed recognition of the original type series. The process of redescription, re-figuring, curation and typification of this collection has helped to make it more accessible to the scientific community, as well as revealing new facts on taxon morphology and specimen localities, as well as details of its acquisition and history.

S9 - AMMONOIDS AND CONODONTS FROM THE FRASNIAN AND FAMENNIAN OF THE WESTERN SLOPE OF THE SOUTH URALS: STRATIGRAPHY AND PALEOGEOGRAPHY

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The Upper Devonian carbonate successions of the Zilim-Zigan Region on western margin of the Bashkirian Meganticlinorium (Bashkortostan, South Urals, Russia) span the entire Frasnian–Famennian (from the *falsiovalis* to *praesulcata* conodont zones) and are composed of deep marine facies with an interval of brachiopod limestone around the level of the Frasnian-Famennian boundary in some sections. Numerous ammonoids and conodonts allow the recognition of conodont and ammonoid zones facilitating broad correlations across the South Urals, Western Kazakhstan, Timan-Pechora, New Siberian Islands and other regions. The numerous ammonoid localities (including Mendym, Ryauzyak, Kushelga, etc.) represent rich faunas dominated by *Manticoceras*. The sedimentation occurred in a series of narrow troughs on a continental margin of Baltica (Kama-Kinel Troughs) and was mainly controlled by eustatic fluctuations, with a main sea-level drop around the *triangularis* zone. The pattern of sea level fluctuations agrees with changes in the ammonoid assemblages towards increasing endemism. Frasnian ammonoids include widespread species (*Manticoceras ammon, M. lyaiolense, M. drevermanni, M. cordatum, M. intumescens,* ?*Ponticeras* sp., *Tornoceras typum,* etc.), which are similar to faunas from the Timan-Pechora area and the New Siberian Islands. Famennian ammonoid assemblages of the *Cheiloceras* and *Prolobites–Platyclymenia* Genozones, on the other hand, are impoverished and show little similarity to the contemporary faunas of the adjacent Mugodzhary Mountains (Western Kazakhstan), being dominated by species of *Cheiloceras* and the locally endemic clymeniid *Platyclymenia tschernyschewi*. This suggests that in the Famennian, the Zilim-Zigan Region, despite a transgression in the *crepida* zone, remained isolated from the Kiya and Kara-Dzhar regions (Kazakhstan).

S12 - COMPARATIVE TAPHONOMY OF VESICOMYID AND BATHYMODIOLIN BIVALVES FROM THE MID-MIOCENE METHANE-SEEP LIMESTONES IN THE BESSHO FORMATION, CENTRAL JAPAN

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Fossil sites of vesicomyids are overwhelmingly more than those of bathymodiolins although both are representative chemosynthetic bivalves in the present sea, but its cause is unknown. The Middle Miocene Bessho Formation consists of slope mudstone, and intercalates seep limestones, over 20 m in diameter. The limestones yield abundant fossils of vesicomyid clams (*Adulomya uchimuraensis*) and bathymodiolin mussels (*Bathymodiolus* (s.l.) *akanudaensis*), but the mode of occurrences shows a contrast between them. The vesicomyid shells not only form clusters in fractured muddy micrite with calcitic veinlets (active and stable seepage phase), but also sporadically occur in the marginal zone transitional to the surrounding siltstone (temporal seepage phase). Almost all of the shells are adult-sized (over 15 cm long), and the ratio of conjoined valves is low (6 to 37%). In contrast, the bathymodiolin occurrence is restricted in the active and stable seepage phase, and they are rare in the temporal seepage phase. Almost all of the shells are small (less than 2 cm) and immature-sized, and the ratio of conjoined valves is high (60-90%). The bathymodiolin shells frequently form clusters, but are randomly oriented in matrix-supported condition with reddish mud fragments. The immature mussels were transported and rapidly buried by habitat-collapses maybe due to hydraulic explosion. The taphonomic contrast suggests that mobile vesicomyids have advantages over sessile bathymodiolins not only in effectively using various seepage phases, but also in escaping from small-scaled habitat-collapse. The Cenozoic burst of vesicomyids may be related with its character as a utility seepage-user.

S19 - TURBULENT LIFESTYLE: CYANOBACTERIA ON EARTH'S SANDY BEACHES – TODAY AND 3 BILLION YEARS AGO

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Modern benthic cyanobacteria are very well adapted to the harsh hydraulic conditions of sandy tidal environments. The microbial interaction with the physical sediment dynamics originates the characteristic 'microbially induced sedimentary structures' (MISS). These do not resemble stromatolites at all, and have been classified as their own group of structures. MISS occur not only today, but they are abundant in shallow-marine sandstones of all Earth ages, including the early Archean time. A fossil tidal flat preserved in the 2.9 billion years old Archean Pongola Supergroup, South Africa, corresponds to the tidal flats that today form along the coast of the North Atlantic Ocean. This ancient tidal flat includes microbial mat-related structures of exceptional beauty. Those MISS record the same types of microbial mats as those we find today in our modern tidal environments. The fossil MISS have in statistical analyses the same geometries and dimensions as the modern ones. The fossil MISS include microstructures that are identical to the microstructures in the modern MISS. The fossil MISS have the same pattern of distribution within the ancient tidal flats as the modern MISS in equivalent modern tidal flats. We conclude that the complicated biotic-physical processes that lead to the specific MISS and their typical distribution cannot be mimicked by the activities of other prokaryotes than cyanobacteria. Therefore, the microbial mats of the Pongola Supergroup may include the oldest known cyanobacteria in Earth's history. Their high diversity suggests a much earlier start of evolution of cyanobacteria than assumed before.

S19 - BIOSTABILIZATION PROPERTIES OF MICROBIAL MATS IN SANDY MARINE ENVIRONMENTS

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In modern marine environments, microbial mats are constructed predominantly by cyanobacteria. In siliciclastic tidal flats, lagoons, and continental shelves, different types of microbial mats are established with respect to hydrodynamic patterns. Lateral successions of mats are termed 'biofilm-catenae'. Such biofilm-catenae can be found not only in modern, but also in ancient shallow-marine settings. The oldest have been reported from the 2.9 Ga Pongola Supergroup, South Africa. Quantitative field experiments using a portable Manzenrieder flume chamber documented how modern biofilm-catenae stabilize tidal deposits. In lower intertidal zones, biofilm-coated sand grains are swirled around by constant turbulence. In upper intertidal zones, endobenthic microbial mats colonize uppermost millimeters of depositional surfaces. The mat-covered surface withstands currents of up to 0.90 cm/s. The biostabilization effect is caused by lower degree of roughness of the mat-interwoven depositional surface. In lower supratidal zones, epibenthic microbial mats can be found. Such mats stabilize sand up to 12 magnitudes. The smooth mat surfaces reduce erosive forces up to 12 magnitudes. The mats withstand currents of up to 1.60 m/s. This biostabilization effect is due to no direct influence of turbulent waters on mat-embedded sand grains. Biostabilization is expressed by a modification of the Shield's relation: $Q = r u^{*2} / (r s - r f)\, g\, \underline{D}^{n}$, where u^* is shear velocity; rf is density of fluid; rs is density of sediment; g is gravity constant; D is actual grain diameter during biostabilization; n is exponent to which D is raised for data to comply to Shield's relationship.

W4 - A NEW GEOSITE "EARTH'S OLDEST CYANOBACTERIA" – WHITE UMFOLOZI INLIER GEOPARK, SOUTH AFRICA

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In sandy marine environments, benthic cyanobacteria form microbially induced sedimentary structures (MISS). MISS do not resemble stromatolites, but come in 17 main types. Due to their specific biotic-physical origin, the structures have been classified as own category in the classification of primary sedimentary structures. While we can study the formation of MISS in modern tidal flats, the structures actually occur in sandy shallow-marine environments since the earliest Archean time. The most spectacular MISS have been detected in the 2.9 Ga Archean Pongola Supergroup, South Africa. The structures are extremely well preserved. They record that cyanobacteria possibly had already by that time developed to the same diversity as today. The fossil tidal flats recorded in the Pongola Supergroup crop out along the river Wit Umfolozi. This site is now one of the geosites for the proposed White Umfolozi Inlier Geopark, Kwazulu-Natal, South Africa. This Geopark is organized by the Council for Geoscience, Pietermaritzburg, Geological Society of South Africa. The proposed geosite has been focus of a documentary produced by Pioneer TV for Discovery.

S27A - THE TAXONOMIC DIVERSITY OF IGUANODONTIAN ORNITHOPOD DINOSAURS IN THE THE LOWER CRETACEOUS OF NW EUROPE

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The Lower Cretaceous continental deposits of NW Europe are almost synonymous with the ornithopod dinosaur genus *Iguanodon*. Despite nomenclatural and diagnostic problems associated with the name *Iguanodon*, this taxon, has the historic burden of being one of the earliest dinosaurs described and named. One consequence of this history is that Iguanodon became an unavoidable repository for the great majority of fragmentary ornithopod dinosaur remains collected from disparate localities distributed across the entire Lower Cretaceous interval. The Lower Cretaceous spans approximately 34Ma of geological time and the present record of comparatively low generic and specific diversity among iguanodontian ornithopods in NW Europe contrasts markedly with high levels of generic and specific diversity reported from a contemporary interval in North America. Given the historic burden associated with the genus *Iguanodon*, a detailed revision of the taxonomic status of material attributed to that genus (as well as closely allied forms) has been undertaken. Evidence supports the case for the recognition of greater generic diversity among iguanodontians of Lower Cretaceous age in NW Europe; this had been masked by the generally poor preservational quality of the material and was significantly compounded by its unnecessarily brief, or incomplete, description. A direct comparison, drawn by assessing the quality of material that has been described and diagnosed, suggests that diversity assessments based solely upon Lower Cretaceous iguanodontians from NW Europe and N America differ substantially. A number of factors need to be explored before such differences can be evaluated palaeobiologically or palaeoecologically.

S13 - LARVAL ECOLOGY IN THE AFTERMATH OF THE END-PERMIAN MASS EXTINCTION: POSSIBLE SELECTIVITY AND IMPLICATION FOR A POSSIBLE PRODUCTIVITY CRISIS

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The majority of marine invertebrates have a bi-phasic life cycle including a planktonic larval stage. Many of these larvae are plankton feeding (planktotrophic). The presence of planktotrophic larvae has far reaching consequences for dispersal, geographic ranges and other biological traits. Based on indirect evidence, it was previously suggested that the end-Permian extinction selected against planktotrophy. Allegedly those families which originated in the Early/Middle Triassic have preferably non-planktotrophic Recent members and it was concluded that the Early/Middle Triassic was an unfavourable period for the origination of planktotrophic groups. Moreover it had been suggested that Palaeozoic groups which were especially diverse in the tropics (e.g., crinoids and articulate brachiopods) had predominantly planktotrophic larvae based on a comparison with biota from the modern tropics. However, newly discovered mollusc larval shells from the Early Triassic of Utah, China, and Far East Russia indicate planktotrophy for the majority of species. This suggests that the end-Permian mass extinction did not select against planktotrophy. It also suggests that marine primary production during the Early Triassic was high enough to sustain large populations of planktotrophic molluscan larvae.

S27B - RADIOLARIANS FROM GRAVELS ALONG THE RIVER EUPHRATES IN AR-RAQQA PREFECTURE, SYRIA

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The distribution and ages of rocks in the Anatolide-Tauride block, south Turkey, are important for understanding the tectonic process of the Alpine orogeny. Although studies have been made on the Anatolide, there is still room for argument regarding the Tauride. Provenance analysis of downstream Quaternary gravel beds is used here to examine the geological nature of the Tauride in the upper part of the stream. The study site is in Ar-Raqqa, Syria. The samples were collected from Quaternary silts, sands and gravel beds along the Euphrates. The gravels include well-rounded clasts of chert, plutonic rocks, gneiss, rhyolites, basalts, silicified rocks, sandstone and mudstone. The deposits exhibit various kinds of sedimentary structures showing eastward palaeocurrents. Stone tools found as pebbles clearly indicate that the age of the sediments is younger than the Lower Paleolithic. Well-preserved radiolarians were collected from eight cherts, four silicified rocks and four siliceous mudstones out of the examined 577 gravel samples. Identified genera are *Thecosphaera?, Archaeodictyomitra, Archaeospongoprunum, Paronaella, Praeconocaryomma, Eucyrtidium?, Napora?, Emiluvia?, Parahsuum?, Transhsuum, Pantanellium?, Gorgansium?, Acaeniotyle?, Parvicingula, Mirifusus, Saitoum?, Pseudodictyomitra, Cryptamphorella macropora?, and Tricolocapsa*. These radiolarians indicate that the rocks were formed during the Jurassic to Cretaceous. The radiolarian cherts, plutonic rocks and gneisses are considered to have come from the Tauride block, SE Turkey, since there is no exposure of those rocks in Syria. It is plausible that a Mesozoic accretionary complex with radiolarian chert is present in the Tauride, notwithstanding that it has not been reported from there.

S9 - UPPER DEVONIAN RADIOLARIANS FROM THE ZERAVSHAN-GISSAR MOUNTAINOUS AREA (UZBEKISTAN REPUBLIC)

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For the first time Upper Devonian radiolarian associations have been recovered from the siliceous-carbonate-terrigenous rocks, collected in the Kule Gorge, left bank of the Dzhindy-Darya River, Zeravshan-Gissar Mountainous area, South Tien Shan, east margin of the Kitab State Geological Reserve (Uzbekistan Republic). Yellowish, black, reddish-grey and grey cherty limestones and siliciclastics of the Akbasay Formation (Frasnian-Famennian) from seven localities yielded differently preserved radiolarians together with conodonts and rare ostracods. From siliciclastics characterized by relatively abundant conodonts of the *punctata - linguiformis* zones, radiolarian associations are represented by few (10s specimens) *Trilonche, Astroentactinia* and *Palaeoscenidium.* The uppermost Frasnian (by abundant *Palmatolepis*) interval is dominated by well preserved, abundant (10s-100s specimens) *Trilonche, Astroentactinia, Palaeoscenidium, Radiobisphaera, Palaeothalomnus*, few (10s specimens) *Nazarovites* and *Ceratoikiscum,* and rare *Stigmosphaerostylus* and *Spongoentactinella.* Silisiclastic sequences characterized by conodont of the *crepida* Zone are dominated by moderate preserved *Trilonche* and more rare (10s specimens) *Astroentactinia*, *Palaeoscenidium* and *Palaeothalomnus.* Cherty limestones with conodonts of the *marginifera* Zone yielded few (10s specimens), poorly preserved *Trilonche* and indeterminable radiolarians. The studied radiolarian associations are represented by widely distributed Upper Devonian taxa.

S13 - PERSISTENT NICHE CONSERVATISM CURBS RECOVERY AFTER CARIBBEAN EXTINCTIONS

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As species are added to an ecosystem, the niche breadths of species contract due to competition and character displacement. Likewise, the removal of species during extinction leads to vacant niches that are predicted to be filled by ecologically-similar species due to competitive release. However, niche conservatism may limit a species' ability to exploit recently vacated niches if ancestral ecological characteristics are retained. With this in mind, we analysed the breadth of niches in the 15 commonest species of free-living cupuladriid Bryozoa from the Caribbean during the last 10 Ma. This time saw major environmental change in the Caribbean when the Isthmus of Panama closed causing a regional massive extinction in most marine groups. Niche breadths were determined using the abundances of over 76,000 colonies and the three environmental variables; percent carbonate and mud in sediments and depth. As diversity increased niche breadths of species narrowed, congruent with character displacement. After extinction however, niche breadths failed to widen immediately, as would be expected via competitive release. Even in the modern day Caribbean, 2 million years after the extinction, niche breadths have yet to re-widen suggesting that niche conservatism can persist for millions of years. This may have implications for understanding the long recovery times observed following mass extinctions.

S13 - EVOLUTION OF CUPULADRIID NICHE BREADTHS DURING ENVIRONMENTAL CHANGE, HABITAT DIVERSIFICATION AND FAUNAL TURNOVER IN THE CARIBBEAN

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The breadth of an organism's realised niche is determined by abiotic factors, such as the distribution and availability of resources to the population, biotic factors, particularly the number of species it has to compete with, and evolutionary history. These processes have seen considerable exploration on ecological and theoretical levels, but not over deep time. We analysed patterns of niche breadth of the 15 commonest species of free-living cupuladriid Bryozoa from the southwestern Caribbean over the last 10 million years. During this time, environments and habitat complexity altered radically as the Isthmus of Panama closed, whilst cupuladriid diversity increased and then fell via origination, extinction and migration. Niche breadths were established using the abundances of over 76,000 colonies and the three environmental variables; percent carbonate and mud in sediments and depth. Niche breadths narrowed significantly over time even though the range of habitats amplified substantially due to the proliferation of reefs at the end of the Pliocene, suggesting that resource availability did not strongly govern niche evolution. Instead, niche breadths narrowed as new species were added to the cupuladriid community congruent with character displacement due to increasing competition. Accordingly, we would predict that when a third of cupuladriids declined in abundance and went extinct in the Pleistocene, niche breadths would widen because of competitive release. However, Pleistocene and modern day niche breadths show no such widening, suggesting that niche conservatism may persist over millions of years.

S3 - THE MIDDLE EOCENE CLIMATIC OPTIMUM: TURNOVER IN CALCAREOUS NANNOFOSSIL ASSEMBLAGES

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The Middle Eocene Climatic Optimum (MECO) at ~40 million years ago (Ma) is a 600kyr long interval of global climate warming that interrupts the overall pattern of long-term cooling recorded through the Eocene Epoch. Variation in the rate of warming across the MECO has been identified from stable isotope records. Unlike other inferred transient warming events of the Paleogene, the onset of the MECO is gradual occurring over ~500kyr before a short-lived (<100kyr) interval of rapid warming to peak temperatures, followed by an abrupt (<10kyr) return to pre-event levels. The MECO is characterised by a significant perturbation of the global carbon cycle involving a shoaling of the calcite compensation depth. Biotic response to the MECO has not been fully explored. Here we present new high-resolution records of nannofossil assemblage turnover from Ocean Drilling Program (ODP) Site 1051 (Blake Nose, NW Atlantic) spanning onset to peak MECO conditions (40.76 to 39.85Ma). We use our records to assess linkages among the origination and extinction rates of nannofossil species, climate perturbation and the surface water state during this interval. Our biotic data help shed new light on the question of the contributions of transient climate events to long-term trends in nannofossil diversity.

S13 - A NEW GRIESBACHIAN CRINOID: IMPLICATIONS FOR PALAEOGEOGRAPHIC RECOVERY PATTERNS

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The class Crinoidea suffered a severe decline in their diversity during the Late Permian extinction event, and records of Early Triassic crinoids are scarce. All the post-Palaeozoic crinoids are included in the subclass Articulata, and the oldest articulate crinoid previously reported is *Holocrinus* spp. (Order Isocrinida) from the Smithian of Japan and Primorye (Russia), and from the Spathian of the western United States. However, a new crinoid has been discovered from the Griesbachian (lower Induan) of Oman. This new species consists only of disarticulated columnals, but it is safely assigned to the order Millericrinida based on the distinct radiating ridges and furrows on the columnal articulations. This discovery not only pushes back the record of the oldest articulate crinoid to the Griesbachian, but also requires a reconsideration of the previous view that the first articulate crinoids after the Permian/Triassic boundary belonged to the order Isocrinida. Furthermore, the new taxon raises the possibility that the Millericrinida might be more ancestral than the order Isocrinida among the articulate crinoids, and/or that two lineages survived the Late Permian extinction event. Also, it has been clarified that the recovery of crinoids after the Late Permian extinction event varied with geographic region, with initial recovery in the Griesbachian of western Neotethys, and later the occurrence of *Holocrinus* in the Smithian of Japan and Prymorye (western Panthalassa), followed by appearance of the same genus in the Spathian of western United States and Italy.

S13 - USING RANK-ABUNDANCE CURVES TO EVALUATE THE PALAEOECOLOGICAL RESPONSE OF MARINE BENTHIC COMMUNITIES TO THE LATE TRIASSIC MASS EXTINCTION EVENT.

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Palaeoecological samples were taken from approximately 1-metre intervals through the Triassic-Jurassic section at Waterloo Bay, Larne, Northern Ireland in order to study the response of marine benthic communities to the Late Triassic extinction event. A total of 1148 individuals corresponding to 33 species were recorded. Rank abundance curves (RACs) were generated and their shape was interpreted using kurtosis, with high kurtosis values representing stressed communities. In addition, geometric and log-normal RAC models were evaluated using the Chi-Squared Goodness-of-Fit Test on five palaeocommunities spanning the pre-extinction, extinction and recovery intervals. Evenness, richness and beta diversity were calculated in order to assess the change in the structure and composition of assemblage composition through the Triassic-Jurassic interval. Richness and beta diversity shifted abruptly after the extinction event. High kurtosis values were observed at the beginning of the extinction event. A parallel, geometric model best fits the data during the extinction event, while in contrast a log-normal model best fits the pre-extinction and recovery data. Finally, the evenness and the kurtosis values were negatively correlated. The geometric model and high kurtosis values confirm the ecological deterioration of benthic communities (low richness-evenness) through the Late Triassic extinction event. Although causal mechanisms of this extinction are still not clear, environmental stress is potentially the most likely factor.

S27C - THE GENUS *PSEUDOBORNIA* (ARTHROPHYTE) FROM THE UPPER DEVONIAN OF RUSSIA: MORPHOLOGY, ANATOMY, AND DISTRIBUTION

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Pseudobornia is a peculiar genus of arthrophytes, which combines morphological features of different plant groups. According to the reconstruction suggested by Schweitzer (1967), *Pseudobornia* was a monopodially branched tree-like plant up to 15-20 m high and up to 0.5 m in diameter at the basal portion of the axis. *Pseudobornia* (with a single species *P. ursina*) was first described by Nathorst (1894) on the basis of impressions of axes, stems, leaves and fertile structures from the Famennian of Spitsbergen (Bear Island). Leaf and stem fragments of *Pseudobornia* are also known from the Upper Devonian of USA (Alaska) and Germany. Recently, specimens of *Pseudobornia* were discovered among collections of the Arkhangelsk Regional museum and in the territorial informational fund “Arkhangelsknedra”. The findings originate from the Upper Frasnian of Russia, North Timan (the Cape of Ludovaty). The studied collection is represented by stem and leaf remains. In addition to a morphological description of the specimens some stem fragments were studied by scanning electron microscope. The anatomical structure of stems of different orders is similar and consists of narrow long tracheids with spiral and scalariform thickenings both on radial and tangential walls. The tracheid pitting is uniseriate. Pith rays were not observed. The primary xylem is apparently preserved in studied stems. Consequently stems of *Pseudobornia* perhaps did not have secondary growth.

S8 - GRAPTOLITE AND CONODONT FAUNAS FROM THE MIDDLE-UPPER ORDOVICIAN SIERRA DE LA INVERNADA FORMATION, CENTRAL PRECORDILLERA OF SAN JUAN, ARGENTINA

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The Sierra de La Invernada Formation (Middle-Upper Ordovician) is exposed on the western flank of the La Invernada Range along the western border of the Central Precordillera, San Juan Province, western Argentina. The formation is a heterolithic siliciclastic succession with interbedded calcarenites and subordinate conglomerates, which is intruded by Late Ordovician basic dykes. Its thickness varies between 1000 and 4000 m due to partial wedging out of the succession to the north and frequent repetition due to faults in the south; its base is not exposed and the formation is overlain by the Silurian-Devonian Corralito Formation. The formation records several deepening-shallowing cycles through the lower Darriwilian-Sandbian-lower Katian interval. Graptolites of the *Undulograptus austrodentatus, U. dentatus, "Holmograptus lentus", "Pterograptus elegans", Hustedograptus teretiusculus,* and *Nemagraptus gracilis* zones together with conodonts of the *Eoplacognathus pseudoplanus, E. suecicus, Pygodus serra,* and *P. anserinus* zones are present in a deepening sequence in the lower part of the formation. The *Climacograptus bicornis, Diplacanthograptus caudatus,* and *Climacograptus tubuliferus* graptolite zones occur together with the *Amorphognathus tvaerensis* and *A. superbus* conodont zones in a deepening sequence in the upper part of the formation. Disregarding non-significant stratigraphic gaps and lack of information, this formation represents one of the most fossiliferous successions of the Middle and Upper Ordovician of the Precordillera and its conodont and graptolite lineages are most useful for world-wide high resolution correlation. Palaeoenvironmental analysis reveals a complex pattern of sea-level changes and related diversification and migration events.

S23 - EXCEPTIONAL CARBONACEOUS MICROFOSSILS FROM THE MIDDLE CAMBRIAN KAILI FORMATION, SOUTH CHINA

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The discovery of HF-extractable organic microfossils in Burgess Shale-type Lagerstätten has provided a valuable alternative for understanding the diversity, palaeoecology and taphonomy of such deposits, as well as allowing the identification of fossil biotas through a wider stratigraphic range than that indicated by macrofossils. The lower-middle Cambrian Kaili Formation in Guizhou Province, China, is widely renowned due to the presence of various taxa typical of the middle Cambrian Burgess Shale and the early Cambrian Chengjiang faunas, most notably non-mineralizing arthropods, stem-lophotrochozoans and lobopodians. Here we report the presence of a diverse microfossil assemblage which occurs at various levels in the organic rich shales within the Kaili Formation. The microfossils are preserved as carbonaceous compressions in an identical manner as those reported for the Burgess Shale, albeit with a lower degree of thermal maturation. The assemblage is dominated by filamentous algae and single-walled acritarchs, but also contains significant metazoan remains such as arthropod spines and *Wiwaxia* sclerites, most of them preserved with sub-micron scale ornamentation. In contrast to previously described examples, however, the Kaili assemblage contains exceptionally preserved cuticle of priapulid-like worms. The specimens exhibit diverse arrays of cuticular projections, including finely ornamented scalids and/or possible pharyngeal teeth. These offer a unique window into the fine-scale anatomy of a group that is represented elsewhere in the Kaili biota by fossils that are macroscopic and articulated, but of limited preservational resolution.

S3 - MICROFOSSIL AND ISOTOPIC DATA FROM THE GORRONDATXE SECTION, N SPAIN: NEW INSIGHTS INTO THE EARLY EOCENE CLIMATIC OPTIMUM

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A long-term warming trend took place from the late Paleocene through the Early Eocene Climatic Optimum (EECO), which was punctuated by several hyperthermal events, transient global warming episodes associated with biotic and geochemical changes such as negative carbon isotope excursions. This warming of about 5ºC was followed by a gradual cooling during the middle and late Eocene that culminated at the early Oligocene. Hence, the aarly-middle Eocene or Ypresian-Lutetian (Y-L) transition emerges as a pivotal period in Cenozoic Earth´s history when the first steps to icehouse conditions took place. We present new microfossil (foraminifera) and isotopic (carbon and oxygen stable isotope) data from the Gorrondatxe section, N Spain, which exposes one of the most expanded deep-marine Y-L successions. Gorrondatxe section has been the subject of several studies, which led to develop a new biomagnetochronological frame-work for the Y-L transition. Furthermore, the level of the Gorrondatxe section that contains the calcareous nannofossil CP12a/CP12b zonal boundary has recently been selected as the Global Stratotype Section and Point for the base of the Lutetian Stage. Changes in the distribution pattern of some foraminiferal taxa and a negative carbon and oxygen isotope excursion (0.5-1‰) above the CP12a/CP12b zonal boundary may indicate warming during the early Lutetian.

S3 - DEEP-SEA BENTHIC FORAMINIFERAL (ELONGATE CYLINDRICAL) RECORD ACROSS THE EOCENE-OLIGOCENE TRANSITION AT THE SOUTHERN LABRADOR SEA (ODP HOLE 647A)

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Elongate, cylindrical benthic foraminifera belonging to the families Stilostomellidae, Nodosariidae and Pleurostomellidae, were a common component of deep-sea foraminiferal assemblages in the Cenozoic before the middle Pleistocene, when they disappeared almost completely. This group was also affected during the middle Miocene and the Eocene-Oligocene transition, all periods of global cooling. The Eocene-Oligocene transition was a crucial episode in Cenozoic history characterized by the change from greenhouse to icehouse conditions and the establishment of permanent continental ice-sheet in the Antarctica. We have carried out a high-resolution study of the elongate cylindrical benthic foraminiferal record at ODP Hole 647A in the southern Labrador Sea, where they constituted a common component of benthic foraminiferal assemblages during the Eocene-Oligocene transition. This site was situated at abyssal depths in the northwestern Atlantic, giving insight into deep-water circulation. Nodosariids and stilostomellids dominated in abundance over pleurostomellids throughout the studied hole, being nodosariids the most diverse. All these three groups showed a distinct increase in relative abundance across the Eocene/Oligocene boundary interval, up to 75% of the total assemblage just after an acme of the calcareous benthic *Nuttallides umbonifer*, indicator of Antarctic Bottom Water in the present oceans. Although all three groups increased they showed different distribution patterns which, integrated with other data, can shed light into the palaeoceanographic and palaeoclimatic changes at the E-O and the causes of their extinction in the middle Pleistocene.

S8 - THE ORDOVICIAN WORLD

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The remarkable increase in marine biodiversity both in the benthos and in the water column during the Ordovician took place in a world of profound physical change. The continents were highly dispersed as part of a process that began in the late Proterozoic and resulted in considerable biogeographical differentiation of faunas inhabiting the most extensive shelves of the Phanerozoic, including those of the tropics. Sustained global cooling during the Early and Mid Ordovician led to a regime of fluctuating climate including the end Ordovician glaciation that induced one of the 'big five' mass extinctions. The climatic change at about the Mid-Late Ordovician boundary broadly coincides with the peak of biodiversity in many groups, the switch from dominance of microbial to metazoan reefs, a possible change from N- to P-limitation in the oceans and a major shift in $^{87}Sr/^{86}Sr$. It was followed by a decline in diversity of several benthic and planktic/pelagic groups. The new pattern of benthic communities, dominated by filter feeders and involving a greater occupation of ecospace than in the Cambrian, was by then well established. Although niche partitioning was common, Late Ordovician communities were not 'saturated' with species. Amongst the many outcomes of research in the past 15 years, including that undertaken within IGCP503 'Ordovician Palaeogeography and Palaeoclimate' and its predecessor IGCP410 ''The Great Ordovician Biodiversification Event', is the greater clarity with which the Ordovician world can now be viewed.

S9 - REVIEW OF EARLY TO MID DEVONIAN TRILOBITE FAUNAS OF SOUTH TIEN SHAN, UZBEKISTAN

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Devonian trilobites from a variety of facies ranging in age from Lochkovian to Eifelian that crop out in a number of sections in the Uzbek part of south Tien Shan were originally described by Weber in monographs published over half a century ago; more recently collected material provides a much larger database, with far greater stratigraphical precision. The faunas include genera (e.g. *Scutellum, Dohmiella, Raerinproetus, Scharyia, Crotalocephalus* and *Acanthopyge)* which are widespread in the equatorial and temperate realm, extending from the 'Kazakh' terranes eastwards through north China to eastern Australia, and westwards through the Urals to the Rheno-Hercynian area, Armorica, Perunica (Bohemia) and to the margins of Gondwana (Morocco). The same or similar species of *Dohmiella, Lacunoporaspis, Raerinproetus, Crotalocephalus* and *Acanthopyge (Lobopyge)* occur in other central Asian (Kazakh) terranes, especially from the Altai-Sayan region (e.g. Rudny Altai, Gorny Altai, Salair, Kuznetsk Basin), and a comparable species of *Weberopeltis* is present in the eastern Urals. Endemic genera are also recorded. A notable feature of the Lower and Middle Devonian trilobite faunas of south Tien Shan is the apparent complete lack of phacopids, which are normally a major component of Devonian trilobite faunas. Phacopids are similarly absent in the Devonian of the Arctic regions of North America, an there may have been similar constraints operating in south Tien Shan, although the associated trilobite faunas in the two regions are dissimilar.

PLENARY - A MOLECULAR PERSPECTIVE ON HUMAN ORIGINS

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Extraction and sequencing of DNA from extinct hominins allow their relationships to present-day humans as well as to each other to be determined with accuracy. I will illustrate this by our work on Neandertals, who became extinct around 30,000 years ago, as well as a hominin bone fragment recently discovered in Denisova Cave in Southern Siberia. I will also describe our analysis of almost 3.7 billion bases from the Neandertal genome that we determined together with colleagues in Croatia, Spain, Russia, Germany and the US. This allows over 60% of all nucleotide sequences in the genome to be studied. Using these data we can now for the first time determine which substitutions occurred on the human evolutionary lineage and which parts of the human genome that was affected by positive selection after fully modern humans diverged from the Neandertal lineage.

S13 - QUANTIFYING SHORT- AND LONGER-TERM RESPONSES TO MARINE ANOXIA: AN ACTUALISTIC APPROACH

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In the Adriatic Sea, hypoxic events may affect up to 3000 km² of the seafloor, leading to extensive benthic mass mortalities. The onset of these catastrophic events, however, is hard to predict. Our research group therefore deployed a benthic chamber that creates and fully documents small-scale anoxia in situ. The instrument combines photo-documentation with detailed chemo-physical analyses and allows the analysis of the behaviours and mortalities of benthic organisms during and after oxygen depletion. The results provide an opportunity to better interpret benthic responses to anoxia in the fossil record. The responses to declining oxygen values and/or to increasing duration of anoxia were the emergence of infauna, atypical or escape behaviors of epifauna, and mortalities. Hermit crabs play a crucial role in the benthic community, in particular through their symbioses with other organisms: their heavily overgrown shells represent mobile aggregations of benthic organisms. The crabs help structuring the overall community because the encrusting species survive when the crabs exchange old for new shells. Hermit crabs changed their behaviour during decreasing oxygen concentrations and most of them ultimately abandoned their shells. The sequence of post-anoxia events revealed that the moribund/dead organisms attracted predators/scavengers, which removed most of the dead material within days. Fish were the first post-anoxia visitors; their numbers gradually decreased during the deployment, suggesting that most of the suitable dead material was consumed early. The second and third groups arriving were hermit crabs and gastropods, respectively. They fed mainly on remains not utilized by fish (e.g. sponges, ascidians).

S17 - ENGINEERING THE FLIGHT OF PTEROSAURS

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The flight apparatus of pterosaurs is unique a thin membrane supported by a single structural spar of articulated bones. This combination resulted in specific requirements for bending stiffness and wing sections unlike those of any extant animals and without any mechanical analogue. Engineering analyses have been used to investigate the distribution and orientation of the wing spar stiffness, revealing a stiffness dominated structure with material disposed to resist dorsoventral bending in the proximal regions and anteroposterior bending in the distal parts. Possible reason s for this stiffness distribution will be discussed. Even the large pterosaurs flew at low Reynolds numbers, a regime where transition and laminar flow effects dominate. Drawing on advances in the understanding of low Reynolds number aerodynamics and through new wind tunnel tests that studied the effects of bone cross section, soft tissue fairing and membrane flexibility, the possible wing sections o f pterosaurs have been analysed for the first time. The results show that thin ections can be as effective as the thicker sections of airplanes and birds at the Reynolds numbers of pterosaur flight and that surface roughness is not necessarily detrimental. The leading edge spar increases the optimum camber, so the best flight capabilities occur at high lift coefficients. Consequently pterosaurs may have been able to fly at significantly lower speeds than previously predicted. This may help to explain how they could become so large yet still manage to land without harmful impact.

S6 - THREE-DIMENSIONAL LANDMARK ANALYSIS OF TWO LATE CAMBRIAN (FURONGIAN) TRILOBITES, *ASIOPTYCHASPIS SUBGLOBOSA* AND *QUADRATICEPHALUS ELONGATUS*

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Two-dimensional landmark analyses have been increasingly performed for trilobites, but three-dimensional landmark analysis has never been attempted. Silicified specimens of the two ptychaspidid trilobites, *Asioptychaspis subglobosa* (Sun, 1924) and *Quadraticephalus elongatus* Kobayashi, 1935 from the middle Furongian Hwajeol Formation, Korea, are well-preserved and retain their original convexity. *Asioptychaspis subglobosa* occurs immediately subjacent to *Q. elongatus*, and, based on morphological similarities between the two species, *A. subglobosa* is considered an ancestral sister taxon of *Q. elongatus*. Three-dimensional coordinates of 30 landmarks were obtained for 40 cranidia of *A. subglobosa* and 22 cranidia of *Q. elongatus* including immature forms. Principle component analysis (PCA) using 2D landmark data of the specimens of all developmental stages failed to discriminate any grouping. On the other hand, PCA using 3D landmark data reveals that the two species are differentiated on the PCA plots even at morphologically immature stages. As the two species do not share a trajectory of ontogenetic shape change, heterochrony cannot be evoked to account for the evolutionary mode. The spatial aspect of shape difference is ascribable to heterotopy. Nevertheless, the migratory paths of landmarks with growth are similar to each other in the two species, suggesting that they are closely linked phylogenetically.

S6 - BIOMETRY OF THE ORDOVICIAN TRILOBITES *KRATTASPIS* AND *HADROMEROS*

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Morphometric study of the Lower Ordovician cheirurid trilobite Krattaspis in two successive beds revealed several character changes in their growth series. Together with the shift in time some of these changes were shifted within the growth series. In general, the regions of skeletal parts most affected by changes during the late ontogeny (holaspid stage) were also changing most during the phylogeny observed in subfamily Cyrtometopinae. However, the morphology of its descendants in many lineages can be explained by changes in developmental timing (heterochrony). Some trends (e.g., the anterior lobe of glabella being relatively longer in larger cranidia) were similar to those of representatives of Cyrtometopus and Nieszkowskia, but the others were opposite. Different cheirurid genera of the Upper Ordovician Boda Limestone and contemporaneous beds in Baltoscandia and elsewhere show different rates in character change and variability.

S19 - ANCHORS AWEIGH: RHEOTACTIC BEHAVIOUR IN THE EDIACARAN ORGANISM *PARVANCORINA*

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Motility of some members of the Ediacara biota is largely assumed and rarely substantiated. Recent ecospace modeling of Ediacaran assemblages has identified only five occupied motile life modes, with a considerable number of other viable but supposedly vacant modes. In this study, specimens of *Parvancorina* (*n*=151) were examined from three separate beds of the Ediacara Member in the lower part of the Rawnsley Quartzite in the western Flinders Ranges, South Australia, which have been excavated, inverted and reassembled to study the fossil assemblages on the bed soles. On all three beds, specimens of *Parvancorina* are preserved as negative (or concave) hyporelief impressions, and are associated with a variety of other body fossils, textured organic surfaces (TOS), and sedimentary structures. Orientation data of *Parvancorina* – coupled with those of other body fossils, taphofossils and tool marks – demonstrate that a significant proportion of individuals on different bed assemblages show a preferred unidirectional orientation that appears to be influenced by bottom currents, suggesting that *Parvancorina* exhibited rheotactic behaviour. To our knowledge, this represents the oldest example of rheotaxis in the fossil record. This and other evidence (including the negative evidence of lack of an obvious attachment point) suggest that *Parvancorina* occupied a previously unrecognized but viable ecospace mode amongst Ediacaran communities: a surficial epibenthic, suspension-feeding organism with free-lying facultative motility. These findings also have considerable implications regarding the morphology and phylogenetic placement of *Parvancorina*, especially previous claims that have suggested arthropod affinities.

S2 - PENNY WISE BUT POUND FOOLISH: THE COST OF EXCLUDING MACROEVOLUTION FROM THE EVOLUTIONARY SYNTHESIS

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George Gaylord Simpson's unification between palaeontology and theoretical population genetics made a considerable—and poorly understood—contribution to the Evolutionary Synthesis (1937-1953). Reading over the shoulders of critics of current evolutionary theory, including Simpson, affords a better view of biology's organizing research paradigm. Beneath Simpson's ratification of geneticists' pan-selectionism lay a concerted effort to dispose of the origin of higher taxa as a unique theoretical problem palaeontologists could claim for their own. Simpson accepted Darwinians' assertion that natural selection does all of the organizing work in evolution, and that population-level studies were sufficient because the alternative seemed worse: Mutation-driven theories based on unwieldy genetic models spoke explicitly to macroevolution. A generation later, Stephen Jay Gould again took up the project of establishing a central position for palaeontologists in theoretical discussions. In 1980, Gould accurately described Simpson's effort as a "consistency argument." Gould's critique, however, was informed by post-Synthesis developments seen as the distilled product of Simpson's era. What counts as "The Synthesis" had changed over time and continues to do so. Adolf Seilacher, removed from the Synthesis fray, has built a research program that breaks some of its cardinal rules. Seilacher's efforts to understand morphological adaptation and "fabricational noise" during ontogeny disrupt the Synthesis paradigm as well as the conventional criticisms of it. Seilacher's work offers a novel basis from which to critique and expand the kinds of theoretical questions we might ask now.

S4 - DEEP PHYLOGENY OF EUKARYOTES: HOW IMPORTANT ARE MICROFOSSILS IN THE GENOMIC ERA?

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Recent analyses of genomic have led to spectacular advances in reconstructing the phylogeny of eukaryotes. The majority of eukaryotic taxa have found their place in one of a few supergroups established based on phylogenetic analyses and molecular signatures. With a rapidly growing genomic database, the relationships between these groups are increasingly resolved. The analysis of genomic data has become an almost exclusive source of information on the deep history of eukaryotes, raising the question about the importance of the microfossil record. Here, I will present the current phylogenomic data on evolution of eukaryotes with special emphasis on phylogenetic position of the most important microfossil groups. I will also use the example of foraminifera to show both the intrinsic limitations of the microfossil record and its importance for calibration of the phylogenetic tree and the testing of phylogenetic hypotheses.

S9 - CONODONTS AND FORAMINIFERS FROM THE DEVONIAN/CARBONIFEROUS BOUNDARY BEDS IN THE SOUTH URALS

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Devonian-Carboniferous boundary beds on the western slope of the South Urals are represented by three lithofacies: clayey-carbonate (Sikaza, Zigan), carbonate (Usuili) and carbonate-cherty (Bolshaya Kushelga). The first two correspond to an open shallow shelf, the third to a depression, with a supposed gap in the succession at the boundary level. The named successions show evolutionary changes in conodonts at the Devonian-Carboniferous boundary. Conodont zones correlate with subdivisions based on foraminifers and other fossils. The Devonian-Carboniferous boundary is placed between the *Siphonodella praesulcata* and *S. sulcata* zones in this region. The *S. praesulcata* Zone corresponds to the beds with the last *Quasiendothyra* and LE palynozone. The lower *S. sulcata* Zone corresponds to the PM Subzone. The conodonts of the *S. sulcata* Zone are found associated with impoverished foraminiferal assemblages, poorly comparable in different sections. The Sikaza section contains *Quasiendothyra communis* and *Septaglomospiranella* spp.; the Zigan Section only *Earlandia elegans* and *E*. aff. *aljutovica.* In the Mugodzhary Mountains, the first *Tournayellina beata pseudobeata,* the ammonoid *Acutimitoceras prorsum*, and the *Vallatisporites pusillites* Zone appear around the base of the Mississippian. The transition from *S. praesulcata* to *S. sulcata* is displayed by increased asymmetry of the platform, curvature of the carina, and later, by the inverted pseudokeel, decreased length of the free blade and narrowing of the grooves. Early *S. sulcata* show considerable morphological variability. Later, the ornamentation becomes considerably finer, and the blade shorter. The transitional Devonian-Carboniferous interval contains the last representatives of the Devonian genera *Palmatolepis* and *Pelekysgnathus*, while *Protognathodus* is absent.

S12 - MOLECULAR PALAEONTOLOGY OF SEEP ECOSYSTEMS

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Chemosynthesis-based ecosystems at methane seeps are typified by chemosymbiotic macrofauna and precipitation of carbonate minerals. The macrofauna and mineral formation have in common that they are both sustained by the oxidation of reduced compounds by chemotrophic prokaryotes. Anaerobic oxidation of methane (AOM) is inducing carbonate precipitation, but also produces hydrogen sulphide, another compound apart from methane utilised by endosymbiotic bacteria in the tissues of chemosymbiotic biota. Unlike the macrofauna with their hard parts, no or very little body fossil evidence of prokaryotes is preserved in the rock record. Molecular fossils, however, provide the means to reconstruct biogeochemical processes at the base of the food web at ancient seeps. These fossils are molecules (lipid biomarkers) that can be assigned to certain source biota and are stable on geologic time scales. Many of them are degradation products of membrane lipids. The analysis of lipid biomarkers significantly contributed to unravelling the process of AOM, which was shown to involve archaea as well as sulphate-reducing bacteria. Since AOM is inducing carbonate formation, the archaeal and bacterial fossils are preserved in a product of their own metabolic activity, favouring excellent preservation. The reconstruction of biogeochemical processes at ancient seeps benefits from a natural tracer experiment based on the fact that methane is strongly depleted in the ^{13}C isotope. The biomass of organisms metabolising methane or compounds resulting from its oxidation reflects this ^{13}C-depletion ('you are what you eat'). Molecular fossils of AOM-performing prokaryotes are, thus, typified by an extraordinary ^{13}C-depletion.

S7 - A BRIEF HISTORY OF TRIMERELLIDE BRACHIOPODS, AND THE ROLE OF PENTAMERIDES AND MEGALODONT BIVALVES IN THEIR DEMISE

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Late Ordovician to Late Silurian benthic communities include three groups of large shells, conspicuous not only by their size, but also by their tendency to occur in aggregated shell beds. They include: 1) Trimerellide brachiopods (Order Craniata), ranging from the beginning of the Late Ordovician (Sandbian) to the end of the Ludlow; 2) Pentameride brachiopods, particularly those assigned to the families Virgianidae and Pentameridae, ranging from late Katian (Late Ordovician) into the Pridoli; 3) Megalodontid bivalves (Order Hippuritoida, Family Megalodontidae), first appearing in the Llandovery and surviving until the Jurassic. Like the trimerellides and pentamerides, they are often massively thickened in the hinge region of the shell, and consequently have a low centre of gravity that stabilises the shells in a vertical position with the valve opening upwards. Thus these three groups (while quite distinct) display considerable similarities – in size, life habits and ecological preferences – and their geological ranges overlap. They presumably competed for space on the inner shelf (mainly in Benthic Assemblages 1-2), and that competition (together with differing responses to the end-Ordovician extinction event) can be directly linked to the demise of some groups and the success of others. The lack of strongly interlocking articulation was likely pivotal in the demise of the trimerellides. The Late Ordovician to Late Silurian interval in Eastern Australia, which was then peripheral to eastern Gondwana, provides perhaps the most continuous record of trimerellides during this time, and, in also having occurrences of both megalodontids and pentamerides, is ideal to test this hypothesis.

S8 - ORDOVICIAN BIODIVERSIFICATION TRENDS IN EAST GONDWANA: COMPARSION BETWEEN CRATONIC AND ISLAND ARC SETTINGS

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More than forty years of intensive study of Ordovician faunas from the cratonic shelf and margin of East Gondwana (represented in eastern Australia by strata in Tasmania and in the Koonenberry Belt of western New South Wales) and correlative successions in the offshore Macquarie Arc of central New South Wales, has contributed to a detailed database of fossil occurrences that enables comparison of biodiversification trends between these contrasting settings. For the Middle and Late Ordovician interval the fauna of the Macquarie Arc includes 403 genera and 425 species representing 36 orders; contemporaneous cratonic shelf and margin faunas comprise 232 genera and 258 species distributed amongst 33 orders. Although these regions are only about 1000 km apart today, relatively minimal biogeographic similarity between their Darriwilian-Katian faunas reflects the >3000 km oceanic separation of the Macquarie Arc and Tasmania prevailing during the Ordovician. For example, only one of sixteen trilobite species occurs in both regions, and there is no commonality of genera or species of free-swimming coiled nautiloids (Tarphyceratids). Ruling out latitudinal or palaeoclimatic differences between these regions, differences in topographic sea-floor gradient appear to be the major contributing factor influencing variation in biodiversification trends between the craton edge and island arc. Faunas of the latter are considerably more diverse, and display greater turnover at species and genus level than those from shallow shelf environments on the craton. Unfortunately little definitive evidence is available of migration between these two regions, possibly due to the deep ocean and probable strong currents separating them.

S26 - BIOTIC CHARACTERISTICS OF DEEP-WATER CHERTS IN THE ORDOVICIAN OF EASTERN AUSTRALIA, AND THEIR CORRELATIVES IN KAZAKHSTAN AND SCOTLAND

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Cherts associated with distal turbidite deposition are widespread in the Early to Middle Ordovician of New South Wales, including probable back-arc basins represented by the Hermidale and Albury-Bega Terranes. Study of more than 2500 bedding-plane parallel sections prepared to a thickness of 50 microns from these cherts enables correlation based on five conodont zones that range in age from late Tremadoc to latest Darriwilian. Comparable cherts are present in two small remnants of oceanic derivation, in the Narooma Terrane (Furongian to Darriwilian) and at Port Macquarie in allochthonous blocks (Late Ordovician). Associated with the conodonts are a range of other fauna, including radiolaria, sponge spicules, very rare acrotretide brachiopods and fragmentary graptolites; occasionally, filaments attributed to algae are present. All these organisms were apparently pelagic or nektic, or were attached to floating material (e.g. the brachiopods), and hence became entrapped in siliceous ooze on the sea floor when they settled under gravity. However, the presence of burrows and bioturbation suggests that deposition did not take place in anoxic environments. Predominant colouration of the cherts examined ranges from honey or amber (typical of semitransparent cherts) to cream-coloured translucent to opaque varieties. The red appearance of some cherts may be related to discolouration due to iron oxidation. Dark brown cherts with evidence of burrowing or bioturbation tend to have a higher silt component. The Ordovician is also a time of extensive chert deposition elsewhere, including terranes in Kazakhstan (commencing in the Late Cambrian) and in the southern Highlands region of Scotland.

S27B - PHYLOGENY OF THE NEOGENE-RECENT GENERA *AMEGHINOMYA* AND *PROTOTHACA* (BIVALVIA: CHIONINAE) IN SOUTHERN SOUTH AMERICA.

