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# 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  
Società Paleontologica Italiana  
Benevento/Pietraroja, (21)22-24(25) Maggio 2019**

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# **RIASSUNTI / ABSTRACTS**

## **Comunicazioni orali**

## Biomineral organic fraction in brachiopod giants and implications for their lifestyle

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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

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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 Calcarei 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

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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<sup>-2</sup> ka<sup>-1</sup>) 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.



<b>Coccolithophore assemblages</b>	<b>Ecological preferences with main references</b>	<b>Surface Ocean Conditions Off Iberian Margin</b>
<i>U. sibogae</i>	Warm and oligotrophic surface waters	Iberian Poleward Current
<i>C. pelagicus ssp. pelagicus</i>	Cold surface waters related to subpolar front	Subpolar surface waters
small <i>Gephyrocapsa</i>	Nutrient-rich surface waters	Portugal Current
<i>C. pelagicus ssp. azorinus</i>	Warm surface waters transported by Azores Current	Azores Current
Sum of cold species ( <i>C. pelagicus pelagicus</i> ; <i>Gephyrocapsa muelleriae/margereli</i> ; <i>Emiliana huxleyi</i> > 4µm)	Cold and nutrient-poor surface waters	Waters with melting icebergs Cold surface waters

Tab.1 - Coccolithophore assemblages and their main ecological preferences (Palumbo et al., 2019 - modified)

This study started with analysis of bibliography and preliminary use of software analysis. Next steps will be sampling and sample preparation, preliminary analysis of abundance variations of useful species and statistical analysis.

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## Prima filogenesi del genere *Nyctereutes* (Canidae, Carnivora): conferme e implicazioni

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Il cane procione, *Nyctereutes procyonoides* (Gray, 1834), è un canide di piccola taglia originario dell'Asia orientale e Giappone, diffusosi anche in Europa centro-orientale in seguito a introduzioni. La tassonomia di questo canide e le sue affinità filogenetiche rispetto ad altri membri della stessa famiglia sono state una fonte di dibattito scientifico. Ad esempio, recenti analisi cromosomiche suggeriscono la possibilità di separare le popolazioni del Giappone da quelle del continente in una specie diversa, *N. viverrinus*. Inoltre, sebbene filogenesi morfologiche basate su campioni attuali indicavano possibili relazioni tra *Nyctereutes* ed alcuni canidi sudamericani, p.e. *Cerdocyon* Hamilton-Smith, 1839, analisi filogenetiche molecolari supportano l'inclusione del cane procione all'interno della tribù Vulpini, insieme ai generi *Otocyon* e *Vulpes*. Dal punto di vista paleontologico, la limitata diversità specifica e l'espansione areale odierna non trovano riscontro nel record fossile del genere, che di fatto testimonia una considerevole abbondanza di specie Plio-Pleistoceniche presenti in tutta l'Eurasia e in Africa.

La presente ricerca riporta la prima analisi di massima parsimonia condotta su specie attuali e fossili del genere *Nyctereutes* basata su un dataset composto da 115 caratteri craniali, dentognatici, cerebrali e postcraniali selezionati ad hoc ed analizzati con il

software freeware TNT v. 1.5.

L'albero di consenso stretto ottenuto da tale analisi, ben supportato come dimostrano test con metodologie di bootstrap e decay (Bremer) index, mostra la presenza di due cladi: il primo composto da due specie africane, *Nyctereutes lockwoodi* Geraads et al., 2010 e *Nyctereutes terblanchei* (Broom, 1948), e un secondo dal problematico taxon da Laetoli, *Nyctereutes barryi* Werdelin & Dehgani, 2011, *Nyctereutes abdeslami* Geraads, 1997 dal Marocco e dalle specie fossili eurasiatiche. Da un lato, il pattern risultante conferma parzialmente alcune ipotesi precedenti, tuttavia, allo stesso tempo, l'albero di consenso stretto mostra numerosi rapporti filogenetici inattesi rivelando possibili relazioni sottovalutate e/o non considerate finora. Una delle principali implicazioni derivanti dall'analisi riguarda lo sviluppo di due modelli alternativi di dispersione degli antenati del genere dal Nord America (luogo di origine dei Caninae) nel Vecchio Mondo.

Infine, l'analisi rivela la peculiarità del *Nyctereutes* di Çalta (Turchia), che risulta piuttosto derivato ed affine a *N. megamastoides* nonostante provenga da un contesto cronologico relativamente antico per il genere (Pliocene inferiore, ca. 4.0 Ma).

## Holocene climate variability of the Western Mediterranean: surface water dynamic inferred from calcareous plankton assemblages

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The Holocene experienced a pervasive short-term climate variability, whose forcing mechanisms as well as its periodicity are still under debate. In this framework, the Western Mediterranean represents a key area to the understanding of past ocean-atmosphere connections and climatic interactions with the North Atlantic region (e.g. Cacho et al., 1999; Sierro et al., 2005). Accordingly, we performed an investigation of the calcareous plankton assemblages at the Ocean Drilling Program Site 976, from the Alboran Sea, with a centennial-scale temporal resolution during the last 12500 years. The coccolithophore and planktonic foraminifera assemblages are compared with available geochemical and pollen data in order to unravel climate-induced oceanographic changes affecting productivity variations and surface water dynamic. In addition, foraminiferal Surface Water Temperatures (SSTs) are also estimated using the modern analog technique SIMMAX 28. The results point out to three long-term assemblage variations tracing the main climate shifts occurring during the Holocene: 1) the increase in abundance of *Syracosphaera histrica* and *Turborotalia quinqueloba* marks the early Holocene humid phase, during maximum summer insolation; 2) the abrupt rise in *Florisphaera profunda* and *Globorotalia inflata* abundances, occurring at ca. 8 ka indicates the development of the modern geostrophic front, the establishment of the Western Atlantic Gyre (WAG) and of a deep nutricline in the Alboran Sea following the sea level rise; 3) the increase of small *Gephyrocapsa* and *Globigerina bulloides* observed at about 5 ka, suggests enhanced nutrient availability in surface waters, likely related to a more persistence and intense wind-induced upwelling, associated with a decreased summer SST. Superimposed on Holocene long-term trends a millennial-scale variability is detected in coccolithophore productivity since the gyre establishment in the last 8 ka. The comparison of productivity changes, expressed as Nannofossil Accumulation Rate (NAR), with oceanographic and atmospheric proxies points out that short-term coccolithophore productivity oscillations were strongly affected by variations in Atlantic surface water inflow, likely in phase with deep water formation in the Western Mediterranean, modulated by North Atlantic Oscillation (NAO). Wavelet analysis on NAR also indicates a shift in the periodicity of the millennial-scale variability in the investigated time frame, highlighting the occurrence of different forcing factors on coccolithophore productivity through the Holocene.

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## Towards a model for the genesis of the Pisco Formation Lagerstätte (Neogene, southern Peru)

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The middle Miocene to Pliocene Pisco Formation of southern Peru is an extraordinary example of marine Fossil-Lagerstätte, i.e., a sedimentary deposit characterized by both an exceptional conservation state (= Konservat-Lagerstätte) and an exceptional concentration (= Konzentrat-Lagerstätte) of fossils, in this case represented by marine vertebrates (including sharks and bony fish, marine turtles and crocodiles, seabirds, baleen and toothed whales, seals, and marine sloths).

With the aim of better understanding this remarkable fossil assemblage and the peculiar causes that led to its genesis and preservation, during the last five years we carried out a multidisciplinary and interdisciplinary research involving various fields of paleontology and, more generally, geosciences.

More specifically, our research activity provided the following results:

- detailed geological maps of the investigated areas (Di Celma et al. 2016a, 2016b)
- integrated biostratigraphic and tephrochronologic analyses resulting in accurate high-resolution dating of the whole fossiliferous sequence (Gariboldi et al. 2017; Bosio et al. 2019)
- a detailed census of the fossils of marine vertebrates exposed in the investigated areas achieved by reporting their vertical and horizontal distribution and first-order taphonomic information on detailed topographic/geological maps and by evaluating quantitative changes in both concentration and diversity (Bianucci et al. 2016a, 2016b);
- taphonomic studies on peculiar fossils characterized by an exceptional conservation state, such as two mysticete skeletons with preserved baleen (Gioncada et al. 2016; Marx et al. 2017) and an exquisitely preserved small dolphin skeleton (Gioncada et al. 2018).

For investigating the causes of the genesis of this Lagerstätte, we carried out:

- an estimate of the sedimentation rates that excludes previous hypotheses (Esperante et al. 2015) according to which the fossil accumulation was mainly due to rapid burial (Gariboldi et al. 2017);
- a rejection of the poisoning hypothesis (Esperante et al. 2015), with the possible exclusion of a few cases (Lambert et al. 2015);
- a detailed analysis of the nodules enclosing fossil vertebrates, which highlighted that this process can explain the conservation of many cetacean skeletons (Gariboldi et al. 2015).

Research is still in progress and more specifically: 1) we are investigating several fossils that suggest sinking of the carcasses into the sediment as a possible cause of conservation; 2) we are looking for proxies that indicate anoxic or suboxic conditions on the sea bottom, similar to what has been done in the underlying strata of the Chilcatay Formation (Bianucci et al. 2018); and 3) we are analyzing the relationships between the stratigraphic intervals of peak concentration of fossils and the reconstructed variations in primary productivity.

By putting together all these results we reconstruct a complex and dynamic model for explaining the genesis of this unique fossil assemblage, based on a combination of conditions accounting for temporal changes of the paleoenvironmental context as supported by the recognized changes in the sedimentation regime.

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## Coccolithophore response to environmental stress: a new perspective

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Coccolithophores are unicellular micro-algae which build around the cell an exoskeleton constituted by platelets ca. 5 µm long (called coccoliths) made of low-Mg calcite. Since their first occurrence in the oceans, these organisms have largely influenced either the oceans and the atmosphere since they both do photosynthesis and calcification. Over the last decades, a large number of studies were dedicated to a better understanding of the response of coccolithophores to environmental perturbations such as ocean acidification, altered concentrations of biolimiting elements and changes in surface water temperature. These studies highlighted how the biocalcification process is controlled by physical/chemical conditions of surface waters and that variations of single parameters can have a dramatic effect on some coccolithophores species. Since the failure of coccolithophores would have a large impact on marine biota and global CO<sub>2</sub> budget, it is important to expand our knowledge regarding the regulating mechanisms of calcification. This could improve the use of coccoliths as paleoenvironmental tracers and, consequently, it could implement the information necessary to predict present-day ocean/atmosphere system evolution. New insights can be achieved via the investigation of single coccolith properties, such as the size, the isotopic composition and the mineralogy. For example, very little is known about coccolith chemical composition and element incorporation mechanisms under different environmental conditions. In this work we selected coccolith specimens from three culturing experiments conducted under "normal" and "trace metal excess" conditions and performed an X-ray fluorescence (XRF) study at Synchrotron (ESRF) of isolated specimens of coccoliths to gain their chemical composition. Maps of single elements were obtained at high resolution (50nm<sup>2</sup>) and allowed not only to detect the presence/absence of the elements but also to observe the elemental distribution in the coccoliths. This approach opens new perspectives for the research studies on coccolithophores.

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## Le biocostruzioni ad alghe rosse calcaree nei terrazzi marini pleistocenici di Capo Rizzuto (KR): similitudini e peculiarità

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La penisola di Crotona rappresenta un laboratorio geologico eccezionale dove affiorano numerosi terrazzi marini che coprono tutto il Pleistocene medio e superiore e che hanno permesso di studiare nel dettaglio i sedimenti che si sono accumulati lungo le paleo-piattaforme continentali. La peculiarità di questi depositi è l'abbondanza di fondi mobili e duri dominati da alghe rosse calcaree. Questa area rappresenta un luogo strategico dove acquisire e interpretare le informazioni paleoecologiche derivanti dallo studio di questi depositi biogenici, nonché la loro risposta alle variazioni eustatiche del livello marino. La geomorfologia dei depositi, la loro distribuzione lungo la paleo-piattaforma e le loro relazioni geometriche e stratigrafiche, la paleogeografia, il substrato, le forme di crescita e l'identificazione specifica dei biocostruttori sono tutti elementi che permettono di dettagliare contesti paleoclimatici simili ma non eguali a quello attuale.

