Biomineral organic fraction in brachiopod giants and implications for their lifestyle

Lucia Angiolini[1], Gaia Crippa[1], Karem Azmy[2], Giancarlo Capitani[3], Giorgia Confalonieri[4], Giovanna Della Porta[1], Erika Griesshaber[5], David A.T. Harper[6], Melanie J. Leng[7,8], Leah Nolan[9], Marco Orlandi[3], Renato Posenato[10], Wolfgang W. Schmahl[5], Vanessa J. Banks[8] & Michael H. Stephenson[8]

[1] Dipartimento di Scienze della Terra "A. Desio", Via Mangiagalli 34, 20133, Milano, Italy; lucia.angiolini@unimi.it
[2] Department of Earth Sciences, Memorial University of Newfoundland, St. John's, NL A1B 3X5, Canada.
[3] Dipartimento di Scienze dell'Ambiente e del Territorio e di Scienze della Terra, Piazza della Scienza 4, 20126 Milano, Italy.
[4] Dipartimento di Scienze della Terra, Università degli Studi di Torino, Torino, Italy.
[5] Department für Geo- und Umweltwissenschaften, Ludwig-Maximilians Universität München, Munich, Germany.
[6] Department of Earth Sciences, Durham University, Durham DH1 3LE, UK.
[7] NERC Isotope Geosciences Facilities, British Geological Survey, Keyworth, Nottingham NG12 5GG, UK.
[8] British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK.
[9] Department of Geology, University of Leicester, University Road, Leicester, LE1 7RH, UK.
[10] Dipartimento di Fisica e Scienze della Terra, Via Saragat, 1, 44121 Ferrara, Italy.

The species of the brachiopod *Gigantoproductus* attain a shell area which is 20 times larger than that of coeval brachiopod species and makes them giants among Carboniferous benthic invertebrates. This is surprising as living brachiopods have a low-energy lifestyle (low metabolism, low growth, feeding and reproduction rates), but it has never been investigated in detail nor satisfactorily explained. Besides being giants, most *Gigantoproductus* species have a very thick shell which is made up of long columnar calcite units.
Multiple analyses [petrography, cathodoluminescence (CL), Scanning Electron Microscopy (SEM), Electron Backscatter Diffraction (EBSD), Transmission Electron Microscopy (TEM)] on the shells of several *Gigantoproductus* species revealed that their biomineral is pristine and contains occluded organic matrix. Nuclear Magnetic Resonance (NMR) and Gas Chromatography Mass Spectrometry (GC-MS) analyses showed that the amino acid composition of this organic fraction is comparable with that observed in Recent brachiopod taxa, enhancing the exceptional preservation of these fossil shells. Its preservation assessed, the carbon- and nitrogen-isotopic composition of the occluded organic matrix within the shells has been used as a fingerprint of feeding strategy, to detect the biogeochemical signatures that identify symbioses vs. a normal suspension feeding strategy.
By a very complex and multidisciplinary set of analyses, we concluded that *Gigantoproductus* species exploited a mixotroph lifestyle, deriving energy and nutrients both from photosymbiotic microbes and from filtered particulate food.

Tridactyl tracks from the Lavini di Marco dinosaur ichnosite (Hettangian, Southern Alps, NE Italy): ichnotaxonomical review and palaeobiogeography

Matteo Antonelli[1], Enrico Sacco[1], Massimo Bernardi[1], Jacopo Conti[2], Riccardo Tomasoni[1], Johannes Pignatti[2] & Fabio Massimo Petti[1]

[1] MUSE - Museo delle Scienze di Trento, Corso del Lavoro e della Scienza 3, 38123 Trento, Italia; matteo.antonelli_1988@hotmail.com
[2] Dipartimento di Scienze della Terra, Sapienza Università di Roma, Piazzale Aldo Moro, 5, 00185 Roma, Italia.