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In the context of determining the fate of the Late Tertiary molluscan faunas of Southern South America and the origin of the Recent assemblages of the Southwestern Atlantic Ocean, a phylogenetic analysis of the Neogene-Recent genera *Ameghinomya* and *Protothaca* has been carried out. The study confirms the systematic validity of both genera and shows the existence of two monophyletic clades. One is constituted by the Miocene Patagonian *Ameghinomya argentina* (the type species of the genus), *A. darwini, A. meridionalis*, the Neogene Chilean *A. volckmanni* and*"Venus" chiloensis,* and the Pliocene-Recent '*Venus' antiqua.* This last taxon constitutes the only extant species of this group in the Southwestern Atlantic Ocean, and has been previously placed in *Protothaca* or *Ameghinomya*. The other clade is represented by the Recent Pacific species *Protothaca thaca* (type species of the genus*), P. grata, P.staminea* and the Australasian genus *Austrovenus* (Pliocene-Recent), a taxon that has been previously proposed to be derived from *Ameghinomya* but, according to the present results, would be more closely related with the *Protothaca* group than to the genus *Ameghinomya.*

S27A - HIGH DIVERSITY OF TURTLES IN THE CRETACEOUS OF THE WESTERN CAMEROS BASIN (BURGOS, SPAIN)

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In the western Cameros Basin (Burgos, Spain), only a single taxon of turtle, *Salasemys pulcherrima*, has previously been reported. However, the study of new specimens allows us to confirm the presence of at least four taxa belonging to the Panpleurodira and Pancryptodira. The Panpleurodira is just represented by an undetermined Bothremydidae from the Maastrichtian of the Santibáñez del Val Formation. Pancryptodira representatives have been found in Lower Cretaceous beds. One of them, recorded in the fluvial sediments of the Pinilla de los Moros Formation (Upper Hauterivian-Barremian) and the Castrillo de la Reina Formation (Upper Barremian-Aptian), is assigned to the basal pancryptodirid Solemydidae. The others, from the Castrillo de la Reina Formation, are considered members of Eucryptodira. This node includes *Salasemys pulcherrima*, previously considered as a putative member of Macrobaenidae. However, Macrobaenidae is not a monophyletic group, rendering the systematic position of *Salasemys* among Eucryptodira uncertain. The other Eucryptodira representative is considered to be a new basal member of this node. Although basal eucryptodires were almost unknown in the European Cretaceous record, the new findings show that its diversity in the Spanish Cretaceous is higher than thought. In fact, different forms have recently been recognized in the Maestrazgo Basin, the Serranía de Cuenca and even in the eastern Cameros Basin. In summary, the new evidence of turtles from the western Cameros Basin allows a better understanding of the diversity of the Iberian Mesozoic turtles. In addition, the combination of endemic taxa with forms shared with other Iberian areas provides noteworthy biogeographical information.

S27A - THE MORE ANCIENT PLEUROSTERNID GENUS (CHELONII, PARACRYPTODIRA) RECORDED IN EUROPE

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During the Kimmeridgian, pleurosternids were one of the most abundant groups of turtles in North America, where several taxa have been identified. However, although their presence is known in Europe based on isolated plates of that age, there was no reference to any genus before the upper Tithonian. We present several specimens from the Upper Kimmeridgian of the Lusitanian Basin, in the western margin of central Portugal. Two relatively complete shells are identified and assigned to a new genus that constitutes the most ancient attribution to a pleurosternid genus in Europe. This is a small pleurosternid with a rounded shell. The morphology of the nuchal plate and the first peripherals are different from that of the other known representatives of Pleurosternidae. In addition to the presence of fine striations perpendicular to the margins of the plates, present in all the pleurosternids, the new genus has a punctuate decoration as in *Pleurosternon*. However, this new turtle differs from that taxon in many characters, such as the absent or xiphiplastral notch and the

presence of a sinuous sagittal sulcus of the plastron scutes. The phylogenetic relationships of the members of Pleurosternidae show that this new turtle is more closely related to the European pleurosternids than to the North American representatives of this group. This vicariant biogeographical distribution on both sides of the North Atlantic Ocean during the Uppermost Jurassic contrasts with that previously described for other groups of reptiles and especially with that of some dinosaur taxa such as *Allosaurus* or *Stegosaurus*.

S3 - PRELIMINARY ANALYSIS OF PLANKTIC FORAMINIFERA IN THE MIDDLE MAASTRICHTIAN OF THE ZUMAIA SECTION (SPAIN)

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New results on turnovers in the planktic foraminiferal assemblages across the middle Maastrichtian at the Zumaia section (North Spain) are documented. The studied interval has 110 meters thick and consists of an alternation of marls and limestones, with intercalated distal turbidites. These sediments were deposited in a deep marine basin of lower-middle bathyal depth. 29 samples were studied quantitatively, in order to recognize changes in the planktic foraminiferal assemblages. 59 species and 17 genera were identified, and two biozones were recognized: the *Abathompalus mayaroensis* and *Globotruncanita stuarti* Zones. Several bioevents were identified before analyzing the planktic foraminiferal quantitative stratigraphic record. These bioevents may be relevant in chronostratigraphy because they could be used as events for global, marine correlation of chronostratigraphic boundaries. In addition, the Shannon and Equitability indices suggest a decreasing trend in diversity across the studied stratigraphic interval. These results agree with the global Maastrichtian environmental changes, implying a progressive cooling and changes in the ocean vertical structure and the global oceanic circulation.

S1 - MACROSTRATIGRAPHY AND MACROEVOLUTION IN MARINE ENVIRONMENTS: TESTING THE COMMON-CAUSE HYPOTHESIS

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Temporal patterns in the sedimentary rock record predict quantitatively many different macroevolutionary patterns in the fossil record, but the reasons for this predictability remain uncertain. There are two competing, but non-mutually exclusive, hypotheses: 1) similarities reflect a sampling bias imposed by variable and incomplete sampling of fossils, 2) similarities are induced by environmental perturbationsthat influence both the pattern of sedimentation and macroevolution (i.e., Common-Cause). Macrostratigraphy, which is based on the quantitative analysis of gap-bound rock packages, permits variation in the rock record to be expressed in terms of quantity and, more importantly, spatiotemporal continuity. In combination with spatially-explicit fossil occurrence data in the Paleobiology Database, it is now possible to test more rigorously alternative hypotheses for similarity and to distinguish between forcing mechanisms. Here I summarize results from interrogating the intersection of a comprehensive macrostratigraphic database for North America (Macrostrat; *http://macrostrat.geology.wisc.edu*) and the Paleobiology Database. Genus-level extinction within North America is better predicted by variation in the North American rock record than genus origination. The distributions of genus first and last occurrence datums within gap-bound rock packages differ significantly and are not consistent with a simple unconformity bias. Instead, the data suggest that biological extinction is closely related to processes that also govern package truncation. Similar results characterize the deep-sea sedimentary record and planktonic foraminifera, further supporting Common-Cause mechanisms as principal determinants of extinction in marine environments. The exact processes that control the Common-Cause link remain unknown.

S3 - MARINE DIATOM RESPONSE TO THE LAST DEGLACIATION OF ANTARCTICA

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Antarctica and its ice sheets play a major role in the global ocean-atmosphere system, hence, it is crucial to understand their past behaviour with a view to understanding their potential variability under a warming climate. Ocean sediments provide intriguing insights into the timing and nature of the rapid climate transition that occurred at the last deglaciation (~13-11 kyr BP). Exceptional, high resolution Antarctic margin sediment cores recovered during the last decade contain an excellent archive of these ice-ocean-climate interactions, often on seasonal timescales, from the last deglaciation and throughout the Holocene. Seasonal laminations are dominated by extraordinarily well-preserved fossil planktonic diatom assemblages; individual species of which are sensitive to sea surface conditions including sea ice concentration, fresh water influx, and open ocean influence upon the margin. During the deglaciation, spring laminae are dominated by diatoms associated with the spring sea ice melt and the formation of a freshwater cap trapping nutrients in the surface waters (e.g. *Hyalochaete Chaetoceros* spp.); summer laminae are associated with diatoms that favour slightly more oligotrophic, open-water conditions (e.g. *Corethron pennatum* and *Rhizosolenia antennata*); and autumn laminations are associated with diatoms that form resting spores in response to lowering light levels and sea ice re-advance (e.g. *Thalassiosira antarctica*). Diatom assemblage data will be presented that sheds light upon this significant change in the Antarctic, and Earth, climate system during the last deglaciation and into the Holocene.

S27D - THE INTRIGUING ORDOVICIAN "TRILOBITE" *TARICCOIA ARRUSENSIS* (ARTHROPODA, NEKTASPIDA, NARAOIIDAE) FROM SARDINIA: NEW DATA AND PERSPECTIVES

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Taricoia arrusensis Hammann, Laske and Pillola 1990 is an Upper Ordovician non-mineralized, blind, effaced "trilobite", without longitudinal segmentation, bearing four thoracic segments. The taxonomic position is still matter of debate; this is due to its peculiar morphology and to the postulated occurrence of some characters used in phylogenetic analysis (e.g. size of pygidium vs. cephalon and the presence of articular half rings on the thoracic segments, or ventral eyes). However, there is general agreement that *Taricoia* is closely related to the Cambrian Polish genus *Liwia* Dzik and Lendzion 1998, within the Nektaspida monophyletic clade. Present studies reveal the possible occurrence of very faint articular facets on the pleurae and nothing else compared with the original description given by Hammann *et al.* (1990). The unsolved problem of the mode of life originates from several controversial data. For example, the "well streamlined" shape of *Taricoia* and its inferred lightness, suggest a possible nectic mode of life; but blindness is unusual for a good swimming planctivore. The occurrence of about 30% articulated secimens and the depositional context suggest a very quiet marginal/lagoonal shallow water environment. More accurate observations on fine-grained beds reveals that more than 95% of the articulated remains of *Taricoia arrusensis* are oriented ventral side up! If we exclude endobenthic behaviour (because of the strange attitude for displacement within the sediment) and subsequently *in situ* fossilisation, we can only invoke peculiar hydrodynamic conditions in order to explain the upside down orientation, in the case of both carcasses and exuviae.

S9 – WHAT IS THE IMPACT OF THE TAGHANIC EVENT ON TABULATE CORALS OF THE ARDENNES?

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The Taghanic event is located in the Middle/Upper Givetian transition (late Middle Devonian). It extends from the middle part of Middle *varcus* to the basal *hermanni* Zones. This event, interpreted as polyphased, is considered as one of the major events of the Devonian (Aboussalam and Becker, 2001). A significant sea level change and a major global warming (Aboussalam, 2003) are probably the main causes to explain this extinction. In the Ardennes, the classical conodont biozonation cannot be used because of a reefal environment. Bultynck's correlations (1974) locate the Taghanic Event in the lower part of the Fromelennes Formation (Flohimont Member). The impact of Taghanic event on tabulate corals is not clear. As for the rugose corals (Coen-Aubert, 2004) the biodiversity of tabulate corals decrease in the middle part of the Fromelennes Formation (Moulin Boreux Member, *hermanni/disparilis* Zone). Tabulate corals are reduced to scolioporids even if they are extremely abundant. Identically, in the Boulonnais area, in the upper part of the Blacourt Formation (Bastien Member), correlated with *disparilis* Zone, the diversity of tabulate corals is also drastically reduced to scolioporids (two *Scolipora* beds) associated with some auloporids. However, a decrease of morphological variability can already be noted at the Flohimont Member (top of *varcus* Zone). Tabulate corals are only represented by small and branching forms.

S3 - YPRESIAN MICROFOSSILS IN THE CORBIÈRES (AUDE, FRANCE) CONTINENTAL MARGIN RECORD AND THE IDENTIFICATION OF AN EARLY EOCENE HYPERTHERMAL EVENT

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The Corbières Foreland Basin represents the southeastern-most extension of the Aquitaine Basin and is thus palaeogeographically related to the West-European Cainozoic Basin. During the Ypresian a succession of marine carbonates, marine marls, brackish marls to sandstones and subsequent fluvio-lacustrine sediments were deposited in the Corbières (Aude, France) area in several sequences. 128 samples were collected in 1m intervals from the neritic „Blue Marls" in order to document the early Eocene palaeo-environmental evolution of this succession through a quantitative analysis of the microfossil assemblages. Samples from the studied section contained only poorly preserved nannofossils of low abundance and diversity, indicating the nannoplankton zone NP11. The occurrences of planktonic foraminifera (e.g., *Morozovella subbotinae*) are in agreement with this biostratigraphic position (P6-7) as are the larger foraminifera (e.g., *Assilina leymeriei*). The ostracod assemblages contain common shelf-dwelling genera (e.g., *Echinocythereis*). Towards the top of the section, an upward-shallowing trend is recorded. The consistent presence of certain nannoplankton taxa points to nearshore, although fully marine conditions with normal salinities. The lower half of the section is characterized by a strongly variable plankton/benthos-ratio. A last pronounced peak (up to 80%) in plankton occurrence in association with the near disappearance of all larger faunal elements and a change in the ostracod assemblage between samples CN25-31 marks a potential location of a post-PETM hyperthermal event. In contrast to the Paleocene-Eocene thermal maximum, which has been recorded in deep-sea to non-marine depositional settings the ETM2 and ETM3, however, have until now only been demonstrated in deep-sea sequences, not in shelf deposits.

S14 - A NEW MOLECULAR TIMESCALE OF ANIMAL EVOLUTION: PARAMETERS TUNING AND PALAEONTOLOGICAL HYPOTHESES TESTING

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Molecular clocks have often been criticised because accumulations of mutations in protein and DNA sequences is generally not clocklike. However, during the last decade, molecular clock models relaxing the constant fixation-rate assumption have been developed and implemented in reliable Bayesian software. Modern, relaxed molecular clocks can be used to generate robust evolutionary timescales, which can either complement fossil-based evidence (for groups with a scant fossil record), or provide independent tests of palaeontological hypotheses. Implementing relaxed molecular clocks is not easy. This is because a multiplicity of parameters must be considered, and their effects on the estimated divergence times must be thoroughly investigated. Here, a new molecular timescale of the animal phyla will be presented. This timescale will then be used to discuss the effect of using (1) different clock models, (2) different priors for key parameters (e.g. the age of the root node), and (3) different levels of bound relaxation around the considered fossil calibrations. In addition, the use of molecular timescales to test palaeontological hypotheses will be illustrated. This will be done presenting an example from our own work in which molecular clocks are used to test two alternative scenarios of siliceous sponge evolution. The first is based on the interpretation of fossil biomarkers and suggests a Cryogenian origin for the siliceous sponges. The second is based on a literal interpretation of the fossil record of the siliceous sponge spicules and suggests the origin of the siliceous sponges was close to the Ediacaran - Cambrian boundary.

S13 - RECOVERY OF CONODONTS AFTER THE PERMIAN EXTINCTION

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Conodonts were in a progressive palaeodiversity reduction since the Carboniferous, and the Late Permian was a historical diversity minimum, with only three families (Gondolellidae, Ellisonidae and Spathognathodontidae) present in the Late Changhsingian. While, as many other groups, conodonts were heavily affected by the events of the Permian-Triassic Boundary (PTB), the severity of this impact has been subject of different interpretations during the last decades. To measure this subject, we have calculated the origination, extinction and radiation rates of conodonts in the interval of late Changhsingian to late Induan. Our study is based on a database of species of Triassic conodonts from a revision of the literature and the study of scientific collections. Our data show that after surpassing the PTB events, the conodonts had a very early recovery, mainly due to the quick diversification of the Spathognathodontidae, followed by its extinction in middle Induan and the diversification of Gondolellidae during the Late Induan and Early Olenekian.

W6 - FUNCTIONAL APPROACH TO THE TRIASSIC CONODONT SPECIES *PSEUDOFURNISHIUS MURCIANUS* VAN DEN BOOGAARD

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Pseudofurnishius murcianus is the most characteric conodont species in the Sephardic province during the Ladinian (middle Triassic). Its P1 element is easily distinguished from other triassic species by the tendency to develop a discrete and small inner platform in the anterior part of a short and laterally compressed blade. While different palaeobiological aspects of the species have been studied, like ontogenetic development, element orientation or apparatus reconstruction, the function of the P1 element remains still unstudied. Therefore the aim of this work is to present a functional approach of the conodont species *Pseudofurnishius murcianus* based on histological, morphological and microwear data. Our preliminary results show clear evidences of microwear in the denticles of the platform and in the adjacent ones in the blade. The distribution of surface damage is in agreement with the reconstructed model of element-to-element occlusion and seems to be more efficient in the platform area. In addition, the crystallite arrangement give the impression to follow a preferred orientation probably related with an optimal mechanical resistance, as it has been already pointed out by other authors. All these evidences are accord with an active processing of the food rather than a filtering function for the P1 element.

S6 - QUANTITATIVE APPROACHES TO GEOGRAPHIC VARIATION: ENVIRONMENT, PALAEOPHYLOGEOGRAPHY, AND ECOMETRICS

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Geographic variation in morphological traits is of interest in many ecological and evolutionary contexts. The geographic distribution of morphology is a complicated matter, controlled by a combination of environment, phylogenetic history, topography, between-species interactions, and chance. The environmental component is further complicated by truly adaptive responses to climate, which have a phylogenetic component to their history, and ecophenotypic responses, which have no genetic basis. Geographic variation in morphology is most often studied within one or more closely related species. At least in mammals, population-level geographic variation within species can be measured in bone and tooth traits such as are found in the fossil record. The relative contribution of environment and phylogeny depends on the history of the particular group and how sedentary its populations have been. In marmots, a widespread group of ground squirrels with a last common ancestry about 3 million years ago, dietary adaptations were a more important factor than either habitat or phylogeny for the geographic distribution of morphology, yet considerable phylogenetic signal could be recovered from the morphology. Palaeophylogeographic methods, when applied to living species with fossil representatives, can help establish a time scale for the processes of population differentiation and speciation. Geographic variation in morphology can also be studied at the community level, where environmentally interactive traits are measured in all species of the community to better understand how species and communities are distributed geographically and how their distribution relates to climate and environment. Such ecometric methods sometimes make good proxies for palaeoenvironment.

S18 - CATS IN THE TREES, SNAKES IN THE GRASS: ECOMETRIC VARIATION IN LOCOMOTION OF TERRESTRIAL VERTEBRATE CARNIVORES

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Organismal structure evolves interactively, with tradeoffs between genetic architecture, developmental processes, anatomical function, and environmental selection. We are studying locomotor traits in two guilds of terrestrial vertebrate carnivores, the mammalian Carnivora and the reptilian Serpentes, examining their evolution in functional, phylogenetic, community and environmental contexts to better understand how the coevolution of morphology and environments interact over long temporal and large spatial scales. Locomotor morphology was categorized as arboreal, scansorial, natatorial, fossorial, cursorial, and generalized terrestrial. In carnivorans, the proportions of the calcaneum were correlated with these categories (N=132; R^2 = 0.35), in snakes, the proportion of body-to-tail was (N=271; R^2=0.43). Using phylogenetic regression, we traced the functional evolution of our locomotor traits on a phylogenetic tree whose branch-lengths were calibrated against the fossil record; the same locomotor specializations have occurred independently in many carnivoran sub-clades when their phylogenetic tree was projected into a functional morphospace. Community sorting of locomotor morphology was assessed by measuring our ecometric indices in the species found across North America at 9,699 points spaced 50 km apart. Mean locomotor morphology in carnivoran faunas made up of a total 43 species was strongly correlated with ecoregion (R^2=0.70) and macrovegetation (R^2=0.49), but poorly correlated with number of species (R^2=0.15), elevation (R^2=0.07), and precipitation (R^2=0.01). Temperature was a much more important factor for carnivoran faunas (R^2=0.48) than for snake faunas (R^2=0.16). The strong correlation between these two locomotor ecometric indices makes them reasonable proxies for use in paleoenvironmental reconstruction.

S7 - ONTOGENY OF EARLY PALAEOZOIC RHYNCHONELLIFORM BRACHIOPODS AND ITS APPLICATION FOR UNDERSTANDING BRACHIOPOD PHYLOGENY

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The larval trophic mode of extinct brachiopods can been revealed indirectly not only from the relative size of the embryonic and metamorphic shell, but mainly also from characters of secretion of the primary and secondary shell fabric, the loss of larval setae, and the formation of adult setae along the shell margin. The metamorphic shells of Early Palaeozoic rhynchonelliforms with inferred planktotrophic larva consistently preserve two pairs of inflated lobes on the dorsal valve, indicating the position of two pairs of larval setal sacs; they also preserve a rudiment of an embryonic or metamorphic protegulum, which formed prior to the settlement of the larva. The regular laminar or fibrous pattern of the secondary shell fabric appears outside the halo, marking the outer boundary of the metamorphic shell. In early rhynchonellates, dorsal and ventral metamorphic shells were secreted simultaneously, with the pedicle emerging between valves. The metamorphic larval shell in these groups shows distinct similarity to that of paterinides. In the strophomenates there was a significant delay in ventral mantle differentiation and secretion of the ventral valve, which occurred only after settlement, while adult attachment structures were secreted by the ventral mantle, rather than representing a definitive pedicle formed from a posterior lobe as in rhynchonellates. Thus, the characters of larval development and early shell formation of the strophomenates are shared with the enigmatic *Solanygolina* and the craniiformeans. This suggests that the lecithotrophic larva of Recent Craniiformea is derived and may be homologous with the Early Palaeozoic 'strophomenate-type' planktotrophic larva.

S9 - SEA-LEVEL CHANGES, KELLWASSER HORIZONS AND CORAL-BRACHIOPOD CRISES DURING THE LATE FRASNIAN IN THE NAMUR-DINANT BASIN (BELGIUM)

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In the Namur-Dinant Basin, the Lower (LKW) and the Upper Kellwasser Events (UKW) are marked by the development of argillaceous deposits with dysaerobic-anaerobic facies and correspond respectively to the maximum of relative sea level (maximum flooding surface) of the two late Frasnian - earliest Famennian third-order sequences. The initial decline of the rugose corals within the Namur-Dinant Basin is recognized in the Lower *rhenana* Zone, and is correlated with the beginning of the rise in sea level triggering the transgressive system tract of the first late Frasnian sequence and following the fall in sea level which marks the top of the middle Frasnian limestone formations and bioherms. This decline was not due to the LKW *sensu stricto*, which happened later and induced strictly no extinction in corals and brachiopods as those occurring below the LKW were still present above. Rugose corals disappeared progressively, along with the tabulates, in the Upper *rhenana* Zone, before the UKW. The brachiopod decline occurred in three steps within the interval spanning the Lower *rhenana* Zone to the *linguiformis* Zone. Most brachiopod orders suffered severely and the major losses occurred at the top of the Upper *rhenana* Zone. These extinction episodes were linked principally to diachronous regional facies changes related to transgressions. For example, atrypids disappeared at the top of the Lower *rhenana* Zone in the deeper part of the basin, just before the deposition of the dark shales of the Matagne Formation, but persisted within the Upper *rhenana* Zone in its shallow parts.

S3 - GLOBAL VEGETATION AND MODELLING NEOGENE CLIMATES

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Predicting the response of Earth's climate to anthropogenic greenhouse gas emissions using numerical climate models is a way of providing policy makers with the information they need to make society wide decisions about the future climate change and its impacts on civilization. To test the predictive ability of models the use of substantial databases of palaeoclimatic / environmental information from periods in Earth history significantly different from the modern is required. The Neogene (Miocene and Pliocene) provides such a time period. It is close enough to the recent for plate tectonic differences to be minimal, but distant enough to offer significantly different climates. Focusing on the mid-Piacenzian warm period a global palaeobotanical database has been constructed containing 202 marine and terrestrial sites. This database is consistent with the BIOME4 mechanistic vegetation model, which has allowed the merger of data and climate model output to create an advanced hybrid vegetation reconstruction. This reconstruction is now being used to facilitate new modelling studies and palaeoecological studies. The vegetation pattern shows a northward shift in evergreen taiga, temperate forests and temperate grasslands. Warm-temperate forests spread across mid and eastern Europe. In Africa and Australia desserts were reduced and replaced by tropical savannas and woodland. Current work is focused on producing another hybrid vegetation reconstruction for the late Miocene (Tortonian). We have constructed a database of 207 palaeobotanical data points. This new reconstruction shows a spread of forests northwards and an even greater spread of warm-temperate forests through modern temperate regions.

S27B - DID MARK TWAIN DISCOVER AMERICA'S MOST IMPORTANT FOSSIL SITE?

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This year is the centenary of Mark Twain's death, and despite all that has been written about him, very few know of his informed, abiding interest in paleontology. In *Innocents Abroad* (1869), he discovers "a mysterious oyster mine" high on a Turkish hillside. Goaded by Alfred Russel Wallace's argument that the earth had been divinely and plainly created for humans, Twain writes the satirical essay, "Was the World Made for Man" (1903), in which his amusing fossil lineages drolly debunk Wallace's teleological claims. In spring 1871, after months of family crises and struggling to write his second book, *Roughing It* (1872), he and his family retreat to Quarry Farm, his sister-in-law's bucolic home in Elmira, NY. As work on the manuscript progresses, he and a close friend prospect for fossils in a nearby quarry, amassing "enough specimens to fill a small museum," pontificating about trilobites, and "having altogether a joyful good time." Then in 1874 his sister-in-law builds an octagonal study in the quarry where, amid fossils and fond memories, Twain writes early drafts of *Huckleberry Finn* and other well-known books during the next 20 summers. Since 2005, fossil collecting in the quarry has yielded over 25 species of marine invertebrates. The most significant of these are phacopid trilobites with characteristic schizochroal eyes, rounded genal angles, and semicircular pygidia. Because the quarry exposes siltstone lying well within the Frasnian Stage of the Upper Devonian, the trilobites collected there may be the first post-taghanic phacopids yet found in North America.

S24 - THE FLORA FROM DECHRA-AÏT-ABDALLAH (MOROCCO): A LOWER TO MIDDLE DEVONIAN TRANSITIONAL ASSEMBLAGE

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The Devonian Period is of major importance in the understanding of the evolution of plants as well as of the whole environment. The terrestrialisation process induced deep changes in the geobiosphere that lead to the establishment of modern environments. The transition from Lower Devonian to Middle Devonian is particularly rich in innovations. The Devonian plant record from Gondwana is however scarce. The plant assemblage from Dechra-Aït-Abdallah (central Morocco) presented here was first reported by Termier & Termier (1947, 1950). The diversity of this assemblage and the obvious need for its taxonomic revision prompted us to review the flora. We collected new specimens at Dechra-Aït-Abdallah. The locality is situated in the southeastern Meseta (east-central Morocco). It is part of a Lower to Late Devonian age allochtonous sedimentary nape dominated by marine carbonates. Plants are allochtonous. A late Emsian age has been proposed based on badly preserved Tentaculita, but other studies indicate an early Eifelian age. The assemblage is moderately diverse and includes representatives of both Early Devonian and Middle Devonian floras. It is dominated by *Aneurophyton maroccanum* Termier and Termier (1950). We here describe and illustrate the plant, and we discuss its affinities. The Protolepidondedrales (Lycophytes) *Leclercqia* and *Haskinsia* are present. Zosterophylls are putatively represented by a spiny axis that recalls *Sawdonia.* Several vegetative axes tentatively assigned to *Psilophyton* have been found. This assemblage represents the only occurrence of early Eifelian plants on Gondwana. Its palaeographical and evolutionary implications will be assessed.

S21 - PHYLOGENIES AND THE FOSSIL RECORD FOR UNDERSTANDING LARGE-SCALE EVENTS IN THE HISTORY OF LIFE

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Major events in the history of life leave imprints in the phylogeny of living species and in the fossil record, but neither line of evidence is always straightforward to interpret. We outline the circumstances under which large phylogenies of extant species are and are not likely to permit detection of a major event. Although such phylogenies are often of limited use, the fossil record can also provide a misleading picture of what happened at major events. The incompleteness of the record has long been recognised as one source of error, but here we discuss two other problems that arise from taxonomic practice even where the record is good, and show how they can either dampen real temporal changes in species diversity or cause apparent changes. Focusing on the group with perhaps the best fossil record, macroperforate planktonic foraminifera, we show how a paleophylogenetic approach can overcome most of these problems and refine our understanding of how life responds to major events.

S20 - APATITE VARIETIES IN LIVING AND FOSSIL SKELETONS

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A synthesis of data from mineralogical and microstructural studies of apatite varieties in Recent and fossil skeletons, with the consideration of ontogenetic and phylogenetic variation, and taphonomic overprint may open a framework for asking new questions relevant to taphonomic and phylogenetic research. Due to medical applications, teeth and bones of humans and other vertebrates are the best studied systems of apatite biomineralization. In invertebrates, apatite lattice parameters are known for chitino-phosphatic shells of lingulate brachiopods and radular teeth of chitons. By integrating a wide set of original XRD data, ESEM observations and data from related publications, our study allows us to hypothesize that apatite varieties can be used as indicators of taphonomic scenarios in numerous case studies. Three general trends form a useful framework for interpretation: (1) an ontogenetic trend from OH-rich apatite to more F-rich apatite; (2) divergence of phylogenetic lineages with developmental programmes initiating biomineralization of apatite varieties with different F-content and (3) taphonomic changes of various extent towards carbonate F-apatite.

S3 - RECENT STUDY OF CONODONTS AND FORAMINIFERS FROM THE CANDIDATE GSSP OF THE CARBONIFEROUS VISEAN-SERPUKHOVIAN BOUNDARY IN THE NAQING (NASHUI) SECTION OF SOUTH CHINA

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The Naqing Section, formerly known as the Nashui section, at Luosu of Luodian County, Guizhou Province, South China, is a relatively deeper-water, carbonate-slope facies section that is a potential candidate GSSP for the base of the Serpukhovian Stage. Additional detailed sampling of the section over the past two years has provided new data for a more detailed biostratigraphy of foraminifers and conodonts across the potential level of the GSSP of the Serpukhovian Stage. Very abundant conodonts were obtained from the Visean-Serpukhovian (V/S) boundary interval (29 species representing 6 genera). Four conodont zones occur at Naqing in the V/S boundary interval through a 40 m section, in ascending order, *Gnathodus bilineatus*, *Lochriea nodosa, Lochriea ziegleri* and *Lochriea cruciformis* zones. Preliminary study of the foraminifers from the V/S boundary interval in the Naqing section in Guizhou and the South Pengchong section in Guangxi of South China shows that the FOD of the *Howchinia bradyiana* lies near the FAD of *Lochriea ziegleri*. This same phenomenon has also been observed in the Vegas de Sotres section in Cantabrian Mountains of Spain (Blanco-Ferrera et al., 2009) and the Verkhnyaya Kardailovka section in South Urals of Russia (Nikolaeva et al., 2009). Correlation of the conodont succession with the foraminiferal fauna through the V/S boundary interval will provide the basis for global correlations between the deep-water facies and shallow-water facies. However, additional work is still needed to adequately resolve the correlation between conodonts and foraminifers across the V/S boundary in the straigraphically continuous sections in South China.

S10 - ECOLOGY OF TESTATE AMOEBAE IN LAKES OF MIDDLE YANGTZE REACHES AND THEIR POTENTIAL AS WATER QUALITY INDICATORS

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The Middle Yangtze Reaches are known as the site of thousands of lakes, and is one of a few (17) regions recognized as both a Global Biodiversity Hotspot and a Global 200 Priority Ecoregion in China. Testate amoebae are benthic organisms characterized by an agglutinated or autogenous shell in the form of a sack. Testate amoebae can be very useful indicators of environmental and palaeoenvironmental conditions because of their high abundance and species diversity, widespread distribution, easy identification, and good preservation in sediments. A total of 22 testate amoebae species belonging to five genera were examined from 35 surface sediment samples collected from 35 lakes and ponds in the Middle Yangtze Reaches of China. Twenty two measured environmental variables were considered, including water property attributes (e.g. pH, conductivity, dissolved oxygen, HCO_3^-, Cl^-, SO_4^{2-}), substrate characteristics, trophic factors like total phosphorus (TP), total nitrogen (TN), and Chlorophyll-a and some environmentally available metals. We used multivariate analysis to evaluate the relations between water quality variables and testate amoebae assemblages. Canonical correspondence analysis (CCA) showed that total nitrogen (TN) and conductivity are the dominant factors that influence the relative abundance of species. Indicator species analysis showed that the sensitivity of lake testate amoebae to eutrophication corroborates previous work based on analysis

of fossil assemblages. *Centropyxis* species like *C. aculeate* and *C.ecornis* and some species of *Difflugia* like *Difflugia biwae* and *D. tuberspinifera* are good indicators of oligotrophic conditions. *Difflugia acuminate, D. corona, D.elegans, D. oblonga*, and *D. smilion* are more commonly found in mesotrophic and eutrophic lakes.

S23 - SYNCHROTRON RADIATION X-RAY MICROTOMOGRAPHY REVEALS THE PRIMITIVE HISTOLOGICAL ARCHITECTURE OF OSTEICHTHYAN SCALES

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The typical cosmoid scale in primitive sarcopterygians consists of outer single layered enamel with underlying dentine, bone and a complex pore-canal system; occasionally buried odontodes occur deep in the bone layer, indicating a superimposed growth mode. On the other hand, the ganoid scale in primitive actinopterygians is made up of multiple-layered enamel (ganoine), dentine and bone; and the dentine layers are distributed at the same growth level, indicating an areal growth mode. Thus there exists an obvious gap between the two types of osteichthyan scales regarding the histological architecture. Recently we have identified the scales of Psarolepis romeri, a basal sarcopterygian fish with a mosaic of osteichthyan and non-osteichthyan gnathostome characteristics. These scales with thick bases and characteristic ornamentation are assigned to Psarolepis according to the crown ornamentation, histological details and its abundance in the whole sample. In order to understand more about the pore-canal system of the Psarolepis scale, we used the X-ray synchrotron microtomography to reconstruct the 3D structure of the system, which was previously only based on thin sections. The model shows an integrated canal system of the scale. In addition to thin sections, our 3D restoration of the Psarolepis scales reveals a unique type of osteichthyan scale in histology. With the multiple-layered enamel, superimposed odontodes together with areal growing odontodes, and a well developed pore-canal system, the histological architecture of the Psarolepis scales bridges the gap between those of the ganoid and cosmoid scales, and might represent a primitive condition in osteichthyans.

S20 - FOSSILIZATION AS A BIOLOGICAL PROCESS: THE ROLE OF MICROBIOLOGY IN TAPHONOMY

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Fossils of soft-bodied organisms and even embryos provide vital information for understanding early animals, their life histories, and their modes of development. Microscopic investigation of Late Proterozoic and Cambrian embryos mineralized by calcium phosphate replacement reveals exquisite cellular and sub-cellular structure. Studies of modern embryos similar in size to fossil embryos offer a window to early metazoan development, and to taphonomic mechanisms. Experimental taphonomy requires approaches that examine processes at biochemical, cellular, and microbial levels that operate in biological time scales. We have found that early steps of fossilization are the consequence first of cellular processes operating in a newly killed marine embryo and then by microbial processes that follow. Rapid enzymatic self-destruction of embryos can be blocked by anaerobic, sufidic, or highly reducing conditions analogous to those relevant for both modern and ancient seas. Microbial processes include rapid colonization of autolysis-blocked embryos by biofilms produced by environmental bacteria. The biofilms generate pseudomorphs, detailed replicas of cellular structures that the bacteria have consumed and replaced. We obtain rapid microbial-dependent taphonomic mineralization, including calcium phosphate, by controlling aerobic vs. anaerobic conditions, pH, and specific ion concentrations. DNA tools allow rapid identification of microbial populations, and mapping the locations of individual microbial species within taphonomic embryos. We suggest that experimental taphonomy requires understanding of the microbiological interactions between the environment and

organisms being fossilized, including the genetics of production of taphonomic biofilms. These data will open new avenues to understanding of relevant microbial processes under various environmental conditions.

W1 - NOVEL IMAGING TECHNIQUES FOR STUDYING FOSSIL ECHINODERMS

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Visualizing the interior and three-dimensional structure of fossils is an important step in elucidating the morphology of species, and can yield valuable palaeobiological insights. Fossil echinoderms may be particularly amenable to such analysis; well-preserved, three-dimensional specimens are known for many different groups. Several non-destructive scanning technologies exist for imaging high-resolution, three-dimensional anatomy. X-ray microtomography (XMT or micro-CT) is appropriate for visualizing millimetre- to centimetre-scale material and is hence well-suited for the study of complete echinoderm fossils. Examples include the ctenocystoid *Ctenocystis*, the cinctan *Protocinctus* and the stylophoran *Lagynocystis*. Synchrotron radiation X-ray tomographic microscopy is a powerful variant of XMT that is capable of generating exceptionally high-quality data. It has been used to image isolated echinoderm ossicles, but these studies are currently in their infancy. Both methods can provide information on articulations, openings and internal characters of fossil echinoderms; such features are of key significance for assessing competing morphofunctional and phylogenetic hypotheses, but can be difficult to study using conventional palaeontological techniques.

PLENARY - FROM ROCK TO REALITY? MULTIPLE APPROACHES TO FUNCTIONAL ANALYSIS IN FOSSILS

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Over the last decade, a suite of computer-based and engineering tools has enabled palaeontologists to conduct sophisticated morphofunctional analyses of fossils. These include imaging techniques such as synchrotron radiation x-ray microtomography (SRXTM), finite element analysis (FEA), quantitative microwear, and freely available morphometric software. Validation studies are increasing our confidence in applying such *in-silico* methodologies, whilst advances in computing power and availability allow us to ask increasingly searching questions, from function of individual taxa to analysis of broad scale functional and evolutionary trends. Typically these studies employ one or two techniques in isolation. The aim of this talk is argue that there is now a critical mass in expertise and availability of such techniques. Therefore multi-dimensional functional analyses, combining several *in-silico* approaches, can now be used to gain the most holistic answer in functional analysis. I will present examples of work that have undertaken such a remit. Functional and ecological diversity and locomotor capabilities in stem mammals is considered, as is the function and evolution of the mammalian tooth. Other studies consider the morphofunctional evolution of the crocodilian and dinosaurian skull. All analyses use a combination of techniques ranging from SRXTM to traditional biomechanics to geometric morphometrics. Agreement of multiple strands of evidence should of course strengthen our confidence in functional interpretation. Furthermore the work is grounded in validation studies in birds and mammals, demonstrating that rocks to reality is not a one-way process, and information gleaned from living taxa is crucial to our understanding of their extinct forebears.

S20 - DIE AND ROT: EXPERIMENTAL TAPHONOMY OF TADPOLES

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The general term 'soft tissues' disguises the variation in fossilisation potential of the different tissues and organ systems of chordates, even within a single taxon. Modelling this using decay experiments can help resolve the affinities of problematic soft-bodied fossils that may represent chordates. Decay experiments also provide information to help constrain the interpretation of specific anatomical features within fossils . We experimentally decayed tadpoles of the frog *Xenopus laevis* to establish the general pattern of degradation and, in particular the fate of the notochord, nerve cord, gut and lateral line system. These share one general feature in common: they are linear structures running the length of the body. As such, distinguishing between the possible alternatives is potentially problematic in fossil material. Muscle tissue and the various internal organs except the gut decay rapidly. The dermal tissue remains coherent until late in the decay history, around which time the notochord and nerve cord also disintegrate. The last to decay are the gut and the eyeballs. Notably, the dermal tissues decayed uniformly over the body surface. A thick bacterial biofilm rapidly developed around the decaying tadpole. This either: (i) was "blanket-like", with its margins fixed to the jar bottom, and the tadpole, although 'floating', trapped below it; or (ii) tightly encased the specimen and secured it firmly to the jar bottom. No variable that correlated with the pattern of biofilm could be identified. Such biofilms inhibit both disarticulation of the carcass and its floating after the build-up of internal decay gases.

W5 - THE SEAMLESS AMALGAMATION OF COMPUTERS AND DEAD PLANTS: COMPARISON OF 3D RECONSTRUCTION TECHNIQUES IN PALAEOBOTANY

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3D reconstruction and visualisation is becoming more commonplace in palaeobotany as a result of increasing methodological refinement and overall cost reduction. As a measure of this, different preparation techniques are now available to suit different kinds of preservation to attain a diversity of reconstruction outcomes. This talk will elaborate comparative methods for reconstructing fossil and modern seeds from the Gingkoales and methods used to reconstruct a diversity of arborescent lycopsid cone species. Of the available fossil Ginkgoalean ovules one have has been prepared as serial wafers and has been studied by a combination of traditional descriptive techniques and 3-D reconstruction constructed from a small number of tomographic slices, while another specimen has been investigated by non-destructive methods through high resolution CT-scanning. Comparisons are made with seeds of the modern ginkgoalean Ginkgo biloba and reveal remarkable evolutionary stasis in ovule phenotype since the Jurassic. Lycopsid cone specimens have been prepared by serial wafers producing a small number of tomographic slices, serial grinding to produce a high resolution destructive data sets, and non-destructive methods using high resolution CT-scanning. Comparative studies of extant specimens using the same techniques allows extraction of the maximum information from living species, and allows results gained from different preparation techniques to be compared against each other. Comparison of using both living and fossil material and using destructive and non-destructive methods gives an excellent set of controls and allows a fair assessment of the methodologies of specimen preparation, reconstruction and the required subjective interpretation.

W1 - SOLVING THE PALAEOBIOLOGICAL PUZZLE OF SEA CUCUMBERS AND THEIR RELATIVES (ECHINODERMATA) – PROBLEMS AND FUTURE RESEARCH NEEDS

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Ophiocistioids and holothurians have the poorest fossil record of any echinoderm group, and their palaeobiology, relationships, and evolutionary history remain some of the most interesting and puzzling unsolved problems in echinoderm palaeontology. However, only limited significant progress has been achieved in this field during the past decades. Future work is urgently needed to extend our knowledge of modern holothurian calcareous ring and ossicle anatomies. The integrative use of old and new technologies, mentionably SEM and X-ray CT-scanning, provides us with a better understanding of evolutionary diversification and functional morphology. A combined study of articulated and disarticulated material with macro- and micropalaeontological methods has also extended our understanding of the diversity and range of both groups. In this presentation, recent ideas formulated in this field and some implications of these ideas as well as remaining gaps in our knowledge are reviewed and discussed.

S3 - THE DIATOM AND SILICOFLAGELLATE RESPONSE TO A MIDDLE EOCENE WARMING EVENT RECORDED IN THE TROPICAL ATLANTIC (DEMERARA RISE, ODP SITE 1260A)

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The Middle Eocene diatom and silicoflagellate record of ODP Site 1260A (Demerara Rise) is studied quantitatively in order to throw light on the changes that siliceous phytoplankton communities experienced during a Middle Eocene warming event that occurred between 44.0 and 42.0 Ma. Both Pianka's overlap index, calculated per couple of successive samples, and cluster analysis, point to a number of significant turnover events highlighted by changes in the structure of floristic communities. The pre-warming flora, dominated by cosmopolitan species of the diatom genus *Triceratium*, is replaced during the warming interval by a new and more diverse assemblage, dominated by *Paralia sulcata* (an indicator of high productivity) and two endemic tropical species of the genus *Hemiaulus*. The critical warming interval is characterized by a steady increase in biogenic silica and a comparable increase in excess Ba, both reflecting an increase in productivity. In general, it appears that high productivity not only increased the flux of biogenic silica, but also sustained a higher diversity in the siliceous phytoplankton communities. The microflora preserved above the critical interval is once again of low diversity and dominated by various species of the diatom genus *Hemiaulus*. All assemblages in the studied material are characterized by the total absence of continental and benthic diatoms and the relative abundance of neritic forms, suggesting a transitional depositional environment between the neritic and the oceanic realms.

S27B - MACROEVOLUTIONARY PATTERNS IN ANTARCTIC NEOGENE RADIOLARIANS

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The potential of Cenozoic radiolarians for evolutionary and biostratigraphic research is greatly underdeveloped: although most living radiolarian species diversity is reflected in the fossil record, only a small fraction of the recovered diversity has yet been recorded consistently. We are starting a new long-term effort to comprehensively document these microfossils, beginning with the collection of quantitative, full fauna data from a distinct biota - the Antarctic Neogene. Counts of several thousand specimens/sample from time series at several selected Antarctic sites will be analysed for macroevolutionary patterns and for quantitative biostratigraphy (e.g. CONOP). More than 480 species have been identified from the early Miocene to the Holocene (vs <200 species in all prior publications), including >100 as yet undescribed forms. Maximum within sample diversity is >200 (vs ca 60 in prior studies). Preliminary results (diversity patterns, major changes in the community structure and composition, species longevities) are compared with both a preexisting macroevolutionary analysis of published biostratigraphic-only data from the same fauna (Lazarus, 2002), and with the known paleoenvironmental history of the Antarctic Neogene. We will also discuss implications for other studies of the fossil record that are based on highly incomplete diversity data.

S3 - THE GLOBAL CHANGE RECORD OF MICROPALAEONTOLOGY

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Progressive innovation amongst planktic organisms, particularly in biomineralization, must have driven profound changes in the geochemistry of the ocean over the Phanerozoic. It has been inferred from numerical models that associated with these evolutionary changes will have been reorganizations of global biogeochemical cycles that generally lead to a tighter regulation of ocean chemistry and of atmospheric pCO_2 (and hence climate). Such inferences need to be tested against the geological record. However, key records of biotic influence, particularly as recorded in the preservation and burial of calcium carbonate ($CaCO_3$) in deep sea sediments, tend to be heavily overprinted by carbonate chemistry responses to long-term tectonic factors such as changing sea-level and major cation ratios (e.g., Mg^{2+}/Ca^{2+}). What then is the global change record of micropalaeontology as pertains to an increasing regulation of pCO_2 and climate? i.e., What is the tell-tale signature of increased biotic regulation of Earth system? In this talk I will summarize the geological record of global carbonate cycling and use observations and model predictions of past perturbation events to illustrate what I argue is a differing behavior of the Earth system prior to, and following, the proliferation of planktic carbonate biomineralizers during the Mesozoic.

S13 - AN EXPERIMENTAL APPROACH TO BENTHIC COMMUNITY DESTRUCTION AND RECOVERY FROM ANOXIA IN THE NORTHERN ADRIATIC SEA

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Anoxia in shallow marine waters leads to biodiversity loss and disrupted ecosystem function (e.g. filter- and suspension-feeding capacity, bioturbation) and can change structurally complex and diverse benthic and pelagic communities into far simpler, depauperated ones (homogenization). The Northern Adriatic Sea is a recognized case study for repeated seasonal low dissolved oxygen events. Using a specially developed underwater-chamber (EAGU) – equipped with camera, flashes and a sensor array – we experimentally recreate small-scale anoxia in a community setting. In a first project we focused on the well-developed macroepifauna in the Gulf of Trieste, Northern Adriatic. The *in situ* experiments successfully mimicked full-scale low DO events and revealed a clear sequence of species-specific behaviours and mortalities correlated to specific oxygen thresholds. The present project will incorporate key representatives of the macroinfauna and meiofauna and will include sediment geochemistry. We will also take the EAGU concept one step further by evaluating post-anoxia developments such as decomposition, scavenging/predation and the recovery of the benthos as a whole. This yield of new details (e.g. never observed behaviours and interactions, i.e. predator-prey interactions), at a finer scale of resolution than ever before, is an important step forward in compiling a broadly applicable catalogue of sensitive and more tolerant species. This will also help evaluate community status, i.e. retrospectively pinpoint past anoxias and predict future community compositions. This also calls for examining both the short- and longer-term recolonization process. Finally, our experiments will help to better understand and interpret anoxia and dysoxia on epicontinental seas in the fossil record.

W6 - LATE TRIASSIC CONODONT LIFESTYLE: CONSTRAINTS FROM OXYGEN ISOTOPES OF BIOGENIC APATITE

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The oxygen isotopic composition of conodont apatite derived from the Late Triassic (Carnian to lower Norian) Pignola 2 and Sasso di Castalda sections in the Lagonegro Basin (Southern Apennines, Italy) was studied in order to constrain the habitat of Late Triassic conodont-animals. Oxygen isotope ratios of conodonts range from 18.5 to 20.8‰ V-SMOV. Using the equation given by Kolodny et al. (1983) and assuming a $\delta^{18}O$ value of Triassic subtropical seawater of -0.12 ‰ V-SMOW, oxygen isotope ratios translate into paleo-temperatures ranging from 22 to 31° C. These warm temperatures, well comparable to those of modern subtropical oceans, suggest that $\delta^{18}O$ values of Late Triassic conodonts reflect surface water temperatures. Based on the oxygen isotope ratios and considering the anatomical characteristics of the conodont animal, Late Triassic conodont animals bearing the studied conodont taxa are interpreted as surface dwellers with a nektonic lifestyle within the euphotic zone.

W6 - Sr ISOTOPIC SHIFT AS A POTENTIAL GLOBAL GEOCHEMICAL MARKER FOR THE BASE OF THE RHAETIAN STAGE

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Looking for a geochemical signature at the base of the Rhaetian Stage, we have investigated the variations of $^{87}Sr/^{86}Sr$ isotopic ratio directly from biogenic conodont apatite of 16 new conodont samples from Tethyan sections straddling the NRB using thermal ionization mass spectrometry (TIMS, University of Geneva, 1σ external reproducibility <7 ppm). Our results identify a negative shift in Sr isotopic ratio from 0.70826 to 0.70774 in Tethys, in correspondence to the first appearance of *Misikella posthernsteini* at the base of the Rhaetian, in good agreement with the drop already observed by Korte et al. (2003). Recently, Giordano et al. (2010) highlighted the high correlatability of the FAD of the Tethyan conodont *Misikella posthernsteini* with both the occurrence of the North American *Epigondolella mosheri* morphotype A and the beginning of the radiolarian *Propavicingula moniliformis* A.Z., which corresponds to the global disappearance of the bivalve genus *Monotis*. The global potential of the Sr isotope stratigraphy rests on the homogeneity of the $^{87}Sr/^{86}Sr$ in oceanic water, since the residence time of Sr in seawater (>10^6 yrs) is far longer than its mixing time (>10^3). Henceforth, any given point in time should be characterized by a unique value of $^{87}Sr/^{86}Sr$ worldwide (McArthur, 1998). Following the new biostratigraphic calibrations, we suggest the negative Sr isotopic shift is a potential global geochemical marker to identify the base of the Rhaetian Stage.