A seguito di numerosi studi effettuati su questi terrazzi (Cutro MIS7 o 9, Capo Colonna MIS 5c o 5a, Le Castella MIS 3), questo lavoro vuole presentare una sintesi di tutte le peculiarità rilevate in questi eccezionali affioramenti, aggiungendo nuovi dettagli su depositi finora non ancora debitamente approfonditi (Campolongo MIS 5e, Torre Brasolo MIS 5c).

Il coralligeno è stato rilevato in tutti i terrazzi. Talvolta si tratta di esempi fossili di coralligeno di plateau su fondo a rodoliti (Cutro, Capo Colonna). Talvolta invece sono biocostruzioni cresciute su altri tipi di substrati comunque mobili: conglomerato basale (in tutti i terrazzi), accumuli conchigliari a Le Castella. Tutti mostrano una geometria sub-orizzontale. Dal punto di vista geomorfologico, solo il terrazzo di Capo Colonna è caratterizzato da rilievi tabulari, mentre in tutti gli altri casi si tratta di rilievi discreti, più o meno isolati. Le dimensioni massime di questi rilievi discreti però sono variabili, da un minimo di qualche decimetro (Le Castella, Capo Colonna) fino a 2 metri (Cutro, Torre Brasolo), cosa poco nota nel Mediterraneo attuale.

Inoltre, riflettono paleocontesti geografici differenti. A Le Castella corrispondono ad una zona protetta a scarso idrodinamismo. A Capo Colonna formano sia gli affioramenti prossimali, corrispondenti quindi in termini di paleogeografia ad aree di acque basse in cui potevano mosaicarsi con altri habitat o dove c'è stato letteralmente meno tempo per svilupparsi durante il ciclo eustatico, sia quelli distali formati invece in un paleoambiente francamente circalitorale. La densità del *framework*, le specie biocostruttrici dominanti e le loro forme di crescita sono risultate essere elementi discriminanti tra i vari terrazzi. *Framework* aperti con abbondanza di matrice fangosa caratterizzano paleoambienti a basso idrodinamismo (Le Castella) o i rilievi tabulari (Capo Colonna), mentre *framework* densi sono indicati per gli affioramenti prossimali e distali di Capo Colonna. *Titanoderma pustulatum* (J.V.Lamouroux) Nägeli in Nägeli & Cramer, 1858, raramente segnalato come biocostruttore primario, domina le biocostruzioni del terrazzo di Cutro ed è abbondante anche a Le Castella. È associato a contesti in cui si ha elevato apporto di fango che si traduce in abbondante matrice nei depositi studiati. La sua forma di crescita (warty) rimane la medesima. A Capo Colonna sono abbondanti *Mesophyllum alternans* (Foslie) Cabioch & M.L. Mendoza, 1998 e *Lithophyllum stictiformae* (Areschoug) Hauck, 1877: il rapporto di abbondanza tra i due è stato usato come indicatore di paleobatimetria, attribuendo rispettivamente al primo ambienti più superficiali e al secondo più profondi. In realtà, questo concetto è oggi in forte revisione. Sicuramente queste abbondanze accomunano le biocostruzioni

fossili a quelle attuali dove molto abbondanti sono le specie riportate.

Le alghe calcaree formano inoltre substrati mobili sotto forma di letti a rodoliti. Esse sono riportate sia nel terrazzo di Cutro, sia nel terrazzo di Capo Colonna. In entrambi i casi fungono da substrato mobile di biocostruzioni algali (coralligeno di plateau). Nel terrazzo di Cutro, costituiscono due generazioni di pralines sferoidali dominate da *Sporolithon ptychoides* Heydrich, 1897 (le più abrase, trasportate) e *T. pustulatum* (le meglio conservate), accumulate insieme. Entrambi i casi rappresentano segnalazioni importanti. Il genere *Sporolithon*, infatti, è raro nel Mediterraneo ed è considerato tipico di acque calde. Il genere *Titanoderma* è raramente segnalato come biocostruttore principale di fondi a rodoliti, ma in questo caso tale segnalazione ben si confà alla presenza di relativa abbondante matrice fangosa. Rodoliti dello stesso morfotipo sono riportate anche a Capo Colonna, dove però sono biocostruite da *Lithothamnion* spp. in un paleoambiente infralitorale. Diverso il letto a maerl della porzione distale, sempre a Capo Colonna, multi-specifico come i letti a maerl del Mediterraneo attuale, e corrispondente alla facies più profonda rilevata nei depositi di questo terrazzo. Proprio in corrispondenza della sezione più distale del terrazzo di Capo Colonna, si apprezza la successione ecologica da fondi a rodoliti a concrezionamento biogenico (coralligeno), ad annegamento da parte dei sedimenti della biocostruzione stessa, come osservato nel terrazzo di Cutro.

L'individuazione e la definizione dei dettagli geomorfologici, sedimentologici e paleontologici associati alle facies dominate da alghe rosse calcaree, sviluppati in paleocontesti relativamente simili, hanno permesso invece di evidenziare delle diversità e di dettagliare al meglio le variazioni incorse negli ambienti marini relativi al Pleistocene medio e superiore dell'area oggetto di studio.

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## Quando il mare inondava la terra emersa: cambiamenti vegetazionali, adattamenti ambientali e preservazioni eccezionali nell'orizzonte a cuticole del Bletterbach (Alto Adige)

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Il Bletterbach, un sito geologico che si trova tra Aldino e Redagno in Alto Adige, è una delle località fossilifere del Permiano superiore più famose del mondo, visto che i suoi fossili hanno permesso la ricostruzione di un complesso ecosistema terrestre datato al Wuchiapingiano, da 259 a 254 milioni di anni fa. Dal punto di vista paleobotanico, sono due i livelli che interessano gli scienziati, il cosiddetto "livello a cuticola" e il "livello a macroflora", poco al di sopra ed al di sotto di un livello di innalzamento massimo del livello del mare. Per capire meglio l'effetto del cambiamento del livello del mare sulla vegetazione locale sono state studiate in dettaglio le cuticole disperse presenti all'interno del "livello a cuticola". L'orizzonte a cuticole è un sottile strato (circa 20 cm) di argillite ricco di frammenti di cuticole. L'analisi delle cuticole sciolte dal sedimento ha permesso di identificare circa 20 taxa di piante fossili diverse, tra forme già note dal Bletterbach ed altre nuove per il Sudalpino. Lo studio qualitativo e quantitativo ha permesso di ricostruire la composizione floristica dopo il massimo innalzamento del livello del mare, e di confrontarla con quella della vegetazione insediatasi prima dell'innalzamento del livello marino. Ha permesso anche di verificare se le piante hanno reagito con protezioni particolari (p. es. spessore, presenza di papille, stomi infossati, ecc.) al cambiamento delle condizioni ambientali. Last but not least, ci ha inoltre permesso di studiare frammenti ridotti di piante ed animali finora non riscontrare a livello fossilifero.

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## A dragonet (Teleostei) from the Eocene of Bolca, and a redefinition of the Callionymoidei

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Dragonets of the suborder Callionymoidei are small demersal fishes found in the upper 900 meters of all temperate, subtropical and tropical oceans of the world. Although these fishes are primarily marine, a few (euryhaline) species are known to enter and live in freshwaters.

Callionymoids have generally been considered notothenioid derivatives with a strong affinity with gobioid clingfishes (e.g., Gosline, 1970). Recent molecular studies, however, revealed a close relationship with goatfishes, flying gurnards and pegasid sea-moths within the syngnathiform clade (Longo et al., 2017).

The Callionymoidei comprises two families, Callionymidae and Draconettidae, with more than 200 extant species (Fricke, 2002). Dragonets are poorly represented in the fossil record. A few articulated skeletal remains are known from the Miocene of the Medi-

terranean and Paratethys, while otoliths are known from Eocene, Oligocene and Miocene deposits of Europe. A new callionymoid fish is presented based on a single diminutive specimen from the Lower Eocene (Ypresian) deposits of the Pesciara di Bolca, northern Italy. The specimen has a standard length of about 13 mm and is moderately well-preserved, in part and counterpart. The analysis of the skeletal anatomy of this specimen reveals a unique combination of derived and plesiomorphic features found in none of the extant callionymoids, which clearly separate it from both the Callionymidae and Draconettidae. The osteological structure of the neurocranium, jaws, suspensorium, opercular bones and caudal skeleton strongly support a sister-group relationship between the new Eocene dragonet from Bolca and the Callionymidae. Moreover, a comprehensive survey of the callionymoid anatomy allows a redefinition of the group based on osteological features. This new small-sized Eocene dragonet possibly had an epibenthic or cryptobenthic lifestyle in the complex and heterogeneous Pesciara paleobiotope, where it occupied sheltered and restricted microhabitats not available to the larger species.

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## Breaking the wall of deep-time macroecology

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Macroecology studies the distribution of species on Earth with the aim of finding large-scale ecological patterns. This discipline was born by focusing on living land and marine species although, recently, with the rise of very large paleontological databases, the study of fossils' macroecology is becoming even more appealing. The most important feature of a species to be estimated for macroecological aims is its geographic range but, unfortunately, the fossil record is too discontinuous in both space and time for accurate estimations, mainly due to taphonomic biases. Despite a great leap forward was made in neontological studies for estimating species' spatial distribution by means of Machine Learning Algorithms, actually all the attempts of reconstructing fossil species geographic ranges make use of polygon-based methods, which simply identify the polygon enclosing all the fossil localities where a species occurred. The most advanced algorithms, instead, need global maps of environmental variables for a species' geographic range computation, thus preventing their use with the fossil record for which the climate of the past is not available. Here, we introduce MlnOSSE, a new method based upon the last and most powerful Machine Learning Algorithm to estimate fossil species geographic ranges. This method works even in the absence of environmental variables, thus allowing species geographic range reconstruction for any kind of fossil record, regardless of the considered temporal interval. MlnOSSE performance was measured by comparing its output with the known geographic ranges of an artificial fossil record properly simulated in order to mimic the complexity of the actual fossil species' spatial and temporal features. MlnOSSE provided more realistic geographic range reconstructions as compared to traditional polygon-based methods. Some land and marine case studies are analysed to show MlnOSSE power and its ease of use. Machine Learning Algorithms are changing the way we use information and it is time to introduce big-data analysis to Paleontology. MlnOSSE can really "boost" paleontological research by allowing macroecological hypotheses testing even with deep-time fossil record.

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## The suid record from Vallparadís Section (NE Iberian Peninsula) and the post-Jaramillo persistence of *Sus strozii* in Europe

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The Vallparadís composite section includes the paleontological sites of Cal Guardiola and Vallparadís Estació, respectively located in the western and eastern bank of the Torrent de Vallparadís (Terrassa, Catalonia, NE Spain). The Vallparadís section spans from



before the Jaramillo subchron to the early Middle Pleistocene (ca. 1.2–0.6 Ma). It includes more than ten layers from which about 30,000 well-preserved large mammal remains have been recovered.

In this study, we describe the suid record from Vallparadís Section. This sample, although relatively small when compared with those of other large mammals from the same site (e.g., hippo or deer), includes a nearly complete skull, several teeth, and postcranial elements, and stands out as the richest European suid collection from the late Early Pleistocene. Suid remains have been discovered from both Cal Guardiola and Vallparadís Estació layers, whose age spans from the Jaramillo subchron (ca. 1.07–0.99 Ma; layer EVT12) to post-Jaramillo time (ca. 0.99–0.78 Ma; layers CGRD7 and EVT7).