During the spring 2018 a new ichnological survey was carried out at the Lavini di Marco tracksite, within a joint project between MUSE and Sapienza University of Rome. The study area is located near Rovereto (Trentino-Alto Adige, NE Italy), on the western slope of Mt. Zugna (Southern Alps). The trampled horizons are referred to the Monte Zugna Fm. (Hettangian, 200 Mya) of the Calcari Grigi Group. These deposits belong to the Trento Platform, a palaeogeographic domain characterized by shallow-water carbonate sedimentation throughout the Early Jurassic. More than 700 tridactyl tracks were identified. The ichnotaxonomical analysis was performed first drawing interpretive sketches of all the footprints, then measuring the main track parameters and plotting them for statistical analysis. The best-preserved tridactyl tracks were modelled by means of close-range photogrammetry to gain objective morphological information. Three methods were used to correlate tracks and their trackmakers: (i) synapomorphy-based approach; (ii) phenetic correlation; (iii) coincidence correlation. The reconstruction of the trackmakers' autopodia was performed supposing the arthral position of phalangeal pads. Morphological and morphometrical analysis allowed us to assign the tridactyl tracks to the ichnogenera *Anchisauripus*, *Grallator*, *Eubrontes* and *Kayentapus*. The two largest footprints of the ichnosite revealed morphological features similar to those of advanced theropods, such as *Megalosauripus* and *Jurabrontes*. The ichnoassemblage shows a clear affinity with those from NE Europe and China. The reconstructed autopodia led to the identification of *Panguraptor*-like and *Sinosaurus*-like trackmakers, small to medium-sized theropods known from the Lufeng Fm. of Yunnan Province (China; Xing, 2012; You et al., 2014). The hind limbs obtained for the two largest tracks revealed the possible presence of large theropods, to date unknown in the Hettangian. They show some affinities with *Saltriovenator zanellai*, the earliest known ceratosaur recently described from Sinemurian marine deposits of Northern Italy (Dal Sasso et al., 2018).
The Laurasian affinity of the Lavini di Marco ichnoassemblage provides a reliable palaeobiological constraint on the Alpine sector in Early Jurassic times. The geological features of this domain reveal several Hettangian-Sinemurian stratigraphical gaps, due to erosion of emerged deposits. According to this new palaeogeographical framework, during the Early Jurassic the Trento carbona-

te platform was probably a distal sector of a peninsular land. Within this restoration, the Western Lombardian sector (Varesotto, Cusio-Biella-Canavese zone), the Briançonnais and the Western Tauern (North-Eastern Alps) acted as possible land bridge with the Laurasian mainland.

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The Last Glacial Maximum along the western Iberian Margin: preliminary high resolution paleoceanographic and paleoclimatic analyses

Carmen Argenio[1], José-Abel Flores[2] & Filomena Ornella Amore[1]

[1] Dipartimento di Scienze e Tecnologie, Università del Sannio, Via dei Mulini - 82100 Benevento, Italy. carmen.argenio@unisannio.it; f.amore@unisannio.it

[2] Departamento de Geologìa, Universidad de Salamanca, Plaza de los Caidos - 37008 Salamanca, Spain. flores@usal.es

During the past 25,000 years, the Earth system has undergone a series of dramatic climate transitions. The most recent glacial period peaked at about 21,000 years ago during the Last Glacial Maximum. Deciphering the evolution of global climate from the end of the Last Glacial Maximum (approximately 19 kyr) to the early Holocene (11 kyr) presents an outstanding opportunity for understanding the transient response of Earth's climate system to external and internal forcing (Clark et al., 2012). This study will provide high resolution paleoceanographic and paleoclimatic analyses focused on the coccolithophore assemblages off the Iberian Margin in a timeframe between 25 and 10 Kyr.