S27B - SEASONAL, INTERANNUAL AND GEOGRAPHICAL DISTRIBUTION OF SILICOFLAGELLATE FLUXES IN THE WESTERN MEDITERRANEAN

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Traditionally, silicoflagellates have been used for biostratigraphical studies and as a proxy for palaeo-temperature reconstructions. However, a lot of aspects of their ecology and distribution remain unknown. In this study 337 samples have been analyzed from five sediment traps deployed in the Western Mediterranean in an attempt to gain some insight into the ecology of this cryptic group than can be useful for future palaeo-ceanographic reconstructions. The sediment traps transect covers three key areas of the Western Mediterranean (Gulf of Lions, Catalan continental margin and Alboran Sea). Three silicoflagellate species were identified: *Dictyocha fibula* (Ehrenberg), *Dictyocha speculum* (Ehrenberg) and *Octactis octonaria* (Ehrenberg). Silicoflagellate fluxes exhibit a clear seasonality and the assemblage composition shows important variations in the different sites that seem to be related to environmental conditions, especially to temperature. The effects of the NAO (North Atlantic Oscillation), ENSO (El Niño Southern Oscillation) and the 2003 summer heat wave on the silicoflagellate fluxes are also discussed.

S20 - TAPHONOMY OF THE HEREFORDSHIRE LAGERSTÄTTE

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Fossils of the Herefordshire (Silurian) Lagerstätte are preserved in three dimensions within carbonate nodules which occur throughout a thick ash deposit. The fossils display a complex range of preservational modes being predominantly composed of coarse calcite but surrounded by early stage kaolinitic clays, ankerites and ferroan dolomites. The fossils may occur centrally or eccentrically within the nodules and there is no relationship between fossil and nodule size. In order to unravel the complex taphonomic pathways operating soon after death and during early diagenesis the fossils, nodules and host sediment have been chemically and texturally characterised using XRF, XRD, EMPA and SEM analysis. Immobile elements in the ash indicate that it originated from an andesitic volcano on a destructive plate margin. Both the ash and nodules demonstrate pronounced sodium depletion. The release of highly mobile sodium ions in solution, soon after ash emplacement, may have been responsible for an increase in alkalinity which could account for rapid carbonate formation. Interestingly, uniform cathodoluminescence suggests that the nodules and the carbonate infilling the fossils precipitated simultaneously. The calcite preserving the fossils cannot have been entirely void-filling because several polychaetes demonstrate a sediment-filled gut that occurs suspended in the body cavity in life position. Decay experiments on polychaetes suggest that the gut would collapse within one week after death thus constraining the rate of calcitization of at least some of the Herefordshire fossils. The highly reactive nature of the host ash is a possible explanation for the preservation of the Herefordshire Lagerstätte.

S27A - THE AUDITORY REGION OF THE LARGEST FOSSIL RODENTS (MAMMALIA, DINOMYIDAE, EUMEGAMYINAE)

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The Dinomyidae are one of the three families of ‘giant’ rodents known from South America. Nowadays, the family includes only the “pacarana” (*Dinomys branickii*), a quite peculiar but poorly studied Amazonian caviomorph. Contrary to this impoverished present record, the past diversity of the group was notable, with an astonishing number of fossil genera and species reaching body sizes even larger than the pacarana. The most extreme is the giant *Josephoartigasia monesi*, the largest rodent ever recorded with an estimated mean body mass close to a ton. *Josephoartigasia* and all major members of the family are placed among the subfamily Eumagamyinae (Miocene-Pliocene). We describe for the first time the auditory region of the subfamily of the giant rodents Eumegamyinae which is characterized by: a short *meatus acusticus externus*, a highly developed *foramen stylomastoideum* and the presence of an ectotympanic cavity placed before the *meatus acusticus externus*. However, this general pattern is not present in all members of the subfamily. *Josephoartigasia* is characterized by having a long tube that projects into the posterior region of the skull and lacks an ectotympanic cavity. Our studies indicate that this region exhibits a set of characters with potentially diagnostic value in the family Dinomyidae.

S5 - THE PALAEONTOLOGICAL COLLECTION AT FACULTAD DE CIENCIAS, MONTEVIDEO, URUGUAY: PAST, PRESENT AND FUTURE

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The Palaeontological Collection at Facultad de Ciencias, in Montevideo is the most diverse palaeontological collection in Uruguay, both in terms of taxonomic and chronostratigraphic scope. It dates back to about 1953 and supports research, teaching and outreach at the Facultad de Ciencias. The collection has grown almost exclusively through the research interests of the palaeontology staff and includes microfossils, invertebrates, vertebrates and ichnofossils mainly from the Uruguayan stratigraphic record, which covers – though not continuously - the late Precambrian to the Quaternary. Almost 9,000 specimens and lots are catalogued and accessible, including 50 type specimens. During most of its existence, the care of the palaeontological collection was inadequate. However, the ethical requirement for the preservation of fossil specimens for the long term and the need to implement internationally agreed best practices in collection management has been recently recognized. With up-to-date training and voluntary students, the collection has undergone a general condition assessment, reordering of the specimens, enhancement of their storage, and a regular monitoring of temperature and relative humidity. The main goals pursued for the near future are to design a collection management policy to govern the care and use of the palaeontological collection and to develop a stable computer catalogue.

S27B - THE FIRST PREDATION BOREHOLE ON A FOSSIL CHITON PLATE (LATE PLEISTOCENE, URUGUAY)

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Predation boreholes on shells are one of the commonest trace fossils in the fossil record. Gastropods have left evidence of this feeding activity on a variety of taxa including bivalves, gastropods, scaphopods, brachiopods and crustaceans, among others. Here we report the first borehole on a chiton plate, which was found in the Late Pleistocene mollusc-rich assemblage at La Coronilla, Uruguay. The specimen is stored in the Palaeontological Collection, Facultad de Ciencias, Montevideo, Uruguay (FCDPI 4891). The borehole is identified as *Oichnus simplex* Bromley, 1981 and occurs on an intermediate valve of the chiton *Chaetopleura angulata* (Spengler, 1797). It is sub-cylindrical, with the external diameter of 1.7 mm and the internal diameter of 1.2 mm. The axis is almost perpendicular to the shell surface and penetration is from the shell exterior. The assemblage also contains naticid and muricid gastropods. As chitons are epifaunal, hard substrate dwellers, the predator may have been a muricid gastropod. The relevance of this discovery is the recognition of a novel trophic interaction between gastropods and chitons in the fossil record that has apparently not been recognized in the Recent.

S7 - MORPHOLOGY AND ECOLOGY OF RECENT BRACHIOPOD ASSEMBLAGES FROM THE CARIBBEAN COAST OF PANAMA

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Although brachiopods are generally impoverished members of modern day benthic communities, they may be locally common, particularly in cryptic habitats. Here we report the discovery of an *in situ* brachiopod assemblage in modern shelf sediments collected by the Panama Paleontology Project in the southwestern Caribbean. Dredge collections from near Portobelo (Panama) find that *Argyrotheca* cf. *cuneata* and the normally deeper-dwelling *Platidia* occur at mid-neritic depths in highly bioturbated sediments of a mud-sand mix, associated with molluscs, echinoderms, Bryozoa and larger benthic foraminiferans. Valve size of *Argyrotheca* is bimodally distributed, possibly because of ecological processes, or alternatively due to the presence of cryptic yet sympatric species. The previously proposed intolerance of *Argyrotheca* to high levels of mud is not corroborated by these new data. The brachiopod fauna in Portobelo is discussed in the context of the wider Caribbean faunas.

S24 - ALIPHATIC AND AROMATIC BIOMARKERS FROM CARBONIFEROUS COAL DEPOSITS AT DUNBAR (EAST LOTHIAN, SCOTLAND): PALAEOBOTANICAL AND PALAEOENVIRONMENTAL SIGNIFICANCE

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The terrestrial terpenoids phyllocladane, kaurane and 4β(H)-eudesmane have been identified in the aliphatic fractions of Carboniferous (Visean) coals from Dunbar, East Lothian - Scotland. Series of alkylphenanthrenes, methylated naphthalenes and alkyldibenzofurans were detected in their aromatic fractions. The land-plant-derived polycyclic aromatic hydrocarbons (PAHs) retene, perylene, cadalene, simonellite, tetrahydroretene, totarane, sempervirane and 2-methylretene, as well as the combustion-derived PAHs pyrene, fluoranthene and benzo[a]anthracene have been also recognized in these Scottish coals. The presence of diterpenoids precursors based on the kaurane and phyllocladane skeletons is clearly correlated with the relative proportion of retene and 2-methylretene. The distributions of methylated naphthalenes were used as maturity markers and indicate that the organic matter is immature. While alkyldibenzofurans are considered potential lichen biomarkers; 4β(H)-eudesmane has been proposed as typical sedimentary marker for some angiosperms and gymnosperms. The land-plant-derived PAHs detected in our coals have been previously associated to conifer resins. Retene and tetrahydroretene could also derive from the diagenesis of compounds with a kaurane-type skeleton, which were abundantly produced by the early Paleozoic land plants. The present coal samples contain abundant and well-preserved miospore and megaspore assemblages, which have been related to a flora of large arborescent lycopods developed on land during the Early Carboniferous. The detected biomarkers can be mostly related to a lycophyte arborescent flora which dominated the Euramerican Coal Measure forests. Consistent with the Rock-Eval results and the palynomorph content, the steroid distribution of these Carboniferous coals suggests a transitional estuarine-bay environment with marine influence.

S27B - ORIGIN AND EARLY EVOLUTION OF SPIRIFERID BRACHIOPODS

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The eospiriferines are the earliest *Spirifer*-type brachiopods and *Eospirifer praecursor* the earliest known species, recorded from the upper Katian (Upper Ordovician) of E China. *Eospirifer*, however, along with some constituents of the *Hirnantia* Fauna and the trilobite *Dalmanitina* (*Songxites*), occurs in the Kuanyinchiao beds (early-mid Hirnantian) at Honghuayuan, Tongzi and Ganxi, Yanhe, northern Guizhou, SW China. Together with the upper Hirnantian of SE China and Tasmania (Sheehan and Baillie, 1981), lower Rhuddanian of northern Guizhou and western Zhejiang, SE China, and upper Rhuddanian of northern Guizhou and western Zhejiang (Rong and Yang, 1981), Ningxia (N China), western Tarim (NW China) as well as Chu-Ili, S Kazakhstan. Two other eospiriferine genera, *Yingwuspirifer* and *Striispirifer* occur in the upper Rhuddanian in many places around the world. *Yingwuspirifer* was an unsuccessful offshoot of the eospiriferines characterized by smooth lateral slopes and a uniplicate ventral sulcus, whereas *Striispirifer* was successful with plicate flanks lacking ribs in the sulcus. The origin of the *Spirifer*-group is still uncertain. There are two basic hypotheses. One, that the eospiriferines was probably derived either from an impunctate orthid, or from a rhynchonellid stock. In contrast the group is monophyletic and derived from the atrypids. Investigation of the ontogeny, particularly the early stages of development of the brachidium and spiralia, together with the absence of crural plates revealed by serial sections of *E. praecursor* indicates that the early spiriferids and atrypids may have shared a common ancester. Major fundamental characters (such as the wide hinge line, interarea and laterally directed spiralia) were already established in the earliest forms, indicating evolutionary experimentation. The absence of a ctenophoridium (=striated cardinal process) cannot be used as a key taxonomic character for the eospiriferines since it occurs in many species assigned to *Eospirifer*, *Striispirifer*, *Janius*, *Nikiforovaena*, *Xinanospirifer* and others in the Silurian or Lower Devonian. Re-assessment of the taxonomic significance of shared characters (such as macro- and micro-ornamentation, deltidium, crural plates, and ctenophoridium) within the eospiriferines is clearly needed.

S14 - DATING ARTHROPOD RELATIONSHIPS USING RELAXED CLOCK, SOFT CONSTRAINS AND DIVERSE PHYLOGENOMIC DATASETS

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With a documented fossil record of 520 Ma and more than a million living species, arthropods are the most abundant group of animals on earth, accounting for 80% of the metazoan biodiversity. Still, knowledge of their relationships is source of debate and their exemplar radiation is mainly unexplored by molecules. We use three distinct large phylogenomic and mitogenomic datasets (up to 198 genes and 80 species) to reconstruct and date the relationships within the arthropod and among their ecdysozoan outgroup. We show that these three datasets agree in supporting morphologically recognised groups such as Tetraconata, Mandibulata and Chelicerata, while relationships among crustacean classes are more disputable. We calibrated molecules with 30 soft constrains based on fossil records spanning from the Precambrian to the Cretaceous, allowing 15% upper and lower overflow probability and using a permissive root prior of 700 ± 200 Ma. We described sequence substitution and relaxed the clock assumption using respectively the best fitting heterogeneous and autocorrelated models. Results suggest that while the arthropods and their immediate Panarthropoda, Nematoda and Scalidophora outgroups may have originated in the Ediacaran or earlier, radiation of crustaceans and myriapods major groups occurred in the Cambrian and that of chelicerates and insects in the Orodovician. From a methodological point of view, most of the estimates varied depending on the type and length of dataset, suggesting that particular care should be given for the selection of molecular marker and that the ideal approach should be to cross-test clock studies with more than one marker.

W1 - BALTIC ORDOVICIAN EDRIOBLASTOIDS MORPHOLOGY: IMITATION OF CRINOID ARMS, ASTEROID RAYS AND RHOMBIFERAN PORE SYSTEM

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Edrioblastoids are a small group of Cambrian and Ordovician stemmed echinoderms with edrioasteroid-style ambulacra lacking food-gathering appendages and interadial plates arranged in circlets. Three edrioblastoid genera from the Cambrian of Australia and Ordovician of Australia (*Cambroblastus*) and North America *(Lampteroblastus* and *Astrocystites*) have been described, all with ambulacra raised above level of bud-shaped theca, interambulacral plates arranged in circlets and the presence of stem as basal characteristics. The unusual combination of edrioasteroid and pelmatozoan features of *Astrocystites* was the basis for Fay (1962) establishing the class Edrioblastoidea class. However, Smith and Jell (1990) consider this group as order Edrioblastoida among class Edrioasteroidea and Guensburg and Sprinkle (1994) as a family of suborder Edrioblastoidina in the order Edrioasterida. Two new edrioblastoid genera have been found in the Ordovician of Baltica (St-Petersburg region). One has a bud-shaped theca with a wide slightly imbricate stem and shows the typical ambulacra and plating arrangement. Another has a stellate theca with rays sharply tapered, a stem of small narrow columnals and the stem facet located in the depression of the five basal plate's circlet. A row of slit-like pores is seen dorsally along each side of the rays. Each ambulacrum is divided into two parts by a delicate high longitudinal crest. Thus this genus combines some characteristics of asteroids (shape of theca), edrioasteroids (ambulacra structure), rhombiferans (pore rows like those of *Cystoblastus*) and crinoids (stem, thecal plating and "arms"). Such unusual combination of features may signal a parallel development of important characteristics of echinoderm classes' bodyplans.

S10 - MOLECULAR RECORDS FOR SPATIAL AND TEMPORAL VARIATIONS OF CYANOBACTERIAL BLOOMS IN RESPONSE TO LACUSTRINE EUTROPHICATION IN CENTRAL CHINA

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2-methylhopanoids, synthesized by some bacteria, cyanobacteria in particular, were detected in a variety of sediments and rocks. Here, we use gas chromatography – mass spectrometry to investigate the spatial and temporal variation of 2-methylhopanols in the sediments from lakes of different eutrophication stages in central China. East Lake, a multiple functional urban lake, is seriously affected by human activities, whilst Liangzi Lake, the second largest freshwater lake in Hubei, is showing a relatively moderate eutrophication. The two lakes enable comparison of microbial processes between the different environmental conditions. The 2-methylhopanols identified are very low in abundance in the lacustrine sediments prior to 1950s, but increase sharply in abundance after 1970s when the local anthropogenic activities intensified. This remarkable increase is observed in association with the decrease in the ratio of pristane to phytane, indicative of the intensification of anoxic condition. Their association infers the oxygen depletion due to cyanobacterial blooms in lakes. The 2-methylhopanols are more concentrated in East Lake than in Liangzi Lake, consistent with the varied eutrophication conditions. The ratios of 2-methylhopanol (C_{32}) to heavy-molecular-weight *n*-alkanols derived from floating and submerged higher plants could indicate that these spatial and temporal variations of cyanobacterial blooms result from anthropogenic lake eutrophication. Our data indicate that 2-methylhopanols are sensitive to eutrophication in ambient aquatic environments.

S27D - AN ORDOVICIAN PYCNOGONID (SEA SPIDER) WITH PRESERVED "HEAD" SEGMENTATION

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The bizarre morphology of living marine Pycnogonida ("sea spiders") has long fuelled dissent over their phylogenetic placement within (and occasionally, outside) the phylum Arthropoda. Pycnogonids figure prominently in recent analyses of anterior limb homologies and ancestral crown-group euarthropod relationships, with substantial support emerging for the concept of Pycnogonida as sister taxon to Euchelicerata on the basis of shared chelate first appendages innervated by the second neuromere (deutocerebrum). A major challenge to further elucidation of these phylogenetic hypotheses is the exceptional rarity of pycnogonid remains in the fossil record, due in part to the fragility of their unmineralized and flimsy cuticular exoskeletons - thus, each new fossil discovery has the potential to add significantly to our scant knowledge of their evolution, palaeoecology, and palaeobiogeography. Here we report the first known occurrence of a pycnogonid from rocks of Ordovician age, bridging a 65 million year gap between controversial Late Cambrian microscopic larval forms and a single documented Silurian (Wenlock) specimen. The new fossil, from the Upper Ordovician (~445-448 Ma) William Lake Lagerstätte in central Manitoba, Canada, is the also first to be reported from the Laurentian paleocontinent and the only record of a fossil sea spider in rocks of demonstrable shallow marine origin. The single incomplete, partially disarticulated specimen represents a relatively large and robust animal with an apparently 5-segmented cephalosoma that does not incorporate the first of 4 limb-bearing trunk segments. It co-occurs with other rare non-biomineralized taxa, including eurypterids and xiphosurid horseshoe crabs (Euchelicerata), and three-dimensionally preserved medusae.

S22 - THE EVOLUTION AND DEVELOPMENT OF TEETH AND JAWS BEFORE GNATHOSTOMES

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The evolutionary emergence of gnathostomes is predicated on the origin of jaws and teeth, long thought to be key innovations that underpinned the adaptive radiation of jawed vertebrates. However, the evolutionary origin of teeth and jaws has been mired in controversy surrounding the interpretation of the jaws in placoderms, primitive jawed vertebrates that fall outside the crown clade of gnathostomes. We sought to resolve this controversy through synchrotron microtomographic analysis of an ontogenetic suite of jaws of the euarthrodire placoderm *Compagopiscis* from the Late Devonian Gogo Lagerstätte of Western Australia. These analyses demonstrate unequivocally that the dental and jaw elements are entirely distinct ossification, as suggested by Ørvig in his histological analyses of *Plourdosteus* gnathals in the 1980s. Both ossifications continue to grow through ontogeny, with distinct teeth added through sequential addition in three polarities in the pattern suggested by Smith and Johanson based on their surface arrangements. The dental elements compound to produce a sleeve surrounding the distal end of the jaw ossification, extending proximally.

S14 - TOWARDS HIGH-RESOLUTION TIMESCALES FOR PALEOBIOLOGY, GEOBIOLOGY AND ASTROBIOLOGY

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A realistic goal for the 21st Century is an accurate digital timescale with a resolution of a few thousand years for the last billion years or so of Earth history. The metronomic framework for such a timescale will be provided by the frequencies of astronomical cycles (orbital eccentricity, axial precession, etc.) identified in continuously deposited reference sections using environmental proxies. Calibration and correlation of the cyclostratigraphic framework will be accomplished by a variety of iterative methods that require both input and error propagation from fields as disparate as biostratigraphy, celestial mechanics, isotope geochemistry, nuclear chemistry, planetary geodesy, magnetostratigraphy, physical oceanography, plate tectonics, and sedimentary geology. It will be important to focus on the absolute ages of key biotic events and GSSPs; to refine the ages of magnetic reversals using plate model interpolations and dating intervals that capture transitions; to determine accurately the durations of global isotopic excursions (e.g., PETM, OAE2 and SPICE); to explore the use of impact ejecta (e.g., Sudbury) as widespread time surfaces; and to continue to refine quantitative approaches to biostratigraphic correlation and range extension. Then there is the challenge of linking the highresolution geological timescale to the history of biology as revealed through comparative genomics. Here, the ways forward involve greater input from paleobiology into molecular clock studies, the use of stem taxa to constrain divergence times, and the use of horizontal gene transfer events as timelines across trees. Together, these advancements should enable new approaches to major questions in paleobiology, geobiology, and astrobiology.

S21 - CHARACTER EXHAUSTION AND EVOLUTIONARY RATES IN TEMNOSPONDYLS

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The interrelationships of major groups of Permian and Carboniferous temnospondyl amphibians (the most diverse group of early tetrapods) are controversial. Current hypotheses for the branching sequence of the major temnospondyl clades present almost any possible permutation of sister-group relationships. A novel analysis based on a revised and expanded morphological data matrix yields a nearly balanced topology encompassing the best known and many of the least well known taxa. This provides a basis for a study of evolutionary rates and character exhaustion. Most temnospondyl clades use up rapidly the amount of characters available to them (i.e. the universe of collated data), for any given number of states. This applies equally to their predominantly Carboniferous and predominantly Permian radiations. Also, rates of character change are nearly uniform across main groups. These finds are in agreement with rapid occupations of morphological space among such groups. The tree is taxonomically enriched through inclusion of additional taxa in a step-wise approach to erecting a complete phylogeny for temnospondyls. The resulting synthetic supertree is used to explore patterns of diversity through the Palaeozoic, with emphasis on origination/ extinction intensities, and to evaluate the impact of time calibration and phylogenetic interpolation on rates of faunal turnover.

W9 - PATTERNS OF MORPHOLOGICAL EVOLUTION IN MAJOR GROUPS OF PALAEOZOIC TEMNOSPONDYLI (AMPHIBIA: TETRAPODA).

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A maximum parsimony analysis of a data matrix including 42 temnospondyl species and 14 outgroup species coded for 246 characters results in eight shortest trees. Temnospondyls emerge as two distinct radiations: one includes edopoids and eryopoids-basal archegosauriforms; the other includes dissorophoids and dvinosaurs. Both receive low statistical support. The branching pattern of dissorophoids remains elusive and is obscured by recurrent homoplasies. The two Micropholis morphs appear as sister taxa near the base of the dissorophoid clade. Perryella is either placed as sister taxon to dvinosaurs or nested within them. Temnospondyls such as the genera Balanerpeton and Dendrerpeton occur close to the node that subtends the dvinosaur-dissorophoid separation. Disparity analysis using Principal Coordinate Analysis of both Manhattan and Euclidean intertaxon distance matrices reveals that all major temnospondyl groups are widely separated in morphospace. Levels of disparity are comparable in the various clades examined, but the dinosaurs tend to be morphologically more diverse than other groups when variance-derived metrics are used. For range-derived metrics, dissorophoids are more disparate than other groups. Overall disparity is similar in edopopids and eryopoids-basal archegosauriforms, as is in dissorophoids and dvinosaurs. However, the latter two groups are invariably slightly more disparate than the former two.

S18 - LOCAL BODY SIZE PATTERNS OF LARGE HERBIVOROUS LAND MAMMALS IN THE MIOCENE OF EURASIA

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Large body size of herbivorous mammals is presumably beneficial in environments with seasonal dryness. The main hypothesis in this study was that in the Miocene, which was a time of mid-latitude drying in Eurasia, we should see a temporal and spatial tendency towards averagely larger body size in herbivorous mammal species in localities, indicating dryer and more open environments. This was tested by gathering specimen-level body size estimates of some abundant Miocene ungulate species (and genera), and analysing whether there is a correlation between mean body mass of the species and mean hypsodonty indices of all ungulates in the localities. Mean hypsodonty is used as a proxy of precipitation. On average the results show a statistically significant, although not strong, positive correlation between mean body mass of ungulates and mean hypsodonty indices in all Miocene localities. There is also a positive correlation between the mean body size of late Miocene rhinoceroses of the genus *Chilotherium* and mean hypsodonty indices of localities. Horses (Equidae), however, have an opposite body size pattern than all the other mammal groups analyzed. Both *Anchitherium aurelianense* and *Hippotherium primigenium* show a negative correlation of their mean body size with mean hypsodonty indices of localities. Further analyses of the European *Anchitherium* and *Hippotherium* localities will be done in order to test whether there are sympatric, similar-sized ungulate species in these localities, which could result in smaller body size of the forest-adapted horses by inducing niche partitioning of abundant ecologically similar and similar sized species.

S12 - THE FOSSIL FAUNA OF MIOCENE COLD SEEP CARBONATES, NORTH ISLAND, NEW ZEALAND

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At least 16 hydrocarbon seep deposits occur in the East Coast Basin, North Island, New Zealand as discrete pods or lenses of authigenic carbonate embedded within thick Lower to Upper Miocene mudstones. The ability to compare these deposits with analogous modern offshore extreme environments allows construction of a spatio-temporal record of long-lived (~24 Ma) sea-floor hydrocarbon release. Palaeontological applications include assessment of evolutionary trends in Pacific deep-sea faunas, generation of palaeo-biogeographic models, and evaluation of migration and distribution of hydrocarbon seep communities, of which current knowledge is incomplete. A checklist of fossils collected from the New Zealand seep deposits includes over 50 zootaxa in over 30 families, plus several ichnotaxa. Since the Late Jurassic, the most common fossil faunal groups reported from seep deposits include vesicomyid, lucinid and thyasirid bivalves, which have modern representatives associated with chemosymbiotic micro-organisms. Similar seep-dominant taxa are found in New Zealand seep deposits, and many of the taxa identified to date appear to have close affinities to modern vent–seep species. Assessment of co-occurring fossil seep species in the New Zealand deposits has also allowed insights into ancient organismal interactions, such as the use of worm tubes as substrates by acmaeid limpets, a relationship that also has been inferred from Late Cretaceous seep fossils in Japan. From work on fossil seep deposits globally, ~80 species have been introduced by various authors, and three more (one provannid, two bathymodiolines) have already been proposed from the New Zealand seep deposits, with several others requiring formal treatment.

S13 - THE INTERRELATIONSHIPS, PALEOBIOGEOGRAPHY AND THE END-PERMIAN EXTINCTION EVENT SURVIVAL RATE OF THE PARAREPTILE CLADE PROCOLOPHONOIDEA

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The parareptilian group Procolophonoidea has been increasingly studied in recent years, and a high survival rate during the end-Permian extinction event has been estimated for the clade. Procolophonoid inter-relationships, however, have remained poorly known because many taxa have lacked adequate descriptions. Recent publications on several South African and Chinese procolophonoids, along with my re-descriptions of the European procolophonids *Anomoiodon liliensterni* and *Leptopleuron lacertinum*, and the putative Permian Russian procolophonoids enable a more in-depth phylogenetic study. Thirty-nine procolophonoid taxa were included in the study, and the results suggest novel compositions of the procolophonid clades Leptopleuroninae and Procolophoninae; the monophyly of the genus *Kapes* is questioned; the phylogenetic position of *Suchonosaurus*, *Pintosaurus* and *Phaanthosaurus* among the other basal procolophonids remains unresolved; and the results cast doubt on Procolophonoidea being divided into the two generally accepted clades, Owenettidae and Procolophonidae. However, when stratigraphically-calibrated, the results of the phylogenetic analysis support separate Owenettidae and Procolophonidae; biogeographically Owenettidae remains restricted to Gondwana, and Procolophonidae either originated in the Permian of Laurasia, or a migration to Laurasia took place among the basal members of Procolophonidae during the Late Permian. Furthermore, in contrast to previous survival estimates, the topology with the best stratigraphic fit indicates that only 57% of procolophonoid lineages might have survived through the P/Tr boundary. Alternatively, it is possible that up to 80% of lineages crossed the boundary, but this requires a scenario that maximizes the number of ghost lineages.

S2 - PHYLOGENETICALLY STRUCTURED VARIANCE IN FELID BITE FORCE: THE ROLE OF PHYLOGENY IN THE EVOLUTION OF BITING PERFORMANCE

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A key question in evolution is the degree to which morphofunctional complexes are constrained by phylogeny. We investigated the role of phylogeny in the evolution of biting performance, quantified as bite forces, using phylogenetic eigenvector regression. Results indicate that there are strong phylogenetic signals in both absolute and size-adjusted bite forces, although it is weaker in the latter. This indicates that elimination of size influences reduces the level of phylogenetic inertia, and that the majority of the phylogenetic constraint is a result of size. Tracing the evolution of bite force through phylogeny by character optimization also supports this notion, in that relative bite force is randomly distributed across phylogeny whereas absolute bite force diverges according to clade. The non-phylogenetically structured variance in bite force could not be sufficiently explained by species' unique morphology or by ecology. This study demonstrates the difficulties in identifying causes of non-phylogenetically structured variance in morphofunctional character complexes.

S15 - THE ORDOVICIAN-SILURIAN TRANSITION IN THE ZERAFSHAN-HISSAR REGION, SOUTH TIEN SHAN

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During the Ordovician to early Silurian the Zerafshan-Hissar Region was situated in southern temperate latitudes, probably within the Gondwanan margin in relative proximity to Central Iran and Sibumasu. The uppermost part of the Ordovician sequence in the region (Archalyk Beds) preserves a record of a short warming episode, which occurred immediately prior to the terminal Ordovician glaciation and can be dated by the occurrence of characteristic graptolites as the *Paraorthograptus pacuficus pacificus* Biozone. It probably corresponds to the Boda Warming Event. Deposition of the Archalyk Beds coincided with immigration and proliferation of benthic faunal associations with abundant stomatoporoids, tabulate corals, pentameridine and atrypidine brachiopods previously alien to the region. Abundance of representatives of the Family Agetolitidae among tabulate corrals and occurrence of *Holorchynchus*, *Proconchidium* and *Schachrioponia* among brachiopods signifies strong affinity to the contemporaneous benthic faunas of South China and Kazakhstanian terranes. There is no convincing record of Hirnantian deposits in the region. The beginning of the Silurian coincides probably with a horizon of barren dolomnites. It is succeeded by argillaceous and bioclastic limestones of the Minkuchar Beds, which can be broadly correlated with the Rhuddanian Stage by the occurrence of chitinozoans. The medium diversity associations of stromotoporoids and tabulate corrals from the Minkuchar Beds show a good sign of faunal recovery after the terminal Ordovician extinction. They are dominated by the stromatoporoids *Ecclimadyction* and tabulate corals of the genera *Palaeofavosites* and *Halysites* and show strong affinity to the stromotoporoid/coral associations of the Juuru Regional Stage of Estonia.

S13 - FUNCTIONAL MORPHOLOGY AND MODULAR LAGS IN RADIATION EVENTS: PATTERNS FROM EARLY ACTINOPTERYGIAN MORPHOSPACE

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Living ray-finned fishes (actinopterygians) are ecomorphologically disparate, ranging in shape from angelfish and sunfish to seahorses and eels. In comparison, the dozen or so Devonian species were homogeneous in body form and presumably in function too. Actinopterygian morphological diversification has been considered a major Mesozoic event, occurring primarily within the teleost clade. However, recent recognition of the proximity of the Palaeozoic Hangenberg extinction to taxonomic increases and fundamental branching events in ray-fin phylogeny provides an impetus for re-examining earlier taxa. The first study of Devonian-Carboniferous actinopterygian morphospace reveals two unexpected phenomena: 1) the diversification of Palaeozoic actinopterygians occurred along functional lines recognisable from extant teleosts; 2) while expansion of cranial morphospace occurred in the immediate aftermath of the Hangenberg mass extinction, post-cranial diversification lagged by one stage. The functional signal suggests hydrodynamic constraints on aquatic vertebrate form. The lag between head and body morphospace expansion indicates a changed relationship between functional modules. The diversification of early actinopterygians was likely first driven by occupation of new feeding niches in post-Hangenberg recovery ecosystems. Specialization of locomotory traits came only later, perhaps as competition increased to pre-extinction levels. This pattern was suggested to occur among living species (e.g. cichlids) at a microevolutionary scale, but had not been observed at larger temporal or taxonomic levels. Lags between diversification within modules - heads and bodies and/or feeding and locomotion - might be a common feature of adaptive radiations.

S27A - *GIRAFFOKERYX PUNJABIENSIS* (ARTIODACTYLA, RUMINANTIA, GIRAFFIDAE) FROM LOWER SIWALIKS (CHINJI FORMATION) OF DHOK BUN AMEER KHATOON, PAKISTAN

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Fossil remains of *Giraffokeryx punjabiensis* (premolar and molar teeth belonging to the upper and lower jaws) have been collected from the Chinji Formation of Dhok Bun Ameer Khatoon (32° 47’ 26.4” N, 72° 55’ 35.7” E). All 21 specimens are isolated teeth, which provide new data and give valuable information on the biostratigraphy and palaeoecology of *Giraffokeryx punjabiensis* as well as the stratigraphy and palaeoclimates of these Miocene rocks of the Chakwal district, Pakistan.

S24 - LIMB BONE HISTOLOGY AND ARCHITECTURE OF *EUSTHENOPTERON*: NEW LIGHTS ON ITS LIFE-HISTORY TRAITS

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Because of its phylogenetic position closely related to tetrapods, the locomotion and life-history of *Eusthenopteron* may be of high interest to understand the evolution of terrestriality among vertebrates. The study of *Eusthenopteron* using Synchrotron multiscale phase contrast and holotomography allows us to investigate from its limb microarchitecture to its histology non-destructively and draws inferences about evolutionary change across the fish-tetrapod transition. The humeral and ulnar microarchitectures of *Eusthenopteron* clearly exhibit longitudinal foramina going through the entire limb bones and meeting at the place of their common articulation. This microarchitectural organization suggests that the “elbow” articulation may have played a higher physiological than biomechanical role. At the histological level, there is no continuing cortical thickening during later growth: after the initial phase of deposition when the cortex thickens rapidly, the cortex becomes thinner again in adult individuals, suggesting that perimedullary and perivascular resorption of the inner part of the cortex proceeds more quickly than appositional growth. Simultaneously with this cortical thinning, there is a reduction in the number of medullary trabeculae resulting in a more open spongy texture in the centre of the bone. The adult humerus is thus more lightly, though more completely, ossified than the subadult. We can therefore conclude than despite its close relationship to tetrapods, *Eusthenopteron* shows no preliminary sign of terrestriality. Its limb microarchitecture and histology clearly reflect an ichthyan aquatic locomotion.

S12 - FOSSIL BRACHIOPODS FROM CHEMOSYNTHESIS-BASED ENVIRONMENTS: A REVIEW

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Brachiopods have been recorded from hydrocarbon seep deposits from the Palaeozoic, Mesozoic, and Cenozoic. To date brachiopods are known from Palaeozoic and Mesozoic hydrothermal vent deposits. Brachiopods were first known from the fossil record before they were discovered as living animals. The discovery of brachiopods from chemosynthesis-based communities is somewhat analogous, being discovered in the fossil record first. However, the analogy breaks down as they are yet to be confirmed from modern chemosynthesis-based environments (CBEs). However, given the generalist and minimalist nature of brachiopod metabolism, it seems likely that they will be found in modern CBEs. Palaeozoic and Mesozoic occurrences are dominated in the literature by records of rhynchonellid brachiopods of the Superfamily Dimerelloidea (specifically Devonian – Cretaceous representatives). These brachiopods can occur in the tens-of-thousands to millions in carbonate deposits a few meters thick and a few tens of meters in lateral extent. A most intriguing aspect of brachiopod palaeoecology is that this type of mass-occurrence (typically dominated by a single brachiopod species) at hydrocarbon seeps is not known after the Early Cretaceous - *Peregrinella* being the last-known representative. However, other records of brachiopods (terebratulids and rhynchonellids) associated with hydrocarbon seeps do occur, although in these instances not in deposit-forming abundance. Records of brachiopods with hydrocarbon seep deposits are more numerous than those from hydrothermal vents. The former may be more easily recognized in the field with typically well-preserved fossils making them more amenable to study than fossils from highly altered hydrothermal deposits.

S4 - LOWER PALAEOZOIC MICROVERTEBRATES AND MACROEVOLUTION

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The past two decades have seen a dramatic expansion in the documentation and understanding of early vertebrate evolution. The advance in knowledge has been driven through the application of micro-palaeontological techniques, the discovery of new lagerstätten and the reinvestigation of previously known localities. With a reasonably robust phylogenetic framework within which to discuss a large number of highly significant microremains, these fragments of dermal armour, scales and teeth have a pivotal role in the developing the new narrative. This is not only in terms of extending the temporal and spatial ranges of many major groups of fish and the development of ichthyolith-based biostratigraphic schemes, but also posing questions for evolutionary hypotheses of some clades. Ichthyoliths have proved invaluable in extending the range of many early vertebrate clades back into the Lower Palaeozoic, the pattern that now emerges is of a major evolutionary radiation through the Ordovician following initial appearance in the Cambrian. Microremains suggest that the stem- to crown-group transition in the gnathostomes was a prominent feature of this early radiation of fishes. Of particular note is the presence of a number of scales with chondrichthyan-like construction from the Middle Ordovician onwards, some 50 million years before the first positive evidence for jaws and teeth in the chondrichthyan clade. The integration of ichthyolith and articulated specimen datasets provides the basis for a number of predictions on the early evolution of sharks that will be confirmed, or rejected, as the fossil record of early chondrichthyans continues to improve.

S20 - MORPHOLOGICAL DECAY EXPERIMENTS APPLIED TO FOSSIL DATA: UNLOCKING THE NON-BIOMINERALIZED VERTEBRATE FOSSIL RECORD

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The origin and early evolution of vertebrates are landmark episodes in the history of life. Only the fossil record can reveal the sequence and rate of evolutionary events at this time, but interpreting the record is fraught with difficulty. The relevant organisms lacked biomineralized hard tissues and we are therefore reliant on taxa from exceptionally preserved biotas, with their associated taphonomic difficulties. Experimental investigations of the morphological decay of extant proxies for early vertebrates reveal important new information about the rate and sequences of character decay and highlight powerful sources of potential taphonomic bias. Combining these decay data with detailed analysis of the mode of preservation of exceptionally preserved, non-biomineralised vertebrates provides a new approach which allows us to test controversial anatomical interpretations, and to constrain the degree to which fossils have been affected by decay-related character loss. Applying this approach to important taxa such as *Metaspriggina*, *Jamoytius*, *Euphanerops*, *Mayomyzon* and *Pipiscius* has revealed a complex pattern with regard to preservation of phylogenetically significant characters in the fossils: some are confirmed as present, some are recorded for the first time, and some are identified as being absent due to decay rather than for phylogenetic reasons. These results have significant implications for interpretations of the anatomy and phylogenetic placement of the fossil taxa, with consequences for understanding patterns of vertebrate character acquisition.

S2 - MACROEVOLUTIONARY IMPLICATIONS FOR A MICROEVOLUTIONARY TECHNIQUE: PUTTING ECOLOGICAL NICHE MODELING INTO A HIERARCHICAL PERSPECTIVE

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A hierarchical view of nature and evolution is a macroevolutionary concept conspicuously absent from the traditional Modern Synthesis perspective. Hierarchy theory divides the natural world into distinct genealogical and ecological realms composed of entities (e.g. organisms, populations, species) with unique births and deaths as well as historical persistence. Entities at each level possess emergent properties that cannot be extrapolated from lower hierarchical levels. However, the Modern Synthesis of the mid-20th century equates processes operating on organisms and populations with those influencing species – negating the reality and unique properties of the species level. We view the fundamental niche (FN) as a species-level emergent property; each species possesses a unique range of environmental tolerances. Ecological niche modeling (ENM) is a technique developed by biologists to understand the abiotic variables constraining species distributions – i.e., ENM estimates a species' FN. Historically, these models have been used to address microevolutionary phenomena. However, when viewed within a hierarchical framework, this technique has significant potential to elucidate higher-level patterns and processes. Ecological niche models constructed for *Loxosceles reclusa* (brown recluse spider) are used to illustrate how this method can test for macro-evolutionary processes such as species selection and the notion that generalist species give rise to specialists, but not *vice versa*.

S27B - SIEVE-SIZE EFFECTS ON PATTERNS OF DRILLING PREDATION IN THE EOCENE AND MIOCENE OF CENTRAL EUROPE

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Bulk samples form the basis of most quantitative palaeontological analyses, but a range of sieve sizes are used by different researchers during sample processing. Several workers have noted the sensitivity of ecological and palaeontological patterns to sieve size. While most scientists implement similar sampling protocols within their individual studies, variable extraction methods may confound meta-analyses that attempt to establish secular trends. This study examines the effects of sieve size on patterns of drilling predation on >17,000 molluscs from 12 Eocene samples from the Paris Basin and 112 Miocene samples from the Central Paratethys using 1 mm, 2 mm and 4 mm sieves. Results depend on taxonomic resolution: assemblage-level drilling frequencies (DF) were consistently higher in the Eocene than in the Miocene, regardless of the sieve size used. In the Eocene, no significant differences in DF were observed between sieve sizes; however, Miocene DFs were significantly different between all size categories. At the class level, both bivalves and gastropods had consistently higher DFs in the Eocene than in the Miocene. In both the Eocene and Miocene, bivalve DFs were not statistically different between sieve sizes, while gastropods had significantly higher values at 4mm. Comparison of family-level DFs within Eocene and Miocene deposits showed no significant effects at different sieve sizes; however, for the families Ostreidae and Veneridae, differences in values compared between the Eocene and Miocene were apparent using a 1 mm sieve, but not so using larger sieves. These results highlight some of the potential problems when comparing studies using different methodologies.

S27B - SPATIAL VARIATION IN DRILLING PREDATION FROM INTERTIDAL, SHALLOW SUBLITTORAL AND SHELF ENVIRONMENTS FROM THE EARLY AND MIDDLE MIOCENE MARINE FOSSIL RECORD OF THE CENTRAL PARATETHYS

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Drilling predation is among the most studied biotic interactions in the fossil record, and its overall patterns are well established on Cenozoic molluscs from North America. Few studies have examined such predation in Europe. This study aims to evaluate molluscan drilling intensities from the Burdigalian, Langhian and Serravallian of the Central Paratethys. Using drill frequency (DF) and prey effectiveness (PE), a measure of prey's ability to survive predatory attacks, we examine taxonomic and environmental effects on drilling predation, evaluate local and regional spatial variation, and compare Central Paratethys values to other contemporaneous basins using > 38,500 whole shells from 162 Karpatian (Upper Burdigalian) and Badenian (Langhian and Lower Serravallian) bulk samples from Austria and Slovakia. DF and PE were slightly higher in bivalves than gastropods, and DF could vary drastically within single environments at single localities (maximum at Immendorf: mean = 10.9 %, standard deviation = 12.9 %). Both DF and PE were more variable in the Karpatian than Badenian. Higher overall DFs, but lower PEs were seen in the Badenian than in the Karpatian. A similar pattern was observed between intertidal and sublittoral deposits. We interpret the increase in predation from the Lower to Middle Miocene to reflect environmental shifts from restricted estuarine to deeper, normal marine conditions. Regional predation intensities from the Central Paratethys are distinctly lower than those of other Miocene seas, potentially due to lower predator abundance, differences in faunal composition, and/or fluctuating salinities typical of inland seas.

S7 - *INTERMEDITES* (DELTHYRIDOIDEA, BRACHIOPODA): THE DISCOVERY OF A SOUTH CHINESE IMMIGRANT

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Intermedites is a well known index fossil common in Eifelian strata in Western and Central Europe and in North Africa. It has hitherto been considered as a descendent of *Arduspirifer*, an Early Devonian genus distributed in the same regions as *Intermedites*. However, side-by-side comparison of *Intermedites* with *Arduspirifer* and South Chinese and Vietnamese delthyridoid brachiopod genera indicates that it is more likely that *Intermedites* originated from the group that includes *Rostrospirifer* and *Otospirifer*. A computer-supported cladistical analysis supports this interpretation. Three-dimensional reconstructions based on serial sections were constructed that enabled, for the first time, a comparison to be made between articulated shells with internal and external moulds that revealed the morphological similarities and differences between genera. The westward migration of southern Chinese spiriferids since the Late Emsian further supports of the loss of endemicity during the Early Devonian.

S7 - NEW IMPLICATIONS FOR THE LIFE HABIT OF *CYRTINA* (BRACHIOPODA, LOWER DEVONIAN)

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The Early Devonian Oriskany Formation of Cumberland/Maryland (USA) is characterized by mainly silicified brachiopod shells. Within this brachiopod fauna "*Spirifer*" *intermedius* is one of the characteristic brachiopods, represented by medium to large shells with rounded ribs and a smooth fold and sulcus. It is usually preserved as conjoined shells, however disarticulated shells also occur. During a revision of "*Spirifer*" *intermedius*, small cyrtinid specimens, probably or closely related to *Cyrtina rostrata*, have been found attached to the shell of the spiriferid, either on the wings or on the sulcus flanks. For the first time, a fixo-sessile life habit of cyrtinids is reported where they are fixed by their high and catacline interarea to the shell of "*Spirifer*" *intermedius*. Silicification has not modified the shell fabric with beekite rings on both the host and the epizoans indicating that silicification preceded decay of the cyrtinid pedicle or that cyrtinids were cemented in juvenile forms. It is suggested that the cyrtinid brachiopod was using the shell as a hard substrate for pedicle attachment profiting from the inhalant/exhalant current system initiated by the delthyridoid spiriferid.

S26 - TIME-SPECIFIC FACIES – MEANING, APPLICATION, POTENTIAL

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The term "Time-Specific Facies" (TSF) was introduced by Otto H. Walliser in 1984. Based on field observations in widely separated areas (Europe, North Africa, Iran, South China, northeastern USA), i.e. even situated in marine settings adjacent to different palaeocontinents of mid-Palaeozoic times, a striking phenomenon became obvious: During well-recognized time intervals very similar lithologies (facies) may be present when developed in an overall similar palaeogeographic setting. These may include different features such as certain sedimentary structures, distinctive rock colours, ore deposits at given stratigraphical positions, widely traceable blooms of specific fossils, or recurring patterns of rock lithologies. These facies features are not unique in the rock column – but the ability to trace them over wide distances during a given time makes them (time-) specific. The phenomena might be linked to global events such as the Kellwasser Event or other global crises. Recognition of TSF in rock sequences allows detailed refinement within successions as well as for high-resolution correlations over long distances – and sometimes globally. Open questions – that have great potential for future research – include: What causes these special conditions within a given time frame (which can range from days to millions of years), what kinds of interactions of the litho-, atmo-, hydro-, and biospheres are involved? What is the effect of climate change on the evolution of organisms, and, conversely, what role do changes in the biosphere play in atmospheric evolution. Finally, do we see areas in the modern world that can be regarded as preserving TSF for future times?

S26 - TRACKING BIOLOGICAL AND SEDIMENTOLOGICAL CHANGES IN EVENT-RELATED CRISIS INTERVALS ACROSS FACIES BORDERS – DO THEY REPRESENT "TIME-SPECIFIC FACIES"? THE KELLWASSER HORIZONS AND THEIR EQUIVALENTS NEAR THE FRASNIAN/FAMENNIAN BOUNDARY

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The Kellwasser Event resp. the Kellwasser Crisis is known as one of the five major mass-extinctions in Earth history since long time. In the final two decades of the 20th century it became obvious that the event in general was not as instantaneous as often claimed (e.g., …"a sharp knife cut"…"at a bedding plane"…, Mc Laren, 1970, 1982), but yields a series of (different) steps spanning a longer time interval (> 1 my). After these phenomena could be shown in the "typical" Kellwasser facies, i.e., the deeper-water cephalopod limestone facies of submarine swells where Kellwasser lithologies are mostly represented by two units of alternating dark gray to black limestones and shales (e.g., Schindler, 1990a,b, 1993), more recent studies of basinal sections enable tracking of distinct event steps – and of different biological and lithological features - into pelitic successions of the adjacent depressions (Gereke, 2007; Schindler & Gereke, 2009). Features below, between and above the immediate intervals of Kellwasser-type rocks can be included, e.g., a characteristic limestone bed below the Lower Kellwasser Horizon as well as a cluster of black shales above the Upper Kellwasser Horizon. As even faint features – always present at exactly the same position within the different successions – can be traced, they may be considered as "Time-Specific Facies" phenomena.

S3 - QUANTIFYING OCEAN ACIDIFICATION DURING THE PETM

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The ocean will absorb increasing amounts of fossil fuel CO_2 in the future, with the *p*H of surface waters decreasing by up to 0.5-0.6 *p*H [*Caldeira and Wickett*, 2003]. The Palaeocene-Eocene Thermal Maximum (PETM) has been suggested as a close palaeo-analogue for future climate change and ocean acidification [*Zachos, et al.*, 2005]. However, a prerequisite for the use of evaluated ecological response during the PETM as a constraint on future impacts on ecosystems of acidification due to fossil fuel burning is knowing how the paleo-*p*H changed at this time. The boron isotopic composition $\delta^{11}B$ of foraminiferal calcite is a proxy for *p*H [*Hemming and Hanson*, 1992], but lack of sufficient amounts of un-recrystallized, single species, foraminiferal calcite from this time interval has prevented the application of established *p*H proxies. We use *in-situ,* high-spatial resolution secondary ionization mass spectrometry (SIMS) to characterize the $\delta^{11}B$ and B/Ca across the PETM in the benthic foraminifer *Oridorsalis umbonatus* at deep-sea Maud Rise (Site 690B) and shelf-depth *Lenticulina* sp. at Bass River. Mg/Ca indicates a two-step temperature increase from 12.7°C to 18.5°C, in agreement with previous work at Maud Rise. Since the boron isotope composition of Paleocene seawater is unknown, we applied the *p*H estimated by an Earth system model as a starting value. The reconstructed *p*H record across the PETM shows a large, two-step reduction coeval with temperature rise, with a recovery period to pre-event values significantly more drawn out than that of the isotopic composition of the ocean.