Several cranial morphological features of the studied sample support an attribution to *Sus strozzi* Forsyth Major, 1881, although the Vallparadís Section suid falls in the lower dimensional range of Early Pleistocene *S. strozzi*. These morphological features include a low and very deep preorbital fossa, a narrow nuchal crest, a well-developed longitudinal swelling in the mid of the mandibular corpus, the presence of styles/stylids in the upper/lower premolars, and especially the “verrucosic” morphology of the lower canine (labial and lingual sides of the tooth with similar length, and longer than the distal side). The attribution to *S. strozzi* is also supported by phylogenetic data.

These results open new interesting questions on the chronological occurrence of Quaternary suids. *Sus strozzi* is relatively common in Europe during the middle and early late Villafranchian (ca. 2.5–1.8 Ma), while it almost completely disappears during the latest Villafranchian (ca. 1.8–1.2 Ma) (only few isolated undeterminable suid teeth are available from Sima del Elefante in this time span). During and slightly after the Epivillafranchian (ca. 1.2–0.9 Ma), *S. strozzi* reappears in Europe although with relatively small samples, at Vallparadís Section and several other sites, whose record is reviewed in this study. These sites include Untermassfeld (Germany; ca. 1.0 Ma), Le Vallonnet (France; ca. 1.2–1.1 Ma), Taman Peninsula (Russia; ca. 1.1–0.8 Ma), Arda River (Italy; ca. 0.99 Ma), and probably Slivia (Italy; ca. 0.8 Ma).

Consequently, in contrast to what has been believed so far, we think that (1) *S. strozzi* survived in Europe (or returned there with a second dispersal event from Asia during the Epivillafranchian) at least until the end of the Early Pleistocene and (2) therefore the arrival of the wild boar *Sus scrofa* in our continent is not earlier than the Early-Middle Pleistocene boundary.

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## New Evidence on the Equidae from the Late Miocene of As Sahabi (MN13; Libya, North Africa)

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As Sahabi is a celebrated Libyan late Miocene vertebrate locality. The discovery of the site was made by Rome palaeontologist, Carlo Petrocchi, in the first half of the 20th century (Petrocchi, 1951; Rook, 2008). The excavations and expeditions in the area have recovered over than 5500 fossil vertebrates from 94 vertebrate localities of the Late Miocene age (MN13; Boaz et al., 2008a).

Among the Equidae, the latest report (Bernor et al., 2008) suggested the occurrence of four species of Hipparion: *Sivalhippus* sp., *Eurygnathohippus feibeli*, *Cremohipparion matthewi* and *Cremohipparion periafricanum* (Bernor et al., 2008; Bernor et al., 2012).

A recent study on the complete fossil collection housed in Laboratory of Evolutionary Biology, Howard University, Washington D.C. (USA) carried out a revised taxonomic identification of the fossil specimens, confirming and sharing new insights on the Sahabi Hipparion assemblage.

A statistical analysis has verified that the large form is best referred to *Sivalhippus* sp., comparing most closely to *Sivalhippus perimensis* (Potwar Plateau, Pakistan) and *Sivalhippus turkanensis* (Lothagam, Kenya). The evidence of this last species supports the biogeographic connection between Sahabi and East Africa, as proposed by Bernor et al. (2012).

Most of the sample has been identified as being referable to *Eurygnathohippus feibeli*, a medium size form represented by several dental and postcranial features on the fossil specimens: ectostylids occasionally on the lower cheek teeth accompanied by more common pli caballinid and the medium size of the postcranial specimens.

A smaller species in the sample has been identified as best referable to *Cremohipparion matthewi*: the small, gracile morphology of several metapodials and other postcranial specimens confirm the presence of this species supported by a few isolated upper and lower teeth. Bernor et al. (2008) identified a few tiny Hipparion specimens as being referable to *Cremohipparion periafricanum*, suggesting a correlation between Sahabi and other Mediterranean latest Miocene localities, in particular Tizi N'Tadderht, Morocco (Cirilli et al., in review).

These new data on the Sahabi Hipparion assemblage confirm the paleobiogeography linkage of Sahabi between the East Africa Lothagam (Kenya) and Middle Awash (Ethiopia), and the Mediterranean Late Miocene localities, replaced that Sahabi represent a true crossroads fauna between Europe and Africa.

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## The unexpectedly complex Quaternary history of the Mediterranean baleen whale fauna

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The present-day baleen whale (Mysticeti) fauna of the Mediterranean is a subset of that of the North Atlantic. Only one species, the fin whale *Balaenoptera physalus*, regularly occurs here, with other mysticetes being just occasional visitors. This depauperate state of the local fauna is a relatively recent phenomenon. A rich Pliocene fossil record shows that several ecologically and morphologically disparate species, representing all of the extant families, once inhabited the waters off present-day Italy. The causes behind this marked difference have long remained obscure, mostly because of a lack of specimens from the intervening Pleistocene. Recent research efforts focusing on this poorly known period now reveal a surprisingly complex picture. Thus, the Mediterranean formerly contained coastal calving/breeding grounds shared by migratory balaenids and balaenopterids, and – surprisingly – was home the enigmatic pygmy right whale *Caperea*, which today is restricted to the Southern Hemisphere. Perhaps most strikingly, a blue whale (*Balaenoptera* cf. *musculus*) with an estimated body length of up to 26 m was recovered from the lower Pleistocene (ca. 1.5–1.25 Ma) marine mudstones of San Giuliano (Matera province, Basilicata region, southern Italy). The Matera specimen is the largest whale fossil ever reported, and sheds new light on the origin mysticete gigantism. Here, we review the Quaternary history of Mediterranean baleen whales, and try to explain how major climatic, oceanographic, and evolutionary change over the past three million years culminated in the depauperate fauna of today.

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## The first occurrence of *Arctica islandica* in the Mediterranean Sea: new data from the lower Pleistocene western Emilia successions (Italy)

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The first occurrence of *Arctica islandica* in the Mediterranean Sea has an historical importance, as in the past it was used as one of the main criteria to mark the former Pliocene-Pleistocene boundary. However, the age of this bioevent was never well constrained. The Arda and Stirone marine successions (Northern Italy) represent key-sections for the early Pleistocene, as they deposited continuously within a frame of climate change, recording the Calabrian cooling as testified by the occurrence of “northern guests”, such as the bivalve *A. islandica*.

Here, we describe the Stirone depositional environment and constrain for the first time the age of the section using calcareous nannofossil and foraminifera biostratigraphy; we correlate the Arda and Stirone sections, complementing biostratigraphic and magnetostratigraphic data available from the literature. Finally, we map the occurrence of lower Pleistocene outcrops with *A. islandica* in the Mediterranean Sea and calibrate the first occurrence of this taxon.

Our results indicate that *A. islandica* first occurred in both the sections, slightly below the top of the nannofossil CNPL7 biozone (dated at 1.71 Ma). The comparison with other lower Pleistocene Mediterranean marine successions indicates that the lowest recorded occurrence of *A. islandica* in the Mediterranean Sea is in the Arda and Stirone sections; the paleoenvironmental conditions present in this region satisfy the ecological requirements for the establishment and the proliferation of the species, which only subsequently has been retrieved in southern Italy and other areas of the Mediterranean Sea.



## Dinosaurs in Italy: from *Scipionyx* to *Saltriovenator*

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During the last three decades, a series exceptional finds has revealed that the “terrible lizards” walked and left their bones even in our country (e.g., Dal Sasso, 2003, 2004). Besides several tracksites, mostly referable to Early Jurassic and Cretaceous times, at least four skeletal remains are known. The first Italian dinosaur was found in 1980 but officially named 18 years later (Dal Sasso & Signore, 1998), and represents by far the most important one: *Scipionyx samniticus* is a striking specimen, preserving soft tissues never seen in any dinosaur (Dal Sasso & Maganuco, 2011), which still represents a unique in the fossil record (for a more complete account, see the specific section devoted to it in this volume). Remains of a second – but much larger – theropod were found in 1996 in the Saltrio Formation (Sinemurian, lowermost Jurassic) of Lombardy. Informally named “saltriosaur”, the specimen was finally described last year (Dal Sasso et al., 2018) as *Saltriovenator zanellai*. It shows a mosaic of features seen in four-fingered theropods and in basal tetanurans, supporting sister taxon relationships with the younger Early Jurassic *Berberosaurus* from Morocco, in a lineage which is the basalmost of Ceratosauria. With an estimated body length of 7.5 m, *Saltriovenator* is the world’s largest and most robust theropod from the Early Jurassic, pre-dating the occurrence of a body mass approaching 1,000 Kg by over 25 My. Moreover, compared to the atrophied hand of later Ceratosauria, *Saltriovenator* demonstrates that a fully functional hand, well-adapted for struggling and grasping, was primitively present.



Fig. 1 - Skeletal reconstruction of *Saltriovenator zanellai*, made by comparing the shape and proportions of the known elements with those of more complete skeletons of related species. For scale is Mr. A. Zanella (1.67 m tall), who found the dinosaur named after him. Credit: M. Auditore

In the same year (1996), ornithischian bones and two nearly complete skeletons were uncovered in the Liburnian Formation (uppermost Cretaceous) of Villaggio del Pescatore (Trieste). Described as *Tethyshadros insularis* (Dalla Vecchia, 2009), the best preserved specimen shows to be a hadrosauroid phylogenetically close to, but outside the North American and Asiatic hadrosaurids. The skeleton has many peculiarities, including cursorial adaptations, and its small size suggests that it may be an insular dwarf. The first sauropod remains were identified ten years later (Dal Sasso et al., 2016) in Cretaceous (Aptian-Albian) deposits of Rocca di Cave (Rome). The most diagnostic bone is an anterior caudal vertebra, which shows a bizarre and unique “inverted” orientation of the zygapophyseal articular facets. Phylogenetic retrofitting tests support the placement of the Italian titanosaur among basal Lithostrotia; palaeobiogeographic analysis based on the resulting phyletic relationships suggests an Afro-Eurasian route for its ancestors.

All the Italian skeletal remains belong to brand new, possibly endemic dinosaur genera. Together with the footprints, these fossils come from marine coastal deposits, documenting a peculiar palaeobiogeographical situation. Similar to *Scipionyx*, “Tito” was member of a population that crossed the western Tethys Sea through a “filtering bridge” composed of a chain of ephemeral islands and peninsulae, known as Periadriatic carbonate platforms, that connected sporadically Africa and Europe since the Early Cretaceous.

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## Differential response of marine benthic communities to the early Toarcian extinction event (Iberian range, Spain)

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In the Early Jurassic (~183 Ma ago) global warming and associated environmental changes coincided with an extinction event in the marine realm (early Toarcian extinction event). Anoxia was previously considered to have been the main cause of extinction, but extinctions also occur at localities that remained oxygenated throughout the event, suggesting that other factors, such as temperature, may have played a major role. To test this hypothesis, we integrated quantitative analyses of benthic macro-invertebrates with high-resolution geochemical proxies on the bulk rock (TOC,  $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) and on brachiopod and belemnite shells ( $\delta^{13}\text{C}$ ,  $\delta^{18}\text{O}$ ) from two sections from the Iberian Range, Spain, with no black shale deposition. The study sites were selected because they record deposition at different water depths along an onshore-offshore gradient of the western Tethyan shelf, which enable us to better understand the role of sedimentary and stratigraphic processes on the distribution of fossils through the extinction event. The dominant benthic groups, bivalves and brachiopods, show a different response to the extinction: brachiopods go through a complete species-level turnover, while many bivalve species range through the event. In the shallower section, changes in richness and evenness correlate with TOC (Total Organic Carbon), suggesting that variations in nutrient input from runoff, and the possible local onset of low-redox conditions (TOC > 4 wt%), controlled faunal diversity. In contrast, at the deeper section, community change correlates with changes in  $\delta^{18}\text{O}$ , indicating that temperature variations might have influenced faunal change. Different stratigraphic patterns of extinction occur between the two localities, with last-occurrences clustering at the maximum flooding surface in the shallower section, and at the transgressive surface in the deeper one. The observed differences between the two localities highlight the important role of local sedimentary and stratigraphic processes in controlling the shape of the geochemical and fossil record, and the need for studying multiple sections along onshore-offshore gradients in order to extrapolate regional and global patterns.