The Iberian Margin (IM) is a key area for climate's variability studies. Modern hydrographic conditions in the area are influenced by the Portugal Current (PC) system (Pérez et al., 2001; Relvas et al., 2007), whose seasonality is driven by migrations of the semi-permanent subtropical Azores High (AH) pressure system (Coelho et al., 2002). During summer, the northward displacement of the AH causes an intensification of westerly winds and subsequently equatorward transport by the PC and upwelling of cold, less salty and nutrient-rich waters (Coelho et al., 2002; Relvas et al., 2007). During winter the AH moves southward and the predominant westerly winds become weak or even reversed, and a warm, salty and nutrient-poor surface current – the Iberian Poleward Current (IPC) – influences the area, probably connected to a northward recirculation of the Azores Current (AzC; Coelho et al., 2002; Relvas et al., 2007). The area also undergoes intra-seasonal oscillations mainly related to changes, during winter, of westerly wind prevalence, induced by the North Atlantic Oscillation (NAO; Trigo et al., 2004). The NAO is defined as the difference between the normalized mean winter (December–March) sea-level pressure anomalies between the AH and Icelandic Low (Hurrell, 1995). During NAO positive anomalies dry conditions occurred over Iberia (Hurrell, 1995) associated with enhanced upwelling (Lebreiro et al., 2006), induced by intensification of westerly winds (Bartels-Jónsdóttir et al., 2006); while NAO negative anomalies occur during periods of IPC prevalence conditions over the area (Sánchez et al., 2007) and weakness of westerlies (Visbeck et al., 2001).

This study will be conducted through the analysis of about 200 samples from the IM. Samples will be analysed and prepared following the methodology illustrated in Flores and Sierro (1997).

Qualitative and quantitative analysis at high/very high resolution will be performed. For quantitative analyses, a minimum of 300 coccoliths will be counted per slide in a varying number of visual fields using a light microscope at 1000x magnification. This will allow a 95% level of confidence to be reached for all species present in at least 1% abundance (Patterson and Fishbein, 1989). In addition, following Buzas (1990), we will refer to species with abundances of less than 1% whose presence is significant from a paleoceanographic point of view. Absolute abundance (coccoliths per gram of sediment) and nannofossil accumulation rate (NAR; coccoliths cm-2 ka-1) will be estimated following Flores and Sierro (1997). Subsequently, to understand variations in the abundances of coccoliths, mathematical and statistical analysis (principal component analysis and wavelet analysis), an integration with isotopic and biogeochemical data and a comparison with other proxies will be carried out. Furthermore, c-calcite system and AMS (Accelerator Mass Spectrometry) data will be acquired in collaboration with the Grupo de Geociencias Oceanica – Universidad de Salamanca.

Coccolithophores, haptophyte algae living in the photic zone, are considered important indicators of environmental conditions and therefore useful paleoceanographic and paleoclimatic proxies. They are characterized by having a cell-wall covering, named coccosphere, composed by many calcified scales known as coccoliths. When the cell dies coccoliths leave the cell and precipitate to the bottom where, by fossilization, they will form calcareous deposits (Steinmetz, 1994).

Coccolithophores are sensitive to some environmental parameters as temperature, salinity, availability of nutrients and sunlight. Palumbo et al. (2019) identified coccolithophore taxa or group of taxa which, thanks to their ecological sensitivity to specific marine environmental factors, are good indicators for the main surface-ocean currents characterizing the Portugal Current System (Tab.1).

The biogeographic distribution of coccolithophores changed in response to environmental changes and for this reason they are considered to be a proxy to study the climate system's variability. Through coccoliths counting, it will be possible to ensue the evolution of abundance variability of most significative species in coccolithophore assemblages. This is necessary to understand the paleoclimatic and paleogeographic context in the studied temporal range.

Paleodays 2019

La Società Paleontologica Italiana a Benevento e Pietraroja

Parte 1: Volume dei riassunti

XIX Riunione annuale SPI
Ente GeoPaleontologico di Pietraroja
(21)22-24(25) Maggio 2019

a cura di Rook L. & Pandolfi L.

Paleodays 2019. La Società Paleontologica Italiana a Benevento e Pietraroja

XIX Riunione annuale della
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Progetto grafico logo di copertina
M. Repola, R. D'Uva

Rook L. & Pandolfi L. (a cura di) 2019. *Paleodays 2019. La Società Paleontologica Italiana a Benevento e Pietraroja. Parte 1: Volume dei riassunti della XIX Riunione annuale SPI (Società Paleontologica Italiana)*. 48 pp. Ente GeoPaleontologico di Pietraroja (Benevento).
ISBN ISBN 979-12-200-4867-5