S14 - EXPLORING THE IMPACT OF CENOZOIC CLIMATE FLUCTUATIONS ON THE EXTANT DIVERSITY OF FERNS

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The presented study explores the influence of the dramatic climatic fluctuations from 65 mya until today on the biodiversity of land plants with focus on the phylogeny of ferns. The focus is on the impact of the Eocene-Oligocene global cooling and the global warming at the Oligocene-Miocene transition. These fluctuations had likely a strong impact on the phylogeny of various lineages of land plants and the spatial distribution of plant diversity. The study address this question by integrating molecular clock based divergence time estimates, estimates based on the fossil record of ferns, ecological niche modelling of ancestral niches, and estimates of changes in the diversification rates. Taxonomically, we focus on three major clades of derived ferns, asplenioid ferns (~700 extant species), dryopterioid ferns (~1700 extant species), and polygrammoid ferns (~1200 extant species). Reconciling molecular clock based divergence time estimates and the fossil record will improve the precision and overcome some of the limitations of each approach. The reconstruction of ancestral climate niche preferences provides an improved understanding of the evolution of the ecological preferences as expected influenced by global cooling and warming events. Finally, the detection of divergence time estimates is pursued with statistical analytical approaches as implemented in some widely used software packages. This fully integrated approach will provide a robust test for the macroecological/evolutionary hypothesis that Oligocene climate fluctuations had a major impact on the phylogeny of ferns and likely other land plants.

S17 - MODERN FUNCTIONAL PRINCIPLES IN ANCIENT EYES (EYES OF PHACOPID TRILOBITES)

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In modern invertebrate eyes there are two separate kinds of visual system. The one consists of a small retina more or less close to the lens (ocellum), in the other the light is focussed by a lens onto a lightguide-like structure, the rhabdome. Many such systems form a mosaic like vision, as we know it from modern insects or crustaceans. In modern eyes of aquatic arthropods there exist sophisticated methods for adapting to reduced light conditions under water, using and expanding these principles. Until now hardly any internal structures of fossilised eyes could be made out. Micro-CT however has revealed first indications as to how the internal morphology of trilobite eyes may have been constructed. Based on this, ideas about their function and further methodological approaches are indicated.

S18 - PALAEOECOLOGICAL INTERPRETATIONS OF AUSTRALIA'S MID-TERTIARY: NEW METHODS AND TENSIONS

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Recent work at two northern Australian fossil localities, Bullock Creek and Kangaroo Well, has greatly expanded the number of mammalian species known at each site. As many as 13 new taxa were recognised from isolated small mammal teeth and jaw fragments at the middle Miocene Bullock Creek site and six at the late Oligocene Kangaroo Well. Presented here are the results of cenogram, arboreal taxa and body mass distribution analyses of the Bullock Creek and Kanagaroo Well local faunas using the revised faunal lists. In conflict with several previous studies, this analysis indicated the presence of open forest at Bullock Creek during the mid Miocene and at Kangaroo Well during the late Oligocene. Previous work focused on taphonomy and geology had concluded that the vegetation at Bullock Creek was savanna-like, the climate seasonally arid and the depositional environment that of a floodplain of a meandering river. Work at Kangaroo Well has been less extensive, but analysis of the Ulta Limestone, in which the fauna is found, suggested it formed under similar conditions, with scrub or low forest vegetation dominant. Disagreement between palaeoenvironmental interpretations reflects an essential conflict in Australian palaeoecological studies. Studies concentrating on the mammalian vertebrate faunas found at mid-Tertiary fossil sites often reach conclusions that are in conflict with studies that focus on the lithological and whole fauna evidence. Progress in palaeoecological reconstruction for this moment depends on resolving this conflict. Ideally, geological and fossil evidence should be used together to ensure a rounded understanding of palaeoenvironments.

S2 - TIERED PATTERNS OF PHANEROZOIC MACROEVOLUTION

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After a long time of near stasis (Butterfield), the evolutionary transformation of organismic form and behaviour gained full speed in the Ediacaran and after the Cambrian explosion of metazoans. At the same time, ecosystems became more complex and did intermittently punctuate evolution at emergent stable domains nested in space and time: (1) *Punctuated Equilibria* (Gould and Eldredge) at the level of species; (2) *Coordinated Stasis* (Brett) at the level of communities; and (3) *Evolutionary Faunas* (Sepkoski) in the whole biosphere. The third tier is accentuated by *Mass Extinctions*; but it also comprises the *Golden Ages* that mostly preceded them. These periods (= typolytic stages of Schindewolf) are characterized by high diversities, as well as bizarre constructions. In analogy to latitudinal gradients in the present biosphere, Golden Ages appear to correspond to global greenhouse states that allowed evolutionary optimization to exceed the limitations of standard bauplans. As this trend was coupled with specialization, it automatically increased vulnerability in the face of unforeseeable global events. Therefore, our agenda should proceed beyond identifying the killer in each mass extinction to the (possibly galactic) cause of Golden Ages since the Ediacaran one. *Golden Biotopes*, however, are not restricted to favourable climates. Evolution also went overboard in the deep sea, where the scarcity of food is outweighed by unusual *time stability*, or in beach sands, ancient lakes, and ancient rivers, where local evolution was probably kindled by the protection from competing immigrants. None of these patterns could have been predicted without the fossil record.

S27D - THE ANTIQUITY OF COPEPODS: CRUSTACEANS FROM A PITCH CLAST IN CARBONIFEROUS GLACIAL DIAMICTITE OF OMAN

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Copepod crustaceans may be the most numerous metazoans on Earth, even outnumbering insects and nematodes. Current evidence suggests that copepods originated in the marine hyperbenthic habitat and subsequently colonized the entire salinity spectrum, with major habitat shifts into the marine plankton, fresh waters, and the evolution of parasitism. Copepods are typically minute and fragile, so they have low fossilization potential and their body fossil record consists principally of one Cretaceous parasite and Miocene fossils. Here, we report a unique occurrence of copepod and other crustacean fragments preserved in a single pitch clast from a glacial diamictite of Carboniferous age from Oman, which extends the fossil record of copepods back by some 300 million years. Geochemical analyses indicate that the pitch source was some 100–300 km SW of the present position of the diamictite, which concurs with geological evidence of ice flow directions. Pollen in the diamictite provides a late Carboniferous age, but the lack of palynomorphs in the clast suggests that the pitch is the result of an oil seep into a subglacial lake with no open water. Some of the fragments clearly belong to the copepod order Harpacticoida, which includes severalfamilies that inhabit fresh waters (including glacial lakes) today. This record concurs with suggestions that harpacticoids colonized fresh waters during the assembly of Pangaea. However, the bizarre, unique circumstances of the find mean that pitch clasts in diamictite are unlikely to be a productive source of fossil crustaceans in the future.

S5 - CHARLES LYELL'S RESEARCH ON FOSSILS FROM THE CANARY ISLANDS

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During the early 19th century there were several theories about the growth of volcanoes. Leopold von Buch (1774-1853) favoured the craters of uplift theory, interpreting volcanoes as blisters on the Earth's surface, whereas Charles Lyell (1797-1875) believed that volcanoes were formed by accretion of eruptive products. Both visited the Canaries but only Lyell tried to support his ideas using the succession of marine sediments and associated fossils intercalated in volcanic deposits to show that the volcanoes grew by accretion over long intervals of geological time. The Natural History Museum in London houses important fossil collections made by Lyell from a raised beach at Santa Catalina near Las Palmas (Gran Canaria), along with related letters and manuscripts. This collection consists mostly of molluscs and bryozoans. They were collected by Lyell when he was visiting Gran Canaria from February to March 1854, helped by a Spanish engineer, Pedro Maffiotte Arocha (1816-1870), who was carrying out works in the island and knew the geology well. Maffiotte continued to send specimens to Lyell after his visit and was disappointed that Lyell published nothing on the geology of Gran Canaria other than brief comments in his 6th edition of *Elements of Geology* (1865). Archival evidence, however, shows how Lyell took pains to seek the help of bryozoologists William Lonsdale (1794-1871) and George Busk (1807-1886), as well as malacologist Samuel P. Woodward (1821-1865), to determine his fossils as probably Miocene in age and of shallow water origin.

S8 - ORDOVICIAN GRAPTOLITES AND CHITINOZOANS AND THEIR LEADING ROLE IN FORMATION OF COMPLICATED PALAEOZOIC PELAGIC BIOTA STRUCTURE

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The Cambrian biota consisted of primary producers (bacteria, planktonic algae, phyto-planktonic acritarchs) together with primary (radiolarians, zooplanktonic acritarchs) and secondary (micronektonic conodonts) consumers. At the Cambrian/Ordovician boundary the “Cambrian” (moderate in the number of taxa present) structure of the pelagic biota developed some complexity – first macrozooplankton (graptolites) appeared among the secondary consumers as some graptolites (first *Rhabdinopora*) changed from benthic to planktonic life habits. In the mid-Tremadocian the number of primary consumers increased with the appearance of zooplanktonic chitinozoans (*Desmochitina, Conochitina, Rhabdochitina*). Pairwise symbiotic relations originated among producers (microphytoplanktonic acritarchs) and consumers (microzooplanktonic acritarchs, chitinozoans, graptolites): acritarchs-chitinozoans and acritarchs-graptolites (apoikia), chtinozoans-graptolites (commensalism). Particularly from this moment, a complex (in the number of elements and their relationships) pelagic biota structure became crucial for the development of the marine biota as a whole. Evolving as a single ecologic-biologic system, the Ordovician pelagic biota controlled the development of benthic associations by means of trophic relations. Global abiotic environmental changes (water temperature, transparency and chemical composition, amount of dissolved oxygen, changes of palaeobasin depths) influenced benthic associations immediately, to a considerable degree, by inducing changes in the pelagic component structure. Modifications in the Ordovician pelagic biota (taxonomic composition, occupation of new ecological niches, new relationships) greatly influenced the benthic palaeo-biota structure. Species and generic diversified and population density peaked among graptolites and chitinozoans in the latter half of Ordovician and could be a driver for the appearance and following explosion of such secondary nektonic and nekton-benthic consumers such as the nautiloids, thelodonts and agnathids. This led to the mature and stable structure of the Palaeozoic pelagic biota. This presentation is a contribution to the RAS Programme “Evolution of the Biosphere”.

S8 - CLIMATE, SEA-LEVEL, TROPHIC CHAINS: WHAT HAPPENED IN THE ORDOVICIAN OCEANS?

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The International Geoscience Programme (IGCP) 503 (2004-2009) targetted the impact of palaeoclimate and palaeogeography on the Great Ordovician Biodiversification Event and sought explanations for this defining moment in the planet’s history. Amongst the other major results generated by the project, we now know that the global cooling in the Late Ordovician started much earlier (probably in the Mid Ordovician), briefly interrupted by a warming event (the ‘Boda Event’) that took place just before the Hirnantian glaciation. Sea-levels have risen continuously since the Early Cambrian, but a major global drop occurred at the beginning of the Late Ordovician. The climate and sea-level variations are reflected not only in the phytoplankton record, but also in the diversity of marine invertebrates. Dependent on the fossil group (each occupying different ecological niches and different parts of the trophic web), different biodiversity pulses occurred and several biodiversification events took place, with biodiversity peaks at different stratigraphical levels on the different palaeocontinents. At a global level, however, the picture is relatively simple: together with increasing sea-level, marine diversity reaches its highest levels during the early Late Ordovician, followed by a moderate but continuous decrease, culminating with the end-Ordovician extinction.

S27B - "FLYSCH-TYPE" BIOFACIES – HOW SHALLOW ARE THE DEEP-WATER AGGLUTINATED FORAMINIFERA (DWAF) IN THE BARENTS SEA DURING THE LATE CRETACEOUS?

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Deep-water turbidites and hemipelagites are common in Late Cretaceous Atlantic and Western Tethyan basins. These sediments contain very similar foraminiferal assemblages dominated by DWAF, known as the Flysch-type biofacies. We analysed foraminiferal assemblages from the Upper Cretaceous Kveite and Kviting formations of the southwestern Barents Sea. Thick sequences of the Kveite Formation, consisting of siltstones and claystones are found in the Tromsø Basin, thinning eastwards into the Hammerfest Basin and changing laterally into the more sandy, carbonaceous and condensed Kviting Formation. Diversified DWAF assemblages in both formations and their similar taxonomic composition to the Flysch-type biofacies suggest they were deposited at a bathyal depth, but not deeper because of the absence of the abyssal "Krashenninikov fauna". Although the same species of Flysch-type biofacies are found in both formations, the Kviting Formation contains less abundant assemblages with a smaller proportion of tubular forms and without *Caudammina gigantea*, which is present in the Kveite Formation and characterises lower bathyal to abyssal environments in the Atlantic and Western Tethys. Thus, the former was probably deposited in a shallower environment than the latter. Morphogroup analysis shows the consistent dominance of tubular and other epifaunal forms with complex trophic relationships and fully occupied niches. This indicates that, at least, the Kveite Formation was deposited in a well-oxygenated, tranquil, mesotrophic marine environment. Furthermore, a decreasing trend in the relative abundance of tubular forms towards the top of both formations indicates a lowering sea level in the study area, associated with the regional uplift of the Spitsbergen-Barents Sea area in the Late Cretaceous.

S23 - CLASSIFICATION, STRATIGRAPHY, PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY OF TRIGONIOIDACEA (NON-MARINE CRETACEOUS BIVALVIA)

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Trigonioidacea Cox is a group of Cretaceous Unionoida (non-marine Bivalvia). It is characterized by a minute but very depressed anterior pedal retractor scar which is distinctly separated from the large and depressed anterior adductor scar. Such a muscle system implies that trigoniodids are probably rapid shallow burrowers. On the basis of the general ornamental pattern at the family and subfamily level, and the features of radial ribs (including the angle of V-shaped ribs on the median flank) and hinge teeth at the generic or subgeneric level, they are grouped into seven families and subfamilies, 26 genera and subgenera. These non-marine bivalves are widely distributed in Asia, particularly in Middle and East Asia, the Far East of Russia and western Europe as well. Stratigraphically, seven trigoniodid assemblages ranging from Hauterivian to Maastrichtian have been recognized. This biostratigraphy could well form a basis for the correlation and dating of the trigonioidid-bearing formations throughout Asia and western Europe.

S13 - POST-K/Pg TERRESTRIAL AND FRESHWATER RECOVERY IN A PHYSICALLY DEVASTATED LANDSCAPE

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The K/Pg impact devastated plants and those animals in food chains reliant directly on primary production. The initial burst of infrared radiation from incoming ejecta killed most of the biota living above ground, especially where firestorms developed. Darkness from atmospheric dust and aerosols then prevented photosynthesis for months. The resulting loss of terrestrial vertebrates and insects is well documented. The surviving mammals were very small, commonly burrowers that had subsisted on roots, seeds, and smaller animals in detritus-based food chains (insects, worms, etc.). Surviving plants recovered from seeds and root systems. Temporary loss of ground-covering plants dramatically increased runoff during rainstorms. Additional runoff occurred because living plants absorb significant storm water. The resulting erosion produced massive increases in sediment load, which we document in the Hell Creek drainage (western USA). Downstream, the K/Pg boundary is marked by the sudden appearance of new facies we interpret to be caused by intense stream activity from increased runoff, and widespread lakes we suggest were formed by downstream deposition of the sediment load that blocked streams. There was a new landscape, with soils removed, rapid channel movements and widespread flooding, all of which provided a very severe environment for the recovering biota. The freshwater biota suffered relatively minor extinction. This biota was protected from the initial IR radiation by water. During the darkness animals were supported by organisms and detritus moved into the streams by increased erosion. The vastly increased sediment load and runoff presented challenges to freshwater survivors adapted to the Cretaceous environment.

S23 - THE END-PERMIAN MASS EXTINCTION: A SINGLE- OR TWO-PHASE EXTINCTION?

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The end-Permian (end-Changhsingian) mass extinction has been unanimously documented as the largest extinction of the Phanerozoic. However, the extinction pattern and cause remain controversial. One of the key issues that may help unravel the causes is to describe the extinction pattern based not only on a single section, but also multiple sections spanning a large palaeogeographic area with different sedimentary settings. In South China, two major different extinction patterns have been recently documented. One suggests that the extinction happened in a short time of less than half million years; and the other favours a stepwise pattern that occurred in two episodes. However, our studies suggest that the two-phase extinction pattern based on stratigraphical ranges of different fossil groups from different sections in South China actually occurs at different levels and the stepwise extinction patterns are largely due to the Signor-Lipps Effect, facies changes or bias introduced through bed-by-bed sampling. The extinction shows the continuously accelerating disappearance of taxa with no distinct diversity fluctuations within the short extinction interval, when the Signor-Lipps Effect is applied. The confidence interval approach is used to re-locate the last appearances of all recorded species. The end-Permian extinction pattern is very different from the two-phase model of the end-Ordovician mass extinction that was interrupted by an invasion of the distinct *Hirnantia* Fauna associated with a glacial pulse. Our analyses using both range data and the CONOP9 approach based on a large data set from different palaeoenvironmental settings demonstrate that the extinction pattern consistently occurred within a short interval.

S14 - PHYLOGEOGRAPHIC PATTERN INDICATED BY ANCIENT DNA ANALYSES OF THE PLEISTOCENE SPOTTED HYENA (*CROCUTA CROCUTA ULTIMA*) FROM NORTHERN CHINA

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The extant hyena species are the remnants of a formerly diverse group of Hyaenidae, which has reached its peak about 5 MYA and contained more than 100 fossil species. Hyenas have become the subject of a number of evolutionary and systematic studies during the last two centuries, due to large part to the dramatically lost of its diversity and geography. The phylogenetic studies incorporating both morphological and molecular analysis have yielded different conclusions regarding the evolutionary relationship between extant and extinct hyenas. In this study, we amplified and sequenced 657 bp of the mitochondrial cytochrome *b* gene from 3 Pleistocene hyena specimens collected from Da'an Cave in Jilin Province in northern China. Both the newly obtained sequences and the homologous sequences collected from GenBank were aligned and used as datasets for phylogenetic analyses. The phylogenetic trees show that: 1) The Chinese extinct individuals and the north African extant spotted hyenas were intermixed, which indicated that, at least with regard to mtDNA sequences, the genetic variation between *Crocuta crocuta ultima* and the modern spotted hyenas is not obvious enough to classify the former one as neither a sub- species nor a different species, as argued by some authors based on morphological traits; 2) The extinct individuals from China and the one from Russia were joined together, appearing as a sister group of the branch combined by the west European fossil individuals and the African extant hyenas, which suggests a phylogeographic pattern of the Pleistocene spotted hyenas.

S23 - A NEW CEPHALOTAXUS FROM THE OLIGOCENE OF GUANGXI, SOUTH CHINA

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Although China possesses most living species of *Cephalotaxus* and has been considered as the distribution centre and refugium of this genus, fossil records are few and dubious. Recently a new species of *Cephalotaxus* has been reported from the Oligocene Ningming Formation of Guangxi, South China, on the basis of leafy shoots and detached leaves with a well-preserved cuticle. The leaves are hypostomatic, with two broad stomatal zones in the abaxial cuticle. Each stomatal zone consists of longitudinally oriented stomata arranged in 9-19 contiguous, regular, longitudinal stomatal files. Stomatal complexes are haplocheilic, monocyclic or sometimes incompletely amphicyclic. Subsidiary cells are 4-6 in number, thickened proximally to form a complete, raised rim around the stomatal pit mouth on the external surface. The adaxial cuticle and the non-stomatal zones of the abaxial cuticle consist of rectangular, elongate or strongly elongate epidermal cells in regular longitudinal files, without papillae or cuticular thickenings. The new species is most similar to the living *Cephalotaxus oliveri* Masters and Cephalotaxus bonseri (Knowlton) Chaney and Axelrod (1959) from the Miocene of Spokane, North America in leaf gross morphology and epidermal characters. A cladistic analysis has been constructed based on epidermal characters for all described fossil species of the genus *Cephalotaxus*, with *Thomasiocladus zamioides* Florin (1958), which is believed to be the earliest reliable fossil of Cephalotaxaceae, as an outgroup. The analysis shows that fossil species of *Cephalotaxus* may be divided into three phylogenetic groups and the group containing *Cephalotaxus ningmingensis* is basal in the genus.

S20 - PALEOECOLOGIC ASSESSMENT OF AN ORDOVICIAN EDRIOASTEROID ENCRUSTED OBRUTION SURFACE FROM THE UPPER ORDOVICIAN (MAYSVILLIAN) BELLEVUE FORMATION, MAYSVILLE, KENTUCKY

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Obrution occurs almost instantaneously, preserving benthic communities *in situ*. Since population studies are most reliable when applied to census assemblages, edrioasteroid paleoecology can best be understood by examining these catastrophically buried communities. This paleoecologic study examines a carbonate hardground encrusted with four species of isorophid edrioasteroids: *Curvitriordo stecki* (N=116), *Carneyella ulrichi* (N=108), *Streptaster vorticellatus* (N=9), and *Carneyella pilea* (N=2). Analysis of edrioasteroid diameters, a proxy for age, shows a bimodal distribution for *Curvitriordo stecki*, suggesting hiatus in recruitment or seasonal breeding. Low juvenile mortality may explain a left-skewed distribution among individuals of *Carneyella ulrichi*. Lack of juvenile individuals of *Streptaster vorticellatus* suggests this population likely matured from a single spat fall. *Carneyella pilea* had too few specimens for analysis. Edrioasteroids exhibit no preferred ambulacral orientation. Spatial analysis (SA) shows an inter-specific clustered distribution. Intra-specific SA indicates a clustered distribution for *Curvitriordo stecki* and *Carneyella ulrichi*. *Streptaster vorticellatus* and *Carneyella pilea* had too few specimens for analysis. Post-mortem preservation of the multi-part theca necessitates rapid burial. Examination of inter- and intra-specific edrioasteroid taphonomy revealed that thecal collapse, disarticulated cover plates, and disarticulated interambulacral plates occurred in nearly half of the population, suggesting brief post-mortem exposure on the paleo-seafloor without protection of sediment cover. Individuals of Streptaster vorticellatus suffered thecal collapse, yet all plates and ambulacra remained intact. Hence, this occurrence provides an intriguing example of an obrution deposit where the agent of mass mortality preceded influx of muds probably resuspended by storm currents following a prolonged interval of sediment starvation.

S14 - EXTINCTION DRIVEN DIVERSIFICATION DECLINE IN REEF CORALS DURING THE LAST 200 MILLION YEARS

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Diversification rates within clades commonly decline over time. This pattern is observed in both the fossil record and in time-calibrated molecular phylogenies. Based on a combination of molecular data and fossil occurrences of scleractinian corals, we found that an increase in the ratio of extinction to origination might be responsible for this decline. We identified a drop in diversification rate in modern reef corals using molecular phylogenies. The fossil record was used to estimate the trajectory of coral speciation rates. Extinction, inferred from the difference of diversification and speciation, increased in importance through time, which suggests that the decline in diversification rate is due to the increasing intensity of extinction relative to speciation. We propose that the increasing role of extinction over time commonly underpins patterns of explosive radiation and subsequent decline that is so often observed within clades. Diversification declines observed both in fossils and molecular phylogenies are largely attributable to heightened extinction when ecological interactions increase. Extinction, by opening up opportunities for new species is thus an important creative force in ecology and evolution, both within and among communities.

S4 - EXCEPTIONALLY PRESERVED MYODOCOPE OSTRACODS FROM THE HEREFORDSHIRE (SILURIAN) LAGERSTÄTTE: IMPLICATIONS FOR THE PALAEOZOIC OSTRACOD RECORD

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The Herefordshire (Silurian) Lagerstätte from the Welsh Borderland, UK, contains a wide variety of invertebrates. Many of the fossils show exceptional preservation of soft tissues in three-dimensions, and are recovered through techniques that yield 'virtual fossils' in the round. Two new species have been recovered from this biota, which on the basis of their well-preserved limb and other soft-part anatomy are assigned to the Myodocopa, as were the two previously described ostracod species from the Herefordshire Lagerstätte. Evidence from the Herefordshire ostracods hints that some palaeocopes - a major Palaeozoic ostracod group - might be myodocopes masquerading in a palaeocope shell. The evidence from soft-tissue anatomy advises caution in classifying so-called 'straight-hinged' Palaeozoic ostracods based on the carapace alone and therefore questions the nature of the shell-based Palaeozoic ostracod record.

S27D - FURTHER INSIGHTS INTO ARTHROPOD SOFT PART MORPHOLOGY: NEW DISCOVERIES FROM THE HEREFORDSHIRE (SILURIAN) LAGERSTÄTTE

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The Herefordshire Konservat-Lagerstätte from the Welsh Borderland preserves a wide variety of invertebrates of mid-Silurian, Wenlock Series age (*c*. 425 MYr). They show exceptional preservation of soft tissues in 3D, and are recovered through serial grinding, digital photographic and computer rendering techniques that yield 'virtual fossils' in the round for study. The arthropod record from this deposit is proving to be rich. To date, the faunal list for this phylum includes a marrellomorph, a pycnogonid, a stem group chelicerate and crustacean, three myodocopid ostracods, a phyllocarid, and a cirripede (barnacle). Ongoing work is supplementing this arthropod suite with at least three more taxa. The first is a bizarre form that combines features suggesting a crustacean affinity with others recalling the onychophorans, and perhaps also the myriapods; it also exhibits several autapomorphies. This species is at the most advanced stage of preparation, and its morphology and affinities will be discussed in detail. Other new arthropod material includes a calymenid trilobite preserving details of the appendages, and a chelicerate likely closely related to the co-occurring *Offacolus*.

S27B - BRACHIOPOD AFFINITY OF THE LOWER CAMBRIAN PROBLEMATIC BIVALVE *APISTOCONCHA*

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The Lower Cambrian small shelly fossil *Apistoconcha* has been problematic, both in terms of its functional morphology and biological affinity, ever since its first discovery 20 years ago. Although originally compared to brachiopods, *Apistoconcha* was most recently redescribed as a mollusc. New material of *Apistoconcha* from South Australia and Greenland includes the first fully articulated specimens and the new material also exhibits a well preserved shell structure, as well as the larval shell morphology. Articulated specimens combining phosphatised shells and internal moulds allow a revised analysis of the arrangement of the soft parts. The shell of *Apistoconcha* exhibits a fibrous shell structure with individual fibres radiating from the apical region of the shell. The arrangement of soft parts, in particular the position of possible muscle attachment scars in *Apistoconcha* most likely reflect a brachiopod affinity of this problematic putative bivalve, and the details of the fibrous shell structure may suggest a relationship to craniiform brachiopods. This conclusion is corroborated by the morphology of the larval shell, which is closely comparable to the larval shells of some of the earliest known (Ordovician) unequivocal craniiforms.

S13 - THE EFFECT OF THE LATE LUDFORDIAN LAU EVENT ON THE CONODONT FAUNAS FROM BOHEMIA

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The purpose of the presentation is to demonstrate taxonomic diversity and intra-specific variability of conodonts of the *Polygnathoides siluricus* Biozone from the Prague Synform (Bohemia) and to demonstrate the effect of the late Ludfordian Lau-event on the conodont faunas during post-*siluricus* time. The *siluricus* time-span is characterized by high taxonomic diversity (both on generic and specific levels); taxa of the genus *Ozarkodina* and *Wurmiella* show also a high intra-specific variability on several stratigraphic levels.

S21 - USING MULTIPLE DATA SETS TO INVESTIGATE ECHINOID PHYLOGENY

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Independent data sets provide one of the most effective ways of testing phylogenetic hypotheses. To examine post-Palaeozoic echinoid relationships, we have built large morphological and molecular data sets. These have been analyzed both independently and in combination. We have scored 306 skeletal characters for type species of 169 extant and fossil families, using *Archaeocidaris* as outgroup. For representatives of the 75 extant families, we have also scored for 102 characters relating to soft tissue anatomy. For these, we have also evaluated 49 characters derived from pedicellarial morphology. Furthermore, we have compiled gene sequence data (18S, 28S and 16S ribosomal genes) from 46 genera with representatives from 13 of the 14 orders of living echinoid, amounting to more than 3000 base-pairs. Independent analysis produces trees that are partially congruent and emphasises regions of the tree that are well supported and those that are poorly supported. Both soft tissue anatomy and gene sequence data provide strong support for many of the major groupings recognized from skeletal anatomy. However, little consensus emerges about the deep relationships and the origins of irregular echinoids due largely to a lack of phylogenetically informative characters in all data sets. Furthermore, the monophyly of clypeasteroids remains problematic, with molecular data being at odds with soft and hard tissue morphology.

W1 - WHY IS IT SO HARD TO ESTABLISH A MOLECULAR FRAMEWORK OF ECHINODERM CLASS RELATIONSHIPS?

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Despite several conserted efforts, the phylogenetic relationships of the five echinoderm classes have remained difficult to resolve with confidence. While there is general agreement that crinoids are sister group to the rest and strong support for echinoids plus holothurians as sister group, the relationships of asteroids and ophiuroids has proved difficult to clarify with any degree of robustness. Currently molecular evidence comes from three sources, ribosomal genes, nuclear protein-coding genes and microRNAs. Ribosomal genes alone, or in combination provide weak and, in some cases, conflicting signal. A major problem here is that, although partial gene sequences are available across a wide range of taxa, these provide only a very patchy and mismatched coverage in combination. Very few taxa have had their complete ribosomal genes sequenced so that large-scale analyses still rely on just one or two taxa per class, and thus limited taxonomic sampling. Protein-coding genes are even more patchily sampled for echinoderms and taxa have been sequenced because of ease of availability rather than to provide broadest within-class sampling. Finally microRNAs may not help reach an answer as the same derived gene repetoire is found in echinoids, asteroids and ophiuroids, with no two taxa sharing a unique microRNA signature.

S22 - ORIGIN OF TEETH IN PLACODERMS, CO-OPTION OF GENETIC REGULATION IN A DEVELOPMENTAL MODEL

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The fossil group Placodermi is resolved to the basal node of the clade of jawed vertebrates and lacks the marginal dentition possessed by the crown-group Gnathostomata (Chondrichthyes, Acanthodii, and Osteichthyes). However, statodont, non-replacing dentitions with regulated, sequential tooth addition can be recognised in the group, but only within the Arthrodira, where new teeth form at the ends of rows in line with the biting edges of the dentition. These teeth develop with regular, tubule containing dentine, comparable to that of other crown-group gnathostomes. Smith and Johanson (2003) built a scenario of dental evolution based on the existing cladogram of placoderm relationships (Goujet & Young 1995), such that teeth, comparable in arrangement, patterning and composition to those of crown-group gnathostomes, occurred only in derived placoderms, the arthrodires. Now, new cladisitic analyses (Brazeau, 2009) show the arthrodires placed closer to the crown gnathostomes and not part of a monophyletic group Placodermi. Development of their teeth could arise from a site specific, sequential addition model similar to that of Osteicthyes and not involve their development from a dental lamina as classically acknowledged for the Chondrichthyes. In this model the archaic gene regulation network would operate to pattern the morphogenetic tooth units as it does in extant osteichthyan fish. All toothed fields start from a pioneer tooth on each bone or jaw, which autonomously regulates the pattern of tooth addition This pattern was originally co-opted from an ancient oro-pharyngeal system of sequentially added teeth in closely linked sets.

S21 - MACROEVOLUTIONARY PATTERNS OF THE TURRITELLID GASTROPODS (FAMILY TURRITELLIDAE) OF NEW ZEALAND

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The turritelline gastropods of New Zealand offer a potentially ideal test case for the study of macroevolutionary patterns as they have a diverse, abundant and well known high resolution fossil record within a well studied and well understood stratigraphic framework. Additionally, several of the fossil genera are also represented by extant species around coastal New Zealand. Their non-overlapping spiral mode of shell growth preserves the entirety of their shell from larvae to death making it possible to compare shape variation (described in detail by geometric morphometric methods) through ontogeny and between species. Where phylogenetic relationships of the species are known, this allows inferences about modes of speciation through the lineage to be drawn beyond the observation that through their geological range, periods of both anagenetic and cladogenetic change appear to occur. Despite their modern and fossil abundances, however, the relationships of all turritellids, not just those of New Zealand, have remained unclear due to the difficulty of describing phylogenetic characters using traditional methods. However, newer methods of incorporating geometric morphometric approaches in defining characters have shown promise in allowing taxa to be incorporated into phylogenetic analyses. Here, the first phylogeny for turritellid gastropods produced using cladistic methods and incorporating geometric morphometric data is presented. This phylogeny of relationships of New Zealand turritellids now allows questions of speciation mode and heterochrony to be addressed while the wealth of other available data for the New Zealand Cenozoic allows correlates and possible causes of morphological change to be examined.

S3 - PREPARATION AND ANALYSIS OF SEASONALLY LAMINATED DIATOM SAMPLES FOR OXYGEN ISOTOPE ANALYSIS FROM THE LATE QUATERNARY ANTARCTIC MARGIN

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Diatoms are known to be excellent palaeoindicators with their oxygen isotope records ($\delta^{18}O_{diatom}$) containing great potential for further understanding climatic and oceanographic changes in areas depleted in carbonates, such as Antarctica. Here ice sheets have played, and continue to play, a major role in the global ocean-atmosphere system, so a sound understanding of the past behaviour of Antarctica and its ice sheets provides us with a view to understanding their variability under a warming climate. This environment is dominated by the seasonal advance and retreat of sea ice with seasonal variability one of the most significant factors regulating the energy balance of Southern Hemisphere atmosphere and oceans. High-resolution Antarctic margin sediment cores contain an excellent archive, often on seasonal timescales, from the last deglaciation and throughout the Holocene. These laminations are dominated by well-preserved fossil planktonic diatom assemblages; individual species of which are sensitive to sea surface conditions. Measurements of $\delta^{18}O_{diatom}$ are usually carried out on bulk samples, containing a variety of diatom species and size fractions, due to the large amount of material required for a single analysis (6-7 mg). It has previously been shown, however, that size-related species/vital effects may exist but the mechanisms underlying such effects are poorly understood. By extracting and measuring $\delta^{18}O_{diatom}$ on individual diatom taxa, these problems can be minimised as well as providing a high-resolution $\delta^{18}O_{diatom}$ record directly reflecting changing seasonal conditions. The methods required to achieve monospecific samples are presented as well as the preliminary results covering the deglaciation interval.

S15 - CARBON ISOTOPE COMPOSITION OF GRAPTOLITE PERIDERM AND WHOLE-ROCK FROM THE AERONIAN (SILURIAN, LLANDOVERY) IN WALES AND SCOTLAND AND ITS USE IN CHEMOSTRATIGRAPHY

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Carbon isotopes are used as a standard stratigraphic tool and $\delta^{13}C$ through geological time reflects past changes within different carbon reservoirs (e.g. global biomass, atmospheric and marine carbon content) and hence $\delta^{13}C$ variation is applied to studies of climate change and stratigraphic correlation. Commonly whole-rock carbon (both organic and inorganic) is used as a means of investigating changing oceanic conditions but bulk organic carbon includes components from a variety of sources, including phytoplankton and zooplankton as well as terrestrially-derived carbon. $\delta^{13}C$ has been applied to specific fossil material but graptolite periderm has been little used for chemostratigraphic study. Using material from the Aeronian (Silurian) interval from Wales and Scotland as examples, we show that the carbon isotope composition of the periderm ($\delta^{13}C_{graptolite}$) provides a signal that is locally different but not consistently so to surrounding whole-rock samples ($\delta^{13}C_{whole\text{-}rock}$). Graptolite periderm $\delta^{13}C$ seems not influenced by astogenetic stage of development or gross rhabdosome type and differences between $\delta^{13}C_{graptolite}$ from different metamorphic grades are minimal. Taken as a whole, the Aeronian interval examined shows little overall change, but large variations are seen on the small scale, possibly reflecting very local carbon cycling. For carbon isotope stratigraphy in such rocks, therefore, large-scale bulk sampling will likely reduce inhomogeneities and give more reproducible results. Furthermore, in situations (for instance associated with sea level fluctuations) where terrestrial organic matter has been incorporated into the sediment, then graptolite carbon may more faithfully reflect bulk marine organic matter.

S13 - PREDATORY ACTIVITY TOWARDS *ROTULARIA* (ANNELIDA) AT THE K-T MASS EXTINCTION

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The evolution of taxa can be significantly influenced by interactions between predators and their prey. At times of biotic crises it is likely that predator-prey relationships are disrupted from their usual patterns. The K-T mass extinction had a significant effect on marine life and the associated decline in primary productivity considerably disrupted food chains. The hypothesis of escalation states that highly escalated prey are particularly vulnerable to extinction following declines in primary production and it can be expected that predators will dominate in the subsequent recovery stage. The study of predatory drill holes in marine fauna allows analysis of predator-prey relationships that may otherwise be lost in the fossil record. Changes in predation towards *Rotularia* (Annelida), from Seymour Island, Antarctica, are observed across the K-T boundary. Trends in drill hole data imply variations in success between predators and *Rotularia* prey occurred at this time. Little is known about the life habit of *Rotularia*. Trends in predation allows analysis of both the lifestyle and evolution of *Rotularia*, as well as determining the role *Rotularia* played during the K-T mass extinction; a time of immense disruption and variation.

S2 - IN SILICO EVODEVO: THE MULTIPLE PATHS TO EVOLUTIONARY CONVERGENCE

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Evolutionary dynamics are well known to involve both path-dependent, historic processes as well as convergence. Such dynamic patterns occur in an ecological scenario, where development seems to play an essential role in defining the possible and the actual. Recent advances in the analysis and modeling of gene regulatory networks reveal unexpected features of these systems and the existence of universal laws in common with other phenomena such as RNA folding. Moreover, by introducing a physically embodied environment with ecological interactions emerging from a community of simple cells, it is possible to see how primitive forms of pre-developmental programs arise and are selected. These include emergence of ecosystems with trophic structure, biofilms with spatial organization or multicellular aggregates. The models reveal some unexpected possibilities for the origins of development and its evolution. The paths followed by simulated ecosystems indicate that few final solutions are possible, but the paths to reach them are rather diverse. I will present some of these modeling efforts and how they might help elucidate some key problems related to the presence of universal patterns in evo-devo and the role of constraints (including physical environment) in canalizing macroevolutionary dynamics.

S27C - 3D X-RAY MICROTOMOGRAPHY RECONSTRUTIONS: AN IMPORTANT PRELIMINARY TOOL FOR PALAEOBOTANISTS

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Over the last decade Micro-CT or X-ray Micro Tomography (XMT), has become increasingly available as an investigative tool. Development of scanning technology has been matched by a rise in computational power and advances in software, reducing the financial and time costs associated with the process. Three-dimensional reconstruction via XMT can hence now move from being reserved for one-off samples with known preservation to a preliminary method of investigation. Palaeobotanical material is often three-dimensionally preserved, and hence well suited to tomographic reconstruction. XMT-reconstruction requires X-ray density contrast between specimen and matrix; while this is present in some plant fossils, which scan well, those preserved as organic material can be 'difficult'. Nonetheless even in these cases XMT data can provide preliminary 3D reconstructions which can serve as an important guide for more traditional (destructive) investigative techniques, such as serial grinding, enabling them to capture the maximum amount of data. This preliminary-scan approach is especially important where anatomically preserved organs which are hitherto unknown are to be investigated. We report here the preliminary results from a project to investigate the anatomy and affinity of a range of Palaeozoic plant-organ fossils using XMT.

S24 - PALAEOVEGETATIONAL AND PALAEOCLIMATIC TRENDS ACROSS THE SILURIAN-DEVONIAN TRANSITION BY PALYNOLOGICAL DATA FROM SOUTHERN TUNISIA

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Analysis of miospore assemblages from Ludlow-Lochkovian strata of borehole section MG-1 (Tunisia, Ghadamis Basin) together with a comparison with associations from coeval Gondwanan and Euramerican localities, permits to define palaeoclimatic and palaeoecological changes across the Siluro-Devonian transition. The palynofacies analysis evidences two transgressive inputs in the generally regressive Acacus Fm., and a transgressive trend in the Lochkovian Tadrart Fm. Sea level change, miospores biodiversity and organic parameters trends appear correlated. Diversity of trilete spores is higher than cryptospore diversity throughout the study section, and trilete spores are particularly abundant in correspondence to transgressive inputs evidenced by peaks in relative abundance of marine elements (acritarchs, chitinozans, prasinophytes). The increasing abundance of trilete spores relatively to cryptospores from middle Silurian to Lochkovian strata is possibly related to the progressive replacement of the primitive, cryptospore-producing plants by the more evolved and environmentally adapted trilete spore - plants. According to the "Wellman effect" cryptospore-plants were more climatically tolerant than trilete spore-plants but were palaeo-ecologically restricted to specific biotopes (e.g. swamps and lake margins). This is usually seen in the higher abundance and diversity of cryptospores than trilete spores in sediments of continental origin, far from marine influences. However, somewhat in contrast with this model, miospore assemblages from the fully continental basal part of the Tadrart Fm. are still dominated by trilete spores. The proliferation and continuing diversification of trilete spores during late Silurian – Early Devonian times is consistent with conditions of widespread equable climates, which favored the evolution of the early land plants.

W1 - PHYLOGENETIC PATTERNS AND CONTROVERSIES IN THE ECHINODERM SUBPHYLUM BLASTOZOA

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The Subphylum Blastozoa was proposed in 1973 for brachiole-bearing, suspension-feeding, stemmed echinoderms that radiated in the Cambrian and Ordovician, competed with similar crinoids throughout most of their Palaeozoic history, and apparently became extinct at the Permo-Triassic boundary. Since then, blastozoan groups have increased in number to eight named classes, at least 17 clades, and about 320 genera. Blastozoans are diagnosed by: 1) erect, usually biserial brachioles attached to recumbent, plated ambulacra (apomorphic), 2) lack of certain coelomic systems in these brachioles, ambulacra, and later erect "arms" (apomorphic), and 3) holoperipheral thecal plate growth with external growth lines (apomorphic?, possibly plesiomorphic). The subphylum has been widely accepted over the past 37 years, but several controversies remain, including: 1) the number of included groups and their phylogenetic relationships, 2) the origin of blastozoans and their likely Early Cambrian sister group/ancestor, 3) how to handle "messy" paraphyletic or even polyphyletic classes (eocrinoids, rhombiferans, diploporans), 4) whether blastozoans are monophyletic or possibly ancestral to crinoids and thus paraphyletic, and 5) whether most homalozoans ("carpoids") are in fact blastozoans. Blastozoans were originally described as having fundamentally different feeding appendages and thecal plating from crinozoan crinoids; they probably originated from different ancestors and appeared at different times, indicating that blastozoans and crinoids are likely unrelated monophyletic groups. Other authors have argued for a direct phylogenetic relationship between crinoids and either primitive Cambrian blastozoans or more derived Early Ordovician caryocystitid rhombiferans, making blastozoans paraphyletic. However, widespread homoplasy and convergence are more likely responsible for the observed similarities.

S3 - EARLIEST EOCENE ENVIRONMENTS ALONG THE NEW JERSEY COASTAL PLAIN (USA)

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The Paleocene and Eocene have become appreciated as climatically dynamic periods with key intervals of rapid global warming, called hyperthermals of which the Paleocene-Eocene thermal maximum (PETM) is the best known. In recent years, high-resolution isotopic and biotic studies on sedimentary sequences of the New Jersey Coastal Plain helped to unravel the progression of environmental changes during the onset of the PETM, but sea-floor conditions were not studied. Here we present high-resolution benthic foraminiferal records on the expanded PETM interval of the Wilson Lake and Bass River cores. The onset of the PETM is marked by isotopic excursions and is placed at the transition from glauconitic sands to silty clay and a change from a diverse middle neritic Paleocene benthic foraminiferal assemblage to an opportunistic outer neritic assemblage. Environmental parameters point toward a drop in ocean current strength, elevated sedimentation rates, possibly higher influx of fresh water, increase in water depth and more stressed eutrophic low-oxygen environments. Diversity trends indicate a gradual recovery during the PETM. An unconformity truncates the upper part of the PETM and the recovery of the carbon isotopic excursion (CIE), suggesting that clay deposition corresponds to the peak interval of the CIE, representing a maximum duration of 70 kyr. The overlying Eocene glauconitic sandy clays contain a fauna comparable to the one of upper Paleocene and indicate persistent high primary production and a return to more vigorous currents. This benthic study helps to further unravel the "regional" biological effects of global warming on shallow (neritic) marine environments.

S20 - CAMBRIAN SMALL SHELLY FOSSILS AND THE TAPHONOMIC PHOSPHATIZATION WINDOW

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Early on, the occurrence of large numbers of Cambrian phosphatic small shelly fossils (SSFs) led to the assumption that apatite was the dominant biomineral in the formation of skeletons in most Cambrian metazoan clades. Most SSFs are now considered as a result of early or later phosphate permineralization, coating, or replacement of carbonatic or organic skeletons and tissues. Only few organisms are recently considered to have possessed primary phosphatic biominerals, such as mobergellids, tommotids, tannuolids, palaeoscolecids phosphatocopids, tubular fossils like *Sphenothallus*, conulariids, and lingulid brachipods. The primary nature of phosphate biomineralization in protoconodonts and lobopods can be doubted. New clues for the distribution of primary biominerals and taphonomic pathways can be derived from comparative studies of organisms both preserved in Burgess Shale-type and Orsten-type preservation. Phosphatization of soft tissues and phosphatic replacement of other biominerals reflects specific environmental conditions and may be linked to the influence of anoxic/dysoxic bottom and pore waters and ion release from organic matter by various decay processes. Phosphatic preservation of volatile tissues may be mirrored by the cyclicity of large-scale sedimentary phosphorite deposits.

S27B - PALAEOTAXODONT BIVALVES FROM THE DARRIWILIAN (MIDDLE ORDOVICIAN) OF BOHEMIA RECLASSIFIED

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Darriwilian palaeotaxodonts from the Prague Basin have been overlooked for a long time. Only Barrande (1881) and Pfab (1934) studied them in the past. *Ctenodonta* (Salter, 1851) was problematic genus until Pojeta (1988) described it from North America. *Ctenodonta applanans* (Barrande, 1881) and *Ctenodonta bohemica* (Barrande, 1881) from the Prague Basin do not belong to *Ctenodonta* and should be reclassified to *Praenucula* Pfab, 1934. *Ctenodonta ponderata* (Barrande, 1881) is the type species of *Concavodonta* Babin & Melou, 1972. In my opinion *Ctenodonta* does not occur in the Prague Basin. *Praeleda* Pfab, 1934 and *Praenucula* have very similar general morphology. Kříž & Steinová (2009) classified *Praeleda amica* (Barrande, 1881) as synonymous with *Praeleda compar* (Barrande, 1881). I consider *Praeleda pulchra* Pfab, 1934 to be valid. According to Kříž & Steinová (2009) *Praenucula dispar dispar* (Barrande, 1881) and *Praenucula dispar expansa* (Pfab, 1934) were classified as *Praenucula dispar*. McAlester (1969) placed *Pseudocyrtodonta* Pfab, 1934 into the synonymy of *Myoplusia* Neumayr, 1884. I classify *Pseudocyrtodonta ala* (Barrande, 1881) as *Myoplusia* but with a question, since it does not have specific muscle scars below the umbo and the shell is more elongated. McAlester (1969) recognized *Synek* Barrande, 1881 to be synonymous to *Palaeoneilo* Hall & Whitfield, 1869. Bivalves from Darriwillian are also known from Spain (Sharpe, 1853, Babin & Gutiérrez-Marco, 1991), France (Barrois, 1891, Babin, 1966, Babin and Beaulieu, 2003, Bradshaw, 1970), Wales (Cope, 1999), Australia (Pojeta & Gilbert-Tomlinson, 1977) and Portugal (Sá, 2008).

S15 - NORTHERN ENGLAND SERPUKHOVIAN (EARLY NAMURIAN) FARFIELD BRACHIOPOD AND PLANT ISOTOPE RESPONSES TO SOUTHERN HEMISPHERE GLACIATION

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The Serpukhovian was a period of climatic change in Gondwana with glaciation being initiated in limited areas of eastern Australia, South America and Tibet. The Serpukhovian is poorly represented by farfield isotope studies. Previous surveys of isotope data from brachiopod carbonate have few Serpukhovian sample points, as well as low values questioned by previous workers. Similarly organic $\delta^{13}C$ which mainly tracks terrestrial plant tissue is poorly represented in the Serpukhovian. The Woodland, Throckley and Rowlands Gill boreholes (northern England) contain a Serpukhovian to Bashkirian farfield record newly dated by foraminiferans. $\delta^{18}O$ values from late Serpukhovian Woodland brachiopods vary between -3.4 and -6.3‰, and $\delta^{13}C$ varies between -2.0 and + 3.2‰, confirming low values recorded elsewhere and suggesting a $\delta^{18}O$ seawater (w) value of around -1.8‰ VSMOW, and therefore an absence of widespread ice-caps. The organic carbon $\delta^{13}C$ increasing trend in the Throckley Borehole (Serpukhovian to Bashkirian; c. -24 to c. -22‰), and the Rowlands Gill Borehole (Serpukhovian; c. -24 to c. -23‰) indicates large-scale burial of organic material, probably in burgeoning lycophyte-dominated coal forest and would imply a steady fall in pCO_2. Therefore these high resolution data show that at least one substantial period of the Serpukhovian cannot have been glaciated. The steady fall in Serpukhovian pCO_2 appears not to have caused large-scale glaciation until the early Bashkirian, but a scenario of coalescing upland icecaps through the Serpukhovian with a background of decreasing pCO_2, appears to be similar to the process that initiated Cenozoic Antarctic glaciation.

S8 - MOLLUSCS AND SHELLY FAUNAS FROM THE ORDOVICIAN OF GIRVAN AND SOUTHERN UPLANDS OF SCOTLAND

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The Girvan and Southern Uplands areas of Scotland are renowned for their Ordovician and Silurian fossils. The Ordovician succession of Girvan is, particularly well known for the famous Katian 'Starfish Beds' (e.g. trilobites and brachiopods). Less familiar are the older Darriwilian and Sandbian faunas, particularly the molluscs and problematic taxa. These often neglected fossils still have much to offer in biodiversity, palaeo-ecology, and biogeography studies. Studies of the mollusc faunas of Girvan show diversity patterns similar to those known worldwide. Gastropods are most common and diverse in carbonate facies, whilst bivalves are more diverse and abundant in siliciclastic facies. Bivalve diversity increases through the Ordovician as did that of gastropods. Diversity of all taxonomic groups decreases overall with increasing water depth. Analysis of whole fossil faunas can provide insights into overlooked fossils which may prove useful in diversity and palaeogeography studies. One such unusual Sandbian fauna in Girvan preserves articulated carpoids and polyplacophorans; without many of the typical, deep water, faunal components of the horizon found in nearby localities. A pyritised specimen of the sponge *Pirania*, known in the Ordovician from Wales and Morocco, has recently been identified from here. The Southern Uplands of Scotland are well known from several classic graptolite studies. The less familiar shelly faunas contain taxa with similarities to Girvan and Pomeroy, Ireland, though distinct differences occur.