## Morphometry and 3D analysis of oyster samples occurring in the Moravian Miocene Carpathian foredeep museum collections and outcrops, but belonging to the Vienna basin realm from geological point of view

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A study is carried out about systematic and morphometric analyses of Miocene oysters from Vienna Basin localities, preserved and stored in the Czech Museums of the Moravia Region (Vlastivědné muzeum v Olomouci and Muzeum a galerie v Prostějově, Czech Republic). The aim of the work is to compare the similarity of the Austrian and Czech samples from morphometric point of view and to highlight the differences of the morphometric characters in the samples coming from two apparently similar geological contexts but disconnected from the genetic and evolutionary point of view. The most common oyster species are characterized by *Crassostrea gryphoides* (Schlotheim, 1820), *Neopycnodonte navicularis* Brocchi 1814 and *Ostrea digitalina* (Eichwald, 1830). A morphometric analyses were performed in order to get oyster shell height (H), shell maximum length (W), hinge length (W1), distance between resilifer area and upper part of the muscle scar (H1), ventral length (W2), distance between lower part of the muscle scar and ventral margin (H2) and opening angle of the muscle scar ( $\alpha$ ). Further W/H, W1/H1 and W2/H2 ratios were calculated, through a regression analysis, showing a direct correlation (2nd degree polynomial function) among these parameters (usefulness proxy in the determination of the uncertain species); these analyses were conducted also for Pliocene specimens from Piedmont area of Valle Botto (NW, Italy). These proxies were performed on two different groups of samples, Austrian and Czech in order to get a different signal of dataset for every samples referable to Vienna Basin and to Moravian part of the Carpathian Foredeep. Comparing the same species of oyster (for example *Crassostrea gryphoides*, Fig. 1) we can observe a different relationship of the morphospace characterization in the two geological contexts; even if the ratio between the parameters seems to be the same



Fig.1 - *Crassostrea gryphoides* from Vienna Basin

for every species, it shows a different and typical signal for Moravian specimens. This allows us to affirm that within the Czech museum collections we can also identify the uncertain samples mixed with the similar in age specimen coming from other geological realms with different features, but with the same paleontological spread.

## Detecting biotic changes across environmental gradients using museum collections: Upper Miocene molluscs of Monti Livornesi (Tuscany, Italy)

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The upper Miocene mollusc assemblages of Monti Livornesi, used as a means to study the nature of Mediterranean benthic communities at the edge of the Messinian salinity crisis, are framed in a high-resolution stratigraphic scheme and quantitatively approached by the study of historical museum collections and novel samples, after a comparison to test for sampling bias. Instead of a single assemblage from either Tortonian or Messinian age, as previously thought, this fauna comes from three consecutive shallowing-upward depositional sequences bounded by regional unconformities, the Luppiano (upper Tortonian-lowermost Messinian), Rosignano and Raquese units (early Messinian; Fig. 1).

Facies analysis, taphonomy and quantitative paleoecology show that the Luppiano assemblage is characterised by aragonitic species from a eutrophic brackish-water shallow marine muddy bottom, the Rosignano assemblage by calcitic species from an oligotrophic coarse-grained seafloor close to a coral reef and the Raquese assemblage from an open-marine muddy bottom. Published comparisons between Miocene and Pliocene faunal lists should be considered only crude estimates of faunal change until more is known about the distribution of species along paleoenvironmental gradients. The analysis of Miocene and Pliocene abundance data allows to frame the Monti Livornesi molluscs along carbonate-siliciclastic and water depth gradients existing at the time of shell bed formation (Fig. 2) and to move forward a better understanding of the effects of environmental deterioration on the Mediterranean biota.

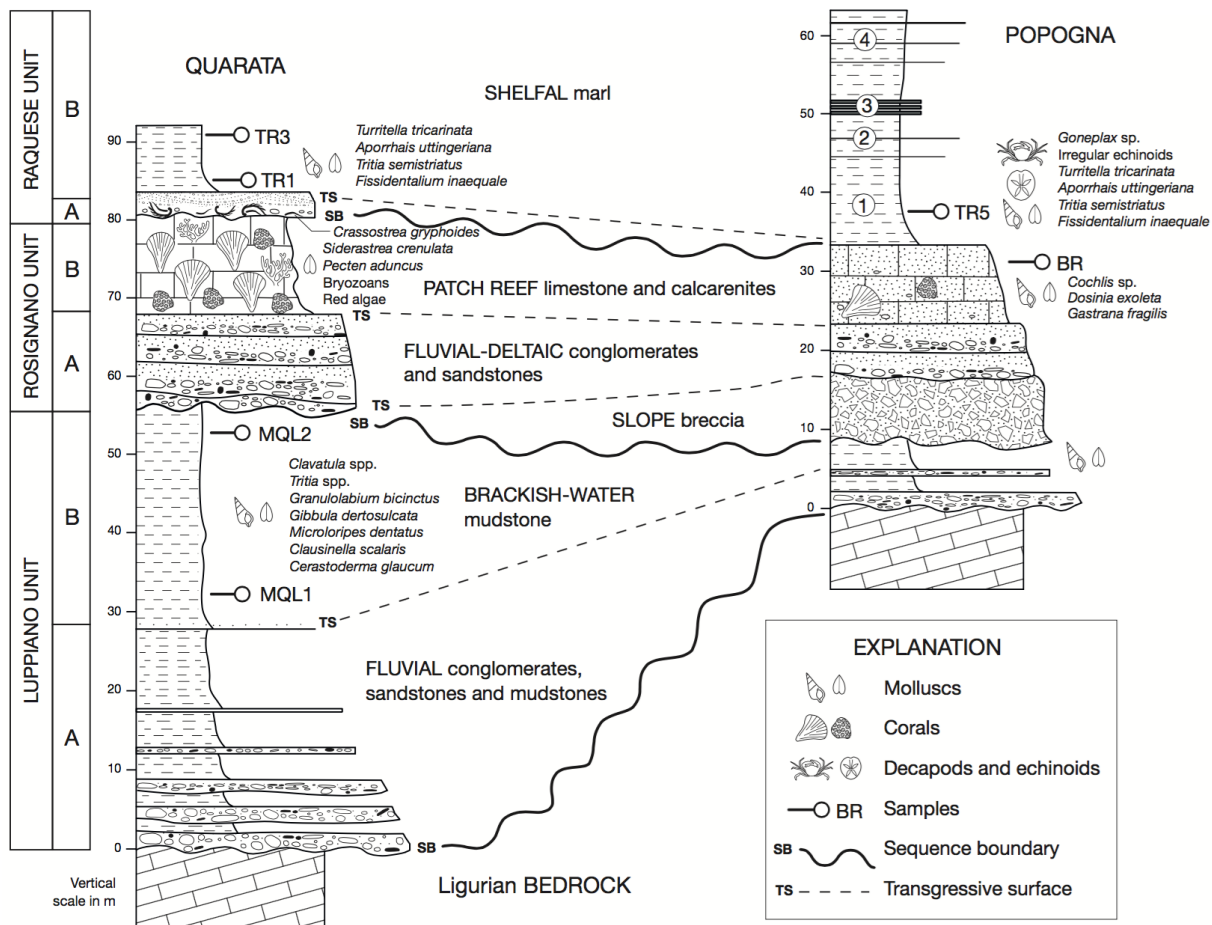


Fig. 1 - Stratigraphic scheme of the Monti Livornesi upper Miocene in the Quarata and Popogna areas with position of novel samples

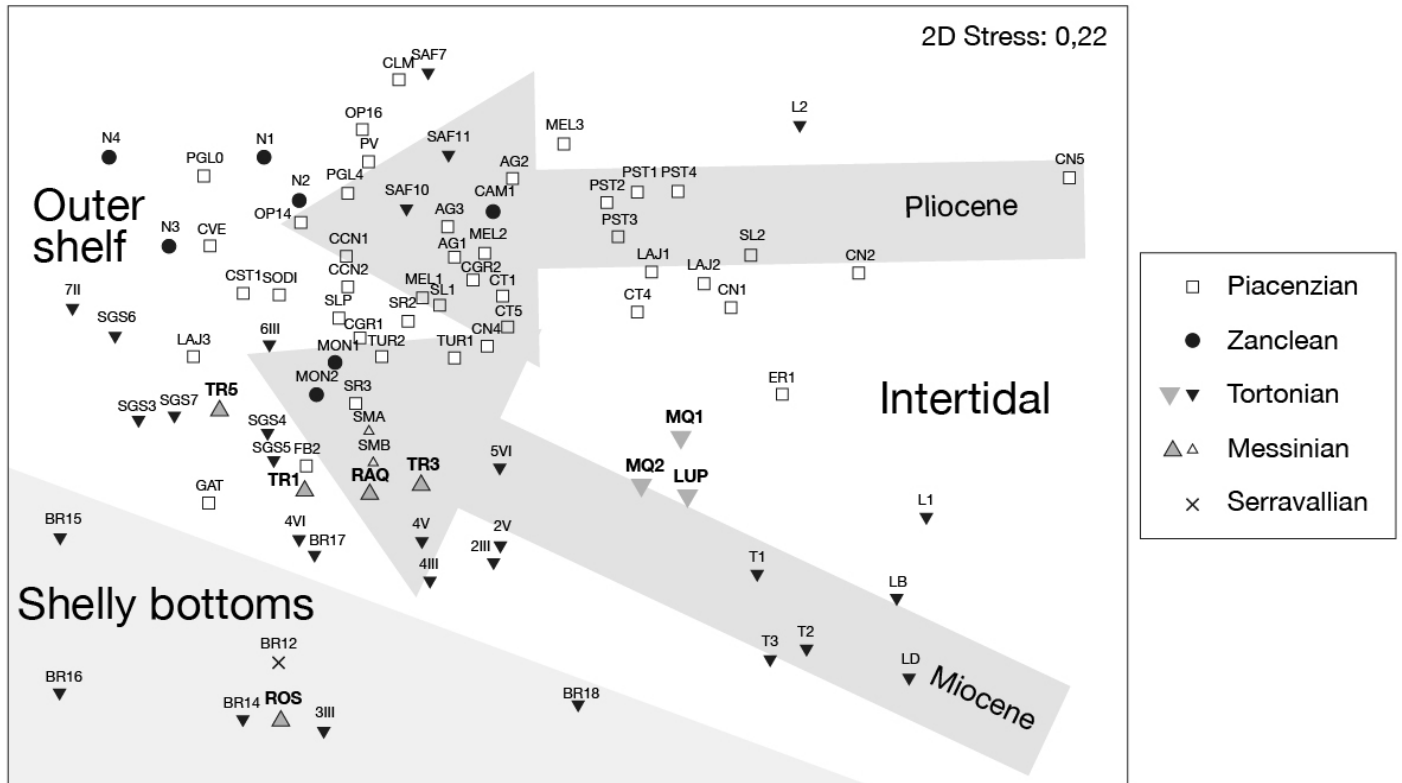


Fig. 2 - Non-Metric Multidimensional Scaling (MDS) ordination of 93 Miocene and Pliocene samples, subdivided per stage, based on the distribution of abundances of mollusc genera. Monti Livornesi historical museum collections and modern samples shown in bold characters and larger triangles. The main axis of the ordination shows the presence of a bathymetric gradient, deepening from right to left. Samples from coarse-grained shelly bottoms occupy the lower left corner of the ordination. Samples from siliciclastic bottoms are ordered following an upper Miocene and a Pliocene gradient. Differences in abundance distributions among Miocene and Pliocene communities are relevant only for onshore communities, not for those offshore

## Deciphering ocean features and climate history from the Paleogene to the present day by using calcareous nannofossils

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Calcareous nannofossils, and by extension coccolithophores, constitute a group commonly used in the paleoenvironmental reconstruction of the Ocean characteristics. As cosmopolitan, widely represented in the current oceans and with associations and taxa affected by environmental parameters, such as temperature, salinity or nutrient concentration, its analysis allows obtaining information about the conditions in which they were developed.