S2 - USING ECOLOGICAL NICHE MODELING TO EVALUATE NICHE STABILITY IN DEEP TIME: ANALYZING LATE ORDOVICIAN BRACHIOPODS OF EASTERN NORTH AMERICA ACROSS AN INVASION EVENT

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The ecological niche of a species can be estimated from a set of species occurrence points associated with data about the environmental conditions at those locations using a method known as ecological niche modelling (ENM). By modelling a species' niche at multiple time slices, the degree of conservatism or niche evolution species undergo during intervals of biotic, environmental, or climatic change can be assessed. This technique has been widely employed with modern organisms, and great potential exists for ENM studies in the fossil record. The Richmondian Invasion, an extrabasinal immigration event, is presented as a case study to investigate the relative stability of ecological niches of eight Late Ordovician (Katian) brachiopods from the Cincinnati Arch of eastern North America. This provides an opportunity to examine whether species altered the parameters of their ecological niches in response to species invasions and ecosystem turnover. Niches were modelled across nine time slices using the Maxent program based on environmental parameters estimated from the sedimentary record including: inferred water depth, lithology, bedding thickness, bedding style, and physical sedimentary structures. Niche stability was assessed through pairwise comparisons of the percent contribution of each environmental parameter to species' niche models between adjacent time slices. The degree of niche stability varied through time. Species exhibit niche evolution prior to the onset of the Richmondian Invasion, but high niche stability during the invasion interval. Niche stability levels relax post-invasion, although stability still significantly exceeds pre-invasion levels. Therefore, these species appear to respond to invasion pressure through niche conservatism.

W10 - BIOSTRATIGRAPHIC CORRELATION OF PERMIAN STRATA FROM SE TURKEY AND AUSTRALIA – AND PALYNOLOGICAL SPECIES AS INDICATOR FOR CLIMATE

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Deposits of the Kaş Formation of SE Turkey (northern Arabian Plate margin, palaeogeographic position 10°S-15°S, deposits dated previously by foraminifera to Tethyan stages) are in this study correlated with Australian strata (previously dated by brachiopod zonation to Russian and global stages). This long-distance, eastern Gondwana-wide biostratigraphical correlation is conducted for the first time in the Guadalupian epoch (Mid Permian). The lower and middle parts of the Kaş Formation, and the upper Muja and upper Collieburn members of the Collie Coal Measures (Western Australia, approx. 65°S in the Permian) are of late Wordian age, extending into the Capitanian. On this basis, the palynological record of these units is now also chronostratigraphically related to the ICS international stages. Assemblages from the Kaş Formation are correlated with those of the upper *D. ericianus* Zone of Western Australia (former *P. rugatus* Zone, Collie Basin). A similar Gondwana-wide Last Occurrence Datum of the distinctive miospore *Corisaccites alutas* Venkatachala and Kar 1966 has been observed. The comparison of the palynological record of the late Wordian of SE Turkey and Australia has also shown that about twenty species were common to both areas (Kaş Formation and upper Collieburn Member). Some species were obviously facies restricted to the respective regional and local depositional environments. From the palaeobiogeographical perspective, it may be concluded that certain species of parent plants probably co-occurred Gondwana-wide during the late Wordian, while the distribution of others was dependent on climate.

S13 - LATE LUDLOW *KOZLOWSKII* EVENT IN BOHEMIA: GRAPTOLITE RECORD COMBINED WITH CONODONT, SEDIMENTARY AND CARBON ISOTOPE DATA

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The shale-dominated hemipelagic succession exposed by Všeradice section in southwestern part of the Prague Synform preserves the most complete Ludfordian graptolite record so far encountered from peri-Gondwanan Europe. Conodont occurrences, although restricted to scattered limestone beds, provide basic correlation between graptolite-bearing shaly facies and conodont-bearing limestone facies which predominates in many other upper Silurian sections. Benthic fauna and sequence-stratigraphic signatures further enhance the correlation. The *Kozlowskii* Event marks sudden extinction of several graptolite clades, including long ranging *Bohemograptus* (with *B. praecornutus*, *B. garratti* and *B. tenuis*), *Neocucullograptus* (with *N. kozlowskii*), *Polonograptus* (with *P. podoliensis* and *P.* n.sp.), and *Paramonoclimacis dalejensis*. The present record, combined with data from Kosov Quarry, suggests that only *Pseudomonoclimacis kosoviensis*, *Linograptus posthumus* and *Pristiograptus dubius* stem survived the crisis which thus eliminated all graptolite taxa with ventrally curved and/or coiled rhabdosomes and resulted in a substantial drop in morphological disparity of graptolites. This graptolite crisis correlates with the middle Ludfordian positive carbon isotope excursion assigned to the Lau Event. Recovery, manifested by the appearance of *Pseudomonoclimacis latilobus* and *Slovinograptus balticus*, closely postdates cessation of the isotope excursion but predates FA of conodont index "*Ozarkodina" snajdri*. Intraformational limestone conglomerate and limestone beds accompanying the graptolite extinction level record a distinct fall in sea-level. Present data demonstrate coincidence of the graptolite crisis with benthic faunal change and eustatic fall in sea-level manifested by carbon isotope excursion and facies change. Despite the lack of high-resolution scenario, the Kozlowskii and Lau events may be assigned to the same eustatic oscillation.

S24 – CHARACTER EVOLUTION AND THE ORIGIN OF LAND PLANTS

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The land plants evolved in two distinct stages: first, through the evolution of an amphibious, archegoniate gametophyte, followed by the *de nove* interpolation of a sporophytic generation between successive vegetative gametophyte phases. All embryophytes possess archegonia, but the fundamental control of cell division during sporogenesis is variable throughout the bryophytes, indicating they did not inherit a canalized genetic program of meiosis. The fossil record of cryptospores allows us to place temporal and morphological constraints on this second phase of land plant evolution. The Cambrian cryptospore *Agamachates* retains spore wall topologies that are consistent with DNA endoreduplication preceding cytokinesis during sporogenesis. This fits the traditional model that posits *Coleochaete* as the embryophyte ancestor. Bower predicted that the sporophyte evolved first through the expansion of sporogenous tissue followed by the loss of spore-generating capabililty to produce the vegetative sporophyte. This too can be seen in some Cambrian and ordovician cryptospores which exhibit highly-organized sheets of spore-bearing packets that mimic thalloid vegetative tissues (similar to *Coleochaete*). Simultaneous sporogenic meiosis appears by the Darriwilian, as evidenced by the introduction of tetrehedral crytospore tetrads in the fossil record. The origin of land plants was not an evolutionary singularity – it occurred as a progressive series character state changes during the evolution of the sporophyte. The process had begun by Cambrian time and was essentially completed with the evolution of plant axes in the Silurian. The demonstration that sporophyte "interpolation" was actively evolving during the Cambrian indicates that the archegoniate condition probably evolved during Precambrian time.

S24 - FUNGI AND FUNGAL-LIKE MICROORGANISMS IN EARLY TERRESTRIAL ECOSYSTEMS

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The study of fungi and fungal-like microorganisms is of relevance to palaeontologists and biologists interested in the ecology of early terrestrial environments and in the evolution of living fungi and fungal-like microorganisms. A fungal way of life is shared by several living groups of organisms, notably Fungi and Oomycetes (= Peronosporomycetes), which are respectively classified in Eumycota and Straminopila. Many of these organisms form close associations with plants. The fossil record of these associations is sparce despite the fact that the link between plants and fungal-like microorganisms is known to go back to the dawn of life on land. The earliest evidence of symbiotic association involves the stem of the plant, and this has been documented in Early Devonian fossils from the Rhynie Chert. This type of symbiosis occurs in living liverworts, hornworts, lycopods, ferns, horsetails. It is very rare in living seed plants where it is found only in the embryos of some orchids. Fungal-plant association specific to the roots of tracheophytes, which is by far the most common form of symbiotic association in the modern flora (ca 80% of species), are known from the Upper Carboniferous. The oldest occurrence was documented in *Radiculites reticulatus* rootlets of a cordaitalean gymnosperm from Grand'Croix (France). Peronosporomycetes are heterokont eukaryotes that nowadays are common saprophytes and parasites of plants, animals and fungi. This group has recently been recognised in the Palaeozoic within the leafy branches of a lycopod from the Carboniferous Period, and plausible Peronosporomycetes have also been recognised in the Rhynie Chert. We describe *Combresomyces williamsonii* in *Lyginopteris* (Pteridosperm) from the English Coal Measures validating and extending recent previous works. *C. williamsonii* provides the earliest evidence for parasitism in Peronosporomycetes and a secure data point to molecular phylogeneticists interested in calibrating the heterokont branch of the eukaryote tree of life. These new discoveries indicate that Peronosporomycetes were also a key component of early terrestrial ecosystems.

S14 - MOLECULAR DATING REVEALS A MID TO LATE MIOCENE ORIGIN OF PRESENT DAY NEOTROPICAL SPECIES RICHNESS IN A DIVERSE GENUS OF GEOMETRID MOTHS

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The genus *Eois* (Geometridae) comprises 250 described, and dozens of undescribed, species. *Eois* is pantropical in distribution with maximum richness in the Neotropics. *Eois* accounts for up to 8.1% of local species richness of Geometridae in Andean montane forests. According to the forest refugia hypothesis much of present day Neotropical biodiversity originated during Pleistocene glacial cycles either due to cyclic elevational shifts of the Andean tree line or by forest contractions and expansions. This has served as a paradigm for the past 40+ years. We used a phylogenetic hypothesis for 142 taxa (2700bp of nuclear and mitochondrial sequences) to infer the ages of clade splits within Neotropical *Eois* by applying a Bayesian relaxed clock approach. Absolute ages were calibrated with two fossils as well as two soft calibration points obtained from a larger scale phylogenetic study dating the Geometridae. Diversification of *Eois* predominantly occurred at a constant rate in the second half of the Miocene with a number of younger divergences in the Pliocene. No substantial diversification can be detected in the Pleistocene even when the lower (younger) 95% confidence interval of ages is adopted as reference. Our results are clear evidence against increased speciation during Pleistocene glacial cycles. The period of diversification of *Eois* does co-incide with, or slightly postdates, the timing of diversification of the most common larval host plant genus *Piper*. We therefore conclude that diversification of *Eois* was more likely driven by increasing Andean uplift starting ~11mya, possibly in interaction with diversification of larval host plants.

S18 - PLIOPITHECID BIOGEOGRAPHY AND PALEOECOLOGY: ASIAN LOCALITIES

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The family Pliopithecidae is a group of primitive catarrhines (Primates) with no known descendants or identifiable antecedents that had a wide geographical range throughout Eurasia during most of the Miocene, from circa 17 to 7 million years ago. Although with seemingly similar habitat demands to large hominoids, and a wide distribution throughout Eurasia, they do not coexist with hominoids except for in only a few of the more than 40 Eurasian pliopithecid localities. The differences between pliopithecid and hominoid ecologies, and the special ecological conditions that allowed the overlap, are the main focuses of this study. The aim is to produce new information on pliopithecids and their ecologies, as well as on environmental conditions around Eurasia during the Miocene. This is done by comparing pliopithecid species and localities as well as those of other Miocene primates in Eurasia. Comparisons between pliopithecid localities are based on the data derived from NOW-database and published faunal lists. Localities are compared using similarity and ecological diversity analyses. Dietary differences between primate species will be specified using GISWear-method that is developed particularly on bunodont teeth to determine the diet. Pliopithecids are considered to be a quite diverse group of primates and preliminary results support this, showing differences between Asian localities both in faunal similarity and diet.

S10 - THE CLOUD PARADIGM: GEOSTABLE MOLECULES AS PROXIES FOR SURFACE OXYGENATION

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Over the past fifty years, geoscientists have struggled to understand how and when the Earth's surface became habitable to complex, intelligent life. One of the prevailing scenarios, comprehensively articulated by Cloud, Holland and others, proposes an initially anoxic or very low O_2 atmosphere. Although photosystem II appeared relatively early, there was an extended period of imbalance between sources and sinks of O_2 through pervasive feedback between biosphere, atmosphere, hydrosphere and lithosphere. Ultimately, O_2 accumulated in the atmosphere to near its present level at about 540 Ma. Life evolved concurrently. This talk examines new evidence for and against this idea based on the distributions and stable carbon isotopic values of molecular fossils that were extracted from well-preserved Upper Archaean sediments. Samples were recovered as drill core from the Mount McRae Formation in the Mt Bruce Supergroup, Pilbara Craton and the Transvaal Supergroup of the Kaapvaal Craton. The molecular fossils we identified comprise a diverse hydrocarbon assemblage including steroids that indicate that oxygen-dependent biosynthetic pathways were extant and carotenoid residues diagnostic for phototrophic sulfur bacteria. Both classes of compounds suggest that small amounts of O_2 were available in the marine environment well before the Great Oxidation Event.

S27B - HETEROCHRONIC EVOLUTION OF ISOROPHID EDRIOASTEROID AMBULACRA IN THE CONTEXT OF SURFACE-VOLUME CONSTRAINTS

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Isorophids bear discoidal thecae with long, thin feeding ambulacra that grow with positive allometry in response to surface area to volume problems. Common peramorphic ambulacral lengthening strategies cover the normally ambulacra-free interambulacral areas with ambulacra. Ambulacral peramorphosis was caused by both acceleration (rapid growth) characterized by overdeveloped ambulacra with a plesiomorphic thecal diameter, and hypermorphosis (extended growth) characterized by overdeveloped ambulacra with an enlarged thecal diameter. Within each of these mechanisms, isorophids use four different strategies to allometrically increase ambulacral surface area. Taxa including *Pyrgopostibulla* and *Torquerisediscus* develop distal ambulacral meandering late in ontogeny. *Streptaster* and *Giganticlavus* pinwheel the ambulacra around the oral surface. *Bostryclavus* and a new Moroccan taxon coil the ambulacral tips. *Thresherodoscus* branches the distal ambulacra repeatedly. No known isorophids elevate the ambulacral tips above the theca suggesting a phylogenetic constraint. Log regression of ambulacral area on thecal volume indicates a strongly constrained allometric pattern whereby ontogenies of all measured species fall on or near the same line (r^2 = 0.962, N = 55), with a slope (k) = 0.654 (+/- 0.018). This slope and associated 0.05 standard error (0.618-0.690) is within the expected bounds of an increasing surface area keeping pace with metabolic demands of increasing thecal size. Living and fossil invertebrates show comparable size scaling allometric values for metabolism, respiration, and feeding surfaces (k ~ 0.5-0.9). This study shows that surface-volume constraints can be overcome in different ways, depending on the ease of the developmental solution in each ancestral pathway.

W1 - *TROOSTICRINUS*, CORONOIDS, AND THE ORIGIN OF BLASTOIDS IN LIGHT OF UNIVERSAL ELEMENTAL HOMOLOGY

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Universal Elemental Homology (UEH) is a new method of assigning high precision homology to skeletal elements across derived blastozoan echinoderms. Unlike other methods, UEH can often establish homology of individual skeletal elements across clades. It has long been recognized that blastoids have unusual morphology, especially in the oral region and the construction of the ambulacral system. In light of UEH, many of these peculiarities can be reinterpreted as apomorphic states of more general blastozoan morphologies. Deltoid plates that form the proximal portion of the theca are derived oral plates – proximal interradial elements that form the mouth frame and proximal food grooves. Side plates are modified floor plates that lie recumbently upon the theca. The oral cone and related morphologies are simply primary peristomial cover plates with or without associated cover plates of the proximal portion of the main food groove. Many blastoid morphologies including details of thecal plating and symmetry have been convincingly argued as synapomorphies uniting blastoids with coronoids. However, a reanalysis of the early blastoid *Troosticrinus* reveals two morphologies generally thought to be unique to coronoids. This early blastoid lacks deltoid bodies that typically form the proximal exterior plating of the theca, and bears coronal canals in addition to hydrospires for respiration. The presence of hydrospires, an elongate lancet plate, and recumbent floor plates in *Troosticrinus* are synapomorphies this blastoid shares with more derived true blastoids. This suggests extremely close phylogenetic relationships between blastoids and coronoids.

S23 - PLIOCENE ANGIOSPERM FOSSILS FROM TENGCHONG IN WEST YUNNAN, CHINA AND THEIR PALAEOCLIMATIC SIGNIFICANCE

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Yunnan is one of the best localities not only for diverse modern plants, but also for preservation of Cenozoic plant fossils. To date 36 species of angiosperm fossils which belong to 20 families and 28 genera have been identified from Pliocene strata of Tengchong in western Yunnan, China. The plant fossil assemblage shows that the Pliocene flora is mainly composed of evergreen broad-leaved trees and lived under a tropical or subtropical climatic condition. By comparing the stomatal ratios of the related living species to the fossil species, the values of palaeoatmospheric CO_2 concentration during the late Pliocene in Tengchong was in the range of 387.5-466.5 ppmv, and the mean value is 433.4 ppmv, which is evidently higher than that of current levels. The palaeoclimatic parameters were quantitatively reconstructed according to the Coexistence Approach (CA) of the nearest living relatives of 36 fossil species. The results show that the Pliocene palaeoclimate of Tengchong is characterized by a mean annual temperature (MAT) of 21.3-25.1 ºC, mean temperature of the warmest month (WMT) 21.3-25.1 ºC, mean temperature of the coldest month (CMT) 10.8-14.6 ºC, difference in temperature between the coldest and warmest months (DT) 11.3-16.3 ºC, and mean annual precipitation (MAP) 1225.7-1638.3 mm.

S27D - A SILURIAN SOFT-BODIED LOPHOPHORATE

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The holotype of the brachiopod *Bethia serraticulma* from the Herefordshire Lagerstätte (Wenlock, England) bears several epibionts. The most curious of these is apparently unmineralised, bilaterally symmetrical, and ~2mm long. It comprises a subconical body attached basally to the host and partially enclosed by a broad 'hood'. Towards the tip the body bears paired coiled tentacles, interpreted as a lophophore. Where the hood attaches laterally a series of transverse ridges and furrows occur. The affinities of this form likely lie with Brachiopoda; the hood is interpreted as the homologue of a dorsal valve/mantle-lobe, and the attachment as the homologue of either a pedicle or the ventral valve, which in some encrusting brachiopods (e.g. craniids, eoconulids) is attached directly to the substrate. The ridges/furrows conceivably represent dorsal mantle canals, but the regularity of their arrangement argues rather for constructional serial-repetition. Brachiopods are not serially-structured, but palaeontological and molecular evidence implies that they derive from forms that to some degree were. This suggests that the new form most likely belongs within the brachiopod stem-group (other positions remain possible); the absence of mineralisation is probably derived. It also demonstrates that unmineralised sessile lophophorates are or were ecologically viable; they may have been a significant element of the Palaeozoic lophophorate radiation.

S20 - RELATIONSHIP BETWEEN NORTHWARD MIGRATION OF MODERN WARM-WATER MOLLUSKS AND SURFACE WATER WARMING IN THE NORTHERN JAPAN SEA

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Compared to open oceans, marginal seas are sensitive to increases in sea surface temperature (SST). One such marginal sea, the Japan Sea, has unique marine conditions and supports a diversity of marine organisms. Changes in the SST of the Japan Sea appear to be related to the inflow of the Tsushima warm current, which transports warm-water taxa northward. The island of Hokkaido in northern Japan has a heterogeneous coastline and marginal seas that are rich in marine life. By conducting surveys of washed up shells on the Japan Sea-side of Hokkaido since 2001, the author examined the relationship between the northward migration of modern warm-water mollusks and surface water warming in the northern Japan Sea. Since 2005, a marked increase has been observed in the occurrence of the paper nautilus, *Argonauta argo*, and the violet shell, *Janthina prolongata*, in beached material during autumn. The occurrence of this phenomenon has been attributed to anomalous increases in SST and the influence of the northwest monsoon in autumn. Colonization of central Hokkaido by warm-water bivalves, such as *Fulvia mutica* and *Nitidotellina hokkaidoensis*, is considered to have occurred in response to relatively higher SSTs in winter, and the occurrence of the graceful cowrie, *Cypraea gracilis*, in southwestern Hokkaido due to high SSTs in summer. Warming of the sea surface in the Japan Sea is considered to be accelerating the northward migration of warm-water mollusks in cold regions.

S8 - UPPER ORDOVICIAN ACRITARCH ASSEMBLAGES FROM THE SOUTHERN HOLY CROSS MOUNTAINS (POLAND)

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The uppermost Ordovician in the southern Holy Cross Mountains in SE Poland (Zbrza and Szumsko Kolonia 2 well) consists of mudstones and sandstones of the Zalesie Formation dated by a *Hirnantia* brachiopod fauna and species of *Mucronaspis*. The acritarch assemblage, documented in these deposits, displays a predominance of *Veryhachium* (more than 70%) occurring together with *Domasia, Deunfia, Leiofusa, Polygonium, Cheleutochroa, Multiplicisphaeridium* and *Polygonium*. These forms are accompanied by *Acanthodiacrodium angustum*, *Timofevia phosphoritica*, *Vulcanisphaera africana*, *V. turbata* and species of *Frankea*, *Cymatiogalea*, *Actinotodissus*. In the Ordovician (and throughout the entire Early Palaeozoic) the southern Holy Cross Mountains (Małopolska Block) was positioned at the margin of Baltica. The occurrence of the Middle Ordovician peri-Gondwanian species (*Frankea*) in the Hirnantian assemblage of the Zalesie Formation appears to have resulted from redeposition of these exotic taxa from the Avalonian terrane that collided with Baltica during the Late Ordovician. The sedimentary record indicates that the Zalesie Formation was deposited in a high energy environment punctuated by reworking and redeposition episodes during the Hirnantian regressive event. The pre-Hirnantian palynological data from Zbrza include acritarch flora consisting of *Veryhachium* occurring in the upper Katian mudstones/claystones of the Wólka Formation together with *Baltisphaeridium* cf. *pseudocalicispinum* Górka, *Baltisphaeridium* cf. *calicispinae* Górka, *Peteinosphaeridium* cf. *trifurcatum, Ordovicidium* cf. *heteromorphicum* (Kjelstroem*).* The lower Katian mudstone/shale succession of the Stawy Formation in the Szumsko Kolonia 2 well, yielded an acritarch assemblage dominated by species of *Baltisphaeridium*, *Polygonium*, *Exculibranchium*, *Orthosphaeridium*, *Ordovicidium*, *Peteinosphaeridium, Multiplicisphaeridium* with subordinate *Veryhachium*.

W5 - X-RAY SYNCHROTRON IMAGING: A REVOLUTION IN PALAEONTOLOGY

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In Palaeontology, external morphological investigations are often insufficient. Both external and internal anatomical characters have to be taken into account in order to fully understand a fossil organism. Moreover, different scales of study have to be used, from the general morphological ones to the histological ones. Initiated at the ESRF in 2000, synchrotron based investigations enable very high quality three-dimensional non-destructive X-ray imaging of various fossils. These methods reveal fossil internal structures with incomparable accuracy and sensitivity. It therefore allows the study of fossils that cannot be investigated by conventional microtomography either due to a high degree of mineralization or low absorption contrast. In the past few years, the rising of phase contrast synchrotron imaging techniques created a kind of revolution in non-destructive investigations of fossil samples, by revealing structures invisible with absorption based techniques. These techniques appears so powerful that nowadays about 90 percent of the scans performed at the ESRF on fossils are using phase contrast based imaging techniques. Among many applications, let's cite: identification of insects trapped in opaque amber, dental developmental pattern of fossil hominids, imaging of microscopic fossils, research of embryos *in ovo*… Through the strong development and palaeontology at the ESRF, and the running projects to improve dramatically the possibilities for fossils investigations, that large European Facility appears nowadays probably the most powerful and sensitive tool for non-destructive imaging on fossils, but technical possibilities offered by synchrotrons are evolving rapidly … especially within the time scale of palaeontology.

S2 - BIOGEOGRAPHIC CHANGE IN INOCERAMID BIVALVES DURING THE MID-CRETACEOUS IN THE NORTHWEST PACIFIC

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Inoceramid bivalves were a common component of Late Cretaceous faunas throughout the ocean and had evolved a variety of life history strategies. Diversification of inoceramids began in the Albian (Early Cretaceous), and inoceramids flourished worldwide in the Late Cretaceous. Early Cretaceous inoceramid occurrences in the Northwest Pacific are very scarce compared with Late Cretaceous occurrences. Recently, however, we discovered the Early Albian inoceramid *Mytiloides ipuanus* from the Yezo Group, northern Japan. The beginning of inoceramid diversification in the Late Cretaceous is seen during the latest Early Cretaceous (Late Albian), which suggests that *M. ipuanus* is an important species for inferring the causes of the flourishing of the inoceramids in the Late Cretaceous.The Albian inoceramids from Japan had a widespread biogeographic distribution. Although *M. ipuanus* was once thought to be endemic only to New Zealand and Antarctica, where it ranges from the early to late Albian, our study demonstrates that it also lived in the North Pacific. *M. ipuanus* evidently was a common Albian inoceramid that was widely distributed in both the North and South Pacific. As mentioned above, the Albian inoceramids generally show widespread palaeobiogeographic distribution, including *M. ipuanus*. However, after an inoceramid faunal turnover across the Early/Late Cretaceous boundary (Albian/Cenomanian boundary), endemic inoceramid species thrived predominantly in the Cenomanian, suggesting that severe environmental changes across the Albian/Cenomanian boundary certainly took place in the Northwest Pacific region. Afterward, widespread inoceramid species were predominant immediately after Oceanic Anoxic Event 2 at the Cenomaninan/Turonian boundary, and then endemism prevailed again after the Early Turonian.

S12 - RECENTLY DISCOVERED CHEMOSYNTHETIC ASSEMBLAGES FROM A POCKMARK SYSTEM IN THE STRAIT OF SICILY AND THEIR BEARING ON COMPOSITION, EVOLUTION AND BIOGEOGRAPHY OF THE MEDITERRANEAN DEEP WATER COLD SEEPS

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Deep-water cold seepage in the deep Mediterranean Sea is a well-documented phenomenon marking the historical evolution of this basin from the early Cainozoic up to present times. A variety of microbial and metazoan chemosynthetic assemblages have been also described from such environments showing, among other, important modifications in their structure in response to major geologic and climatic events. Modern examples of deep-water cold seeps and related ecosystems are mainly concentrated in the Eastern Basin, with the exception of recently discovered site in the Western Mediterranean (Alboran Sea). Here we report a new site identified in December 2009 in the Strait of Sicily, Central Mediterranean. The site occurs in the Gela Basin and is characterized by a cluster of pockmarks in ca. 800-850 m of depth (cruise MEDCOR of RV *Urania:* EU Hermione programme). Bottom sampling (dredges, grabs, gravity cores) provided dead specimens of chemosynthetic molluscs and siboglinid polychaetes. Bivalves and sibloginids pertain to thiotrophic taxa recorded from analogous settings in the Eastern Mediterranean. In order of relative abundance, the dominant species are bivalves in the families Lucinidae (e.g., *Lucinoma kazani*, *Myrtea amorpha*), Vesicomyidae (*Isorropodon perplexum*), and Thyasiridae, plus siboglinid tubes belonging to *Lamellibrachia* sp. Small gastropods (*Xylodiscula* sp., *Taranis moerchi*) are known to be preferential inhabitants of such reducing habitats. Miliolid benthic foraminifers area are also consistently present in the muddy sediment from these Sicilian cold seeps. Remarkable is also the presence of living populations of callianassid decapods (*Calliax*). Biosomes and bioclasts shed by these organisms combine in forming very distinct carbonate sediments. Recovered authigenic carbonate crusts often embed shells and remains of chemosynthetic organisms. This finding documents that the deep-water cold seep fauna of the Mediterranean Sea is relatively diverse and distributed basin-wide. Most of its components are possibly endemic to this basin since not recorded in the adjacent Atlantic Ocean, by large inhabited by closer but different taxa. The recent deep-sea fauna linked to hydrocarbon and hydrogen sulphide seepage shows some affinity with Pliocene counterparts (such as the Stirone river site) but strongly differs from the ocean-type communities described from the Miocene of the Mediterranean Basin.

S5 – CURATION OF COMPLEX PALAEONTOLOGICAL OBJECTS: COBBLES ENCRUSTED BY MULTIPLE INDIVIDUALS AND SPECIES FROM THE JAPANESE PLEISTOCENE

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Fossils most often consist of discrete objects such as the complete skeleton of an individual (e.g. a gastropod shell) or part of a multicomponent skeleton (e.g. a vertebrate tooth). Cataloging and labelling these specimens is relatively straightforward. However, hard substrates (shells and clasts) with multiple encrustations and borings by marine organisms can present greater difficulties. A remarkable locality at Kuromatusunai in northern Japan exposes 6.5 metres of Pleistocene Setana Formation, dated at about 1 million years old. These marine gravels contain shells and well-rounded lithic clasts that are densely encrusted by bryozoans and other sclerobionts on all available surfaces. Up to 25 different bryozoan species can be found on a single cobble. Fully curating such cobbles presents a major challenge: with little or no free space for affixing labels, how can individual encrusters be indicated and catalogued? We present the results of our evaluation of various imaging techniques (microphotography, macrophotography, SEM, 3-D laser scanning etc), and ways of incorporating annotated images into the specimen database (KE EMu) employed by the Natural History Museum.

S18 - THE NON-MARINE EOCENE-OLIGOCENE CLIMATE TRANSITION OF THE NORTHERN GREAT PLAINS, USA: INSIGHTS FROM RARE EARTH ELEMENT SIGNATURES OF FOSSIL BONE

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The nonmarine White River Group of the northern Great Plains is a succession of fluvial, lacustrine, and eolian strata that records the transition from Eocene “hothouse” to Oligocene “Icehouse” conditions in North America. Previous interpretations of paleoclimatic change have been based on changes in sedimentology, paleosols, and vertebrate assemblages. Rare earth and trace element (REE/TE) signatures within fossil bones provide a new archive of paleoclimatic information that can be used to augment existing datasets. Modern bones are very low in total concentration of REE, but upon fossilization are enriched up to several orders of magnitude as these elements are incorporated into the apatite crystal structure of the bone. The resultant REE/TE signature is a function of the geochemical conditions at the time of fossilization and reflects differences in redox, pH, and the degree of sediment-water interaction within the meteoric zone. Analysis of fossil bone from the nonmarine Eocene-Oligocene Group of Nebraska, South Dakota, and Wyoming shows differences in both lateral and vertical trends in REE/TE signatures reflecting changes in paleoenvironmental settings and overall paleoclimatic change across the Eocene-Oligocene Transition (EOT). Lateral changes within time-equivalent strata are a function of facies variation and degree of associated paleosol development. Vertical changes in REE/TE signatures across the EOT are a function of changing paleoclimatic conditions and appear to be related to $\delta^{13}C$ values of fossil bone carbonate. Vertical changes in REE/TE signatures are also periodic and, although not exact, are close to Milankovitch frequencies.

W4 - GEOCHEMICAL FINGERPRINTING OF FOSSIL VERTEBRATES FROM THE PALEOGENE WHITE RIVER GROUP OF NEBRASKA, SOUTH DAKOTA, AND WYOMING, USA: A TOOL TO PROTECT FOSSIL RESOURCES ON FEDERAL LANDS

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Over the past decade, Temple University has partnered with several different federal agencies in an effort to apply geological and geochemical methods to the interpretation and protection of vertebrate fossil resources. In particular, we have worked to refine the application of rare earth element (REE) patterns in fossil bone as a means to link fossils to particular stratigraphic horizons, bone beds, and geographic regions. To date, we have analyzed nearly 300 individual fossil specimens dispersed over a 125 km region of the Paleogene White River Group in the northern Great Plains of the United States. REE are incorporated into bone during the fossilization process. The REE signature characteristics of an individual bone are determined by the geochemical conditions and degree of water-rock interaction during fossilization. Fossils from individual sites with simple taphonomic histories have very similar REE patterns; those from complex sites may have different patterns. Fossils are cleaned of sediment and diagenetic minerals, and 0.1 g of cortical bone is analyzed by inductively coupled plasma-mass spectrometry. Signatures are analyzed using various statistical and graphical techniques. Our results to date show that bones from different regions have distinct REE signatures, and that on a local level (less than one kilometer), bones can be differentiated based on depositional environments, stratigraphic position, and degree of ancient soil formation. Fossils from areas impacted by fossil poaching can be cataloged into a REE signature database, thus providing law enforcement officers with a tool to establish the provenance of suspected stolen fossils.

S19 - STRUCTURE AND EVOLUTIONARY IMPLICATIONS OF FINELY PRESERVED CHAETAE ASSOCIATED WITH *PELAGIELLA*, A STEM-GROUP GASTROPOD FROM THE KINZERS FORMATION (EARLY CAMBRIAN) AT LANCASTER, PENNSYLVANIA

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A small slab of shale from the Kinzers Formation bears about 30 impressions of tightly coiled, rapidly expanding shells, accompanied by clusters of what appear to be chaetae associated with their apertures. Similar shells without associated soft parts were described as *Pelagiella exigua* by Resser and Howell (1938). *Pelagiella* is a characteristic constituent of Early and early Middle Cambrian small shelly faunas. Steinkerns of two species bear impressions interpreted as muscle scars. In one case, these are offset, suggesting partial torsion (Runnegar, 1981; *Lethaia 14*); a muscle scar in the other species has been compared to that of the columella muscle of *Haliotis* (Landing *et al*., 2002; *JPaleont 76*). Long treated as a monoplacophoran, *Pelagiella* is now regarded as either a 'paragastropod' or an archaeogastropod. The structures reported here are fine, straight or gently curved, bristle-like, and must have been relatively stiff. Two clusters are associated with most shells in consistent orientations adjacent to the shell aperture, implying that they were paired. Their form and proportions are strikingly like those of parapodial chaetae of certain polychaetes. However, the shells are typically molluscan in their rapid logarithmic expansion. It is improbable that the body-plan of this animal was worm-like. Chaetae occur in chitons and juvenile octopods, but they are not more generally characteristic of molluscs. Molecular phylogenetic studies suggest close affinities among annelids, brachiopods and molluscs. These observations suggest that *Pelagiella* was a stem-group gastropod that retained chaetae as a primitive character of common lophotrochozoan ancestors of Mollusca, Annelida and Brachiopoda.

S5 - THE FOSSIL RESINS IN THE ENTOMOLOGY COLLECTION OF THE ILLINOIS NATURAL HISTORY SURVEY: OVERVIEW AND CURRENT WORK

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An historically significant and scientifically valuable collection of fossil resins has been recently re-discovered in the entomology collection of the Illinois Natural History Survey. Work has begun to conserve, prepare, and curate this unstudied resource. The vast majority of the collection was originally amassed by Dr Milton Sanderson, between the late 1950s and his retirement from the Survey. Since that time, the material has been relegated to unsorted, long-term storage and was all but forgotten. The collection comprises largely unsorted and totally unprocessed amber and copal from the Dominican Republic and Madagascar. From this effort, preliminary results indicate a significant number of inclusions in both resin types, comprising zoological and botanical remains. Ongoing work will focus on identification and preparation of inclusions, in tandem with databasing and digitization, utilizing a newly developed imaging-based rapid data acquisition protocol adapted for use with the Specify Collections Management Software. This effort is hopefully one of many initiatives intended to bridge the gap between paleontological and neontological collections-based research.

S27D - WATER BUGS (INSECTA: HETEROPTERA) FROM THE EARLY CRETACEOUS OF BRAZIL: ANCIENT ORIGINS OF THE MODERN FAUNA

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Preliminary results of a monographic revision of aquatic and semi-aquatic Heteroptera from the Early Cretaceous (Aptian) Crato Formation Lagerstätte of northeastern Brazil, reveal a diverse assemblage of stem- and crown-group families. At least 11 families of water bugs are present, representing numerous undescribed taxa. Morphological examination allows identification of novel combinations of both pleisiomorphic and derived character suites. Results to date shed critical light on character acquisition and transformation during the mid- to late- Mesozoic radiation of crown-group Nepomorpha and Gerromorpha. The application and further development of UHR-CT imaging techniques facilitates unprecedented acquisition of morphological data from these exceptionally preserved three-dimensional specimens. This allows direct comparison with modern representatives, providing unique insights into the early evolution of modern water bug clades. Furthermore, these remarkable fossils aid in reconstructing the historical biogeography of Gondwanan biotas. This study confirms that modern water bug families were already well established by the Early Cretaceous and formed an integral component of Mesozoic freshwater ecosystems.

S27C - DASYCLAD ALGA *CYMOPOLIA* FROM THE KALANA LAGERSTÄTTE (SILURIAN) AND ITS EVOLUTIONARY SIGNIFICANCE

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Much of our understanding of the diversity and anatomy of the earliest macroalgae comes from their well-preserved carcasses of calcium carbonate. However, these fossils represent only a small portion of the algal flora that was flourishing in the shelf areas of the past seas and oceans. The non-mineralized or weakly calcified algal species, that are rarely preserved and have been found only in a few lagerstätten, suggest, that the extent of their stratigraphic ranges and the richness of their geological history has been under-estimated. The Silurian (Aeronian) algal lagerstätte in Kalana, Estonia, has revealed a rich non-mineralized algal flora, comprising mainly species attributable to Rhodophyta and Chlorophyta. The latter is represented by the order Dasycladales – a group of unicellular, but huge, morphologically complex green algae, which are generally supposed to be easily fossilizable due to their extracellularly laid calcareous coat. Based on the radially symmetrical euspondyl thallus architecture, periodically occurring constrictions along the stalk that give the plant a segmented appearance, and tufts on branched laterals at the growing tips of the plants, a close relationship with the extant genus *Cymopolia* is suggested for one of the most abundantly occurring dasyclade species. The major difference of this Silurian species from extant *Cymopolia barbata* lies in the lack of a calcium carbonate skeleton. The fossil evidence from the Kalana lagerstätte suggests, that some of the dasyclad algae, e.g *Cymopolia*, may have maintained their basic morphology almost unaltered for over 400 million years, with the main innovation being the extracellularly laid calcium carbonate skeleton.

S26 - BLACK AND WHITE COLOUR IN SEDIMENTS: A JURASSIC SWITCH?

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The black colour of sediments has often been used as an indicator of oxygen conditions and/or high content of organic matter. Specific intervals of the Phanerozoic (Cambrian to Silurian, Late Devonian-Mississippian, Permian to Triassic, Early Jurassic and Cretaceous) are marked by black shales. Moreover, black sediments appear to be a common presence in the Palaeozoic/Triassic, especially in intra-carbonate platform/reef basins where a uniform dark colour characterizes entire sequences, commonly formed of alternating limestones and bituminous shales. Classical examples of the latter scenario are the Monte San Giorgio marine vertebrate sites from the Middle Triassic, the recently discovered coeval sites of southern China as well as the Late Triassic Zorzino Limestone of northern Italy, that have yielded a fauna of perfectly articulated fishes and marine reptiles, well-known worldwide. However, starting from the Late Jurassic through the Cretaceous and the Eocene, similar spectacular fossil preservation is reported from comparable intra-platform basins in white *Plattenkalk* limestones, e.g. Solnhofen-Eichstatt-Cerin (Late Jurassic, Germany-France), Polazzo and Nardò-Italy, Lebanon, Mexico (Cretaceous), Bolca (Eocene-Italy), etc. We hypothesize that the boundary marking the change between black/white intra-platform basinal sediments possibly coincides with a precise moment somewhere in the Jurassic, when the new palaeogeographic configuration due to the breakup of Pangea and the development of primary hard-shelled producers might have induced a significant change in the marine biological carbon pump and a consistent switch in organic matter preservation.

S27A - MORPHOMETRIC ANALYSES OF RECENT AND FOSSIL TOOTH PLATES OF THE GENUS *LEPIDOSIREN* (LEPIDOSIRENIDAE, DIPNOI)

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The dipnoan fossil record from South America is limited, and fossils related to the Genus *Lepidosiren* are scarce and found only in Bolivia (Upper Cretaceous), Peru (Paleocene), Argentina (Eocene), Brazil and Colombia (Miocene). The most interesting and controversial record is *Lepidosiren megalos* from the Solimões Formation (Acre Basin, Brazil), described from a partially complete skull and four isolated tooth plates, originally distinguished from the living species, *Lepidosiren paradoxa,* only by the larger size of its remains. Since the holotype of *Lepidosiren megalos* is lost, morphometric analyses based on the measurements of angles of ridges, length and width of 57 tooth plates of *L. paradoxa* and 19 tooth plates attributed to *L. megalos* were used to determine the validity of *L. megalos*. Cluster and PCA analyses including all measurements showed a complete separation of these nominal species, with the two major components corresponding to the height and the size of the tooth plates. However, a second set of analyses, using only the angular variables, showed no significant separation and strong overlapping of tooth plates of both species. Thus, *Lepidosiren megalos* can be distinguished from *L. paradoxa* only by the larger size of its fossil remains. Consequently, the previous suggestion that *Lepidosiren megalos* is not a valid nominal species is now confirmed by morphometric analyses; and *L. megalos* must be considered as junior synonym of *Lepidosiren paradoxa*. Additionally, an X-ray diffraction analysis showed that the mineralogical composition of both the fossil and recent tooth plates is hydroxylapatite ($Ca_5(PO_4)_3(OH)$).

S27A - PETALODONTIFORM (CHONDRICHTHYES: HOLOCEPHALI) TEETH FROM THE PASSA DOIS GROUP, PARANÁ BASIN, SOUTHEASTERN BRAZIL

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Richly fossilifierous lenticular bone-beds and shell-beds of the Middle Permian Corumbataí Formation (Passa Dois Group) vary widely in length and thickness. They are recurrent within the large Paraná basin and originated in an epeiric sea, the salinity and depth of which varied considerably through time. Petalodontiform teeth from the Corumbataí Formation in the State of São Paulo have been recovered together with dipnoan tooth plates, mainly from bone beds exposed in road cuttings at two localities in the municipalities of Rio Claro and Angatuba. The Brazilian tooth material varies from 8.41 to 12.99 mm in length, from 2.78 to 5.93 mm in height and 6.68 to 7.72 mm in width. We discuss their morphology and possible systematic affinities, as well as their significance as palaeoenvironmental proxies.

S27A - NEW DATA ABOUT PALEONISCIFORMES (LOWER ACTINOPTERYGIANS) FROM THE IRATI FORMATION, PARANÁ BASIN, BRAZIL

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The fossil record of the Irati Formation comprises plants, vertebrates (fish and reptiles), invertebrates (insects, crustaceans, foraminifera), palynomorphs (pollen grains and spores) and ichnofossils. The only tetrapod records to date are the mesosaurs (Progranosauria - genera *Mesosaurus*, *Stereosternum* and *Brazilosaurus*). Isolated teeth, scales and spines of xenacanth sharks and lower actinopterygians are also present. Some articulated scales and bones of 'Paleonisciformes' have been collected in the municipalities of Angatuba (State of São Paulo), Três Barras (State of Santa Catarina) and São Mateus do Sul (State of Paraná), but to date no complete fishes have been described. During the 1960s and 1970s a few complete paleonisciformes were found at Petrobras mines during the exploitation of bituminous black shales in São Mateus do Sul Municipality, but these specimens, for which only photographs are available, were never described and are presumed lost. We report new findings of cranial bones and articulated scales in the upper part of the Irati Formation above the bentonitic ash fall layers that occur intercalated with the Irati sedimentary rocks in São Mateus do Sul. Additionally, disarticulated remains of adult and juvenile mesosaurs were found within a 300 mm thick layer, representing the thickest sequence affected by volcanic ash falls. Ash falls may have played a role in the mortality of the fishes and the disarticulation of the skeletons and are associated with storm events in the sea, represented by common storm deposits within the Irati Formation.

W10 - POLYCHAETE JAWS IN SILURIAN OF THE PRAGUE BASIN (CZECH REPUBLIC)

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Polychaete worms represented by jaws - called scolecodonts - are relatively common fossils in the Upper Silurian of the Prague Basin (Barrandian area, Czech Republic). The previous reports on the occurrences of these fossils described only specimens found on the bedding surfaces of shale. The present research is focused on isolated specimens recovered from residua (from limestone, tuffaceous limestone and shale). The following genera has been determined: *Kalloprion* Kielan-Jaworowska, 1962, *Kettnerites* Žebera, 1935, *Lunoprionella* Eisenack, 1975, *Mochtyella* Kielan-Jaworowska, 1961, *Oenonites* Hinde, 1879, *Pistoprion* Kielan-Jaworowska, 1966, *Protarabellites* Stauffer, 1933, *Rakvereprion* Mierzejewski, 1978, *Symmetroprion* Kielan-Jaworowska, 1966, *Tretoprion* Hints, 1999 and *Vistulella* Kielan-Jaworowska, 1961. These new results have confirmed the presence of genera common to other regions which brings the possibility of comparison of Perunica (peri-Gondwana) with Baltica.

S13 - BIOTIC RADIATION FOLLOWING THE EARLY TRIASSIC RECOVERY IN SOUTH CHINA

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The Triassic recovery and radiation from the end-Permian mass extinction is believed to be considerably delayed. A question is how to understand the recovery and radiation. Although the diverse benthic faunas in fossil records were considered to be indicators of the recovery (radiation) in the Griesbachian (Oman) or Anisian (Qingyan), we propose the composition and integrity of the trophic structure in ecosystem as the definition of the biotic recovery and radiation. A normally and fully functioning ecosystem is biologically composed of various trophic organisms such as producers, consumers and decomposers. An ecosystem dominated by some lower trophic forms, like the microbial and/or disaster groups in the aftermath of the mass extinction, is incomplete but characteristic of ecological crisis. Some organisms crucial to the recovery might not be preserved as fossils but the existence of the consumers at high trophic levels can be taken as a proxy of the development of the ecosystem. The Ichthyosauria was a unique reptile group that returned to marine ecosystems from land during the Permian-Triassic transition and which occupied the highest part of the trophic system in the Mesozoic ocean. Consequently, the occurrence of ichthyosaurs is suggested as an indication of the ending of recovery and the onset of radiation following the Late Permian mass extinction. Thus the first radiation happened in the Spathian according to the occurrence of ichthyosaurs. The data of ichthyosaurs from South China also indicate that the early radiation occurred in a slightly restricted deep carbonate facies where ammonoids and bivalves also were common.

S20 - SEEING THROUGH THE DIAGENESIS OF SCHIZOCHROAL TRILOBITE EYES

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The schizochroal eyes of phacopine trilobites are unique in the animal kingdom and have attracted attention for over 120 years. Recent work has shown that the doublet lenses in these eyes were originally calcite in the upper region and high-magnesian calcite in the intralensar bowl forming the lower region. Examination of lenses in numerous taxa raises the question as to whether this doublet model is applicable across the Suborder Phacopina and whether it is primary or a diagenetic artefact. Variation in both chemistry and microstructure between lenses is present even within a single specimen, highlighting the irregular millimetre scale variability of diagenetic alteration. If the way in which these unique lenses functioned is to be elucidated, it is vital to see through the effects of diagenesis to determine their original chemistry and microstructure. EDS and EPMA have provided information on the chemical composition of lenses while EBSD and TEM have been used to reveal details of internal microstructure. Comparisons of the resultant chemical and microstructural patterns in twenty species from different stratigraphical units in seven countries, coupled with the study of epitaxial cements has enabled diagenetic pathways to be determined. These pathways, which are controlled by the concentration and location of magnesium, provide insights into the original lens composition, while magnesium migration, determined by microdolomite crystal size, gives an indication of original lens structure. Using this information, lens function has been optically modelled using Code V software, revealing the likely focusing and light gathering capabilities of the lenses *in vivo*.

S20 - SOFT TISSUE PRESERVATION IN DEVONIAN VERTEBRATE FOSSILS FROM WESTERN AUSTRALIA

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Soft anatomy comprises about 95% of the body of an average vertebrate. However, the fossil record is overwhelmingly dominated by mineralised skeletal tissue. Fossils of jawed vertebrates from the Gogo Formation, Western Australia, are among the oldest (380 My) to preserve 3D soft tissue structures. The Devonian reef complexes are exposed for over 350km and preservation differs between the principal sites where soft tissues have been recovered. Initially only small pieces of phosphatised body wall musculature were recovered, most likely preserved through bacterially mediated phosphatisation. Synchrotron scanning has demonstrated not only the structure of the muscle blocks but also revealed the presence of some abdominal organs. The liver is consistently replaced by baryte whether preserved in a placoderm or osteichthyan (palaeoniscoid). It is here suggested that original preservation was by bacterial action on decaying sulphur-containing organic matter under reducing conditions and that this has been secondarily oxidised to baryte. δ34S values of sulphide minerals are consistent with sulphate reduction in a closed system. Other evidence for reducing conditions within the nodules is the occurrence of framboids. Mineral replacement of organs by baryte is most common from the Longs Well area whereas replacement of soft tissue by microcrystalline apatite is more common in Paddys Valley. In addition, structural analysis by pyrolysis gas chromatography mass spectrometry of the ancient fish scales has revealed a series of aliphatic components (alkenes and alkanes) and a series of low molecular weight aromatic hydrocarbons ranging up to C16 (including phenol) representing the biopolymers of the scales.

W9 - NEW INFORMATION ON THE ENDOCRANIUM AND VISCERAL SKELETON IN AUSTRALIAN PTYCTODONTS

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The ptyctodonts described from the Gogo Formation (Frasnian, Late Devonian) are represented by three genera, including *Materpiscis*, the first genus in which an embryo has been described, *Austroptyctodus* in which three embryos have been described and *Campbellodus*, the only known genus with extensive body scales. The superb three dimensionally preserved bone and soft tissue in the Western Australian specimens has provided the most detailed knowledge of the ptyctodonts to date. This exceptional morphological detail enabled the reinterpretation of the ptyctodont skull roof bone pattern and the resulting phylogenetic analysis supports a threefold division of the ptyctodonts, with *Rhamphodopsis* being the most basal taxon. New complete and articulated, three dimensionally preserved, ptyctodont fish from the genera *Austroptyctodus*, *Campbellodus* and *Materpiscis* reveal new anatomical features. *Materpiscis attenboroughi* is the only known specimen with the articulated jaw, including the autopalatine, palatoquadrate and articular preserved *in situ.* A newly prepared specimen of *Austropytctodus* has some of the posterior viscerocranial elements, including the branchial arches and perichondral ossifications interpreted as labial elements. Both new specimens of *Austroptyctodus* and *Campbellodus* preserve the complete perichondral ossifications of the braincase confirming that, the endocranium in ptyctodonts comprises four separate paired ossifications: paired nasal ossifications and medially fused ethmoid, orbital and occipital elements. The arrangement of the ptyctodont endocranium may shed light on whether the presence of neurocranial fissures represents the derived or pleisiomorphic condition for jawed vertebrates.

S9 - THE ECOLOGY OF UPPER KELLWASSER PRODUCTIVITY

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The terminal Frasnian Upper Kellwasser (UKW) interval of globally correlated high marine productivity is associated with a precipitous decline in marine faunal diversity. This study examines the ecological dynamics of the UKW interval as manifested in the fossil and geochemical records in an effort to understand how changes in the Earth system may have precipitated a major biotic crisis. Two groups of organisms were key determinants of the ecological stoichiometry of UKW productivity: sulfate-reducing bacteria (SRB) and prasinophyte green algae. Anaerobic SRB influenced euxinic conditions that extended from the sediment water interface into the photic zone and facilitated recycling of both N and P, fueling primary production. Prasinophytes are abundant in Late Devonian black shales. Modern prasinophytes are characterized by a C:P higher than more recently evolved algae, suggesting that in a Late Devonian marine system, dominated by prasinophytes, organic carbon fixation was purchased with a smaller P investment than would be required by the dominant algal forms today. Consequently, even a relatively small increase in the flux of fixed N might have been sufficient to initiate and sustain UKW productivity. Nitrogen isotope abundances from the UKW do not offer evidence of an increased rate of autochthonous N fixation. Elemental and isotope compositions along an UKW transect of the Appalachian Basin, however, suggest that terrestrially-derived N contributed to marine productivity. The export of fixed N from expanding forest ecosystems may have played a direct role in the Frasnian/Famennian extinction.

S22 - TINKERING WITH ROOT DEVELOPMENT AND TOOTH DIVERSITY

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How can tinkering with regulatory processes during developmental biology contribute to diversity in tooth morphology? Normally the focus in this sort of study is entirely with the modification of the cusp pattern, but in this study the focus lies on other aspects of tooth morphology; mainly the modification of root development. And interestingly, for some tooth types it seems that the regulation of root development is essential for maintenance of the cusp pattern. All rodents have continuously growing incisors and the developmental aspects of this regenerating system have been reasonably well studied. Some rodent species such as the guinea pig and the sibling vole also have continuously growing molars. The transition from low-crowned molars to high-crowned and open-rooted cheek teeth is reasonably common in the fossil record. From one developmental perspective these open-rooted molars are vastly more interesting than the incisors: they have a complex cusp pattern. This pattern needs to be maintained over time because it is worn down constantly. Basic immunohistochemistry and radioactive in situ hybridization techniques were used to analyze the patterns of proliferation and the distribution of regulatory molecules, and we added an extra level of information by generating 3D reconstructions of whole teeth showing the entire pattern. For this analysis tissues were used of the mouse, guinea pig and sibling vole. The most apical part of the tooth, where normally root formation occurs, remains proliferation free in continuously growing molars. This is unlike the situation in non-regenerating molar of the mouse, which does grow roots. Here the most apical zone is originally also proliferation free, but the proliferation zone shifts towards the apical mesenchyme at the moment when root formation is initiated. In the continuously growing molars the mesenchymal proliferation never shifts, keeping the roots dormant. We also show that different zones are associated with different regulatory molecules. Both processes, the maintenance of the complex cusp pattern and the postponement of root formation, are regulatory connected, by means of the spatial regulation of the proliferation in the mesenchymal component of the tooth.

S27B - POLYMORPHISM IN COLOUR PATTERN IN THE SILURIAN NAUTILOID *PHRAGMOCERAS* BRODERIP, 1839

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The highly developed colour pattern polymorphism documented in the Silurian nautiloid *Phragmoceras* has not been traced in any other nautiloid genus. Two specimens of *P. imbricatum* Barrande, one from the lower Ludlow of Bohemia and the other from the upper Wenlock of Wales, show quite different types of coloration. The first displays narrow, densely spaced longitudinal bands subparallel to the axis of the shell, combined with narrower transversal bands. The second specimen shows transverse bands, dorsally and ventrally subparallel to growth lamellae; laterally they run obliquely to the growth lamellae. Two other types of colouration have been discovered in several specimens of *Phragmoceras* from the lower Wenlock and upper Ludlow of Gotland. The colour pattern in *P. eurystoma flexibile* Hedström is characterized by brownish zigzags around the whole circumference of the shell. In contrast, brick-red colour bands in *P. dubium* Hedström follow growth lines along the whole circumference of the shell. Densely spaced colour banding is also present near the strongly contracted aperture of adult specimens. These great differences in coloration, occurring in palaeopopulations of *Phragmoceras* species probably isolated in time and space, reflect a genetic basis for colour polymorphism. If pigmentation pattern served as a form of crypsis, e.g. as an effective strategy to avoid predation, then quite different types of coloration in *Phragmoceras* may indicate different solutions to this problem. Colour pattern has been regarded as useful tool for taxonomic purpose in ectocochleate cephalopods, but the documented polymorphism in *Phragmoceras* has limited significance for taxonomy.

S3 - PLANKTONIC FORAMINIFERA FAUNA AND BIOSTRATIGRAPHY OF THE ÇEŞMELER MEMBER, MAÇKA-TRABZON, NE TURKEY

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Upper Cretaceous planktonic foraminifera faunas were obtained from the Çeşmeler Member, which crops out in the Maçka 29 km south of Trabzon, NE Turkey. The Çeşmeler Member with a thickness of about 210-320m consists of marl, sandy limestone, clayey limestone interbedded with pyroclastic rocks. The stratigraphic range of this sequence could not be precisely determined due to the lack of adequate fossils, although only thin sections were used as source for fossils because of hard textured rock. It is the first time planktonic foraminifera and radiolaria faunas are obtained in this study from acidic residue. Ten species of *Whiteinella*, *Helvetoglobotruncana*, *Marginotruncana*, *Dicarinella* and *Hedbergella* indicating Turonian-Coniasian age and extracted by HF acid were defined in the marl and clayey limestone samples of the Çeşmeler Member. Four biozones from these planktonic foraminifera species were determined as *Whiteinella archaeocretacea* (lower Turonian), *Helvetoglobotruncana helvetica* (middle Turonian), *Marginotruncana sigali* (upper Turonian) and *Dicarinella primitiva* (lower Koniasiyen) Zones. Furthermore, radiolaria fauna consisting *Paronaella* spp., *Halesium* sp., *Crucella cachensis* Pessagno 1971, *Crucella* sp., *Patelulla* sp. *Stichomitra* sp., *Stichomitra communis* Squinabol, 1903, *Nassellaria* indet., ?*Pseudodictyomitra* sp. cf. *P. pseudomacrocephala* Squinabol, 1903 and representing early Turonian is identified from the studied sequence.

S6 - THE OLDEST PALAEONTOLOGISTS: ON USING OUR ANCESTORS AS INVOLUNTARY SAMPLERS FOR PALAEONTOLOGICAL STUDIES

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Correlations between species diversity and several topographic/geomorphologic landscape features show that early humans exhibited opportunistic predator behaviour. Because of this, faunas in Palaeolithic archaeological sites closely reflect the ecological diversity of their surroundings. The location of those sites, however, was not chosen at random, and an assessment of the bias present in archaeofaunal data must be undertaken before using them for palaeontological studies. Spatial (assisted by GIS software) and statistical analyses confirm a strong preference for south-facing caves or shelters in gentle slopes at moderate to low altitudes; life-history traits or ecological evolution of a species could then be studied from archaeological data, but past species distributions or effects of climate change studies would be strongly biased, especially on mountain or cold climate species. This methodology can be used to study assemblages accumulated by other predators (e.g., hyena dens) to increase the number and volume of palaeontological samples, thus increasing as well the representativeness of the studies conducted with them.

S13 - HIGH SEDIMENTATION RATES IN EARLY TRIASSIC SHELF SETTINGS: A CONTROL ON POST-PERMIAN BIOTIC RECOVERY?

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Analysis of marine Permian-Triassic sections demonstrates that continental margin and platform settings worldwide exhibit higher bulk accumulation rates and more clay-rich compositions in the Early Triassic relative to the latest Permian. These changes, which cannot be explained by regional variations in tectonic setting and sequence stratigraphic factors, probably resulted from a substantial increase in the flux of eroded material from adjacent land areas owing to accelerated rates of chemical and physical weathering as a function of higher surface temperatures, increased precipitation, and changes in landscape stability tied to the destruction of terrestrial ecosystems. Modern studies have shown that increased sedimentation rates have serious biological consequences for most aquatic organisms, both freshwater and marine. Responses include reductions in feeding activity, growth rate, development, body size, resistance to disease, reproduction and survival. Modern benthic marine ecosystems living under conditions of high sedimentation rate are typically composed of low diversity, high dominance, high abundance, small-sized assemblages. Such 'abnormal' communities are typical of the majority of Griesbachian-Smithian shallow shelf ecosystems studied to date, and hence we postulate that enhanced sediment influx prevented the recovery of shelf communities through much of the Early Triassic. This additional environmental control on Early Triassic recovery may explain why low palaeolatitude shelf ecosystems did not fully recover until the Anisian despite the fact that low oxygen conditions did not affect marine shelves beyond the Griesbachian. Sites that record relatively rapid post-extinction recovery (e.g. Wadi Wasit, Oman) were located in offshore settings with no evidence of enhanced sedimentation rates.

S27A - LATE PLEISTOCENE CONTINENTAL MAMMAL ASSEMBLAGES OF NORTHERN URUGUAY (SOUTH AMERICA)

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Mammalian diversity, paleoenvironments and paleoclimatic conditions can be analyzed from the study of rich fossiliferous continental Late Pleistocene beds (the Sopas Formation), that crop out in northern Uruguay (mid-latitudes of South America). Until now, 45 mammal genera have been found including the typical extinct terrestrial herbivorous South American megamammals (glyptodonts, ground sloths, toxodonts, litopterns, horses and large llamas) and extant herbivorous (tapirs, peccaries, deer, some guinea pigs), mainly associated with open/semi-open environments (riparian forest and open woodland to savanna and grassland). Fresh-water mammals, inhabitants of fluvial and lacustrine environments, have also been recovered (river otters, tapirs, rat-marsh, coypus, capybaras). Five genera of deer (six species) are present including species with simple to dichotomously branching antlers. Predators are well represented by extant and extinct felids (jaguar, mountain lion, an ocelote-like and the saber-tooth cat) and also by large extinct canids. Biotic interactions are corroborated in carnivore coprolites containing bones and teeth of small mammals. The mammalian assemblages includes some "brazilian" taxa (tapirs, porcupines, capybaras, ocelote, peccaries) living today in tropical/temperate areas of South America and suggests a mild climatic conditions likely related to the last Interglacial or Interstadial. Seasonality is discussed taking into account birds and ichnofossils.

S6 - A HYPERSHERICAL THEORETICAL MORPHOSPACE FOR MOLLUSCAN SHELL FORMS

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A theoretical morphological model defines a set of hypothetical organic forms, or a theoretical morphospace, in which a particular shape is plotted with orthogonal axes chosen to represent morphological traits. In particular, a variety of helicospiral models have been widely applied to morphology of molluscan shells. However, a parameter representing dilation and/or rotation of the aperture in a helicospiral model is often inconvenient to document the range of actual shell form: in some cases, a slight change in shape requires a great change in the parameter or a slight change in the parameter causes a considerable change in shape. Such a property of a helicospiral model inevitably makes the Euclidian distance in the morphospace unreliable as a disparity metric if a set of hypothetical forms are mapped in the Cartesian coordinate system. A 3D hyperspherical theoretical morphospace for the Raup's model is introduced to overcome this problem. In this morphospace, a particular shape is represented by a single point on the closed hypersphere. If one of the three parameters is fixed to a constant value, the cross section of the hyperspherical morphospace is depicted as a two-dimensional sphere on which each shape is represented by spherical coordinates, i.e., the angles of latitude and longitude. The distance between shapes in the hypersphere is represented by the angle between positional vectors of the shapes. The neighborhood of a particular point in this morphospace can be approximately regarded as the Euclidean space since a hypersphere is a kind of manifold.

S22 - CHONDRICHTHYAN PALAEOECOLOGY IN A WHALE CARCASS RICH ENVIRONMENT IN THE LATE EOCENE OF EGYPT

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Eocene rocks of the Wadi al-Hitan World Heritage Site, Egypt, are famous for their fossil vertebrates. Rapid lateral facies changes from shallow marine sands of the Birket Qarun Formation to open shelf mudstones of the Gehannam Formation allow fossils to be recovered from different palaeoenvironments within the same stratigraphical interval. Chondrichthyan remains are widespread but largely restricted to dental material which is extremely diverse and shows many trophic adaptations. The dental morphology of the species present can be used to assess trophic structure. Chondrichthyans from the sandstones include extremely abundant teeth of the carcharhinid *Negaprion*, with very common dasyatid batoids and a small hemigaleiid; durophagous and planktivorous batoids, and pelagic lamniformes are rare. Assemblages from more offshore facies contain diverse small nectobenthic generalist carcharhinids, *Pristiophorus* and *Heterodontus*, with frequent specimens of plantivorous batoids and pelagic lamniformes. In each palaeoenvironment, assemblages of chondrichthyans directly associated with large whale skeletons differ from those from the open sea floor. There is some evidence of *Carcharocles* associated with the carcasses, but otherwise probable scavengers are restricted to small *Galeocerdo*. The main differences between the chondrichthyans associated with whales from those in nearby sediments is the greater abundance of taxa otherwise associated with deeper water facies, and of taxa that are likely to have been associated with reefal environments. It is therefore probable that whale skeletons acted as reefs on the seafloor long after death, creating a mosaic of seafloor environments and trophic niches, and contributing to the high chondrichthyan diversity seen.

S1 - GEOLOGICAL AND ANTHROPIC CONTROLS ON THE SAMPLING OF THE TERRESTRIAL FOSSIL RECORD: A CASE STUDY FROM THE DINOSAURIA

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Recent studies agree on the generalities of dinosaurian diversity, though few have applied a comprehensive approach to the issue of uneven sampling. We utilise rarefaction, several sampling proxies (rock outcrop area and numbers of formations, collections, and localities), and a specimen completeness metric, in order to evaluate the effects of different types of sampling bias on dinosaurian diversity. Rock outcrop area estimates are typically based on geographically restricted data, whereas diversity estimates are global. Consequently, correlations may be absent when rock outcrop area is compared to global diversity, but positive correlations can occur when the diversity data are restricted to the same region as the outcrop data. Number of formations performs well as a sampling proxy: although 'formations' are arbitrary units, they capture aspects of habitat diversity that affect species numbers. Previous observations that sea level correlates positively with dinosaurian diversity are only partially supported. Sea level is an important control on observed diversity in the terrestrial fossil record, at least during the Jurassic and Early Cretaceous. However, the quality of the terrestrial fossil record can improve at times of lower sea level, perhaps because enlarged land area increases actual diversity and the opportunities to preserve terrestrial fossils. Thus, individual analytical methods cannot capture all of the effects of uneven sampling, and can lead to a distorted picture of diversity patterns: this suggests that a multi-method approach is key to teasing apart the complex interactions between genuine evolutionary change and sampling biases.

S27B - LATE TRIASSIC RADIOLARIAN BIOSTRATIGRAPHY OF THE KOCALI COMPLEX, SE TURKEY

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The Kocali complex, including widespread radiolarian bearing sediments, is situated in SE Turkey along the Assyrian-Zagros Suture Zone. Recent studies have shown that the depositional age of this complex lasted from middle Carnian to Cenomanian. Late Triassic deposits of the Kocali complex are mainly represented by basic volcanic rocks with pelagic interbeds (pelagic limestone, cherty limestone, chert etc). Biostratigraphy of the radiolarians of these pelagic sediments has been clarified from six stratigraphic sections (Sorhin, Bulam-2, Banibari, Tarasa, Korun-1 and Korun-2) located to the north of Adiyaman city. The radiolarian fauna of the Sorhin section is of late Middle Carnian age, corresponding to the upper part of the '*Tetraporobrachia haeckeli*' Zone. Five samples were collected from the Bulam-2 stratigraphic section. The age of the sample from the lower part of the section is early Middle Carnian, corresponding to the lower part of the '*Tetraporobrachia haeckeli'* Zone. The uppermost part of the section is late Norian in age, corresponding to the '*Betraccium deweveri'* Zone. The radiolarian fauna of the Banibari stratigraphic section is middle Carnian to early Norian. Samples taken from the lowermost part of the section correspond to the '*Tetraporobrachia haeckeli'* Zone and the lower part of the '*Nakasekoellus inkensis'* Zone, while the central part of the section corresponds to the '*Capnodoce antiqua'* subzone of the '*Triassocampe nova'* Zone. The Tarasa section is dominated by basic volcanics and only two samples collected from pelagic sediments in the central part of the section yielded abundant radiolarian faunas. The age of the lower sample is late middle Carnian, corresponding to the upper part of the '*Tetraporobrachia haeckeli'* Zone, while the age of the fauna obtained from the upper sample is latest Carnian/earliest Norian to early Norian age, corresponding to the '*Capnodoce ruesti'* Zone. The age of the sample taken from the lowermost part of the Korun-1 section can be assigned as middle late Carnian to early Norian, corresponding to the '*Capnodoce-Trialatus*' Zone, while the age of samples taken from the upper part of the section is Rhaetian, corresponding to the "*Livarella densiporata"* Zone. The radiolarian fauna from the sample obtained from the lowermost part of the Korun-2 section indicates a late Early Norian to early Middle Norian age, corresponding to the upper part of the '*Capnodoce antiqua*' subzone of the '*Triassocampe nove*' Zone. Samples collected from higher parts of this section yielded characteristic taxa of Rhaetian age that correspond to the "*Livarella densiporata*" Zone.

S8 - PALAEOGEOGRAPHIC DISTRIBUTION OF ORDOVICIAN HYOLITHS

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Although hyoliths are known from virtually the entire globe, their palaeographic distribution was obviously not uniform. During the Ordovician they occurred mainly in African Gondwana and European peri-Gondwana. Hyoliths show a high endemicity in these regions and the areas contain, possibly, some genera not found elsewhere. This aspect is even more obvious at the species level because there are no common species or genera between Gondwana, peri-Gondwana, Baltica and Laurentia. In total 32 hyolith genera have been established for the Ordovician; 23 of them have been reported from European peri-Gondwanan terranes. The genera *Bactrotheca*, *Carinolithes* and *Quadrotheca* apparently appeared first in Baltica (Floian-Darriwilian stages) and afterwards in European peri-Gondwana (in the Darriwilian-Sandbian stages). This suggests an clear migration from Baltica to peri-Gondwana, also in more general terms because the peak of diversity in Baltica precedes such a diversity peak in the peri-Gondwanan terranes. The diversity of the hyoliths increased during the Ordovician with a peak during the Darriwilian (Llanvirnian; Oretanian) and their highest peak in the Sandbian-Katian (Caradoc) interval. This pattern is best documented in peri-Gondwana. However, the Laurentia and Baltica regions show a diversity maximum in the Darriwilian (Llanvirn; Oretan). Baltica and Laurentia are relatively poorer in terms of Ordovician hyolith diversity. Globally the highest hyolith diversity has been reported from Perunica.

S9 - CONODONT BIOFACIES AND PALAEOENVIRONMENT: A CASE STUDY FOR THE MIDDLE AND UPPER DEVONIAN OF THE SPANISH CENTRAL PYRENEES

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The stratigraphic arrangement and chronologic correspondence of the South Central Pyrenean Devonian rocks have largely been discussed and interpretations are numerous. As a result, different authors assigned the same stratigraphic units to a different regional subfacies and, consequently, interpretations of the basins evolution changed. Main discrepancies resulted from the controversial location of the Renanué Subfacies (RS) and the correspondence of the rocks cropping out in the Tor-Casamanya (Andorra). The RS has been interpreted in, at least, three different ways: 1) own unit (Subfacies), 2) part of the Sierra Negra Subfacies (SNS), 3) allocated in the Baliera Subfacies. The Andorran outcrops were not attributed to any unit and its affinities remained unknown until recently. Detailed conodont and microfacies studies of SNS and RS key sections encompassing Givetian and Lower Frasnian rocks have demonstrated that the conodont biofacies are quite different and that they probably don't belong to the same unit, as many authors have assumed previously. For instance, the Givetian genera *Schmidtognathus* and *"Ozarkodina"* and the Frasnian genus *Ancyrodella* are only found in SNS. Rocks of both areas of the same age are also different: black mudstones dominate in SNS, while grey to light dark wack-packstones are common in RS. The combination of biofacies and microfacies indicate a deeper environment for the SNS sediments. Comparable conodont biofacies and lithologic successions in Andorra and SN suggest that Andorra is a key area to unravel the Middle and Upper Devonian history of the SNS and, also, reinforces its separation from RS.

S9 - PYRENEAN CONODONTS AS A RELEVANT TOOL FOR EVALUATING THE PRAGIAN/EMSIAN (LOWER DEVONIAN) BOUNDARY CONCEPTS

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The decisions on the Pragian/Emsian boundary has led to dispute and confusion. The combination of nomenclatorial concepts from Rhenish and Hercynian Lower Devonian subdivisions produced a time scale in which the overlap between traditional (German) Emsian and original (Bohemian) Pragian strata was soon demonstrated. Subsequent discussions, aiming at the establishment of the Emsian GSSP, resulted in a final decision that even chopped off more Pragian. This current GSSP is located at the entry of *Polygnathus kitabicus* in the Zinzilban Gorge section, Uzbekistan. After many years of debate, SDS´s recent evaluation of the boundary (2008) resulted in the majority opinion of looking for a different level in Uzbekistan that is closer to the traditional (German) boundary; this new level can also be correlated with rocks from the Iberian Chains (Spain) close to the entry of *Pol. excavatus* 114. In the Spanish Central Pyrenees, there are three relevant sections that permit an evaluation of the two concepts. Isábena 1 contains first occurrences of both key taxa in stratigraphic sequence. Baliera 6 exhibits the upper part of the *kitabicus* Zone and lowest occurrence of *Pol. excavatus* 114. Villech I-A contains lowest occurrences of *Pol. kitabicus* and *Icriodus sigmoidalis*. The entries of the latter and of *Pol. excavatus* 114 coincide in the Iberian Chains (base of Mariposas Fm.) This set of three sections shows the stratigraphic distance (and time) between the two boundary concepts and helps to reinforce the need for a redefinition of the Emsian GSSP, supporting the 2008 SDS consensus.

S26 - COLOUR CHANGE AND GLOBAL EVENTS, A HOAX? A CASE STUDY FROM THE LOCHKOVIAN (LOWER DEVONIAN) IN THE SPANISH CENTRAL PYRENEES

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Too often precise correlation of events is based on physical methods and the perception of their uncontestable advantage over palaeontological methods is becoming a prevalent, but non-sound doctrine. Within these beliefs, fits the recognition of global bio-events as it is assumed that most of them are connected to facies change. Following this argument in reverse thinking, many authors consider that a sharp facies change that is widely recognized is likely to be “a priori” an optimal candidate for an isochronous (Global!) event without further, especially biotic, testing. Lochkovian rocks from the Spanish Central Pyrenees represent an exceptional laboratory to test these ideas as a sharp colour change from black to light colour sediments is widespread and as conodont record is one of the wealthiest worldwide. Detailed biostratigraphic study of four key sections that belong to the same facial unit, in the Spanish Central Pyrenees, shows that this geo event is neither isochronous nor linked to any biotic event. These data disputes the common belief that sharp lithologic changes in pelagic sequences can be expressions of global (or even local) (geo) events and vindicates the outstanding roll of basic and sound palaeontological studies in unravelling the History of the Earth.

S8 - AN EXCEPTIONALLY PRESERVED BIOTA FROM THE EARLY ORDOVICIAN OF MOROCCO

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Exceptionally preserved biotas are rare in Ordovician rocks: the few reported examples are taxonomically depauperate and from restricted marine environments. Consequently, our understanding of the Great Ordovician Biodiversification Event, one of the most dramatic episodes in the history of marine ecosystems, is based almost exclusively on the biomineralised fossil record. The discovery in south-eastern Morocco of the first Early Ordovician exceptionally preserved biotic complex from a normal, open marine setting fills an important gap in our knowledge. The highly diverse Moroccan assemblages range in age from latest Tremadocian to late Floian and document the earliest stages of the Ordovician radiation. Importantly, they include a number of taxa characteristic of Early to Middle Cambrian Burgess Shale-type faunas together with elements representative of more modern biotas. The mode of preservation of the fossils, entombment within and below event beds, followed by early diagenetic pyrite mineralisation, is similar to that of the Early Cambrian Chengjiang fauna of China. This discovery provides a faunal and taphonomic link between the iconic Burgess Shale communities and post-Cambrian Palaeozoic biotas. The new discoveries indicate that Burgess Shale-type taxa continued to have an important impact on the diversity and ecological structure of deeper marine communities after the Middle Cambrian. This warrants reassessment of the concept of a dramatic turnover between the Cambrian and Palaeozoic Evolutionary Faunas. In addition, the presence in the unmineralised biota of post-Cambrian taxa alongside Burgess Shale-type elements indicates that significant diversification occurred prior to the Tremadocian.

S18 - CARNIVORE TOOTH FRACTURE AND PLEISTOCENE PREDATOR-PREY DYNAMICS

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Broken teeth are a fact of life for many carnivores. Among living species, fracture frequencies are highest among species or populations that regularly consume bone. Heavier carcass utilization results in bone consumption and is associated with increased levels of food competition. Interestingly, multiple populations of New World Pleistocene carnivores, including lions, sabertooth cats, gray wolves, dire wolves, and coyotes display greater numbers of broken teeth and heavier wear than their modern counterparts. This suggests increased food competition in the Pleistocene and likely reflects greater abundances of large carnivores than are observed anywhere at present. Recent studies of extant large carnivores, such as gray wolves, indicate that uncontrolled populations of predators can limit prey populations well below carrying capacity. If so, then New World late Pleistocene large mammal predator–prey systems were likely characterized by highly competitive large carnivores with relatively heavy tooth wear, alongside well-fed ungulate prey with relatively light tooth wear. This contrasts markedly with most present-day systems where large predators are rare and ungulates are abundant, often to levels where they are food-limited. If the North American late Pleistocene was top-down regulated as suggested by the carnivore tooth wear data, then the arrival of a new top predator, humans, could have tipped the balance against the megafauna through a sequence of cascading trophic interactions in which native carnivores were compelled to switch to lower ranked prey as competition intensified. In this scenario, the carnivores would have been responsible for most of the killing of mega-herbivores.

S15 - CHITINOZOAN BIOTOPES, CLIMATE BELT CONTRACTION AND POLAR FRONT SHIFT TOWARDS THE HIRNANTIAN (440MA) GLACIATION

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Recently, it has been shown that Ordovician chitinozoans, like graptolites, were "mixed layer" marine zooplankton and that their global distribution was primarily controlled by variations in Sea Surface Temperature. Here, we present new data on the palaeobiogeographical distribution of chitinozoan biotopes during the end-Ordovician Hirnantian glaciation. These are compared to those from the pre-glacial Sandbian (460Ma). We demonstrate that severe cooling towards the Hirnantian glacial maximum resulted in (i) a steeper latitudinal temperature gradient and (ii) an equator-ward shift in the position of the Hirnantian austral Polar Front from 55-70°S to 40°S. This is deduced from an expansion and diversification of the Polar fauna. These changes are equivalent to those in Pleistocene glacial maxima. Our data show that Late Ordovician surface ocean temperature gradients, and fluctuations between glacial and interglacial states, may have been much more similar to modern oceans than hypothesized before. This information critically affects how we conceptualize Late Ordovician climate change and how we should define boundary conditions for numerical climate models. Significantly, our data suggest that a disruption of marine habitats and net reduction in ecospace in mid-latitude biotopes, in front of the advancing Polar Front and as a consequence of rapid climate change, resolves as a likely cause of the mass extinction in the zooplankton at the end of the Ordovician.

S15 - DRILLING THE EYES OUT OF TRILOBITES: FIRST RESULTS FROM STABLE ISOTOPE ANALYSES OF ORDOVICIAN *CAROLINITES*

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The Early-Mid Ordovician has long been considered a super-greenhouse world, partly based on depleted $\delta^{18}O_{carb}$ values from bulk carbonates and brachiopods (-10‰ to -5‰). More recent work on $\delta^{18}O$ of conodont apatite, suggests a cooling Ordovician climate and the establishment of 'modern' equatorial sea surface temperatures (SSTs) by the Mid Ordovician. The fidelity of the both these records still is debated. To interrogate the idea of an Early Ordovician greenhouse climate, we conducted pilot stable isotope analyses on the eyes of *Carolinites*. These trilobites have huge eyes that contain potentially one of the best sources of pristine Early Ordovician biogenic calcite. Importantly, they also had a tropical distribution and an epipelagic mode of life. If pristine, the $\delta^{18}O_{carb}$ from trilobite eyes might allow estimates of SST in a similar way to those from Cenozoic surface-dwelling planktonic foraminifera. Our initial results suggest superficial micro-recrystallisation of the eye-surface, relatively little difference between the isotope signature of bulk rock and fossil eyes, and light $\delta^{18}O$ values for *Carolinites* eye calcites (-8‰ to -7‰). These are equivalent with published ^{18}O-depleted values for Arenig brachiopods that have been considered to be primary. Mn and Fe concentrations in the eye calcites are consistently lower, by ~1000 ppm and ~2000 ppm respectively, than cements in the bulk rock while Mg and Sr values are much higher (by 1000's ppm): this is wholly consistent with the eye calcites being a non-ferroan, relatively pristine biogenic calcite and suggests that any surface recrystallization was early rather than later diagenetic.

S3 - PALEOTEMPERATURE AND SEASONALITY DURING THE EARLY EOCENE CLIMATIC OPTIMUM (EECO): EVIDENCE FROM STABLE O AND C ISOTOPE PROFILES OF FISH OTOLITHS FROM BELGIUM

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The early Paleogene greenhouse world comprises variable paleoclimate conditions providing an indispensable deep-time perspective for the possible effects of human-induced climate change. We investigate the long-term trend of rising global temperatures culminating during the Early Eocene Climatic Optimum (EECO), based on data from the mid-latitude marginal marine Belgian Basin. These data are derived from fish otolith $\delta^{18}O$ compositions of four non-migratory benthic species belonging to the families Congridae and Ophidiidae. The otoliths are derived from mid-shelf to coastal deposits of middle to late Ypresian age. Both bulk and incremental microsamples were analyzed by IRMS. A cross-plot of bulk otolith $\delta^{18}O$ vs. $\delta^{13}C$ results shows significant offsets between the taxa of both families. Ophidiid data probably represent true bottom water temperatures of the Belgian Basin. The mean annual temperature (MAT) of the EECO is calculated at 27.5°C, which is in line with other proxy results. However, variations in MAT up to 6°C suggest a more pronounced expression of climate variability in mid-latitude marginal basins than in tropical areas. Incremental analyses revealed a ~9.5°C mean annual range of temperatures, similar to modern seasonality in the same region. These results suggest that early Eocene mid-latitude marginal marine environments such as the Belgian Basin are well suited to infer paleoclimate variability at seasonal and long-term time scales.

S19 - DIRECT EVIDENCE FOR ANIMAL FEEDING RELATIONSHIPS IN THE CAMBRIAN MARINE ECOSYSTEM, EXEMPLIFIED BY PRIAPULID WORMS

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Fossil evidence for reconstruction of Cambrian food chains is obtainable in different ways including: 1) the functional morphology of fossil animals that may be used to infer feeding mechanisms (e.g. predatorial habits) and trophic types 2) the assessment of coprolite contents and feeding traces and 3) the analysis of preserved gut contents. Because they bring direct evidence for feeding relationships, gut contents are the most valuable source of information for reconstructing the food chain. This study focuses on priapulid worms, which played an important role in Cambrian ecosystems as infaunal predators and bioturbators of sediment. It is based on numerous specimens of *Ottoia prolifica* from the Middle Cambrian Burgess Shale that contain identifiable food remains in their gut. These are mainly hyolith exoskeletal fragments (cones, opercula and helens of *Halophrentis carinatus*), brachiopods (e.g. *Micromitra burgessensis*), small trilobites (agnostid and non-agnostid larval stages) and rare bradoriids (e.g. *Liangshanella burgessensis*). These gut contents provide direct evidence that *Ottoia* fed on a variety of small, epibenthic, mostly slow-moving prey. *Ottoia* most probably lived in subhorizontal burrows within the uppermost layer of bottom sediment and fed by probing the water-sediment interface either randomly or in response to chemical/tactile stimuli (e.g. circumoral region). Prey were grasped by the eversible toothed pharynx and drawn into the gut in a similar way to Recent priapulid worms. This represents one of the simplest types, and probably the most ancient type, of predation in animal phyla.

S20 - TAPHONOMY OF THE UPPER DEVONIAN VERTEBRATE BONE BEDS AT LANGSĒDE CLIFF, LATVIA

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The first detailed taphonomic study of the vertebrate assemblage from the upper Frasnian Ogre Formation, at the Langsēde Cliff, Imula River, western Latvia, was carried out in 2008. Abundant remains of *Bothriolepis, Holoptychius, Devononchus*, and more rare fossils of *Psammosteus*, *Platycephalichthys,* and lungfishes were found in a siliciclastic sequence. More than 650 vertebrate fossils examined are represented mainly by well preserved, but wholly disarticulated, placoderm and psammosteid plates, and sarcopterygian scales and teeth. However, complete distal pectoral fin segments and an articulated head shield from *Bothriolepis*, as well as a complete sarcopterygian lower jaw, have been found. The assemblage is dominated by the placoderm *Bothriolepis maxima*. The size distribution of the placoderm bones indicates the age of the fishes within the assemblage was approximately the same. Bones are distributed laterally in distinct linear zones, almost perpendicular to the dominant dip azimuth of the cross-beds and ripple-laminae, most probably corresponding to depressions between subaqueous dunes. The extent of convex-side-up orientation varies within the excavation area. The degree of fragmentation of the bones and disarticulation of the skeletons suggest rewashing and transportation of carcasses before final burial. Deposition most probably took place in a shallow sea environment under the influence of rapid water currents. A vertebrate conglomerate succeeded by cross-stratified sandstone with indicators of tidal influence, and then ripple-laminated sandstone, indicates gradual infilling of the tidal channel.

S27B - PERMIAN FORAMINIFERA AND CONODONTS (ARTINSKIAN-MURGABIAN) FROM THE RUTEH FORMATION IN THE HIV AREA, CENTRAL ALBORZ, NORTH IRAN

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Outcrops of Permian rocks are present northeast of Hiv in Central Alborz, North Iran. This sequence consists of the Dorud (Asselian-Sakmarian), Ruteh (Artinskian-Murgabian) and Nesen (Early Djulfian) formations. The Ruteh Formation (332.5 m) consists mainly of alternating grey, medium to thick–bedded, fossiliferous limestones with chert nodules and beds, and can be subdivided into six informal members. This formation unconformably overlies the Dorud Formation and is covered disconformably by the Nesen Formation. The conodonts and rich foraminifera indicate an Artinskian-Murgabian age for the Ruteh Formation. Three foraminiferal biozones have been distinguished in the Ruteh Formation of this region: the *Schubertella-Mesosubertella* (Artinskian), *Dunbarula-Neoschwagerina* (Early Murgabian) and *Neoendothyra-Globivalvulina* (Late Murgabian) assemblage zones. Two conodont biozones have also been distinguished in the Ruteh Formation of the region: the *Sweetognathus whitei* Zone (Artinskian) and *Ellisonia–Merillina* Assemblage Zone (Late Artinskian-Early Murgabian). The *Sweetognathus whitei* conodont zone is correlated the *Schubertella-Mesosubertella* foraminiferal zone and the *Ellisonia–Merillina* conodont zone is correlated with the *Schubertella-Mesosubertella* and *Dunbarula-Neoschwagerina* foraminiferal zones in the studied region.

S27B - LATE LADINIAN TO EARLY CARNIAN AMMONOIDS FROM THE ASHIN FORMATION IN THE NAKHLAK AREA, CENTRAL IRAN

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The turbiditic, siliciclastic Ashin Formation (Upper Ladinian to Carnian), up to 304 m thick, crops out widely in the Nakhlak area, Central Iran. The rocks consist mainly of turbiditic volcaniclastic sandstones and shales that were deposited in the distal parts of submarine fans on the continental slope and abyssal plain. Ammonoids collected from the Ashin Formation, together with radiolarians, bovalves and foraminifera, indicate a Late Ladinian to Early Carnian age. The ammonoids belong to four genera, with two identifiable to species level: *Proarcestes* sp., *Megaphyllites* sp., *Arpadites* cf. *szaboi* (Boeckh) and *Romanites simionescui* Kittl. *Romanites simionescui* has previously been reported from the Sina Formation of the Aghdarband area in northeastern Iran and from the Himalaya, Tibet and Timor in East Asia. The studied ammonoids belong to a single bio-province at the southern margin of Turan continent. The palaeobiogeographical relationships of Triassic ammonoids in the Nakhlak area (Alam and Ashin formations) with those of other areas show the existence of a province on the Southern margin of Eurasia from the easternmost to westernmost portion of the Paleothetys Ocean. This distribution shows a provincial distinction of the Eurasia continent (to the north) from Gondwana (to the south) and also the boundary between Eurasia and Gondwana in northern Iran.

S3 - CHANGING ATMOSPHERIC CO_2 AND THE EVOLUTION OF PALAEOZOIC PHYTOPLANKTON: CAUSES AND CONSEQUENCES

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Significant correlation exists between the curve of modelled atmCO_2 variation and global diversity trends of oceanic microphytoplankton at the scale of the entire Phanerozoic. Moreover, the three most significant drops in Phanerozoic atmospheric CO_2 coincide in time with the establishment of three main evolutionary punctuations in the plant kingdom: the origin of bryophytes, the rise of dominance of tracheophytic plants and the origin of lignophytes: each one of these phases has corresponded to a cumulative increase of the sequestration of standing carbon biomass in the terrestrial reservoir through Palaeozoic times. The decline of atmospheric CO_2 precedes a parallel declining trend of standing acritarch diversity during Palaeozoic times by 10 m.y.; we show that the gradual decline in acritarch diversity observed during late Silurian - late Devonian times is causally linked to the decline in dissolved CO_2 in the oceans. Palaeozoic phytoplankton were initially well adapted to conditions of high pCO_2(aq) and did not possess effective CCMs: as CO_2 dropped from 15 PAL in the Silurian, to 1 PAL at the end of Devonian, acritarchs suffered massive extinctions. In addition, Palaeozoic oceanic phytoplankton had to adapt to the rapidly increasing POM and DOM delivery to shallow shelf habitats, due to the rise of the land plants. These data establish a link between the effect of terrestrialization on pCO_2 and the near extinction of the acritarchs, which had profound impact on the collapse of the trophic web at the end of the Devonian.

S24 - CRYPTOSPORE ASSEMBLAGES FROM THE HIRNANTIAN OF ANTICOSTI ISLAND, QUÉBEC, CANADA, AND FROM VALGA-10 BOREHOLE, ESTONIA : PALAEOPHYTOGEOGRAPHIC AND PALAEOCLIMATIC IMPLICATIONS

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Rich palynological assemblages have been recovered from deposits of Hirnantian age in Anticosti Island (Québec, Canada), and from borehole Valga-10 in southern Estonia. The assemblages are rich and well preserved and include acritarchs, chitinozoans, and cryptospores. The age of the deposits is well constrained by means of palynomorphs (acritarchs and chitinozoans) as well as sequence stratigraphic and chemostratigraphic correlations. Cryptospores assemblages from the two localities are similar and are also broadly comparable to the few known coeval assemblages described elsewhere. They include 16 species and testify for the first time to the presence of an extended and diverse bryophytic cover during Hirnantian times in Laurentia and Baltica. The present findings contribute to a questioning of the current scenario of a Gondwanan origin of land plants and their successive spreading to lower palaeolatitudes. The recovery of diverse and abundant cryptospores in Hirnantian deposits may be related to increased input of land-derived sediment during the global sea-level fall linked to the Late Ordovician glaciation, but also demonstrate tolerance to a wide range of climatic condition of the early land plant flora.

S16 - THE EVOLUTIONARY SOURCES OF DINOSAUR BODY SIZE EVOLUTION

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Body size is associated with, among many other things, life history, population growth rate, metabolism, locomotion, population ecology, reproduction and even the rate at which genes evolve. We study the evolution of body size in dinosaurs using multiple large datasets and novel phylogenetic methods which can automatically detect shifts in the rate of evolution through evolutionary time and among subgroups. We find that, taken as whole, dinosaurs underwent a rapid and short-lived burst of diversification of size early in their evolutionary history; during this burst the rate of body size evolution increased 10-fold. Following this initial increase we find that the rate falls precipitously to a level comparable to that initially seen. The rate remains at this level until near the end of the group's history where there is another significant burst of size diversification. The pattern observed across the whole group masks considerable variation in rates within subgroups of the dinosaur phylogeny. The subgroups also show variation in rate through time with some recapitulating the burst pattern observed across all dinosaurs. The long-held view that the diversity in body is the product of homogeneous macroevolutionary processes may not be correct; rather our findings suggest that dinosaur body size evolution is better characterised by varying rates.

S27B - SHELL MICROSTRUCTURE OF THE EARLY CLAM *POJETAIA* AND THE INDEPENDENT ORIGIN OF NACRE WITHIN THE MOLLUSCA

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Pojetaia and *Fordilla* are the oldest bivalve molluscs, occurring in roughly co-eval rocks from the Tommotian, and are the only undisputed, well-known clams from the Cambrian. New specimens and unpublished photographs reveal that *Pojetaia* and *Fordilla* had a laminar inner shell microstructure of foliated aragonite, a newly discovered texture found in many modern monoplacophorans. A similar shell microstructure, a probable precursor to foliated aragonite, is seen in *Anabarella* and *Watsonella*, providing support for the hypothesis that these tall, laterally compressed molluscs are the ancestors of bivalves. Foliated aragonite shares many similarities with nacre, and it was probably the precursor to nacre in bivalves. No cases of undisputed nacre occur in the Cambrian, in spite of much shell microstructure data from molluscs of this time period. Thus, although nacre is considered by many to be homologous among molluscs, we conclude that it originated independently in the molluscs that have it: gastropods, bivalves, cephalopods, and monoplacophorans. This independent origin of nacre appears to have taken place during, or just prior to, the Great Ordovician Biodiversification Event and represents a significant step in the arms race between predators and molluscan prey.

S27A - A NEW TRIASSIC BRACHYOPOID AMPHIBIAN (TEMNOSPONDYLI: BRACHYOPOIDEA; BRACHYOPIDAE) FROM UPPER CENTRAL THAILAND

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A fossil brachyopoid amphibian has been obtained from a stream bed in Nongphai District Petchabun Province, upper Central Thailand. It comes from the Nam Pong Formation, Rhaetian, upper Triassic. The fossil skull is embedded in a sandstone concretion and comproses a nearly complete set of cranium, armed jaws with pedicellated teeth, hyomandibular bones, and some cervical vertebrae, totalling 27.0 cm in length and 31.5 cm in width. The fossil is closely similar to the genera *Batrachosuchus* and *Sinobrachyops* in terms of the unarmoured craniam, forward eye and large fanged teeth. The latter indicate a feroceous fish eater habit. This fossil amphibian is potentially a new genus and certainly a new species and is the first brachyopoid recorded from the Southeast Asia.

S14 - MULTIPLACOPHORANS, POLYPLACOPHORANS, STEM GROUPS AND CROWN GROUPS – A MOLECULAR PALEOBIOLOGICAL PERSPECTIVE ON EARLY CHITON EVOLUTION

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Extant chitons (Polyplacophora: Mollusca) have a conservative morphology with eight dorsal shell plates surrounded by a tough scleritated girdle. Their fossil record extends back to the Late Cambrian, but undoubted members of the crown group are not known prior to the late Palaeozoic. The recent discoveries that multiplacophorans (Silurian to Carboniferous) are seventeen plated relatives of chitons have interesting implications. We here present a new exceptionally preserved hercolepadid multiplacophoran from the Devonian (Early Givetian) Silica Fm. of Ohio. Multiplacophorans exhibit a range of characters unknown in crown group chitons (i.e. seventeen shell plates in seven transverse bands and large spines with aesthete canals) as well as some distinct features with parallels in some members of the crown group (e.g. sutural laminae). Multiplacophorans have been interpreted as crown group chitons (Neoloricates), but their unusual appearance is hard to reconcile with the conserved bodyplan of the crown group as well as their stratigraphic range. Distinct autapomorphies have previously been used incorrectly to argue that fossil forms represent stem taxa of larger groups. We therefore tested the alternative scenarios using a molecular clock. Molecular clock estimates indicate that crown group chitons diverged in the late Palaeozoic at a time consistent with the appearance of undoubted neoloricates in the fossil record. Thus, multiplacophorans appear to be stem group polyplacophorans and are either close relatives of the neoloricates or have evolved certain crown group characters convergently.

S3 - SOME JURASSIC AND CRETACEOUS WARM AND COOL GREENHOUSE REGIMES (BASED ON RADIOLARIANS AND AMMONITES

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The appearance of Tethyan species *Archaeodictyomitra amabilis*, *Gongylothorax favosus*, *Sethocapsa funatoensis*, *Tethis bernoullii* and *Zhamoidellum ventricosum* co-occurring together with typical boreal Parvicingula at 62ºN in the Bathonian-Callovian of Koryak Upland coincides with the presence of ammonite genera *Choffatia*, *Putealiceras* and *Lunuloceras* (Vishnevskaya & Filatova, 2009). The existence of the richest unique radiolarian assemblage with 70% of Tethyan species at 62º N in the Oxfordian-Kimmeridgian of Koryak Upland corresponds with invasion of Tethyan ammonites *Ochetoceras*, *Amoebites* and *Cardioceras* up to 55ºN (Sey & Kalacheva, 1983) and reflects hot “greenhouse”. The third warm-water ammonite invasion (*Aulacosphinctes*, *Beriasella*, *Subplanites*, *Primorites*, *Virgatosphinctes*) into boreal area (55ºN) during early-mid Volgian is synchronous to Tithonian assemblage with *Parvicingula haeckeli*, bearing *Tethysetta hexagonata*, *T. spinosa*, *Caneta blomei*, *Podobursa tricola*, *Zhamoidellum ovum*, *Stichomitra tairai* and other Tethyan species. Significant changes in many groups of marine organisms were characteristic for the Santonian-Campanian boundary (Vishnevskaya & Basov, 2007). Almost half of ammonoids became extinct (Yazykova, 2002). Some phylogenic lineages of the radiolarian were interrupted. The Santonian thermophilic assemblage changes by the early Campanian cryophilic one with acme multilayered spongy walls family Prunobrachidae well adopted to cold-water environments. The extinction of warm taxa of planktonic foraminifers (Vishnevskaya, Kopaevich, 2009) is also connected with Santonian-Campanian boundary, which Huber et al. (2002) recorded as marker between hot and cool greenhouse regimes.

S3 - RADIOLARIA AND SPONGE SPICULE EVOLUTION AS REFLECTION OF OCEAN CHANGE

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The comparison of some siliceous sponge spicules and radiolarian spines and spicules from different age intervals of Cambrian, Ordivician, Devonian, Triassic, Jurassic, Cretaceous and recent sediments has been carried out. The similarity, difference and connections among detail structures of sponge microspicules and radiolaria spines and their evolution have been considered and illustrated. Trends of morphological changes of radiolarian and sponge spicule elements during million of years show the decrease of its volume size, loss of siliceous type of inner spicules or decrease of its size in radiolaria. Microspicules (Sterrasters) of sponges of class Hexactinellida thrived during the Cambrian, diversified during the Jurassic and reached acme in Late Cretaceous, but sometimes were considered as radiolaria (Huang, 1967; Benson, 1983; Alexandrovich, 1992). The main peculiarity of sterraster is orientation of miriade of microspicules to centre of body similar to point-centered rays of the most ancient Cambrian radiolaria of family Echidninnidae (Won, Below, 1999), which Bengtson (1986) proposed to assign to the Porifera. Sponges, being benthos forms, conserved macro- and microspicules, but significantly developed and improved them from thick massive to thin graceful during geological time from Proterozoic up to Recent, while radiolaria lost heavy weight engineering in process of ocean expance during late Mesozoic-Cenozoic.

S14 - INTERRELATIONSHIPS OF MAJOR CLADES OF BRYOZOA: INTEGRATING MOLECULAR EVIDENCE WITH THE FOSSIL RECORD

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The three major bryozoan clades (Phylactolaemata, Stenolaemata, Gymnolaemata) are set apart by having distinct zooidal body-plans, reproductive strategies and rates of diversification. Molecular results will be presented for the interrelationships between these three clades, while providing time estimates for their origins. Our interpretations come from an extensive, date-calibrated molecular phylogeny of bryozoans, based on DNA sequences from two nuclear ribosomal genes (18S and 28S rDNA) and five mitochondrial genes (16S and 12S rDNA, cytochrome *b* and cytochrome oxidase subunits 1 and 3. Bryozoan monophyly is supported. Despite the earliest fossil evidence for the Bryozoa coming from the calcified marine class Stenolaemata (~480 Ma), our evidence from complete mitochondrial genomes places the uncalcified freshwater bryozoan class Phylactolaemata as the most basal taxon (Phylactolaemata (Stenolaemata (Ctenostomata, Cheilostomata))). Four (Cryptostomata, Cystoporata, Fenestrata, Trepostomata) of the five orders of class Stenolaemata, all of which appeared during the Early Ordovician, are thought to have gone extinct by the Late Triassic, with only the order Cyclostomata surviving through to the present-day. Controversy exists whether the Cyclostomata are a truly monophyletic group, or whether they include recent representatives of the other stenolaemate orders thought by most to be extinct. Calibration of our published cyclostome phylogeny helps to discriminate between these two possibilities.