On this occasion some research cases carried out essentially in the ODP and IODP programs are shown, covering a wide latitudinal range.

The combination of micropaleontological with other biogeochemical data permits to reconstruct the position of the CCD and or the distance of the ice-sea in the Eocene-Oligocene. Associations of indicators of eutrophy/oligotrophy, have allowed to reconstruct sequences of climatic alternation at orbital scale in basins of the western Mediterranean. In the equatorial Pacific a proxy has been developed for the reconstruction of paleo-ENSO and the monitoring of the thermocline at millennial scale during the Pleistocene.

On the other hand, some examples taking into account statistical techniques and image analysis are used to quantify the effects of overgrowth or dissolution, and how it can be correlated with parameters such as CO<sub>2</sub> concentration in the past.

In a changing planet provoked by human activities, the study of scenarios from the past that approach those that are taking place today, constitutes a valuable tool, and the calcareous nannofossils are a fundamental part to approach this knowledge.



## Lopingian (late Permian) conifers from Bletterbach (Dolomites, NE-Italy): morphometric range and $\delta^{13}\text{C}$ signature

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Conifers are the most successful group among the Permian gymnosperms. They originated during the late Carboniferous (Pennsylvanian) when their first representatives, the walchian Voltziales, were small trees with a regular branching system and narrow triangular to needle-like leaves. More derived conifers, the voltzian Voltziales, were better adapted to seasonally dry environments than their ancestors and became dominant in the Euramerican floras during the late Permian (Lopingian). The Bletterbach (NE Italy) flora is one of the most diverse and best documented late Permian (Lopingian) floras and includes several plant groups such as sphenophytes, seed ferns, putative cycadophytes, ginkgophytes and conifers. The latter are the most diversified and the dominant plant group of the flora, including five genera (i.e. *Ortiseia*, *Majonica*, *Dolomitia*, *Pseudovoltzia* and *Quadrocladus*) and at least eight species, three of which (*Pseudovoltzia sjerpii*, *Quadrocladus solmsii* and *Quadrocladus* sp. cf. *Q. orobiformis*) recorded for the first time from the Bletterbach. The exceptional preservation of the macroremains and cuticles enabled detailed morphometrical analyses; taxon-specific carbon stable isotopic analyses were carried out on cuticles and coalified tissues collected from the best 50 shoot fragments of the Bletterbach conifers. The combination of morphometric and taxon-specific geochemical analyses is here applied for the first time. Both the morphometry and the taxon-specific analyses highlighted intra-specific and/or intra-generic variability. A geochemical characterization at specific level was not possible, suggesting a general environmental uniformity and a similar carbon fractionation of the Bletterbach conifers. *Majonica alpina* represents however an exception. Its carbon isotopic composition is remarkably different from the other conifers, reflecting its distinct individual geochemical signature or an adaptation to a specific ecological niche. No significant isotopic differences were observed between photosynthetic and heterotrophic tissues, nor a correlation was found between isotopic values and “age” of the leaves. Both results suggest that the Permian conifers from Bletterbach were evergreen plants. The combined use of morphometry and stable isotopic geochemistry has a high potential for taxonomical identification and ecological characterization of fossil plants.

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## Recent sedimentary evolution of an estuarine environment: a multiproxy approach based on benthic foraminifera and historical pictures

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Palaeoenvironmental reconstructions take place especially in coastal marginal areas, interesting for their high variability in terms of physical-chemical-biological parameters, rapid landscape transformations, sea level changes, human interactions and accessibility. A multi-proxy approach based on benthic foraminifera, sediment grain-size, total organic carbon content, major and trace element concentrations, and radionuclide activities investigated the recent landscape evolution of the Canche Estuary (Hauts-de-France).

In estuarine areas, the difficulty in collecting undisturbed non reworked sediment cores often leads to unreliable radiometric dating. We faced this issue when dating sediments based on <sup>210</sup>Pb and <sup>137</sup>Cs activities in the present study in the Canche estuary. As an alternative method, aerial historical pictures were used for the first time as a dating method. The sediment core represents a typical fining-upward succession in a low-impacted tide-dominated estuary filled by progradation. In the bottom part of the core, foraminiferal assemblages are dominated by *Criboelphium excavatum* and *Elphidium margaritaceum*. *Haynesina germanica* is the most abundant taxon in the middle part of the core while *Entzia macrescens* is dominant in the upper part. In approximately one hundred years, an initial naked tidal flat has been gradually replaced by a vegetated salt marsh.

The present study sheds light on how background knowledge provided by historical sources (such as pictures, maps, or chronicles) could be relevant to enhance modern palaeoenvironmental reconstructions. When dating is not provided by classic radiometric methods, historical pictures (<100 years) may constitute a valuable alternative method to reconstruct recent environments

## Cryptic biogenic crusts from Lesvos submarine caves (Aegean Sea, eastern Mediterranean)

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The biogenic crusts inside two submarine caves of the Aegean Sea were studied to characterize the organisms involved in their formations. The walls and ceilings of the studied Fara and Agios Vasilios caves (Lesvos Island, Greece) are mainly covered by bryozoans and serpulids and, to a lesser extent, coralline algae, scleractinian corals, sponges and vermetids. Often the skeletons of these organisms were cemented together to form small and flat bioconstructions (Fig. 1).

The quantitative relationships among the skeletal components in the biogenic crusts vary according to sample location: coralline algae and corals dominate close to the opening of the caves, whereas serpulids, bryozoans and sponges are the main crust builders in the innermost cave sectors. Fine sediment (microcrystalline calcite) is a minor component of the crusts and consists of two fractions: the autochthonous micrite, mineralized directly inside the crusts through organomineralization processes, and the allochthonous micrite, derived from the erosion of carbonate skeletons and/or substrate. Crusts typically show scarcity of microbial autochthonous micrite and abundance of endolithic sponges, whose organic tissue decay left some of the hollows filled by spicules. The abundance of sponges, competing with carbonatogenic bacteria for the same living cryptic spaces, may have prevented the development of microbialites. This competition could explain the morphological differences between the studied biotic crusts and the large biostalactites, characterized by abundance of microbialites and shortage of sponges, that are common in other Mediterranean caves (i.e., Sicily, Apulia and Cyprus).

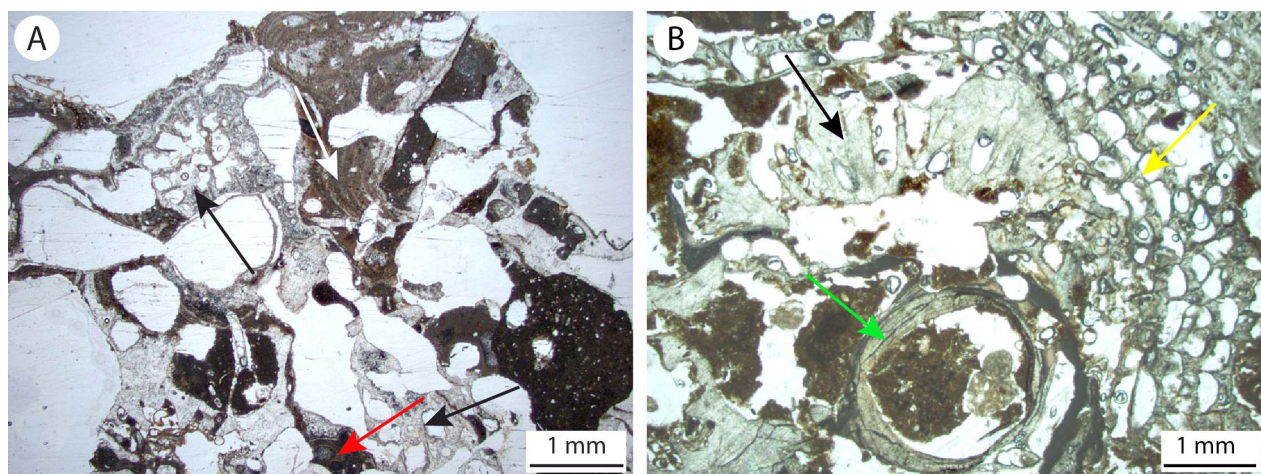


Fig. 1 - Microfacies of the biogenic crusts found in Agios Vasilios (A) and Fara (B) caves. Black arrows: scleractinian corals; red arrow serpulid; white arrow: calcareous alga; yellow arrow: bryozoan; green arrow: vermetid

## The wild boar (*Sus scrofa*) from Palombara Marcellina, a “new” old Pleistocene site in the Campagna Romana (Latium, Central Italy)

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The site of Palombara Marcellina was discovered at the end of the 19th century near the homonymous railway station located about 30 km north-east of Rome. After more than a century the revision of the site and its paleontological content is in progress. Here, we present the Suidae material and an historical background.

In 1889, one karst filling deposit, relatively common in the Campagna Romana, attracted the attention of some quarrymen who were working in the area. The circular-shaped opening, filled with a tufaceous layer, resembled an old and abandoned well, pushing the quarrymen to dig in search of water. However, their expectations were not met, and instead of water they find fossils.



The “avanzi di giganteschi Cignali” (= remains of giant boars) were the most notable discovery. They were so large-sized that Alessandro Portis (1853-1931), who firstly described the site, referred them to *Sus strozzi* or *Sus falconeri*. However, Hans Georg Stehlin (1870-1941) changed this attribution a few years later, during a visiting period to the “Regio Museo Geologico Universitario” in Rome. In fact, he noticed that the cross-section of the lower male canine in this sample was not of the “verrucose type”, but actually “scrofic”. The latter condition of this trait is —as the etymology suggest— distinctive of *S. scrofa*.

After the initial research impetus these remains were almost forgotten and seldom cited in the literature. In 2017 a revision of the fossils started with a field survey promoted to better define the stratigraphy of the site and its age. The tuffaceous layer that overlaid the deposit has long been referred to the Late Pleistocene, while its description best fits to a so-called “pisolitic tuff”, a product of the early phases of activity of the Alban Hills and the Sabatini Mounts. This constrains the site to be older than ~560 ka. Relatively complete and well preserved Epivillafranchian-Galerian wild boar specimens are rare in Europe, and hence the revision of the fossils from Palombara Marcellina provide new data for testing the biochronological and paleoenvironmental significance of the species.

## The Pleistocene molluscan fauna from Gravina in Puglia, 200 years after Arcangelo Scacchi

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In 1835, the naturalist Arcangelo Scacchi, native of Gravina in Puglia (Bari), reported a fossil fauna from the surroundings of his hometown (Scacchi, 1835). His work includes about 170 molluscan species, with the addition of some serpulids and “zoophytes” (bryozoans and corals), all from contrada Albanello, few kilometres south of Gravina in Puglia.

Several field trips to contrada Albanello allowed a rather rich molluscan fauna to be collected. The area is mildly hilly, heavily cultivated, with a silty-clayey soil and few, small and poorly exposed outcrops. Fossils were mostly hand-picked from the ground, with particular care also to small sized specimens.

A much richer molluscan fauna was also collected at contrada Rifezza, some 10 km south of the former. In this case, fossils were also collected from a silty-sandy outcrop.

Over 110 species have been so far identified from both localities, most of which are currently under study. Five of the 13 species described by Scacchi (1835) were found, all from contrada Albanello. Three of them, the bivalves *Tellina trigona* (= *Microstagon trigonum*), *Arca pectunculoides* (= *Bathyarca pectunculoides*) and the scaphopod *Dentalium olivi* (= *Gadila olivi*), are of particular interest since their original type material is no longer available in the Scacchi collection, which is housed at the Palaeontological Museum of the Naples University (Cretella et al., 2004). The present topotype material could be therefore useful for designating neotypes. The fossil molluscs from Gravina in Puglia reported by Scacchi have been referred to the early Pliocene in literature. Instead, they are from Calabrian deposits (MNN19e biozone), belonging to the Argille Subappennine informal unit, of outer to mid shelf setting.

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## Vincoli strutturali ed ambientali sulla riduzione delle appendici pari nei vertebrati

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La riduzione e/o la perdita delle pinne pari o degli arti costituisce una tendenza evolutiva relativamente comune tra i vertebrati dal corpo allungato. Infatti, molti gruppi di pesci e tetrapodi allungati hanno perso le loro appendici pari in modo indipendente. Abitudini fossorie e ambienti complessi sono generalmente considerati come fattori potenzialmente rilevanti che possono aver influito sulla riduzione dello scheletro delle appendici. Questo può essere vero per gli anfibi e i rettili, ma nei pesci esistono dei vincoli strutturali che impediscono la perdita delle pinne pettorali, essendo l'intero cinto integrato funzionalmente e strutturalmente allo scheletro craniale e considerato che le pinne sono usate per controllare il rollio e il beccheggio durante il nuoto. In questo lavoro, suggeriamo che gli unici pesci a mostrare una riduzione nelle pinne pettorali siano quelli che hanno sviluppato uno stile natatorio di tipo anguilliforme poiché questo consente di equilibrare il corpo durante il movimento senza bisogno delle pinne pari. È stato compilato un database che comprende 137 specie di pesci e 222 specie di rettili e anfibi, definendo quali caratteri (binari) la presenza di appendici, le abitudini di vita e, nel caso dei pesci, l'acquisizione di una morfologia corporea di tipo anguilliforme.

Dopo aver plottato queste specie su un albero filogenetico, è stata analizzata la correlazione tra stile di vita (e allungamento per i pesci) e perdita delle appendici utilizzando l'analisi comparativa del software BayesTraitsV3. I Bayes Factors ottenuti indicano una forte evidenza di correlazione tra: (i) perdita delle pinne pettorali e coesistenza di allungamento anguilliforme e abitudini fossorie, habitat di reef o di praterie marine nei pesci, (ii) perdita degli arti e fossorialità o grass-swimming tra rettili ed anfibi.

## Planktonic foraminifera response to Sapropel S1 in the south Adriatic Sea

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Detailed climate and ecological changes during the last Sapropel (S1) formation, interruption and ending is studied in the Adriatic Sea. This study aims to unravel in detail the internal climate oscillations of this fascinating period in the Holocene evolution of the Eastern Mediterranean Sea.

In this study we present a high resolution and multiproxy approach carried out on core ND\_14\_Q\_AR, collected during the oceanographic cruise NEXTDATA 2014 conducted by Institute for Coastal Marine Environment (IAMC-CNR) on board by URANIA vessel. The core was recovered in the southern part of the Adriatic Sea at 1013 meters water depth. Planktonic foraminiferal distribution, U/Mn ratios, a proxy for deep sea oxygenation, combined with oxygen stable isotopes in *Globigerinoides ruber* allowed us to recognise and characterize the pre-sapropel phase, the two S1 intervals, S1 interruption and post-sapropel phase.

High abundance percentages of warm planktonic foraminifer *Globigerinoides ruber* white variety and the decrease in abundance of species linked to deep vertical mixing and cold-deep water conditions such as *Globorotalia inflata* and *Neogloboquadrina pachyderma*, respectively, characterized the S1a and S1b. Relatively light  $\delta^{18}O$  during both S1a and S1b supports also the dominance of warm and potentially fresh surface conditions. Nevertheless, an ecological niche turnover between *G. ruber* white and *G. ruber* pink variety by the second part of the S1a and along the S1b support improved water mixing during these intervals. Higher percentages of *G. quadilobatus* and *G. siphonifera* during the S1b could indicate, opposed to S1a, a greater oxygenation of the upper part of the water column during winter and summer. The interruption phase, between the S1a and S1b, is characterized by a strong increase in cold and mixing water species (*G. inflata* and *Neogloboquadrina*). These surface water conditions are consistent with the deep Adriatic Sea evolution according to the U/Mn record. Minimum in oxygenation (high U/Mn ratios) occurred at the first part of S1a while a ventilation improvement occurred during the second part of the S1a reaching conditions comparable to those of the S1b. Minimum U/Mn values during the S1 interruption confirms a deep re-ventilation event associated to this period. This multi-proxy approach proves to be a powerful tool to analyse parallel changes in both surface and deep marine conditions. This research was financially supported by ERC-Consolidator TIMED project (REP-683237).

## Baza-1 (SE Spain): a new and exceptional Pliocene continental site in Europe

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The early Pliocene continental record (Ruscinian: 5.3-3.4 Ma) is scarcely represented in Europe. It is characterized by a humid and warm subtropical climate in the Mediterranean basin, which is preceded by the dry and cold Messinian period.

In the Iberian Peninsula, Ruscinian is characterized by the presence of faunal records of African origin, especially by rodents (e.g., the genus *Paraethomys*).

Although microvertebrate Ruscinian records are relatively abundant, sites with faunas of large mammals are quite scarce in Europe. Mention must be made of Megalo Emvolon in Greece, Malusteni in Romania and several locations in the Roussillon, France. In the Iberian Peninsula it is worth citing a number of sites such La Calera in the Calatayud-Teruel basin, Layna in Soria, Alcalá de Júcar in Albacete, or Camp dels Ninots in Caldas de Malavella (Gerona) in the Ruscinian-Villafranchian boundary at 3.2 Ma.

In this context, the Baza basin, in southeastern Spain, has one of the best Plio-Pleistocene continental records of Europe, with special interest on the early Pleistocene sites of Orce, where some of the earliest evidences of human presence in Europe, close to 1.5 Ma, have been found. There are also several localities corresponding to the Pliocene, but they normally only record the presence of microvertebrates. No Pliocene locality with record of large mammals was known, except for the Early Villafranchian (see Maldonado-Garrido et al., 2017, and references therein).



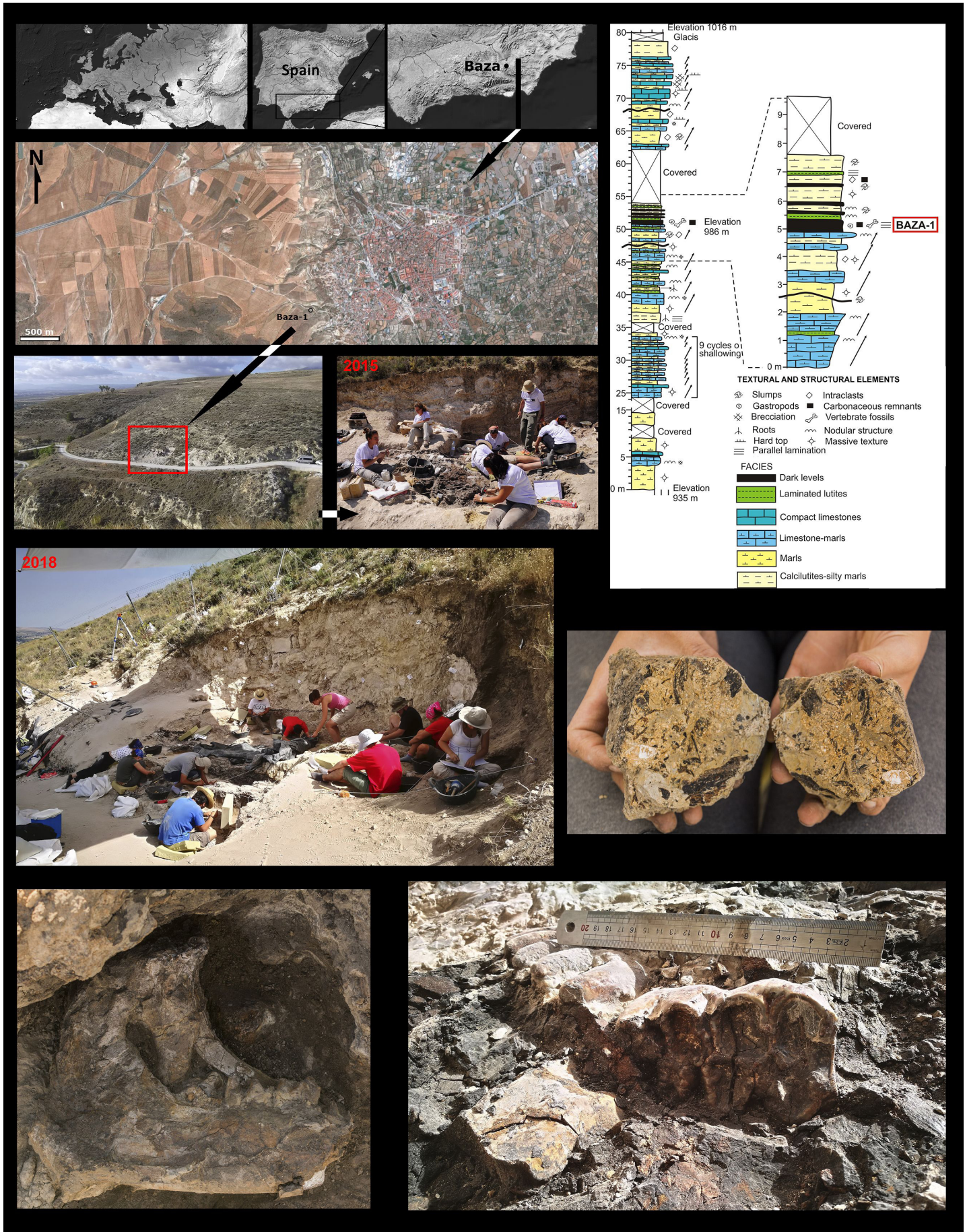


Fig. 1 - Geographic location, stratigraphy, excavation, and fossils of Baza 1. Fossils: vegetal fragments (below the stratigraphic series), mandible of *Stephanorhinus cf. jeanvireti* (bottom left), and palate fragment of *Anancus arvernensis* (bottom right)



This absence of early Pliocene record is now covered by the site of Baza 1 (Fig. 1). At the moment, only 24 m<sup>2</sup> have been partially excavated, and  $\geq 700$  fossil remains of large vertebrates have been unearthed, referred to *Anancus arvernensis*, *Mammut borsoni*, *Stephanorhinus cf. jeanvireti*, *Hipparion sp.*, *Alephis sp.*, Antilopini indet., Cervinae indet., Suinae indet., and Carnivora indet. (large size) (Ros-Montoya et al., 2017). There are also abundant micromammals, especially rodents (*Ruscinomys sp.*, *Apocricetus barrierei*, *Debruijnimys julii*, *Apodemus gorafensis*, *Castillomys gracilis*, *Occitanomys cf. brailloni*, *Paraethomys meini*, *Paraethomys aff. abaigari*, *Stephanomys cordii*, *Trilophomys cf. castroi* and *Eliomys aff. intermedius*) (Piñero et al., 2017). In addition, there is an important record of chelonians, Testudinidae indet.

The biostratigraphic data obtained from the fauna of micro and macro-mammals indicate that the Baza-1 site has a chronology between 4.2 and 4.5 Ma.

The site has an extraordinary potential. Its thickness is 1.5 m and its extension is still unknown, comprising at least several hundred square meters or, very likely, several thousand, still to be delimited. The fertile stratum is affected by seismicity and it was slightly slipped towards the interior of the basin. It corresponds to a fossil swamp with stagnant anoxic waters where the animals were possibly trapped in mud, especially in the case of megafauna. Plant remains were also fossilized in peat bogs, conserving their woody structures.

This site is coming to fill the scarce existing paleontological record for the chronologies that follow the Messinian, not only in the Baza basin, but also in the Iberian Peninsula and Europe in general.