S16 - SOME POSSIBLE DIRECTIONS FOR FUTURE TREE-BASED STUDIES OF RATES

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The many hypotheses predicting changes or differences in rates of morphologic evolution make their most explicit predictions given phylogenies. However, phylogenies are themselves unknowns that face the complementary problem: they make their most explicit predictions given rates. Thus, many methods devised to improve phylogenetic inference also are useful for testing whether rates differ over time, phylogeny, and/or different anatomical features. For example, modern likelihood and Bayesian tests of divergence times do not assume a single “clock,” but instead allow for shifting rates over phylogeny. This provides a framework for assessing whether rates change over time or shift markedly at different points on phylogeny. Application of this approach to Cambro-Ordovician rostroconchs corroborates the idea of a marked decrease in rates in one clade. This approach also can test whether 2+ partitions of anatomical data evolve at different rates. However, although copious biological theory predicts different rates among different partitions, a priori partitions might be inexact: e.g., not all mollusc shell characters evolve quickly even if most do. Moreover, we do not know enough about some extinct taxa to recognize partitions. Here, we can modify compatibility tests originally used to weight characters. Using inverse modeling, one can assess probabilities of observed character state distributions at different rates, and then test whether rate distributions fit 1-rate, 2-rate, etc. models. The partitions derived then provide tests and refinement of biological hypotheses: for example, although the fastest changing characters among snails are shell characters, not all shell characters fall in “high rate” partitions.

S1 - IMPACT OF OUTCROP AREA ON ESTIMATES OF PHANEROZOIC TERRESTRIAL BIODIVERSITY TRENDS

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Studies of biodiversity through time have primarily focused on the marine realm, which is generally considered to have a more robust record than terrestrial environments. Recently, several authors have challenged this assumption and argued that the record of life on land is comparable or even more robust than that of the shallow oceans, preserving an exponential rise in diversity, even when corrected for sampling biases such as changes in continental rock volume through time. We evaluate relations between terrestrial diversity and exposed areas of terrestrial sediments using compiled data on areas of continental outcrops and generic diversity from the Paleobiology Database; the latter consists of sampled occurrences of taxa, allowing actual sampled diversity to be utilized rather than metrics utilizing first and last appearances of taxa, and avoiding issues such as the ‘Pull of the Recent’. Terrestrial vertebrate generic diversity and outcrop area through time are highly correlated for both the globe and for North America, and the calculated relationships are similar to those seen for shallow marine settings. Residual diversity shows no directional trend through time, and does not support an hypothesis of long-term increase in terrestrial biodiversity through time. Furthermore, estimates of the original extents of terrestrial habitats are not correlative with either current outcrop area or diversity. This suggests that, at a global scale, the terrestrial record is far poorer than that of the shallow marine shelf, at least for estimating standing diversity.

S27C - CARBON ISOTOPIC COMPOSITION AND WATER-USE EFFICIENCY OF EARLY DEVONIAN TO EARLY CARBONIFEROUS LAND PLANTS

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Experiments with modern plants imply that there is a negative linear relationship between water-use efficiency (WUE) and carbon isotopic composition (usually in the form of $\delta^{13}C$ values) of plants, so WUE differences of ancient plants may be reconstructed through C-isotopic analysis of fossil plants. This study focuses on eight representative fossil plant genera from the Early Devonian to Early Carboniferous time period (410- 320 Ma): *Archaeopteris, Drepanophycus, Geselia, Leclercquia, Pertica, Psilophyton, Rhacophyton* and *Tetraxylopteris*, which were collected from multiple localities in the Appalachian Basin. These taxa show considerable variation in $\delta^{13}C$ values, ranging from -20‰ to -30‰. At some localities, several different genera occur in the same outcrop, which will allow evaluation of differences in WUE among fossil plant taxa. Since environmental parameters would be the same or quite similar, differences of carbon isotopic composition would be caused by genome characteristics of different plant lineages, and so would the values of WUE. Several taxa are long-ranging, which will allow assessment of secular changes in WUE within individual lineages of early land plants. It is also possible to compare the same plant taxon from different geographic sites during the same geologic time period, which could supply ecological information oregarding different habitats.

S23 - THE EVOLUTION OF THE PALAEONTINIDAE (INSECTA: CICADOMORPHA)

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The fossil record of the Palaeontinidae is reviewed and the wing venation is revised. The genus *Fletcheriana* is believed to represent a transition between the Dunstaniidae and the Palaeontinidae. This result is consistent with the previous view that the Dunstaniidae is ancestral to the Palaeontinidae. The fusion of veins RP and M1 in the palaeontinid hindwings implies a change of the mechanism of flight and an improvement in flight ability. The presence of a reduced costal area and the rigid basal leading edge of the palaeontinid forewings suggest gain of lift. Solnhofen Palaeontinidae and most Cretaceous Palaeontinidae form a monophyletic group. The phylogenetic relationships of the late Palaeontinidae are reconstructed, including (from stratigraphically oldest to youngest) the German Solnhofen palaeontinids, Spanish, British and Chinese taxa, and the Brazilian taxa. The Solnhofen Palaeontinidae are basal to Cretaceous Palaeontinidae by the mesonotum lacking distinct longitudinal carinae. A rapid succession from early to more derived Palaeontinidae took place during the Late Jurassic. Early Palaeontinidae declined sharply in the Late Jurassic, probably owing to the rise of newly evolved insectivorous animals like early birds and mammals. Late Palaeontinidae with better flight ability survived and became a dominant insect group during the latest Jurassic. In the late Early Cretaceous, the Palaeontinidae became extinct first in Euro-Asia and subsequently disappeared in South America.

S20 - COMPARATIVE TAPHONOMY OF PALAEONTINIDAE AND TETTIGARCTIDAE (INSECTA: HEMIPTERA) FROM THE MIDDLE JURASSIC OF DAOHUGOU, CHINA

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The Middle Jurassic Daohugou deposits of China is amongst the most important insect Lagerstätten. Although tens of thousands of fossil insects have been discovered from Daohugou during the last ten years, little is known about their taphonomy and preservational environment. Palaeontinidae and Tettigarctidae, common large arboreal cicadas during Mesozoic times, were examined from Daohugou in detail. Quantitative taphonomical analyses of 279 specimens of Palaeontinidae and 115 of Tettigarctidae revealed significant differences in both body orientation and preservation quality between the two groups. Most Palaeontinidae were preserved in dorsoventral position, with four wings spread like a flying butterfly, while most Tettigarctidae were in lateral position with four wings overlapped over the abdomen. Lots of palaeontinid specimens (40.1%) were isolated, almost complete forewings or hindwings. By contrast, most tettigarctid specimens (87%) were whole bodies with forewings and hindwings articulated. The difference indicates that Palaeontinidae experienced a much longer floating time due to their high wing surface/body mass ratio (high 'SM index'), increasing opportunities to decompose. Both groups showed significant differences (Kolmogorov-Smirnov test) between body-size and preservation quality: smaller specimens are better preserved. The well-preserved whole-bodied Palaeontinidae and Tettigarctidae suggest that the Daohugou Lagerstätte was a low-energy preservational environment. Furthermore, comparative taphonomical analyses of Palaeontinidae from Daohugou and other localities suggests that the Daohugou specimens were better preserved in respect of their detail and completeness.

S23 - A NEW FERN-LIKE PLANT WITH PINNULES FROM THE UPPER DEVONIAN OF SOUTH CHINA

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A fern-like fossil plant was recently discovered in the Upper Devonian (Famennian) Wutong Formation of Anhui Province and Jiangsu Province, South China. This plant has three orders of axes and laminate pinnules with dichotomous veins. First-order axes sometimes bear dense aerial roots. Second-order axes occur in loose helices on the first-order ones. Third-order axes are alternately or suboppositely attached to the second-order ones, resulting in a branching system in one plane. Laminate pinnules are borne alternately or suboppositely on third-order axes. Fertile ultimate appendages are arranged alternately or suboppositely on third-order axes. Each fertile appendage is three dimensionally dichotomous up to eight times and terminates in numerous sporangia in pairs. Sporangia are elongate and show long tips. This plant differs from the Cladoxylopsida *sensu lato* in the character of fertile ultimate appendages, absence of whorled laterals and presence of laminate pinnules. It differs from the Rhacophytales mainly in the presence of pinnules and lack of both quadriseriate branching and catadromic aphlebiae/aphlebia-like appendages. Possibly derived from the iridopteridaleans, this new plant demonstrates a high level of evolution among fern-like plants.

S10 - BACTERIALLY INDUCED CALCIUM CARBONATE PRECIPITATION AND ITS IMPLICATION FOR MICROBIALITE FORMATION

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Microbialite is widely distributed in the Precambrian and immediately after faunal mass extinctions in the Phanerozoic. Many fundamental questions remain unanswered related to microbialites, such as the role of microorganisms in the formation of microbialite and the sparsity of microbial fossils isolated from these rocks. Here we present some data to explore these issues by using cultivated bacteria from alkaline caves. Our data demonstrates that the bacterially-induced formation of calcium carbonate is ubiquitous in karst caves. As much as 73% of the cultivated bacteria from the cave dripping water can induce the precipitation of calcium carbonate. Detailed inducing mechanisms were investigated with strain 5C-1, a strain of the heterotrophic *Bacillus* sp. isolated from calcium carbonate sediments in the cave. The growth of 5C-1 was found to greatly enhance the pH value, and precipitates were formed with the pH values greater than 8.6. The accumulation of extracellular polysaccharide substance (EPS) was observed to favour the precipitation of carbonate minerals. Cells and extracellular enzymes are not the critical factors in limiting mineral precipitation in our microbial systems. Interestingly, imprints of bacterial cells and spores were observed to be present on the surface of the precipitates forming a peanut or a dumb bell shape, probably indicative of escape mechanism of the microbe during the mineralization of calcium carbonate which thus led to the sparsity of microbial fossils preserved in the microbialites.

S23 - EARLY PERMIAN VEGETATION PRESERVED IN VOLCANIC AIR-FALL TUFF FROM INNER MONGOLIA: FOREST RECONSTRUCTION, PALAEOECOLOGY, AND PALAEOBIOGEOGRAPHY

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Catastrophically preserved forests from the deep past offer a rather unbiased window into the composition and ecology of ancient vegetations that in turn can enhance larger scale palaeoecological and palaeoclimatic interpretations. The Permian Period is a critical interval for these studies because it encompasses transitions between icehouse and greenhouse conditions when the luxuriant tropical floras of the Carboniferous were changing slowly through the impact of these alternating climate changes. An earliest Permian volcanic air-fall tuff from Inner Mongolia, China, preserves an *in situ* forest that grew on an extensive peat deposit that exists today as a mineable coal seam. Here we report the first reconstruction of an actual site of a peat-forming swamp forest of Permian age which represents also the first such reconstruction for the late Palaeozoic of East Asia. The flora was dominated by Marattialean tree ferns, tree lycopsids, and Noeggerathiales, a generally rare group of extinct spore-bearing plants of uncertain systematic position. This composition is both similar and distinctly different from that recognized in floras of the same time interval in Europe or North America. Plant remains were quantitatively recorded in three plots of together more than 1000 m^2 and consequently reveal clearly the complexity of Late Palaeozoic vegetation and contributes significantly to a more complete understanding of the palaeoecology and palaeophytogeography of tropical vegetation of the early Permian. The plots show forest heterogeneity including the first site ever recorded that was dominated by Noeggerathiales.

S27B - CARBON AND SULPHUR STABLE ISOTOPES FROM THE DEEP-WATER DOUSHANTUO FORMATION SUGGEST A STRATIFIED EDIACARAN OCEAN IN SOUTH CHINA

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Recent geochemical studies of the Ediacaran Doushantuo Formation (635-551Ma) in South China have revealed a substantial variation of $\delta^{13}C$ among different facies, thus positing a question as to whether the $\delta^{13}C$ excursions in the Ediacaran can be used as a correlation tool for the stratal sections of different facies. Furthermore, $\delta^{34}S$ features are poorly known to date outside shallow-water sections. Here we report the results of a $\delta^{13}C$ and $\delta^{34}S$ study from the deep-water Doushantuo Formation at Wenggao, northeastern Guizhou, South China. The studied section is lithologically dominated by black shale of deep water origin, with some turbidite and olistolith carbonate beds. Isotope data show highly positive pyrite $\delta^{34}S$ values (~30‰) at the Nantuo/Doushantuo boundary and negative $\delta^{13}C$ values (-2‰ to -6‰) in the cap carbonate, which are identical to those of the shallow platform. $\delta^{13}C$ and $\delta^{34}S$ trends above the cap carbonate, however, differ from the shallow platform sections, suggesting that a chemocline between shallow platform and deep-water enviroments developed after the cap carbonate. Our data show that relatively positive $\delta^{13}C$ values (up to 0.76‰) in the middle Doushantuo Formation possibly derived from the shallow platform by turbidity flows, and negative $\delta^{13}C$ values (as low as -5.94‰) may represent the signature of the local environment. If this is true, then the Ediacaran ocean after the cap carbonate was stratified with a $\delta^{13}C$ gradient greater than 6.7‰.

S23 - REVISION OF THE OOFAMILY DICTYOOLITHID DINOSAUR EGGS

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Currently, the oofamily Dictyoolithidae is only found in China, and includes one oogenus and four oospecies. Based on evolutionary trends evident in dinosaur eggshells (Zhao, 1993), the Dictyoolithidae may be the most primitive known group. Dictyoolithid eggs are round or near-round in shape, 12 to 15 cm in diameter, with smooth outer surface and relatively thick eggshells. Eggshells appear to be composed of superimposed shell units in radial section, and show a reticulated organization. The shell units are randomly arranged and seldom interconnected in tangential section, in contrast to the honeycomb-like eggshell structure of faveoloolithids. Dictyoolithid pore canals are irregular in shape. Following the dinosaur egg parataxonomy of Zhao (1975), we studied dictyoolithid egg materials from the Tiantai Basin, Zhejiang Province. We carefully observed the microstructural eggshell characters in both radial and tangential section, as characters that can only be observed in tangential section are critical for distinguishing between dictyoolithids and faveoloolithids. Based on eggshell thickness, the number of superimposed layers, and the presence or absence of shell unit fusion near the outer surface of the eggshell, we have revised the Dictyoolithidae to include five oospecies in three oogenera, including two new oogenera and two new oospecies, and *Protodictyoolithus neixiangensis* comb. nov. Zhao, 1994, *Protodictyoolithus jiangi* comb. nov. Liu and Zhao, 2004, and *Dictyoolithus hongpoensis* Zhao, 1994. Furthermore, we assign *Dictyoolithus gongzhulingensis* from the Lower Cretaceous Quantou Formation of Gongzhuling, Jilin Province to a new oogenus. Putative specimens of *Dictyoolithus hongpoensis* have recently been discovered in the Upper Cretaceous Chichengshan Formation of Lishui, Zhejiang Province, but their referral to this oospecies is doubtful.

S16 - TESTING FOR HETEROGENEITY IN RATES OF MORPHOLOGICAL EVOLUTION: DISCRETE CHARACTER CHANGE IN THE EVOLUTION OF LUNGFISH (SARCOPTERYGII; DIPNOI)

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Quantifying rates of morphological evolution is important in many macroevolutionary studies, particularly when assessing adaptive radiations and punctuated equilibrium in the fossil record. However, relatively little work has been done on quantifying rates of morphological change using discrete characters. Here, we introduce a likelihood ratio test for testing heterogeneity of rates across a cladogram using discrete characters. The method, which is based on a Poisson process model, can also be used to identify points on a cladogram (branches or entire clades) with significantly high or low rates of change compared to the rest of the tree. We illustrate the method using a dataset on lungfish, which have long been considered “living fossils” due to an apparent decrease in morphological rates of change after their Devonian radiation. We find that morphological rates are highly heterogeneous across the phylogeny and recover a general pattern of decreasing rates along the phylogenetic backbone towards living taxa, and from the Devonian until the present. We also find a hitherto unrecognized spike in rates around the Permo-Triassic extinction, and a significant slowdown in rates in the Mesozoic, tens of millions of years later than previously thought.

S13 - MACROFLORAL RESPONSE TO THE END-TRIASSIC MASS EXTINCTION EVENT - EVIDENCE OF PLANT DIVERSITY VARIATION AND TURNOVER THROUGH THE TRIASSIC/JURASSIC BOUNDARY IN THE SICHUAN BASIN, CHINA

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The end-Triassic mass extinction event is extensively known; however, the terrestrial response of this event is still poorly understood mainly due to lack of continuously developed Triassic-Jurassic sequences and floral remains. The Sichuan Basin is a typical Mesozoic basin with extensive distribution and development of the Triassic-Jurassic strata in China. The well-developed section in Hechuan of southern Sichuan Basin is considered to be a typical profile for investigating the Upper Triassic and Lower Jurassic sequences. The T/J boundary is in between the Upper Triassic Xujiahe Formation and the base of Lower Jurassic Zhenzhuchong Formation. The fossil plant remains are well documented in both formations in Sichuan Basin. Here we briefly report our results on the variation of floral diversity through the Triassic-Jurassic boundary deposits in the Sichuan Basin. It is recognized that the floral biodiversity of the Hechuan region of Chongqing, in southern Sichuan Basin shows a distinct change through the Triassic and Jurassic transition; and the floral diversity loss reaches up to 92.5% at species level. Meanwhile, in the northeastern region of the Sichuan Basin, the floral diversity declines by about 50% across the T/J boundary at species level with a remarkable turnover of genera and species. This signifies that the terrestrial floras in the Sichuan basin show a distinct response to the end–Triassic mass extinction event. However, there are some regional differences of the extinction and turnover rates for floral variations in the basin, which shows some similarities to those terrestrial events in the T/J boundary in Europe. The potential reasons and mechanisms that cause the floral diversity differentiation of the T/J boundary in the Sichuan Basin are briefly discussed in this work.

S23 - FOSSIL FERNS FROM THE EARLY JURASSIC IN WESTERN HUBEI, CHINA: BIODIVERSITY, REPRODUCTIVE STRUCTURES AND EVOLUTIONARY IMPLICATIONS

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During the past decades, increased progress has been made on the systematic and phylogenetic analyses of ferns and allied plants based upon morphology and molecular data leading towards a full understanding of the fern tree of life. However, fossil records of ferns in deep time provide unequivocal and indispensable evidence for exploring diversity variation, evolutionary radiation and phylogeny of this plant group. The Lower Jurassic Hsiangchi Formation in western Hubei, China is well known for its abundant and diverse fossil ferns, including five families (Marattiaceae, Osmundaceae, Matoniaceae, Dipteridaceae and Dicksoniaceae), 25 species and 11 genera. Recent investigations on fossil ferns based on well preserved specimens from the Hsiangchi Formation have revealed the detailed fertile structures of a diverse fossil fern flora, including *Marattia asiatica*, *Phlebopteris polypodioides*, *Dictyophyllum nilssonii*, *Coniopteris* cf. *bella* and *Coniopteris* sp. *In situ* spore ultrastructures of *Marattia asiatica*, *Phlebopteris polypodioides* and *Dictyophyllum nilssonii* provide palaeobotanical evidence and positive support for the phylogeny and evolution of both fossil and living ferns. The ferns from the upper part of the Hsiangchi Formation are dominated by matoniaceous and dipteridaceous groups, and are associated with the Marattiaceae, Osmundaceae and slender herbaceous Dicksoniaceae. This is a representative fern community recognized from the Southern Floristic Province in China during the late Early Jurassic, indicating a tropical to subtropical climate with warm and humid conditions, which is favorable for peat accumulation.

S23 - *IN SITU* SPORES OF TWO DIPTERIDACEOUS FERNS FROM THE JURASSIC OF CHINA AND THEIR EVOLUTIONARY IMPLICATIONS

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The Dipteridaceae is a representative leptosporangiate fern family with a single extant genus *Dipteris*. During the Mesozoic, the family was globally distributed with up to six genera and 60 species. Among them, *Dictyophyllum* and *Hausmannia* are two representative genera of the family. So far only four species of *Dictyophyllum* have been described from their *in situ* spores in the Triassic and Jurassic. All of the previously described species of *Hausmannia* are based on compression/impression fossils, and little is known about the fertile structures including sporangia and *in situ* spores of this genus. Well-preserved compression specimens of *Dictyophyllum nilssonii* (Brongniart) Goeppert were investigated from the Lower Jurassic Hsiangchi Formation in western Hubei, southern China. The reproductive characters including sporangia and *in situ* spores were examined using LM and SEM. The *in situ* spores are trilete, averaging 40 μm in diameter and comparable to the dispersed trilete spore genus *Dictyophyllidites*. This represents the first *in situ* spores of fossil *Dictyophyllum* that are described in Asia. A new species of *Hausmannia* (*H. sinensis* Wang and Zhang) was reported from the Middle Jurassic of Nei Mongol (Inner Mongolia), Northern China based on exceptionally well-preserved fertile specimens, including sori, sporangia, annuli as well as in situ spores (Wang and Zhang, 2010). The spores are trilete and circular to oval in outline with baculate to subverrucate sculptures, ranging from 20 to 30 μm in diameter, and are comparable to the dispersed types *Apiculatisporites* Potonie and Kremp and *Baculatisporites* Thomas and Pflug. Recent phylogenetic investigations based on molecular and morphological data suggest that the family Dipteridaceae is considered as systematically a monophyletic clade of gleichenioid (including Dipteridaceae, Gleicheniaceae and Matoniaceae), showing a great potential for exploring the phylogeny and evolution of leptosporangiate ferns. The current study on fertile organs and *in situ* spores of *Dictyophyllum* and *Hausmannia* from the Jurassic of China provides further evidence for comparisons with fossil and living records of the Dipteridaceae, and is hence helpful in exploring the diversity and evolution of this important leptosporangiate fern lineage through time.

S23 - PROGRESS ON UPPER PERMIAN BOULTONIID BIOSTRATIGRAPHY: ITS EVOLUTIONARY AND PALAEOGEOGRAPHIC IMPLICATIONS

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The genus *Palaeofusulina* has long been regarded as the index fossil for the Changhsingian of the upper Permian. In recent studies we found the early Wuchiapingian *Palaeofusulina* fauna at the Penglaitan section, the GSSP for the base-Wuchiapingian, in South China. This fauna is dominated by large-sized and long-fusiform *Palaeofusulina* with subordinate *Gallowayinella* and *Tewoella*. The primitive form, *Palaeofusulina minima*, is rare in number. Both the elongated *Palaeofusulina* and *Gallowayinella* show close similarities in their shell size, shape, wall structure and the coiling pattern of the inner volutions. It is highly possible that the elongated *Palaeofusulina* was derived from *Gallowayinella*. This *Palaeofusulina* fauna disappeared about 11 meters above, and has not been found in any other Wuchiapingian strata at the section. *Palaeofusulina* is also provides reliable palaeogeographic constraints on the East and Southeast Asian Terranes of the latest Permian. The Gyanyima Limestone, with the absence of *Palaeofusulina* and presence of *Dilatofusulina*, located at lower latitudes in the Neotethys. The boultoniid genus *Dilatofusulina* is found for the first time in southern Tibet. It is recognized as the terminal genus in the lineage of *Dunbarula-Nanlingella-Parananlingella–Dilatofusulina*. A new foraminiferan zone, the *Reichelina pulchra–Colaniella parva–Dilatofusulina orthogonios* Zone, was proposed to represent the last abundant phase of foraminiferans just before the end-Permian mass extinction. This zone can be correlated broadly with the middle to upper parts of the *Palaeofususlina sinensis* Zone in the Eastern Tethys based on advanced features observed in major elements of the fauna.

S14 - INTEGRATING MOLECULAR AND PALAEONTOLOGICAL APPROACHES TO TELLING EVOLUTIONARY TIME

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Molecular clocks have usurped the traditional role of the fossil record in providing a timescale for evolutionary history. However, the choice of fossil calibration points and their associated prior probabilities have the greatest effect on any molecular clock study. It is therefore critically important that fossil data are correctly represented. No protocols have yet been established for implementing prior probability distributions that reflect the degree to which fossil minima approximate the time of divergence. Instead, clock analyses have adopted expeditious solutions such as normal, log-normal and uniform probability distributions that assume some general relation between fossil minima and divergence dates, but are not informed by any palaeontological or geological data. We have explored the implementation of a variety of palaeontological and geological data as prior probabilities on fossil calibrations within a Bayesian molecular clock analysis of metazoan diversification. These include using subjective data such as phylogenetic bracketing and, more objectively, temporal variation in rock outcrop area. These priors tightly constrain posterior probabilities, yielding divergence estimates that slow variable concordance with raw palaeontological estimates.

S3 - BEHAVIOUR OF NANNOFOSSIL ASSEMBLAGES IN CHALK CYCLES, LOWER EOCENE OF THE SHEFELA REGION, ISRAEL

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Chalk interbedded with chert is common in the Eocene of the Levant margin. The Mor Formation at Nahal Sekher near Beer-Sheva, Israel is of this lithofacies, and demonstrates a rhythmic pattern of sedimentation. The sections are dated as NP12-13 of the Paleogene calcareous nannofossil scheme. Although land-based, preservation quality allows a quantitative study of the nannofossil population. Five meters of section were sampled at high resolution, through three alternations of homogeneous/laminar chalk and more indurated, burrowed beds. Ichnofossil suites imply transition from oxic to dysoxic sea floor from base to top in each cycle. The corresponding nannofossil population changes from abundant discoasters and thoracosphere fragments at the base, with upwards increase in size of larger coccoliths and decrease in dominance of smaller ones. Smaller coccoliths belong mostly to *Reticulofenestra* spp. whereas large coccoliths are usually *Coccolithus*-type. Using typical sedimentation rates of chalk for southern Israel, cycle length approximates 40 Kyr, in the Milankovich obliquity band. These cycles occur at low latitudes in the Tethys in a warm climatic zone under conditions of halothermal circulation, prior to the Eocene Climatic Optimum. We propose that an oscillating Oxygen Minimum Zone (OMZ) in the Levant region was controlled in part by Milankovich-forcing. Obliquity-band perturbations are often interpreted as controlling climate and precipitation. They here governed open-ocean productivity in the photic zone, that influenced both the nannofossil populations in near-surface waters and oxygenation conditions on the sea floor. Consequently, water stratification and nutrient input exert primary influence on coccolith size.

S24 - THE ORIGIN OF LAND PLANTS AND ITS IMPACT ON THE ENVIRONMENT OF PLANET EARTH

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Land plants (embryophytes) are a monophyletic group that evolved as an adaptive response to the invasion of the land. Fossil evidence for the earliest land plants consists of dispersed spores and fragments (enigmatic cuticle-like and tubular structures). Actual megafossil remains are extremely rare, most likely because these plants lacked lignified tissues and were consequently of low fossilization potential. Nonetheless, fossil and other evidence suggests that plants invaded the land in the Mid Ordovician and consisted of basal embryophytes believed to have been of a ‘bryophyte-like’ grade of organization. These plants were probably generalists that tolerated a wide range of environments and were cosmopolitan. A similar flora appears to have persisted for at least 30 million years. The emergence of polysporangiophytes (vascular plants and their immediate predecessors) is shrouded in mystery. However, by the Late Silurian it appears that vascular plants dominated the vegetation and ‘bryophyte-like’ plants had been outcompeted and relegated to subsidiary components. As vegetation increased in stature and aerial coverage it began to have increasing affects on the environment (through biomass accumulation and burial and, more importantly, weathering and soil formation). This talk will review evidence for the nature of the very earliest terrestrial ecosystems and their impact on the environment. Important questions concern: (i) the nature of the earliest land plant vegetation and its aerial extent; (ii) the biota of non-vegetated areas (in terms of biological soil crusts and microbial mats); (iii) the affects of these different terrestrial biotas on weathering and soil formation (including carbon burial).

S10 - A MORPHOLOGICAL, MINERALOGICAL, GEOCHEMICAL, AND ISOTOPIC STUDY OF A 3.3 GA PHOTOSYNTHETIC MICROBIAL MAT FROM BARBERTON, SOUTH AFRICA

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The biogenicity of biosignatures in ancient sediments needs to be based on the attributes of microbial life – namely the physical structure, organic and elemental composition, and traces of its metabolism. Here we use the example of a 3.3 Ga-old microbial mat formed on littoral biolaminated volcanic sediments from the Josefsdal Chert in the Barberton greenstone belt to demonstrate not only its biogenicity but also its photosynthetic nature. The mat surface consists of 0.25 µm thick filaments embedded in thick EPS. FIB sections cut vertically into the mat show that immediately beneath the mat surface there is a 0.5-3µm thick layer of alveolar kerogen beneath which is a finely granular layer in which the kerogen is calcified (primary aragonite). Fe, Mg, and Cr are associated with the aragonite. The total thickness of the mat is about 10 µm. Concentrations of 1% S in the kerogen (sulphurisation) plus associated pseudomorph pyrite crystals suggest sulphur reducing bacterial activity. The latter is most likely implicated in the calcification of the mat, as in modern photosynthesising mats. C isotope ratios of the carbonaceous layers of the biolaminated sediments are -27.8‰. The environmental context of this shallow-water mat, together with its morphological, mineralogical, geochemical, and isotopic characteristics, is a strong indication of its biogenicity and photosynthetic (anoxygenic) nature. Excellent preservation of the structure was assured by precious hydrothermal silicification.

S8 - LATE ORDOVICIAN TRILOBITE BIOFACIES OF EASTERN LAURENTIA: PALEOECOLOGICAL PATTERNS IN THE WAKE OF THE ORDOVICIAN RADIATION

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Trilobite distribution, abundance and diversity in the Late Ordovician of Laurentia must be understood in the context of environmental changes associated with the Taconic Orogeny. Establishment and infilling of the Taconic Foreland basin led to profound changes in the distribution of lithofacies and biofacies across the eastern half of the continent. Here we report on trilobite faunas of the latest Sandbian to Katian interval. Regions in the mid-continent, such as central Oklahoma, have a relatively continuous record of carbonate deposition, and diverse platformal biofacies that pass down-ramp into deeper subtidal, low-diversity cryptolithine faunas. In the foreland basin, cryptolithine biofacies became widespread in the Katian, and expanded geographically as the clastic wedge prograded westward. Sedimentary evidence indicates that cryptolithines have a broader bathymetric range in the foreland basin and emerged at least locally into shallow subtidal, storm-influenced settings. Up-ramp, around the margins of the basin in such regions as southern Ontario, more diverse biofacies lack cryptolithines and share taxa with mid-continent faunas. Preliminary data also indicate that the distribution of trilobite biofacies reflects patterns in the carbonate isotope stratigraphy, suggesting a relationship with various water masses recorded by aquafacies. The emerging patterns of biofacies distribution demonstrate the influence of regional processes on trends in diversity, faunal turnover and replacement over a broad area of Laurentia. Continents will thus have unique aspects to their macroevolutionary signatures that must be identified and isolated in broader assessments of the Ordovician Radiation.

S27D - STRATIGRAPHIC BIAS IN THE EXPRESSION OF A LATE CAMBRIAN TRILOBITE EXTINCTION, LAURENTIAN NORTH AMERICA

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Trilobite extinction at the base of the Late Cambrian Sunwaptan Stage (Furongian) in Laurentia is associated with rising sea level. Sequence stratigraphy predicts that sea level change influences the apparent tempo of faunal turnover. Condensed intervals develop at platform drowning or back-stepping, so that extinctions appear as abrupt events. In Nevada, the base of the extinction interval (*Irvingella major* Zone) is marked by a shift from shallow subtidal to deeper subtidal facies. The *I. major* Zone is a cm-thick condensed interval at the top of the shallow subtidal succession, so that trilobite turnover appears remarkably swift. Similarly, in Wisconsin, *I. major* Zone faunas appear abruptly above a maximum flooding surface that separates shoreface sands from overlying offshore facies. In contrast, there are minimal facies changes when sedimentation keeps pace with accommodation space. In Oklahoma, deposition occurred in an archipelago of igneous islands that was submerged during the late Steptoean and early Sunwaptan. As sea level rose, shallow water environments persisted and sedimentation rates remained high through the extinction interval. The succession comprises sandy bioclastic carbonates without discernable facies changes. However, the *I. major* zone is expanded into a 2 metre-thick interval of stacked rudstones. Although still geologically rapid, this pattern is quite different from the nearly instantaneous extinction apparently recorded in Nevada or Wisconsin. A vexing issue in analysis of Cambrian trilobite extinction has been the absence of a consistent signature of environmental change. Our data indicate that apparent differences between regions are simply consequences of local stratigraphic contexts.

S3 - CONODONTS AS PALAEOTHERMOMETERS IN ANCIENT OCEANS: TESTS AND LIMITATIONS

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Conodonts have the potential to unlock the intricacies of the Palaeozoic climate system, and this is particularly true if isotopic analyses of single tooth-like 'elements' can be used to differentiate evolving sea surface palaeotemperatures and oceanic water masses. They have a diagenetically inert apatitic composition, an ecological distribution as both pelagic and nektobenthic organisms, a well-established biostratigraphy, and are abundant in Cambrian–Triassic rocks. However, ionprobe analyses of $\delta^{18}O$ in conodont elements have proceeded directly to palaeotemperature interpretation without a full understanding of inter- and intra-element variability or of potential post-mortem artefacts. Ion microprobe analysis of Ordovician–Silurian elements establishes that: 1. $\delta^{18}O$ within elements can vary by up to ~4‰ in crown tissue, but typically does so by ~1‰; 2. $\delta^{18}O$ varies systematically across some elements suggesting an underlying microstructural control; 3. $\delta^{18}O$ varies between same taxon representatives by up to ~2‰; 4. $\delta^{18}O$ of some exemplars of pelagic and nektobenthic taxa are distinguished by a 2–3‰ offset; 5. processing techniques have a significant affect on $\delta^{18}O$ values; 6. thermal alteration of elements does affect the isotope signal. Single element ionprobe $\delta^{18}O$ values are closely comparable to those derived from multiple element silver phosphate precipitates, but the magnitude of $\delta^{18}O$ variation observed in ionprobe analyses (up to 4‰) is equivalent to that interpreted as representing cooling oceans over the duration of the Ordovician. Bulk chemical and ionprobe analyses may have hitherto masked such variability, which has implications for the selection of material for isotopic studies.

S6 - WISDOM TEETH: A STUDY OF MORPHOLOGICAL VARIATION OF WOODRAT (NEOTOMA) MOLARS USING GEOMETRIC MORPHOMETRICS

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Neotoma have a particularly important role in our understanding of the climate of western North America over the late Quaternary, because they leave an ecological record in the form of palaeomiddens. Plant macrofossils, pollen, and fecal pellets from these middens have been used to reconstruct the plant communities and temperature of ecosystems on a fine scale. We used molars of woodrats to identify species that created palaeomiddens and improve our ecological reconstructions. We developed an image database of molars from 396 individuals of nine species of Neotoma and Hodomys alleni, a sister taxon to the genus. We then compared geometric morphometrics, elliptical Fourier analysis, and extended eigenshape analysis to determine the best criteria for differentiating between species. In future research, we will use these criteria to re-examine taxonomy of extinct species, excluding size criteria, since woodrats are known to adapt in body size easily. We will also examine variation in size and morphology over geographic range, both latitudinally and longitudinally, and differences between ecosystems.

S27B - THE CENOZOIC FOSSIL RECORD OF ANTARCTICA

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The modern Antarctic fauna arose following the Cretaceous-Tertiary extinction event. Biotic recovery occurred throughout the Cenozoic Era, which was a period of climatic and tectonic change in the Southern Hemisphere, and this led to Antarctica developing a unique biota. Using the Cenozoic Marine Fauna Database (SOMBASE-GSCM) and the Southern Ocean Mollusc database (SOMBASE) with the aid of GIS we are studying the changing diversity and distributions of molluscs through the Cenozoic. This information combined with molecular evidence from recent species is enabling us to look for large scale patterns in Cenozoic biodiversity change in the Antarctic and how this relates to the distribution and diversity of organisms at the present day. Studies are also being carried out on key Antarctic fossil sites, such as Seymour Island, where fossil assemblages from the Cretaceous to the Eocene can be studied, and King George Island, where there is a diverse early Miocene section. Also, a series of studies of taxa through time are being undertaken; the first focuses on the bivalve genus *Limopsis*, which is one of the most diverse mollusc genera in the Antarctic today. Using information from databases, taxonomic work and molecular phylogenetics, the Cenozoic evolutionary history of the clade in the Southern Hemisphere has been traced from the Cretaceous to the present day. Links can be made with large scale geological and climatic changes in the Southern Hemisphere such as the development of deep water circulation after the onset of the Antarctic Circumpolar Current.

S2 - MASS EXTINCTIONS: BACKGROUND EXTINCTIONS WRITTEN LARGE OR DIFFERENT IN KIND?

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There is considerable debate on the role of mass extinctions in the long-term evolution of life: do they exacerbate background trends or do they reflect distinct extinction mechanisms not operative during background times? Many studies suggest the former, implying that normal causes of extinction (of which habitat loss is the main type) are likely to be the principal cause. Of course habitat loss can occur in a number of ways. In the marine realm shallow marine habitat area declines during regression, but it can also occur during transgression if it is associated with the spread of anoxic (uninhabitable) bottom waters. These mechanisms contrast with claims for mass extinction specific mechanisms such as hypercapnia and ocean acidification[4]. Claims for the latter kill mechanism are currently especially hard to prove given our lack of knowledge of how the modern marine biota is responding to ocean acidification: recent studies of groups as diverse as cephalopods and calcareous nanoplankton suggest that an acidification kill mechanism will produce a decidedly non-intuitive selectivity. Extinction due to habitat loss is the best general explanation for marine mass extinctions, but it remains to be seen how selectivity operates in terrestrial environments. The extinction of plants at the end of the Permian is an especially notable event that may require some extraordinary kill mechanism.

S21 - HOW DO FOSSILS INFLUENCE ESTIMATES OF PHYLOGENY?

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Phylogeny is the grounding for most macroevolutionary and comparative studies, but conclusions are only as good as the accuracy of the cladograms on which they are based. Neontologists often discount the importance of fossils, claiming that their incompleteness makes them obfuscate or positively mislead cladistic inference. Given the importance of paleontological data in macroevolutionary work, therefore, do we need to be especially cautious? Initial studies of 45 predominantly vertebrate data sets demonstrate that adding fossils is no more likely to change the reconstructed tree than adding living taxa. Moreover, there is no evidence that the presence of fossils decreases phylogenetic resolution. Do preliminary findings for vertebrates hold true for other higher taxa? And can we predict when fossils are likely to have their biggest impact? In general, we predict this will be most marked in volatile trees with uneven taxon sampling, and with large extinct branches. A more pressing question now is whether the fossil record biases the preserved sample of characters in such a way that the trees inferred from them are likely to differ from those that would be derived from more entire data sets. For example, all but the most exceptionally preserved arthropod fossils lack details of the appendages (antennae, mouthparts and legs, etc.) – precisely those characters that are usually cited as most diagnostic or pivotal in phylogenetic analyses. Preliminary results show no systematic biases. However, we also investigate the putative phenomenon of stemward slippage resulting from the early taphonomic loss of the most derived characters.

S1 - WHAT DO CLADISTICALLY IMPLIED GHOST RANGES TELL US ABOUT THE FOSSIL RECORD?

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Plots of observed fossil ranges onto cladistic hypotheses highlight putative ghost ranges: intervals where the presence of a lineage is inferred because its purported sister group is observed. The congruence between cladistic branching order and the stratigraphic order of first fossil occurrences has therefore been used as an index of fossil record quality. Received wisdom holds that ghost ranges should become more common with antiquity. Large scale empirical studies show that ghost ranges are more common towards the early Palaeozoic, but surprisingly also the Cenozoic. Greatest congruence is in the Mesozoic. How can this be? We quantify several factors reasoned or observed to influence stratigraphic congruence (e.g., tree size, tree balance, taxonomic level and the temporal extent of the clade). Several are not uniformly distributed through time. Most significantly, however, the taxonomic composition of our sample changes to reflect faunal turnover. Different groups have a characteristic congruence signature that probably owes much to their preservation potential. Moreover, support and lability measures for cladograms of different higher taxa also show significant variation, and this may reflect their probable accuracy. Unlike estimates of fossil record quality based on, say, sedimentary rock exposure, inferences made from ghost ranges inevitably reflect the taxonomic composition of that record, and our grasp of phylogeny. Poor congruence for a given interval or group may result from a patchy record, misleading cladograms or both. Whichever is the case, such examples are least promising for elucidating macroevolutionary patterns. Strong congruence suggests that both trees and stratigraphy reflect evolutionary history.

S21 - ARTHROPOD TAGMOSIS: INFERRED EXPRESSION OF DEVELOPMENTAL GENES IN EXTINCT TAXA

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The evolutionary success of arthropods is partially attributed to their segmented body plan. A key feature of their evolution is that most segments bear a pair of appendages, with anterior/posterior differentiation of appendage identity along the body axis (tagmosis). The major clades of extant arthropods (Chelicerata, Crustacea, Hexapoda, and Myriapoda) are primarily defined by the tagmosis of their head appendages, which are adapted for various feeding and sensory functions. Fossil arthropods of the Cambrian explosion have even more diversity in head tagmosis. Developmentally, tagmosis is associated with expression of Hox genes, which are a group of homologous body patterning genes, found in all bilaterians. Obviously, gene expression cannot be studied experimentally in the fossil record. Therefore, to make inferences about developmental mechanisms leading to the diversity of arthropod body plans, a different approach is needed. Phylogenies were constructed using a matrix consisting of 399 morphological characters coded for 68 extant and 16 fossil arthropods. Different methods of phylogeny reconstruction were explored, including parsimony and Bayesian inference. Hox expression data are available from all the major extant arthropod clades. Using those data, anterior/posterior expression patterns were mapped onto a consensus tree topology, and ancestral character states for key fossil nodes were reconstructed. Although previous studies have attempted to predict developmental gene expression patterns in trilobites, this is the first attempt to do so with explicit use of phylogenetic methods including both extant and extinct taxa.

S15 – A HIGH RESOLUTION RECORD OF THE LATE CAMBRIAN SPICE EVENT ON AVALONIA: CAUSES AND AFFECTS

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The Steptoean Positive Carbon Isotope Excursion (SPICE) records a global perturbation in carbon cycling during the earliest Late Cambrian (Furongian) that immediately follows a major extinction in Laurentian trilobites. SPICE is best known from carbonate platform successions on Laurentia and elsewhere, but is also recognised in largely anoxic shelf mudstones on the Baltic Platform. The causes of SPICE remain uncertain. In North America, sedimentological evidence has been used to link the peak positive excursion to a (glacio?)eustatic fall in sea-level, and the excursion has been interpreted in terms of enhanced productivity, global marine anoxia, or increased terrestrial weathering of shelf carbonates. We report a high resolution record of SPICE in organic matter from the biostratigraphically well-constrained Outwoods Shale Formation of the English west midlands – the first record of the event on palaeocontinental Avalonia. The excursion builds to a maximum $\delta^{13}C_{org}$ amplitude of 4.1‰ (at values of -25.6‰), before immediately decreasing more gradually to background levels (-29.7‰); it is followed by a minor positive excursion which may equate with a similar one recognised in Siberia. The onset of SPICE coincides with the widely recognised Early Furongian eustatic sea-level rise, and we consider its overall pattern to be most consistent with an initial bloom in productivity (and carbon burial) caused by stepwise flooding of the shelves, followed by a gradual return to background levels once the bio-limiting elements in submerged soils became exhausted. Subsequent sea-level fall may have prompted recycling of the relatively $\delta^{13}C$-rich sediments on the shelves and might be the cause of the later, smaller positive excursion.

S23 - THE DIVERSITY OF SAURICHTHYIDS FROM MIDDLE TRIASSIC (ANISIAN) OF SOUTHWESTERN CHINA

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Detailed systematic work on recently discovered saurichthyids from Middle Triassic (Anisian) of southwestern China recognizes eight species based on more than 150 well preserved specimens. Besides the two species of *Saurichthys*, the remaining taxa are three generic-level morphotypes (Type A, Type B and Type C) of remarkable diversity both in anatomy and ecological adaptation: Type A is mainly characterized by a boot-like cleithrum, dorsally situated pectoral fins and some other correlated features; this group probably represents a new lineage adapted to surface water with a similar lifestyle and locomotion pattern as extant needle fishes; Type B possesses a wide and flat skull roof with a peculiar arrangement of dermal bones and proportions of endorcranium, its crushing teeth suggesting a different feeding strategy and ecologic niches from *Saurichthys*; Type C, is a typical benthic form, distinguished evidently from other saurichthyids by possessing a extremely narrow skull roof between orbitals, a dorsaloventrally compressed skull with sensory canal openings in the skull roof conspicuously large while the ones in the mandible are rather degenerate, transverse processes extending laterally in abdominal neural arches, all fins distally rounded in contour. With such a considerable richness and diversity, therefore, the diversification of saurichthyids in Anisian also reflects the rapid recovery of the Triassic marine ecosystem following an early Triassic stagnant phase after the end-Permian extinction.

S23 - ORDOVICIAN CONODONT DIVERSIFICATION IN THE LOWER YANGTZE VALLEY

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Following restudy of the Ordovician conodont taxonomy and ranges of the conodont species based on previously-published data and our own new data, the stratigraphical ranges of conodonts in each conodont zone from the Ordovician of Lower Yangtze Valley (especially that of the Nanjing Hills area) are summarized herein. Five bio−events can be recognized in this area during the Ordovician. The conodont radiation in the studied area reached its acme at the Tremadocian−Floian boundary (*Serratognathus diversus* zone), early Dapingian (*Baltoniodus triangularis* zone), Middle and Late Darriwilian (*Eoplacognathus suecicus* zone). The conodont fauna experienced revolutionary changes during the early Darriwilian (*Lenodus antivariabilis* zone) and early Katian (*Hamarodus europaeus* zone). Our research suggests that the conodont radiation may be related to sea−level changes.

S23 - DISTRIBUTION OF LIVING PLANKTONIC FORAMINIFERA IN THE SPRING SOUTHERN SOUTH CHINA SEA

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Plankton tow samples collected in the southern South China Sea (SCS) during May 2004 were quantitatively analyzed to investigate the relationship of living planktonic foraminiferan distributions to upper ocean environmental parameters. The results show that *Globigerinoides sacculifer*, *Globigerinoides ruber*, *Globigerinella aequilateralis*, and *Neogloboquadrina dutertrei* dominated the foraminiferan assemblages. Dominant species show a general distribution pattern with *G. sacculifer* and *G. ruber* mainly dominating assemblages north of 9°N, while the high relative abundance of *N. dutertrei* and *P. obliquiloculata* was mainly distributed in stations south of 9°N, together with the abnormal high relative abundance of *G. aequilateralis*. We suggest that the distribution of living planktonic foraminiferans in the spring southern SCS was mainly controlled by the combined impacts of productivity and temperature in the mixed layer. *G. sacculifer* and *G. ruber* show negative correlations with the average chlorophyll-a (Chl-a) concentration and positive correlations with temperature and density of the mixed layer, indicating that they prefer warm and oligotrophic waters. Both *N. dutertrei* and *P. obliquiloculata* show similar distributions, and are positively correlated with the average Chl-a concentration, suggesting that they have the potential to be used as productivity proxies in this region. *G. aequilateralis* is strongly correlated with the average chlorophyll-a concentration of the upper 50 m, however, its relative abundance is significantly higher in plankton tows than in sediments, indicating its proneness to burial dissolution and thus is not suitable for productivity reconstruction. Our results also provide a preliminary interpretation of the depth distributions of the most common species in the spring Southern SCS, with *G. sacculifer*, *G. ruber*, *N. dutertrei* and *P. obliquiloculata* mainly dwelling in the upper mixed layer, while *G. aequilateralis*, *Orbulina universa* and *Globorotalia menardii* are abundant in the thermocline water mass.

S23 - PALAEOBIOLOGY OF THE EDIACARAN DOUSHANTUO FORMATION: CURRENT CONTROVERSIES ON EARLY ANIMALS AND THEIR ENVIRONMENTS

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The Doushantuo Formation in South China plays an important role in the study of Ediacaran biological evolution and environmental changes, particularly the origin of animals and oceanic redox evolution. However, there are a number of unresolved controversies with regard to the stratigraphic correlation, depositional environment, and palaeobiological interpretation of the Doushantuo rocks and fossils. This review focuses on two selected controversies: whether the lower Doushantuo Formation in the Yangtze Gorges area was deposited in an isolated lake, and whether Doushantuo microfossils such as *Tianzhushania spinosa*, *Megasphaera ornata*, and *Parapandorina raphospissa* represent giant sulfur bacteria or animal embryos. We conclude that, although some mineralogical and geochemical data from the lower Doushantuo Formation in the Yangtze Gorges area could be interpreted as evidence for lacustrine deposition, regional stratigraphy and palaeobiological data indicate at least episodic palaeo-oceanographic connection between the Yangtze Gorges area and deep-water basinal facies in southeastern China. The balance of evidence favours an interpretation of a restricted shelf lagoon during the deposition of the lower and middle Doushantuo Formation in the Yangtze Gorges area. Although some morphological aspects of *Tianzhushania spinosa*, *Megasphaera ornata*, and *Parapandorina raphospissa* are similar to those of giant sulfur bacteria, the totality of their morphologies is more consistent with an animal embryo interpretation, although we are not convinced that these fossils can be interpreted as embryos of bilaterian animals. A resolution of Doushantuo depositional settings and fossil affinities would place important constraints on the timing and environmental contexts of early animal evolution.