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## Ostracods as palaeoenvironmental indicators in late Quaternary sediments from IODP Leg 381, Gulf of Corinth

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During the IODP Expedition 381 "Corinth Active Rift Development" in the Gulf of Corinth three sites were drilled that provide a high-resolution record of sedimentation in the center of the Gulf of Corinth (M0079 and M0078) and in the eastern part of the gulf, in the Alkyonides Gulf (M0080). Micropaleontological investigations performed onboard indicated alternation between marine and "isolated" (eg. non-marine) environments. In such settings, ostracods can be particularly helpful because, unlike other commonly used micropaleontological proxies such as foraminifera and nannoplankton, they occur in almost all aquatic environments, from deep marine to temporary freshwater.

Ostracods from cores M0080A and M0078A were investigated. The ostracod fauna is extremely well preserved and abundant. The upper 114 meters at site M0080 in the Alkyonides Gulf recorded major marine-lacustrine environmental changes reflecting large oscillations in global sea level of (typically ~ 125 – 130 meters for a glacial-interglacial cycle), tectonic processes and the depth of about 60 meters for the Rion sill at the eastern entrance to the Gulf of Corinth. Interglacial bathyal marine sediments representing Marine Isotope Stages (MIS) 1, 5, 7, 9 and 11 are characterised by continental slope assemblages dominated by taxa such as *Henryhowella*, *Bosquetina*, *Cytheropteron*, *Polycope* and others. In sharp contrast, sediments associated with glacial (low global sea level) stages MIS 2, 4, 6, 8, and 10 are dominated by brackish to freshwater taxa such as *Candona*, *Leptocythere*, and *Amnicythere* indicating an "isolated" environment. These results indicate frequent and abrupt changes occurred in the Gulf of Corinth during periods of glacial inception and deglaciation. Pre-MIS 11 deposits contain abundant *Cyprideis* and *Tyrrenocythere*, suggesting brackish, coastal environments. Preliminary results from site M0078 in the central Gulf of Corinth will also be presented. The micropaleontological record will be used in conjunction with other studies to examine the tectonic history of the basin.

## Large mammal fauna from the late Middle Pleistocene sites of Melpignano and San Sidero (Lecce, Southern Italy)

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Salento (southernmost part of Apulia) is well known for its Quaternary vertebrate paleontological record coming from caves, located both on the Adriatic and Ionian coasts (e.g., Grotta Romanelli, Grotta Zinzulusa, Grotta del Cavallo) and from karst fissures, locally known as *ventarole* (e.g., Sternatia, Fondo Cattie). These latter are generally filled by reddish sediments, *terre rosse* in the lower part, and brownish sediments, *terre brune* in the upper, both particularly rich in vertebrate fossil remains. These deposits were first described by Mirigliano in 1941. Since then, several institutions such as the Italian Institute of Human Palaeontology (IsIPU) and Italian Institute of Prehistory and Protohistory (IIPP), continued the fieldwork activities in Salento. Unfortunately, the rich and diverse fossil specimens were dispersed among different museums and other institutions from the early stages of the excavations. The large mammal assemblage from the *terre rosse* of Melpignano and San Sidero sites was chronologically referred to the early Late Pleistocene (MIS 5) whereas the assemblage from the *terre brune* was referred to the end of the Late Pleistocene-early Holocene. In the last decades, the research in the fossiliferous area of Maglie was conducted by a team from the Department of Earth Science of Sapienza University of Rome. New mammal fossil remains coming from the late Middle Pleistocene of Melpignano and San Sidero are here described. The aim of this work is therefore to describe and update the mammal faunal list coming from these two localities. Thus, also the previous fossil collections from Melpignano and San Sidero are reassessed. The analysis of the mammal remains, and their comparison with those from the faunal assemblages of other Middle-Late Pleistocene sites of the Apulian Peninsula, led us to provide a new biochronological and paleoenvironmental framework for Southern Italy.

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## The ecology of Eurasian mammoth chronospecies

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The concept of chronospecies is of key importance in Paleontological systematics. In most cases, morphology is the only feature we can measure when dealing with fossils. With chronospecies, evolutionary change is driven by the temporal sequence rather than true speciation. Pleistocene mammals show some of the most important examples of chronospecies, one of them resulting in the Eurasian mammoth lineage (from *M. meridionalis* to *M. trogontherii* and eventually to *M. primigenius*). The earliest representatives of the *Mammuthus* genus are known from the Pliocene of Africa and identified as *M. subplanifrons*. The dispersal of this genus over Eurasia drove a well-known sequence of evolutionary changes involving skull and dental morphology. Specifically, the shortening and heightening of mammoths' skull and mandible proceeded along with the increased hypsodonty and number of enamel bands in the molars. All these evolutionary features are usually interpreted in light of adaptation to the new, colder and more arid environmental conditions characterizing the Boreal hemisphere during the Pleistocene. Actually, the climatic hypothesis is the more advocated for these morphological changes in the Eurasian mammoth lineage, but it was never tested because of the lack of spatially explicit estimations of Pleistocene climate. With the ever and ever popular use of Global Circulation Models it is now possible to have geographical reconstructions of Earth's climate evolution, with a very high temporal resolution. We used the most advanced ecological tools, typically employed with living species, combined to the recent available reconstruction of Earth's past climate to describe and compare the climatic niches of the *M. trogontherii* and *M. primigenius* species and to test if the morphological differences between these species are really related to a climatic shift in their niches.

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## New considerations on the Sahabi's rhinocerotids (late Miocene, Libya)

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Sahabi is a very well-known latest Miocene vertebrate site in northern Libya. The discovery of Sahabi as a large terrestrial vertebrate paleontological locality and the recovery of abundant vertebrate fossils from the site in early years are undoubtedly due to

the efforts of Carlo Petrocchi (Boaz et al., 2008; Rook, 2008). From 1934 to 1939 Petrocchi conducted several seasons of field survey and excavation and undertook intensive laboratory work for the restoration and preparation of collected material (Petrocchi, 1934, 1941, 1943). Unfortunately, most of Petrocchi's Sahabi collection is nowadays missing. This is, for instance, the case of rhinoceros material collected during the 1930s.

Albeit represented by a small number of specimens, according to the literature, the Sahabi rhinoceros' sample is significant and composed by the following fossils:

- o A mandible with a large-sized lower incisor, briefly described by Petrocchi (1951), would belong to either a brachypothere or an acerathere although the latter group is recorded only doubtfully in northern Africa (one uncertain record from TiziN'Tadderht, Morocco; Zouhri et al. 2012).
- o A large-sized M2 from Sahabi was initially assigned to the American genus *Teleoceras* and later to a baluchithere (*Indricotherium* or *Baluchitherium* = *Paraceratherium*, family Hyracodontidae, subfamily Indricotheriinae (D'Erasmo 1954); the taxon occurred from the middle Eocene to the late Oligocene in Eurasia and it seemingly never reached the Afro-Arabian continent). Nevertheless, the M2 from Sahabi concurs well, morphologically and dimensionally, with a referral to *Brachypotherium lewisi*, a taxon well-documented from Lothagam (Kenya). The tooth also resembles in morphology the M2 of *B. heinzlini* from the type locality of Sinda 15 (Democratic Republic of Congo).
- o A P2 from Sahabi, collected during the 1980s (Bernor et al. 1987), differs from several species belonging to *Ceratotherium*, including *C. neumayri*, and it resembles the genus *Diceros*, sharing some characters with *Diceros bicornis*. Nevertheless, considering the ambiguous generic status of several African dicerotine (alternatively assigned to *Ceratotherium* or *Diceros*), a provisional attribution to '*Diceros*' sp. is here proposed for the Sahabi specimen, pending the discovery of more preserved material.
- o An isolated rhinoceros phalanx (Heissig 1982) is here attributed to Rhinocerotidae indet. due to the absence of detailed morphological and morphometric studies on Neogene rhinocerotid phalanges.

The rhinoceros association (*Brachypotherium* and a dicerotine) recognised at Sahabi has been recorded at Lothagam, upper and lower Nawata, and at Mpesida (Kenya), suggesting a biogeographic affinity with the eastern Africa assemblage.

Despite the Rhinocerotidae material from Sahabi is relatively scarce (the family is represented by four specimens only), it represents one of the few latest Miocene localities of Northern Africa and one of the six localities that yielded remains of Rhinocerotidae.

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## Volumetric body mass estimate in fossil tetrapods based on 3D reconstructions

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Body size is one of the most crucial biological properties for both extant and extinct organisms as it influences the ecology, metabolism, reproduction rate, life span, growth rate fecundity and several other physiological aspects. Taking into account the strong relationship between these aspects and body mass, the quantitative analysis of body size evolution through geologic time in vertebrates is a powerful tool to investigate major macroevolutionary patterns and processes. This is true particularly for tetrapods, where the evolution of body mass can be framed within broader studies on trophic structure (quantitative ecospace modelling), metabolism, locomotion and center of mass. Over the years several classical regression formulas based on different skeletal elements have been proposed to infer body mass on the basis of large datasets of extant taxa. However, the results obtained by this approach can be misleading, especially if applied to clades that are phylogenetically distant from the extant organisms used to derive the regression formulae or are characterized by very peculiar long bone proportions. These issues have been recognized previously, and with the increasing application of three-dimensional imaging techniques in paleontology, volumetric body mass estimates have become increasingly popular as well. In this contribution we present a novel volumetric body mass estimate approach, based on 3D reconstruction of tetrapods, digitally sculptured around 3D photogrammetric models of almost complete and articulated skeletons, and using a range of possible densities for living tissue. We apply the method to both Pleistocene mammals



(dwarf elephant from Sicily) and therapsids, a middle Permian dinocephalian (*Tapinocanius*) and Late Triassic dicynodont (*Lisowicia*). Our results confirm previous observations, showing that the classical regression formulae, based on long bone circumferences, often lead to a substantial overestimate of body mass, especially in taxa characterized by peculiar osteological proportions such as those shown by the insular dwarf elephant and the very large dicynodonts. The study demonstrates that volumetric methods are most robust and reliable to estimate the body mass in extinct vertebrates for which relatively complete skeletons are available.

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## Melanosomi fantastici e dove trovarli

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La melanina è un pigmento prodotto biologicamente da tutti i vertebrati e contenuto in microscopici organelli cellulari chiamati melanosomi. I melanosomi pur essendo importanti componenti della pelle e degli occhi sono presenti anche all'interno degli organi interni in molte specie di vertebrati. La capacità di discriminare gli organi sorgente dei melanosomi, pelle o organi interni, rappresenta una sfida cruciale per un'accurata interpretazione della colorazione integumentaria nei vertebrati fossili. Un nostro studio su 14 specie viventi di vertebrati, ha dimostrato che l'unione tra geometria e distribuzione degli elementi in traccia dei melanosomi rappresenta un nuovo, potente metodo per differenziare gli organi ricchi di melanina. Un nostro studio pilota, condotto su quattro esemplari di vertebrati fossili ha dimostrato che i melanosomi fossilizzati, se provenienti da differenti regioni del corpo, posseggono una distinta morfologia e un diverso contenuto di metalli. Il presente studio è basato su una nuova analisi di 25 esemplari fossili di vertebrati eccezionalmente preservati, appartenenti a tutte le classi tassonomiche e provenienti da otto località fossilifere diverse (Largestätten), che spaziano dal tardo Carbonifero (300 Ma) al Miocene (10 Ma). Il sincrotrone a fluorescenza a raggi X è stato usato per mappare la distribuzione spaziale di 11 elementi chimici (P, S, Cl, K, Ca, Ti, Mn, Fe, Ni, Cu, Zn) sia dei tessuti fossili che del sedimento che li ospita. L'analisi statistica multivariata dei dati mostra che la composizione chimica degli elementi in traccia dei melanosomi differisce in base alla località geografica di provenienza, suggerendo un ampio controllo diagenetico sulla composizione chimica finale dei melanosomi. Tuttavia, un'analisi di dettaglio sui singoli esemplari fossili dimostra che ci sono differenze statisticamente significative tra la chimica dei tessuti ricchi in melanosomi e il sedimento. Si nota inoltre un segnale chimico caratteristico dei diversi organi (occhi, pelle, fegato e potenzialmente reni) permettendo in alcuni casi un'interpretazione dettagliata dell'anatomia interna. Lo studio degli elementi in traccia dei melanosomi rappresenta quindi un nuovo valido strumento per l'investigazione dell'anatomia interna dei vertebrati fossili.