S23 - CUSP SIZE, CROWN OUTLINE SHAPE, AND OCCLUSAL GROOVES PATTERN OF M^1S IN MIDDLE AND LATE PLEISTOCENE HOMININS OF CHINA

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Morphometric methods have been employed here to study the relative cusp basal areas, crown outline shape, and main occlusal grooves patterns of *Australopithecus*, African early *Homo*, Asian fossil hominins, and contemporary modern humans M^1s. This study suggests that 1) the paracone enlarges with metacone being stable relatively, while the protocone and hypocone comparatively shrink from *Australopithecus* to modern humans, 2) the outline of *Australopithecus* M^1s are relatively symmetrical with the mesial outline being vertical (anatomical position) and the distal outline being round, while those of modern humans are protruded in the mesiobuccal outline and shrink at the intersection point between distal groove and crown outline, 3) occlusal buccal and lingual grooves move mesially and mesial grooves move buccally along the human family evolutional line; moreover, the occlusal buccal groove of *Australopithecus* M^1 is vertical and mesial groove horizontal, the angle between these two grooves is approximately 90°, while the occlusal buccal groove is inclined distally, and mesial groove becomes curved in the modern human, the angle between these two grooves exceeding obviously 90°; moreover, the distance between the central fovea and distal fovea is smaller in the *Australopithecus* than in the modern human. Eleven original and one cast teeth of Chinese fossil hominins were involved in the present study, with *Homo erectus,* archaic *Homo sapiens*, late *Homo sapiens* being included, spanning the Middle and Late Pleistocene. In conclusion, Chinese *Homo erectus*, archaic *Homo sapiens*, late *Homo sapiens*, and contemporary modern humans display no significant difference in the M^1 relative cusp basal area except for the paracone. However, the ratio of

paracone basal area/relative metacone basal area, crown outline shape and main occlusal grooves pattern may be used to discriminate among them based on their ontogeny. Furthermore, the similarities and differences between the Chinese and European fossil hominins of the same age are also explored in this study, which shows that those unique traits, M^1s—relatively large hypocone and small metacone, existed in *Homo neanderthalensis* and *Homo heidelbergensis*, but were not observed in those of the Chinese fossil hominins, suggesting that the gene communication between them during that time was limited.

S23 - THE MIDDLE DEVONIAN FLORA OF XINJIANG, CHINA: NEW EVIDENCE OF DIVERSITY AND PALAEOGEOGRAPHY

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We report extensive new collections from the Upper Member of the Hujiersite Formation, Hoxtolgay, Xinjiang, China which allow a modern reconsideration and expansion of this palaeogeographically important flora, preserved as compressions. The age is confirmed as late Mid Devonian (Givetian) based on palynology. Members of the flora studied so far include diverse species of the lycopsid genera *Leclercqia*, *Haskinsia*, *Colpodexylon* and *Drepanophycus*, the zosterophyll *Serrulacaulis*, the iridopteridalean *Compsocradus*, the progymnosperm *Aneurophyton*, plus *incertae sedis* plants *Taeniocrada*, *Tsaia*, and *Blasaria*. The plant assemblage is dominated by lycopsids, with the overall composition closely related to that of the Middle Devonian of Venezuela and New York State. However Pseudosporochnales are an important missing component. The assemblage is significantly different from that from South China (Yunnan). A new species of *Leclercqia* was found. The new fossils consist of tiny axes and 6-7 tipped leaves with a hooked central segment; the leaf morphology, significantly different from the type species *L. complexa*, suggests a climbing habit.

S23 - RECENT ADVANCES IN RESEARCH ON AVIAN ORIGINS

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The last two decades have witnessed great advances in research on avian origins. These advances were made by conducting more comprehensive phylogenetic analyses, by discovering new specimens of both non-avian dinosaurs and basal birds that provided significant osteological and even behavioral information, and by analyzing bone and eggshell microstructure to infer growth strategy and physiology in non-avian dinosaurs and early birds and even to recover molecular information. Here I highlight three issues that are often considered to raise problems for the theropod hypothesis of avian origins: 1) the question of how feathers and flight could have evolved in dinosaurs; 2) the 'temporal paradox' in the stratigraphic distribution of theropod fossils; and 3) supposed homological incongruities. Significant advances have been made recently towards resolving each of these issues. Discoveries of non-avian dinosaur specimens preserving soft tissues have demonstrated that a variety of feather morphotypes occurred among non-avian dinosaurs before the origin of Aves and that feathers may represent a defining feature for Dinosauria or an even more inclusive group; discoveries of various Jurassic non-avian maniraptoran theropods have greatly improved the congruence between stratigraphy and phylogeny for derived theropods; and, finally, significant new information recovered from both newly and previously collected theropod specimens suggests that apparent conflicts between palaeontological and neontological data concerning the homologies of some important structures are non-existent, and that some structures including manual digits probably underwent developmentally and functionally complex transformations during the transition to birds.

W4 - AN INTRODUCTION TO THE CHINA FOSSIL PRESERVATION FOUNDATION (CFPF)

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The rapid development of modern paleontology worldwide made fossil protection a global issue of concern to scientists, the public and educators. With her rich resources of fossils and contributions to understanding the origin and evolution of life, China attracted worldwide attention. The rapid development in China has caused extensive damage and plundering of invaluable and irreplaceable fossils, and the situation grows worse. To confront illegal fossil excavation and smuggling, the CFPF was established in 2008, an action jointly proposed by over twenty Chinese academicians and scientists. CFPF is to promote lawful actions to protect and conserve fossils and other geological resources. In three years, the CFPF has launched several projects: 1) It provided 5-year funding to *Fossil* magazine, in order to broaden its social influence by enhancing its scientific content and publication quality; 2) funded a project "Science-Reading through Gift-Books" to encourage popular science, with the focus on fossil protection; 3) is organizing the "China Preservation and Geological Environment Protection Frontier Forum" for April 16, 2010, Macau, and will sign a formal agreement with the Macau Special Administration to build a "China Dinosaur Museum"; and 4) it funded 15 students and young paleontologists to help them attend the 3rd IPC, London. Fossil protection is a global issue for science, which matters not only for conservation of natural resources on the earth but also for the future of paleontology in China and elsewhere. We sincerely call your attention on the issue, and appreciate your support, morally and financially.

S27B - SPECIATION DURING THE CENOMANIAN RADIATION OF AMMONITES IN THE WESTERN INTERIOR SEAWAY OF NORTH AMERICA

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Fine-scale studies detailing the mechanics of specific evolutionary radiations can help us understand how and why species form. During the Middle and Late Cenomanian, acanthoceratid ammonites entered the newly-formed Western Interior Seaway of North America and underwent an adaptive radiation within this new habitat. Careful dissection of species-level geographical and morphological patterns reveals details of how environment and developmental lability worked together to fuel diversification. Speciation events that established new endemic genera within the Western Interior Seaway preferentially occurred within a more northern region, centered in what is today eastern Wyoming. On the other hand, speciation events that established new genera that eventually emigrated out of the seaway (*e.g., Metoicoceras*) occurred in the south (New Mexico and Texas). Later speciation events within these genera are more geographically widespread. Genera arising within the northern endemic center show a pronounced size divergence, being predominantly progenetic dwarfs (adult diameter <2 cm) on the one hand and relatively large forms (adult diameter up to 40 cm) on the other. This shift away from intermediate sizes towards small and large extremes is the opposite pattern to that predicted by the "island rule," which argues that restricted resources and/or habitat space tends to drive species to intermediate sizes. Most endemic speciation events involved changes in developmental timing of characters, rather than the appearance of entirely new traits. The northern "endemic generation machine" shut down after the *Dunveganoceras pondi* Zone (earliest Late Cenomanian), after which most speciation events filled in pre-existing genera rather than producing new genera.

S23 - BIODIVERSITY PATTERNS OF LOWER - MIDDLE ORDOVICIAN MARINE MICROPHYTOPLANKTON IN SOUTH CHINA: RELATION TO THE EVOLUTION OF THE MARINE INVERTEBRATES

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The Great Ordovician Biodiversification Event (GOBE) is one of the most significant radiations of marine invertebrates during the Phanerozoic marked by rapid increase in biodiversity and an important phase in palaeoecological evolution. Acritarchs are considered to represent the cysts of marine phytoplankton and thus represent an important part of the base of the marine food chain in the Palaeozoic. In this context, 'the Ordovician palaeoecological revolution' was related to the diversification of the phytoplankton as evidenced by the record of acritarchs and prasinophytes. Studies of acritarch biodiversity changes in the Lower and Middle Ordovician of the South Chinese Yangtze Platform were so far focused on drawing total diversity curves, which were compared with palaeoenvironmental factors such as sea level changes. In the present study, additional curves are presented, including measurements of mean diversity, as well as origination and extinction rates. More than 100 samples for palynological and diversity analysis were collected from six sections located in different lithofacies on the Yangtze Platform. The diversity changes vary across the different areas in South China, perhaps related to different environmental changes, especially sea level variations. The peaks of acritarch diversity of South China appear in the *C. deflexus - A. suecicus*, and *U. austrodentatus* graptolite biozones that correspond to transgressions in the early Floian and early Darriwilian. With rising sea levels, the spreading of continental masses and increasing habitat space, the disparity of acritarchs increased rapidly during the Early-Middle Ordovician. Remarkably, the rapid increase of acritarch assemblages in the Floian interval corresponds to the increase of new acritarch forms. The phytoplankton curves are compared with the diversity changes of different invertebrate fossil groups, including chitinozoans, conodonts, graptolites, trilobites, and brachiopods. It can be assumed that the Ordovician phytoplankton radiation paralleled a long-term rise in sea level with an accompanying expansion of flooded continental shelf areas. The availability of increased quantities of phytoplankton in the Lower-Middle Ordovician of the Yangtze Platform allowed the radiation of zooplanktonic groups, and at the same time accelerated the diversification of suspension feeders.

S10 - THE OCCURRENCE OF ARCHAEAL AND BACTERIAL TETRA-ETHER MEMBRANE LIPIDS IN STALAGMITES, DRIPPING WATER AND OVERLYING SOILS IN CENTRAL CHINA

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Lipids in stalagmites were recently found to have a great potential in palaeoenvironmental reconstruction whereas in contrast large molecular compounds like glycerol dialkyl glycerol tetraethers (GDGTs) have rarely been investigated. Here we dissolved five grams of stalagmites in hydrochloric acid (3 M) under room temperature to extract the lipids released, which enables the construction of a high-resolution record. The GDGTs profiles analyzed by liquid chromatogram and tandem mass spectrometry show the predominance of crenarchaeol over branched GDGTs in the stalagmites from the Heshang Cave in Central China, possibly indicative of the dominant contribution of the Crenarchaeota in cave environments. It is notable that only crenarchaeol, though in low concentration, can be detected in lipids extracted from dripping water. However, the GDGTs distributions in three overlying soil samples as well as a soil profile, collectively exhibit the dominance of bacterial GDGTs over archaeal GDGTs, quite different from those identified in stalagmites. This difference implies that most GDGTs in stalagmites may be inherited from the subsurface dripping water rather than the overlying soils. The TEX_{86} values calculated on the basis of GDGTs are found to be

comparable with stalagmite $\delta^{18}O$ data, with enhanced values being associated with depleted $\delta^{18}O$ data, suggesting that archaeal membrane lipids in stalagmites can trace monsoon-induced climate variations, in particular palaeo-temperature changes.

S3 - NON-MARINE OSTRACODS FROM THE CRETACEOUS OF MONGOLIA

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During the Early Cretaceous, species of genera *Cypridea*, *Mongolianella*, *Lycopterocypris*, *Limnocypridea*, *Rhinocypris*, *Therosynoecum* and *Ziziphocypris* were dominated and wide spread among ostracod assemblages. They were wide spread in Lower and part of Upper Cretaceous deposits of Mongolia, Transbaikalia and China. Whereas during the Late Cretaceous time, grand changes in the quantity of ostracods took place. Representatives of Mesozoic genera, such as *Cypridea*, *Lycopterocypris*, *Timiriasevia* and *Ziziphocypris* have developed Late Cretaceous associations and survived into Late Creatacious, while species of Cenozoic genera of *Limnocythere*, *Ilyocypris*, *Cyprinotus*, *Cypria* and *Eucypris* have appeared. In contrast, by the end of the Early Cretaceous, widespread genera, such as *Limnocypridea*, *Mongolianella*, *Rhinocypris* and *Theriosynoecum* had disappeared completely. Simultaneously, the representatives of the genera of *Talicypridea*, *Altanicypris*, *Khandia*, *Bogdocypris* and *Mongolocypris* have appeared and were wide spread on the Asian continent during the Late Cretaceous. Furthermore, investigations of non-marine Cretaceous ostracods show that the Early and Late Cretaceous of Mongolia corresponded to the different stages in paleogeography at the end of Mezosoic era. Each epoch was characterised by the formation of different sedimentary basins and corresponding landscape and particular paleoclimatic conditions. During the Early Cretaceous, development of the extensive lake basins and humid climatic conditions were the most important characteristics for Mongolia. In contrast, during the Late Cretaceous, all conditions have changed sharply. The lake basins were strongly reduced; the climate became arid with seasonal alternation and sands formed along the lake coasts.

S8 - LATE ORDOVICIAN LAGERSTÄTTEN IN MANITOBA, CANADA: GLIMPSES OF SOFTBODIED DIVERSITY

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Three Ordovician sites in Manitoba yield fossils that exhibit considerable soft tissue preservation. The Cat Head and William Lake biotas occur in the Williston Basin; the Airport Cove biota is in the Hudson Bay Basin. The older and deeper water Cat Head is early Maysvillian; William Lake and Airport Cove represent shallower marginal marine settings of Richmondian age. Many of the taxa are rare or unknown elsewhere in the Ordovician of Laurentia. These are not yet thoroughly documented, but will significantly enhance our understanding of global biodiversity and provide unique information about select marine communities prior to the Late Ordovician extinctions. The Cat Head biota includes sponges, conulariids, brachiopods, possible hydrozoans, nautiloids, trilobites, and dendroids. Beautifully preserved algae, interpreted as rhodophytes, heterokontophytes, and chlorophytes, are among the best “seaweeds” known anywhere in the Lower Palaeozoic. The William Lake and Airport Cove sites represent distinct depositional environments, but share elements including algae, large problematic tubes, and unique early eurypterids. *Lunataspis aurora*, found at both sites, is among the oldest known true horseshoe crabs. Thin-bedded dolomudstones at William Lake contain common medusae (jellyfish). These occur in association with articulated eurypterids within homogeneous layers or lenses in the dolomudstones, suggesting rapid deposition in a restricted shoreline setting. A single pycnogonid specimen from William Lake is the geologically earliest known adult sea spider. At Airport Cove, laminated calcareous dolostones were deposited under conditions of more open circulation. Fossils include scolecodonts and abundant noncalcified algae; eurypterid sclerites are preserved as organic cuticle retaining exceptional detail.

S4 - INTEGRATING MOLECULAR AND PALAEONTOLOGICAL DATA ON THE EVOLUTION OF COCCOLITHOPHORES.

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Coccolithophores are both an important component of the modern phytoplankton and a major fossil group of great importance for biostratigraphy and palaeoceanography. In consequence they have been and continue to be the subject of extensive and diverse research. Whilst phylogeny is rarely a prime objective of such research a wide range of new data of phylogenteic value is being generated. This includes description of new rare but phylogetically informative extant taxa, environmental DNA studies using clone libraries and pyrosequencing, and palaeontological study of exceptionally preserved biotas. This data is providing a much fuller picture of the evolution of coccolithophores and their response to environmental change through the Cenozoic. This talk will summarise significant new results and their implications. We will also discuss the degree to which integrated analysis of this type highlights the limitations of both the molecular and the palaeontological record and the consequent value of combining the two.

W1 - A COMPUTATIONAL MODEL OF GROWTH IN PALAEOZOIC ECHINOIDS

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A model of echinoid growth using a Bertalanffy growth model for plate growth and an inhibition-activation model for plate addition successfully reproduces many patterns characteristic of modern echinoid skeletons. Modern echinoids invariably have 20 columns of plates, arranged in biserial columns in each of 5 radial and 5 interradial areas. Palaeozoic echinoids appear odd because of their range of morphological disparity characterized by the number of plate columns (15 to over 150). The same model for growth of individual plates can be applied to both modern and Palaeozoic echinoids, with different values for the parameters of rate and maximum size. The assumption of isotropic plate growth is valid except for some types of imbricate plating. The same inhibition-activation model is valid for Palaeozoic forms, although requiring additional plate insertion loci to reproduce multiple plate "columns" in the interradii. Patterns of plates in the radii can be reproduced using a model of the underlying water vascular "tree" to guide plate accommodation caused by expansion of the radii during growth. Modeling results reproduce many otherwise unexplained features observed in Palaeozoic skeletons, including orphaned plates, pentagonal plates, and intercalated columns. The concept of plate column is misleading, especially for Paleozoic forms. The disparity in these forms should instead be related to properties of individual plate growth and addition in cohort sets from multiple insertion loci in the interradii. Models suggest a basis for deducing developmental homologies from reinterpretation of species descriptions with changes in the commonly accepted interpretations of morphology in Palaeozoic echinoids.

S7 - REVISED TAXONOMY AND INTERPRETATION OF LIFE POSITION FOR THE BRACHIOPOD GENUS *AMBOCOELIA* IN THE MIDDLE AND UPPER DEVONIAN APPALACHIAN BASIN OF NEW YORK STATE

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In the Northern Appalachian Basin, *Ambocoelia* is occurs commonly throughout Middle and Upper Devonian strata. Originating in the Eifelian, *Ambocoelia umbonata* persisted through both the Kačák and Taghanic biocrises, finally meeting its demise during the Frasnian/Fammenian extinction. The only other form of *Ambocoelia* in the Devonian succession of New York, *A. umbonata gregaria* originated in the early Frasnian, and became extinct in the latest Fammenian. James Hall (1860) originally described this form as *A. gregaria*, but later reassigned it to *A. umbonata gregaria*, noting that its similarity to Middle Devonian forms made him hesitant to classify it as a distinct species (Hall, 1867). Subsequently, numerous workers have taken to referring to this form as *A. gregaria*. Collection of additional material from the type localities of *gregaria* has allowed a better taxonomic description, resulting in a taxonomic elevation to *Ambocoelia gregaria*. Comparison of adult and juvenile forms and the environmental preference of *A. umbonata* and *A. gregaria* suggests that the latter exhibits a paedomorphic morphology that likely evolved from *A. umbonata* through neotony. Morphological comparison of both species has allowed for revised interpretation of its life position: adult *A. umbonata* would have been unable to possess a functional pedicle because the umbonal curvature blocks the delthyrium, in contrast to *A. gregaria*, which exhibited an unrestricted pedicle opening, similar to juvenile *A. umbonata*. We conclude that adult forms of *A. umbonata* lived pedicle valve down, while *A. gregaria*, with a functional pedicle, lived pedicle valve up.

S7 - A NEW SPECIES OF *AMBOCOELIA* (BRACHIOPODA) FROM THE MIDDLE DEVONIAN (*ENSENSIS* ZONE) SILICA SHALE OF NORTHWESTERN OHIO, U.S.A.

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A new species of the cosmopolitan genus *Ambocoelia* is described from the Middle Devonian (Givetian) Silica Shale (*Ensensis* Zone) of northwestern Ohio, U.S.A. Specimens come from Silica Shale dump piles at the abandoned Essroc Quarry, and are presumably from units 16-17 of the Silica Shale which is reported in the literature as an argillaceous limestone rich in the brachiopod *Ambocoelia*. Three-dimensional reconstruction with a section distance of 25 µm, resulting in over 300 serial sections per specimen, were used to identify and compare internal morphological features for the newly described form and the type species for the genus, *Ambocoelia umbonata*. Ambocoeliids from the Silica Shale are planoconvex, with a poorly defined ventral sulcus and no visible fold. Similar to *Ambocoelia umbonata*, the shells of this new form are extraordinarily thick for their size, in particular in the umbonal area. In adult forms, the delthyrial gap is relatively large compared to other species of *Ambocoelia*, and partially covered by secondary shell material. This form possesses a bilobed, tuberculate cardinal process, inconspicuous crural plates, and spires with 4-5 coils. While *Ambocoelia* sp. nov. from the Silica Shale of northwestern Ohio possesses many features in common with *Ambocoelia umbonata* from New York State and *Ambocoelia tuberculata* from southern Ontario, Canada, further work is necessary to determine if this species is intermediate between these forms, which have their first appearance just prior to (*A. umbonata*) and slightly after (*A. tuberculosis*) the form described here from the Silica Shale.

S9 - QUANTITATIVE ANALYSIS OF THE LATE MIDDLE DEVONIAN (GIVETIAN) TAGHANIC BIOCRISIS IN THE TYPE AREA (NEW YORK STATE APPALACHIAN BASIN) AND THROUGHOUT NORTH AMERICA

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The late Middle Devonian (middle-upper Givetian) “Taghanic (*Pharciceras*) Event” was originally named for goniatite turnovers in the northern Appalachian Basin during the deposition of the Tully Limestone. Subsequently, it has been associated with the extinction of most of the long-persisting ‘Hamilton Fauna’ over a period of approximately 0.5 million years, and is now recognized worldwide as the Global Taghanic Biocrisis. Our previous work has focused on paleoecological reconstruction of faunas through this biocrisis using a high-resolution stratigraphic framework along a complete onshore-through-offshore gradient in the type-area. This has revealed at least three main pulses of faunal transition within the northern Appalachian Basin, each characterized by the step-wise incursion of, and resulting replacement by, an extra-basinal fauna during a time of geologically rapid local and global environmental changes. In this study, we have quantitatively analyzed the faunal changes in the type-area and throughout North America. In the Appalachian Basin deposits of New York State, extinction at the species-level was greater than 50% within the ‘Hamilton Fauna’. Corals show the highest extinction levels of any major group, perhaps as a result of the onset of the third tectophase of the Acadian Orogeny which resulted in a drastic increase in sediment supply to the basin, thereby prohibiting coral biofacies. Furthermore, preliminary analysis of genus-level brachiopod occurrences throughout North America, for intervals before, during, and after this biocrisis, suggests that extinction was greatest in the type-area, which locally underwent some of the most severe environmental changes when compared to other parts of North America.

W1 - NEW FOSSIL DISCOVERIES INDICATE A DIVERSE CAMBRIAN RECORD OF SPANISH ECHINODERMS

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Recent sampling of localities from the Cambrian of North Spain has yielded a large collection of more than 2000 complete or partially complete fossil echinoderms. This material demonstrates that Spanish echinoderms were initially present in low diversity, with only eocrinoids and edrioasteroids known from Cambrian Series 2 (Lower Cambrian). During Cambrian Series 3 (Middle Cambrian), however, diversity increased considerably, and three major groups make their first appearances: stylophorans, cinctans and ctenocystoids. Many of these groups include new representatives never before documented from the Cambrian of Gondwana, including cothurnocystid stylophorans, columnar-bearing eocrinoids, isorophid edrioasteroids and new clades of ctenocystoids and blastozoans. No echinoderms are reported from the Furongian (Upper Cambrian), apart from disarticulated and non-diagnostic ossicles. This result is probably not an exception and indicates how poorly known Cambrian echinoderms are worldwide, except for a few other well-known examples from Europe and North America, and suggests where collector efforts should be concentrated in the near-future.

S9 - PARASITISM IN DEVONIAN STROMATOPOROIDS

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Palaeozoic calcareous sponges were associated with tube-like structures of unknown biological affinities. These tubes have diversified morphological features – they are straight or helicoidal and some of them may possess their own calcareous wall; they may also have internal structures such as tabulae or diaphragms. The interaction between these tubes and hosting organisms was usually classified as commensalism. The aim of this study is to analyze the relationships between stromatoporoids from the Devonian of Ardennes and infesting organisms. The studied material comes from the Givetian outcrops around the fortifications in Mont d'Haurs near Givet (northern France). 30 out of 250 samples of stromatoporoids display traces of hosting. Infesting organisms are assigned to *Torquaysalpinx* ichnosp.; they infest skeletons of stromatoporoids, mainly belonging to the genera *Atelodictyon*, *Actionostroma* and *Salairella*. The *Torquaysalpinx* organisms were penetrating the skeletons of stromatoporoids *in vivo* and for this reason they were called endobionts (Tampanila 2005). Tapanila (2008) has shown cases, where interaction between two organisms may be regarded as parasitism. One of such cases is when one of involved organisms reduces the growth rates of its host. A decrease of growth rates is observed in our material. Moreover, the infestation causes changes of the host's phenotype, which is also a sign of parasitism. Such observations clearly show that *Torquaysalpinx* sp. were parasites of stromatoporoids. This is the first evidence for parasitism in stromatoporoids in particular, and in Palaeozoic sponges.

S20 - THE TAPHONOMY OF BIRDS AND DINOSAURS FROM THE JEHOL BIOTA (EARLY CRETACEOUS) OF CHINA

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The Jehol Biota, a collective term for the diverse assemblages of invertebrate, plant and vertebrate fossils known from numerous localities within northeastern China, has provided invaluable data on the palaeo-biology of late Mesozoic continental ecosystems, and, in particular, the evolutionary inter-relationships of dinosaurs and birds. The taphonomy of these assemblages is less understood. Vertebrate carcasses were supplied, in various states of completion and articulation, to the lake floor, where they often underwent further disarticulation. There is thus little or no evidence at many localities for carcasses having been entombed within depositing event beds at the time of, or shortly after, death. The opisthotonic posture (dorsal recurvature of the anterior vertebral column) displayed by many specimens is thus more likely to have originated post-mortem rather than peri-mortem. This is not inconsistent with a mass-kill hypothesis implied by the occurrence of numerous articulated skeletons of the same taxon on a single bedding surface. The feathers of birds and dinosaurs can be preserved as carbonised impressions in which melanosomes (sub-micron sized pigment bodies) occur as solid bodies and moulds. Alternatively, the melanosomes alone can be preserved. The feathers of birds varied in their preservation potential: parts of individual feathers and the feathered integument as a whole are not preserved. This complicates attempts to resolve the extent of feather covering in non-avian theropods, where there is no *a priori* reason to assume a near-continuous covering *in vivo*.

S23 - DISTRIBUTION OF POLYCYSTINE RADIOLARIANS IN THE NORTHERN SOUTH CHINA SEA IN SEPTEMBER 2005

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There were similar radiolarian species compositions in the northern and the southern South China Sea (SCS) during the start and end of the summer monsoon. Tropical-subtropical warm species *Peromelissa phalacra*, *Pterocorys hertwigii*, *Botryocyrtis scutum* and *Tetrapyle quadriloba* were the dominant species in the northern and the southern SCS, suggesting that the radiolarian biocoenosis in the northern SCS in September 2005 still was under the influence of the summer monsoon and might be mainly derived from the southern SCS. The patterns of distribution and the abundances of the species *B. scutum*, *P. hertwigii*, *Cornutella tuberose* and *Didymocyrtis tetrathalamus tetrathalamus* also suggest that western equatorial Pacific waters did not yet influence the studied region at the time of sampling while the summer monsoon did. The depth-distribution of radiolarian abundance in the northern SCS in September 2005 was characterized by daily fluctuations, and the highest abundance generally occurred at depths of 0-75 m, i.e., above the chlorophyll-a maximum and encompassing the thermocline. Moreover, the highest abundance of radiolarians was closely related to the water mass. The comparison between the radiolarian thanatocoenosis in surface sediments and the radiolarian biocoenosis in upper waters showed that the distribution of the radiolarian biocoenosis may vary seasonally. *Tetrapyle octacantha* and *Spongotrochus glacialis* are proxies for upwelling conditions in the tropics. In the northern SCS the relative abundances of *B. scutum* and *P. hertwigii* were both positively correlated with the temperature in surface waters, and thus can be used as indicators of tropical surface waters.

S23 - OCCURRENCE OF HORSESHOE CRAB FOSSILS FROM THE MIDDLE TRIASSIC OF SW CHINA

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A horseshoe crab *Yunnanolimulus luopingensis* (Arthropoda: Xiphosurida) was reported recently from laminated micritic limestone of the Member II of the Guanling Formation in Luoping County, Yunnan Province, SW China. This interval is assigned to Aisian Stage of the Middle Triassic based on the index conodont fossil *Nicoraella kockeli*. Primary research indicates that the fossils belong to the Mesolimuloidae and show affinities with extant taxa, indicating its position within the crown group of the Xiphosurida. This is the first occurrence of horseshoe crab fossils in China. The discovery extends the geographic distribution of the fossil horseshoe crab, and provides new information on the evolution and ecological changes through time of this animal group.

S23 - A PARATAXONOMIC REVISION OF THE CRETACEOUS FAVEOLOOLITHID EGGS OF CHINA

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Faveoloolithids, a unique group of dinosaur eggs, are characterized by a honeycomb-like eggshell structure. Because of the limitations arising from the equipment and research methods available, previous workers were unable to adequately classify the faveoloolithids recovered from Henan, Hubei, Zhejiang and Inner Mongolia in China, the Gobi Desert in Mongolia, and Bosung in South Korea. At this stage, this group only contained two oospecies: *Faveoloolithus ningxiaensis* and *Youngoolithus xiaguanensis*, while the parataxonomic position of other specimens within the Faveoloolithidae was uncertain. We present detailed descriptions of the holotypes of *F. ningxiaensis* and *Y. xiaguanensis*, and of some new material from the Tiantai Basin, Zhejiang Province, along with comments on the parataxonomy of this group of eggs. We erect one new oofamily, containing the single oospecies *Y. xiaguanensis*. We also describe five new oospecies in two new faveoloolithid oogenera. We summarize the characters that are crucial for identification of faveoloolithid and youngoolithid eggs, to provide a basis for comparisons with other material. In addition, we emphasize that tangential sections through the eggshell are essential for recognizing eggs that belong to one of the two oofamilies mentioned above. Otherwise, specimens belonging to these oofamilies may be confused with dictyoolithid eggs.

S23 - APPENDICULATE NATURE OF THE JAW APPARATUS OF ANOMALOCARIDIDS: WITH A DISCUSSION ON THE ORIGIN OF ARTHROPOD MOUTHPARTS

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Close examination of anomalocaridid specimens reveals the appendiculate nature of the circular jaw: four pairs of head appendages fused to form a mouthpart around the mouth opening. Arthropod mouthparts have evolved into a number of forms. At the centre of their origin is the labrum. Most evidence points to the common origin of the labrum as a highly reduced appendage. However, many workers still regard it as an outgrowth of the body wall. The anterior and posterior larger plates in the circular mouthparts of anomalocaridids are formed by the paired limb bases fused in the midline, resulting in an anteromedian plate and a posteromedian plate, respectively. This mode of formation is generally similar to that of the labrum and labium in extant euarthropods. Furthermore, their position relative to the mouth corresponds to those of the labrum and labium, which are immediately in front of and behind the mouth opening in the midline, respectively. The posteromedian plate is probably homologous with the fifth appendage of euarthropods (the labium in Hexapoda and Myriapoda). The homologue of the anteromedian plate with the labrum is presently uncertain because of the controversial ideas on the origin of labrum from the protocerebral segment, tritocerebral segment, or an outgrowth of the body wall. In anomalocaridids, the anteromedian plate resembles the labrum in function, position and mode of formation and represents the second appendage. If the labrum is an appendage, the present evidence suggests that it was tritocerebral in origin.

S8 - DIVERSITY AND PALAEOBIOGEOGRAPHIC PATTERNS OF ORDOVICIAN GRAPTOLITES IN DISTINCT ENVIRONMENTS OF SOUTH CHINA

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The analysis of the Ordovician graptolite diversity across several distinct environments in South China, including nearshore, inner-shelf, outer-shelf, slope and basin, indicates a pattern with the lowermost being in the nearshore, increasing progressively towards the outer-shelf, and the maximum on slope and slight decrease towards basin. Plotted against graptolite zones and 'Time unit', the graptolite diversity presents clear evolutionary patterns in distinct environments throughout the Early and Middle Ordovician, with the variously intermittent occurrences of graptolites and low diversity in the nearshore and shelf environments, and by contrast a completely continuous succession on the slope, continental rise and basin. A synthesized graptolite diversity of South China against 'Time Unit' displays a step-wise increase pattern with three peaks from the Early Ordovician to the Sandbian (Late Ord.): mid Floian (Early Ord.), late Dapingian—early Darriwilian (Mid Ord.), latest Darriwilian (Mid Ord.), which coincides basically with the transgression events in South China, implying a close relationship. The biogeographic distribution of four ecologically representative graptolite groups of Ordovician in South China, i.e. *Pseudisograptus*, *Isograptus–Parisograptus*, *Undulograptus austrodentatus* and the *Corymbograptus varicosus* group, displays a significant parallelism with the coast or shelf margin, suggesting that the distribution may be shaped by water depth, submarine landscape and the distance from the coast.

S23 - GRAPTOLITE FAUNA AND BIOSTRATIGRAPHY OF ORDOVICIAN NINGKUO AND HULO FORMATIONS IN SE CHINA

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Graptolites from the Ningkuo and Hulo formations are the most diverse and well-preserved among the Ordovician faunas in China. The two formations are distributed in the Anhui–Zhejiang–Jiangxi border region and in the northern Hu'nan, S. China, within the slope facies of the Jiangnan Region. The Ningkuo Fm is characterized by dark grey to black shale intercalated with some limestone, while the Hulo Fm is typified by black cherts and siliceous shale with layers of limestone. They span the interval from earliest Floian (O_1) to earliest Sandbian (O_3). The graptolites, dominating the fossils of the formations, are exquisitely well-preserved, commonly pyritic and in full or half reliefs. The graptolite fauna of the two formations include some 110 species belonging to 41 genera. In total 14 graptolite zones are recognized in the two formations, which are, in ascending order: Ningkuo Fm: 1) *T. approximatus*, 2) *Pend. fruticosus*, 3) *D. 'protobifidus'*, 4) *C. deflexus*, 5) *Az. suecicus*, 6) I. *caduceus imitatus*, 7) *E. clavus*, 8) *U. austrodentatus*, 9) *Acr. ellesae* (spanning the boundary of the two formations); Hulo Fm: 10) *Nichol. fasciculatus*, 11) *Pter. elegans*, 12) *'H. teretiusculus'*, 13) *Nem. gracilis*, 14) *Dicran. sinensis*. These biozones are well correlated with those from other continents or regions.

S23 - MIOCENE MAMMALIAN FAUNAL SUCCESSION FROM DAMIAO, CENTRAL NEI MONGOL

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Nei Mongol (Inner Monglia) has long been known in the paleontological community for rich vertebrate fossils, however, it lacks well developed sections and the superimposition of fossil levels. Here we present the preliminary result of our field investigations during 2006-2009 in the Damiao area, central Nei Mongol. Three main fossil horizons represented by over 20 localities produced faunas of different ages covering early Miocene, latest Middle Miocene and earliest Late Miocene. The early Miocene fauna is represented by rich material of *Sinolagomys*, *Tachyoryctoides* and small sized cervoids. The late Middle Miocene fauna is comparable with the Tunggur fauna with a pliopithecid. The latest fauna documents the earliest record of *Ochotona*, *Nannocricetus* etc., representing the earliest Late Miocene. All three faunas have similar faunal composition with abundant small mammals (insectivores, rodents and lagomorphs) and rich cervoids, indicating a relatively stable local habitat for this time interval.

S7 - SOFT-TISSUE PRESERVATION IN THE EARLY CAMBRIAN BRACHIOPODS FROM THE CHENGJIANG FAUNA OF CHINA AND ITS IMPLICATIONS

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Brachiopods, a group of exclusively marine, bivalved invertebrates, made their first appearance in the earliest Cambrian, and have an extensive fossil record exhibiting morphological diversity and geological continuity throughout the Palaeozoic era. Nevertheless, most of them are known exclusively from the fossil records of only shells. Consequently, our knowledge of extinct taxa relies heavily on analogies with their extant relatives; yet these analogies have been untested conjectures regarding stem-group clades. Interestingly, phosphatic and calcareous-shelled brachiopods from the well-known Chengjiang fauna have exquisitely preserved soft tissues, including pedicles, setae, mantle canals, digestive tracts and lophophores, which reveal the body plans and the evolutionary acquisition of morphological novelties in early stocks, and also provide a good opportunity for testing analogies with the extinct taxa from extant representatives. These fossils have corroborated the view that brachiopods developed a complex organization of tissues, and achieved considerable evolutionary success already by the start of the Cambrian Explosion. Studies of Chengjiang brachiopods suggest that a spirolophous lophophore may be a plesiomorphic feature at least for all linguliforms, and demonstrate the danger of assuming that the anatomy of stem group brachiopods can be directly extrapolated backwards from the extant group.

S23 - NEW OCCURRENCE OF SOFT-TISSUE PRESERVATION IN BRACHIOPODS FROM THE LOWER CAMBRIAN WULONGQING FORMATION (SERIES 2, STAGE 4) OF YUNNAN, SOUTHERN CHINA

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Exceptional Burgess shale-type preservation of brachiopods has the potential to elucidate the character states of the soft anatomy of brachiopods, and also provides a window into their palaeoecological and palaeo-community reconstruction. Nevertheless, the most important discoveries of soft parts in Cambrian brachiopods are mostly from the Early Cambrian Chengjiang Konservat Lagerstätte. A recent geological survey of South China has led to the discovery of another muddy depositional sequence in the Lower Cambrian Wulongqing Formation (Guanshan Fauna), where brachiopods with exceptional preservation of soft-part anatomy occur. The muddy deposits are widely exposed around the Kunming-Wuding and Malong-Yiliang area, Yunnan Province, and are probably equivalent to stage 4 of Cambrian Series 2 in the new international stratigraphic chart. As seen in the Chengjiang fauna, soft parts preserved in the Guanshan brachiopods comprise imprints of the lophophore, mantle canals, notably setal fringes and pedicles. By contrast, the brachiopod assemblage in the Guanshan fauna is numerically dominated by abundant eoobolides, and a moderately diverse variety of other obolids. The brachiopods comprise the botsfordiid *Diandongia pista*, obolids *Eoobolus* and *Palaeobolus*, abundant *Heliomedusa*-like fossils, some small-sized acrotheloid and acrotretoid brachiopods, as well as the new linguliform brachiopod *Acanthotretella decaius* and sparse calcareous-shelled brachiopod *Kutorgina* and *Nisusia*. This is the first record of acrotretoid brachiopods from shale-hosted siliciclastic deposits in the Yangtze platform of south China, which can be compared with individuals etched from the coeval carbonates, thus providing valuable data for our further understanding of the body plan and palaeoecology of the acrotretid brachiopods.

S23 - THE COMMUNITY STRUCTURE AND COMPOSITION OF THE CAMBRIAN (SERIES 2) CHENGJIANG FAUNA, SW CHINA

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On the basis of the published species data (227 species from >18 phyla) and field sampling data (114 species, 18406 individuals) from the Chengjiang-Haikou-Anning area, we quantitatively analyzed the palaeo-community structure and composition of the Cambrian Chengjiang Fauna (Cambrian Series 2, eastern Yunnan, China). The results demonstrate that arthropods dominate the community both in species diversity (species: 37%) and abundance (individuals: 51.8%). Priapulids (individuals: 22.6%) and brachiopods (individuals: 16.3%) follow in abundance rank. The arthropod Kunmingella douvillei (26.2%), the priapulid Cricocosmia jinningensis (15.4%) and brachiopod Diandongia pista (11%) are the most abundant species. Ecological analyses show that the community is dominated by epifaunal organisms (species: 63%, individuals: 68.4%), followed by infaunal organisms (species: 11.9%, individuals: 25.9%), nektobenthic organisms (species: 11.5%, individuals: 2.6%), and pelagic organisms (species: 5.3%, individuals: 3.1%). The diverse feeding strategies, with dominant suspension feeders (species: 35.3%, individuals: 26.1%) and

hunter/scavengers (species: 31.3%, individuals: 40.4%), indicate a complex food-chain and strong competition in this early Cambrian community. Our data also indicate that the epifaunal vagrant omnivorous (28.2%), infaunal vagrant hunter/scavengers (19.8%), epifaunal sessile suspension feeders (17.7%) and epifaunal vagrant hunter/scavengers (15.3%) are the most abundant ecological groups, represented primarily by arthropods, porifers, priapulids and brachiopods. Ecological group analyses indicate that the early Cambrian Chengjiang Fauna has similar community patterns and function relations as that of modern shallow marine settings.

S27A - DIVERSITY AND FOSSIL RECORD OF THE CERATOPSIAN DINOSAURS

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The Ceratopsia, dinosaurs such as *Triceratops* with horns on their faces and neck frills, originated in the Late Jurassic, and became dominant herbivores in the Late Cretaceous. Meanwhile, the angiosperms, flowering plants, originated in the Early Cretaceous (approximately 100 million years ago), and attained a great radiation from the mid-Cretaceous. By the Late Cretaceous, angiosperms dominated environments formerly occupied by ferns and cycadophytes. In order to test whether there is any correlation between the evolution of Ceratopsia and angiosperms, we built a new species-level dataset of all Ceratopsia. Ceratopsian diversity is low in the Late Jurassic and the early Early Cretaceous, and shows a marked increase during the late Early Cretaceous. During this time, ceratopsian evolution does not seem to have been influenced by the angiosperm radiation. However, a steep drop in ceratopsian diversity followed in the early Later Cretaceous. Ceratopsian diversity reached a peak in the late Campanian and then dropped slightly in the Maastrichtian. The empirical pattern of ceratopsian diversification is matched to various proxies for sampling (e.g. number of formations with ceratopsians, number of formations with dinosaurs, number of terrestrial formations, number of publications, number of workers) to determine whether the record could be influenced in a coarse way by any sampling bias. Matching of ceratopsian and angiosperm records is assessed to determine whether there could be any inter-relationship between herbivore and plant group.

S23 - MORE EDIACARA-TYPE FOSSILS FROM THE BLACK SHALE OF THE UPPER DOUSHANTUO FORMATION, GUIZHOU, CHINA

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The Ediacaran black shale of the upper Doushantuo Formation of the Yangtze platform yields abundant fossils preserved as carbonaceous compressions, which are dominated by the macroscopic algae and termed as the “Miaohe biota”. Recently, an eight-armed fossil *Eoandromeda octobranchiata* from a new locality of the Miaohe biota in Guizhou was proved to be an Ediacara fossil from the Ediacaran Rawnsley Quartzite of South Australia. The same Ediacara fossil preserved as cast or mould and carbonaceous compression in two contrasting taphonomic windows highlights the potential for more Ediacara fossils from the Ediacaran black shale. Here we report a new Ediacara fossil from the black shale of the upper Doushantuo Formation in Guizhou. The fossil shows similar structures as an overprint of the arms on *Tribrachidium*. The new discovery further supports assumption that more Ediacara fossils with carbonaceous compression will be found and provide more anatomical information for the interpretation of the Ediacara fossils.

S3 - PALAEOZOIC VERTEBRATE MICROFOSSILS: STABLE ISOTOPE AND ELEMENTAL GEOCHEMISTRY IN PALAEOCLIMATE STUDIES

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Fossil apatite of conodonts, and early fish exoskeletal microremains (dermal scales) from the Silurian and Devonian of Arctic Norway, Siberia, central Asia, and Baltic states have been analysed for stable oxygen isotope and elemental geochemistry. Vertebrate taxa examined include acanthodians, chondrichthyans, galeaspids, heterostracans, mongolepids, and thelodonts. Spot geochemistry analyses by Energy Dispersive X-ray Spectroscopy were conducted on fine polished thin sections of vertebrate scales measuring elemental composition of separate tissues, in relation to their histology and recrystallisation level. Bioapatite silicification and enrichment in heavy elements corresponds to microfossil structure and colour alteration, indicating weaker preservation and re-crystallization respectively. Oxygen isotope ratios give distinguishably lower heavy oxygen values in vertebrate microremains from the Lower Silurian of central Asia, and much higher in those of the Upper Silurian of the Baltic palaeobasin. As a first conclusion, this significant loss of initial enrichment in heavy ^{18}O isotopes, if concerning the general oxygen isotope composition of Palaeozoic vertebrate bioapatites, may be directly correlated with the poor preservation. Additionally, the $\delta^{18}O$ ratios appear to be strongly species-dependent, which may refer either to specific palaeobiological isotope assimilation in biominerals, or to specific susceptibility and loss of primary isotopic signal.

S22 - EVOLUTION OF VERTEBRATE EXOSKELETON: SILURIAN THELODONT BIODIVERSITY AND TISSUE DEVELOPMENT

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Thelodont microremains from the Silurian of the central Asia (northwestern Mongolia and Tuva), as well as from central and southern parts of the East Siberia between Yenisey and Lena rivers (Siberian platform), have been studied, yielding a large number of endemic species. A separate palaeobiogeographical province spread as warm epeiric seas over the Siberian palaeocontinent may be considered, referring to it as a possible place of origin and radiation of many groups of early vertebrates, including several genera of thelodonts.The internal structure of the thelodont exoskeleton has been considered in relation to the scale morphology, taxonomy of disarticulated microfossils, and phylogeny. Among the thelodont scale crown tissues, the following types of dentine have been recognised: 1) irregular thin canal dentine (*Loganellia*); 2) regular thin canal dentine (orthodentine), in *Angaralepis*; and 3) thick canal dentine (*Helenolepis*, *Talimaalepis*). The exoskeletal tissue histology throughout the Silurian is interpreted as a thelodont histological evolution pattern. The internal structure of the *Angaralepis* scales shares some similarities with loganid scales, for example absence of a pulp depression and thicker dentine canals, with thin tubule dentine in a regular tubule branching pattern, contrary to the irregular one of loganiids. The genus *Talimaalepis*, known so far as consisting of a single species, is now proposed as consisting of two species. The histology of *Talimaalepis* scales shows an intermediate position between the *Loganellia* (Fam. Loganellidae) and *Helenolepis* (Fam. Phlebolepidae). However, the phylogenetic affiliation of *Talimaalepis* is under further consideration.

S20 - TAPHONOMICAL ASPECTS OF THE MIDDLE DEVONIAN FOSSIL ASSEMBLAGES AT LODE CLAY QUARRY (LATVIA)

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The Lode clay quarry (Middle Devonian, Lode Formation) is a well-known fossil vertebrate locality, which has yielded lots of fossil fishes and agnathans of Givetian age. Sedimentological studies indicate a deltaic origin for the deposits - the opinion based upon observations that slump depressions are filled by very fine-grained clay. Over the decades 15 taxa of vertebrates, and a number of fossil invertebrates and plants have been reported from the deposits of the Lode Formation. The material includes complete skeletons of the antiarch *Asterolepis ornata* and the sarcopterygians *Laccognathus panderi*, *Panderichthys rhombolepis*, and *Eusthenopteron kurshi*, as well as fossils of juvenile sarcopterygians, acanthodians, and placoderms. The fossil remains have been preserved mainly as accumulations of bodies or skeletal elements without being dispersed throughout the section. The state of preservation ranges from complete skeletons to abraded fragments depending on conditions before and during burial. In certain cases elongated elements exhibit some orientation, matching the presumed palaeocurrent direction. The sequence of disintegration of sarcopterygian bodies has been characterized. Studies of several assemblages illustrate how the hydrodynamic regime, sediment movement, anatomical peculiarities of fishes with regard to the type of sutures between the bones and other factors have influenced the preservation of fossils within the different assemblages. It is concluded that calm hydrodynamic conditions and extensive deposition of very fine sediments infilling slump depressions resulted in the excellent preservation of fossils making the Lode clay quarry one of the scientifically important sites on a global scale.

S1 - DISENTANGLING PALAEODIVERSITY SIGNALS FROM A BIASED SEDIMENTARY RECORD: AN EXAMPLE FROM THE LOWER TO MIDDLE MIOCENE OF CENTRAL PARATETHYS

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Sequence stratigraphic architecture can control diversity patterns, especially on a regional scale. We studied a major change of marine molluscan faunas across the 3rd order sequence boundary from the Lower to the Middle Miocene of the Paratethys. Taken at face value, the pattern suggests a transition from low-diversity Karpatian (Upper Burdigalian) to highly diverse Badenian (Langhian and Lower Serravallian) assemblages. Due to strong facies shifts, however, the Karpatian faunas are mostly preserved in nearshore settings, but the Badenian faunas range from intertidal to shelf depth. Quantitative data (223 bulk samples, 469 species 65,000 shells) from shell beds of 4 Karpatian and 6 Badenian localities capture the anatomy of this faunal transition. Palaeogeographical position of localities and environmental data from foraminifera suggest water depths from the intertidal to several tens of meters. Ordination methods indicate that benthic assemblages developed along the same depth-related environmental gradient across the sequence boundary. The immigration of several thermophilic molluscan families and superfamilies reflects climatic changes at the onset of the Langhian transgression. Our quantitative approach, however, points towards the strong facies shift at the Lower / Middle Miocene boundary as the main reason for the apparent faunal turnover observed from regional species lists, because species abundance patterns from local assemblages indicate largely persisting palaeocommunities.

S26 - MODERN SHELF ANOXIA AND DEAD ZONES AS ANALOGUES TO ANCIENT ANOXIC FACIES OF EPICONTINENTAL SEAS: FROM SETTINGS TO PROCESSES

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“Dead zones” are coastal areas low in dissolved oxygen and devoid of mobile fauna. Their number is rapidly increasing (presently >400 systems, covering >245,000 km²) but they are poor equivalents to ancient shallow-water black shales, which were mostly deposited on epicontinental seas during sea level highs. Dead zones occur on peri- and epicontinental seas one order of magnitude smaller, and are largely driven by eutrophication. High primary productivity alone is insufficient to establish benthic anoxia, and isolation of benthic water layers appears to be a prerequisite. Similar to some modern examples, most large ancient epeiric seas were microtidal and characterized by estuarine-type circulation and distinct density stratification. Predicted climate change will deplete oceanic oxygen by increasing stratification and warming; minor changes in oceanographic processes could lead to major expansions of OMZs onto coastal shelves, a scenario proposed for many ancient epeiric seas. Experimental studies on the broad northern Adriatic shelf show that the bottom water oxygen ranges from 4-6 ml l-1 during summer and may decrease to zero within several days. H_2S starts to develop at the onset of anoxia. PH-values in 2 mm depth decrease from 8.15 to 7.6 within hours, indicating that the most reactive organic matter is rapidly decomposing in the uppermost few mm of the sediment. These data correlate with behavioural responses and mortality sequences of benthic macrofaunas, including echinoids, crustaceans, molluscs and anemones. Although dead zones and ancient shelves are different settings, the processes occurring during oxygen crises should be comparable.