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## The use of aerial- and close-range photogrammetry for the mapping of the Lavini di Marco tracksite (Hettangian, Southern Alps, NE Italy)

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During the spring 2018 several flights with Unmanned Aerial Vehicles (UAVs) were performed at the Lavini di Marco tracksite with the aim of producing a detailed geothematic map. This research is part of a joint project between the Sapienza University of Rome and the MUSE, with the cooperation of the Geological Survey and the Fire Department of the Autonomous Province of Trento.

The Lavini di Marco ichnosite is located near Rovereto (Trentino-Alto Adige, NE Italy), on the western slope of Mt. Zugna (central-eastern Southern Alps; 45°50'52.25"N; 11° 2'4.71"E).

The trampled surfaces belong to the Calcarei Grigi Group (Hettangian-upper Pliensbachian), exactly to the Middle Peritidal Unit of the Monte Zugna Formation (Hettangian).

The ichnological survey was carried out using two different approaches: i) traditional methods (field ichnological works) and ii) aerial- and close-range photogrammetry.

Aerial photogrammetry was performed using two distinct UAVs in order to obtain orthophotos and orthoplanes of the track-bearing horizons. The aerial survey took several workdays with about 2500 images taken to cover an area of ~0.6 km<sup>2</sup>.

Close-range photogrammetry was executed following the procedure proposed by Mallison & Wings (2014). More than seventy 3D models were obtained and interpreted by means of color-coded and contour line images, which allow to improve the ichnological knowledge of the tracksite. The 3D models of the best-preserved tracks were used for the osteological reconstruction of the trackmakers' autopodia, supposing the arthral position of the phalangeal pads. Three indirect methods were used to correlate tracks and their trackmakers: (i) synapomorphy-based approach; (ii) phenetic correlation; (iii) coincidence correlation (see Carrano & Wilson, 2001)

The final map was produced with different level of knowledge due to the distribution of tracks and current state of site preserva-

tion. Furthermore, it represents a complete documentation that will be used for future work of enhancement, preservation and valorization of the tracksite.

The ichnotaxonomical review of the quadrupedal trackways led us to emend the diagnosis of *Lavinipes cheminii* Avanzini et al. (2003) and to assign several other sparse tracks and trackways to *L. chemini*. The skeletal reconstruction of fore and hind limbs points towards *Gongxianosaurus* sp. as the most suitable trackmaker of *L. cheminii*. The herein supposed Laurasian affinity of the Lavini di Marco dinosaur assemblage clashes with the previous hypotheses that always link the Southern Alps sector with the Gondwana mainland.

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## Tube structure of agglutinate-worm bioconstructions (Sabellaridae, Polychaeta): new Mediterranean records

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The so-called “sandcastle” Sabellaridae worms can form unusual reef-like aggregates on mesolittoral to upper infralittoral bottoms, where they catch suspended sandy particles to construct their agglutinate tubes. Reef formation and persistence depends upon suitable environmental conditions, namely turbulent waters with continuous supply of sand grains.

As for other reef-forming taxa, sabellariid worms enhance sediment trapping and substrate stabilization, and provide microhabitats for associate organisms. Due to their ecological importance, these vulnerable and brittle bioconstructions deserved protection, also considering that they are rare and restricted to particularly suitable coastal areas (Sanfilippo et al., in prep.). Data on architecture and fine structure of sabellariids, as well as modality of gluing by the waterproof biocement, is scant and usually focused on Pacific taxa. Less is known on tube structures of the atlanto-mediterranean genus *Sabellaria*.

Newly discovered *Sabellaria* reefs from the southern coast of Sicily allowed us material to investigate the distinctive structure of the tube wall, the bonding modality of grains by adhesive, and the chemical composition of this biocement. Tubes are constructed with agglutinate sandy particles prevalently consisting of carbonate bioclasts with dominant fragments of bivalve and gastropod shells, rare foraminifers tests, echinoid plates and ostracods. The tube wall shows a distinctive three-layered structure with each layer characterized by different particles size, shape and arrangement (Fig. 1). Observations also confirm that worms are selective in the choice of grains.

SEM analysis of the wall revealed a “popped bubble” feature that indicated a solid foam-like material for the biocement. EDS confirmed the presence of calcium, magnesium, and phosphorous in the biocement, with varying amounts of these three elements at different locations on the same sample.

The nature of biocement is of paramount relevance in ensuring a certain persistence of the reefs in the high hydrodynamic settings where they develop, and to allow their possible fossilization however very unlikely. Fossil record is therefore scant, with only one sabellariid-rich bed, deposited during the Upper Miocene of SE Spain, in palaeoenvironmental conditions comparable to those where sabellariid reefs presently occur.

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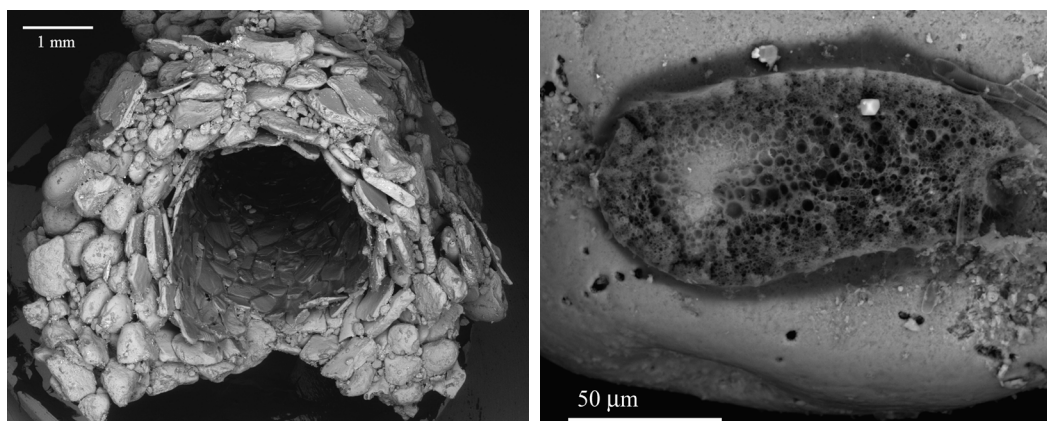


Fig. 1 - Left: Agglutinate wall structure at the opening of the tube. Note the preferential selection of the grains. Right: Detail of biocement showing the solid foam structure

## Valore filogenetico delle ossa mascellari e mandibolari dei lacertidi (Squamata: Lacertoidea): studio di un caso con materiale dell'Oligocene francese

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A causa della scarsa conservazione e disarticolazione, numerose specie fossili di lucertole appartenenti alla famiglia Lacertidae sono state descritte sulla base di singole ossa, per lo più dentali o altri elementi dentigeri. In questo studio, abbiamo usato delle ossa disarticolate precedentemente riferite a lacertidi e provenienti da quattro località oligoceniche francesi (Coderet, La Colombe, Roqueprune 2, Mas de Got B) per confrontare i segnali filogenetici di tre elementi di mascella e mandibola: dentali, mascellari e premaxillari.

Abbiamo così identificato quattro morfotipi tra i premaxillari, sei tra i mascellari e otto tra i dentali. Questi morfotipi sono stati quindi trattati come unità tassonomiche operative singole per ogni località in tre diverse matrici basate sugli stessi 244 caratteri e 51 taxa (una matrice per ogni elemento). Successivamente, la posizione filogenetica dei morfotipi all'interno del taxon Lacertoidea (Lacertidae, Teiidae, Gymnophthalmidae, Amphisbaenia) è stata testata usando la massima parsimonia. Gli alberi di consenso risultanti con dentali e mascellari hanno mostrato entrambi una grande politomia comprendente quasi tutti i morfotipi. La politomia nell'albero con i dentali era formata da tutti i membri di Lacertidae inclusi nell'analisi, mentre la politomia dell'albero di consenso con i mascellari includeva Lacertoidea e l'outgroup Toxicofera. Al contrario, l'albero con i premaxillari ha mostrato una risoluzione distintamente migliore, ma la maggior parte dei morfotipi ricadeva al di fuori di Lacertidae.

In una seconda fase, abbiamo confrontato quantitativamente e qualitativamente i dati ottenuti dai tre elementi scheletrici. I nostri risultati suggeriscono che la combinazione di caratteri convergenti e dati mancanti sia la causa del posizionamento "outgroup" dei morfotipi dei premaxillari. Le politomie trovate nell'albero di consenso con i mascellari sono probabilmente dovute al cattivo stato di conservazione. Nel caso dei dentali, l'elevato numero di morfotipi e quindi l'elevata quantità di dati mancanti è probabilmente la causa della bassa risoluzione dell'albero.

Tentativi con set di dati più piccoli hanno mostrato risoluzioni paragonabili ai premaxillari, con tutti i morfotipi inclusi in Lacertidae. Tuttavia, un'identificazione affidabile fino al livello di specie sembra essere possibile solo con una combinazione di caratteri provenienti da elementi mascellari e/o mandibolari diversi. Pertanto, le descrizioni di nuove specie basate esclusivamente su singoli elementi devono essere trattate con cautela.

## Preliminary description and taxonomic analysis of a balaenopterid whale skeleton from early Pleistocene of Apulia

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An almost complete whale skeleton housed in Museo di Scienze della Terra di Bari (University Aldo Moro of Bari) is described for the first time. The skeleton was discovered in 1968 at Lama Lamasinata (Bari, Italy) (Montenegro, 2016), in Pleistocene shallow water calcarenite/calcirudite sediments belonging to the Calcarenite di Gravina formation. It is 11 m long. Vertebrae are almost all in continuity and articulated, especially the lumbar and caudal ones, although the caudal vertebrae are missing for an estimated length of about 2 m. Most of the ribs are present, some of them are particularly well preserved and still articulated. Many bones of the right limb are preserved. Mandibles are also present and articulated. The skull bones are partially missing or fragmentary because of the anthropic action, but squamosals, basioccipital bone and the right tympanic bulla are preserved. The presence of unfused vertebral epiphyses allows the fossil to be referred to a sub-adult stage. Although the skull bones are almost all missing, the completeness of the postcranial skeleton and the characters of tympanic bulla allowed the whale skeleton to be referred to *Balaenoptera* cf. *borealis* Lesson, 1828. The Pleistocene whale record on a global scale is very scarce (Deméré et al., 2005), so the *Balaenoptera* skeleton from Bari represents one of the most complete specimens of balaenopterid for Quaternary.

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# **RIASSUNTI / ABSTRACTS**

## **Posters**



## The crucial role of photogrammetry in reconstructing the foot skeleton of *Spinosaurus*

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Three-dimensional digital imaging and analysis has become an invaluable aid for studying fossils. Among these methods, photogrammetry is increasingly becoming a standard methodology for bone and surface digitizing in palaeontology. Here we share some basic methods for obtaining high quality 3D models, from optimal to suboptimal conditions, and encourage the use of photogrammetry as a technique for both researchers and curators. The technique has several strengths. Primarily, it is an efficient way to gain important insights into anatomy and functional morphology; secondarily, it is a powerful and effective way to disclose and disseminate research results; finally, it enhances the possibilities of fossils preservation, as it permits the generation of perfect copy, using a non-invasive and relatively rapid technique.

The materials used and scanned for the present are the foot bones of specimen FSAC-KK 11888, a partial subadult skeleton of *Spinosaurus aegyptiacus*, recovered from the Cretaceous Kem Kem beds of North Africa and recently designated as the neotype of the species (Ibrahim et al. 2014). Presently, *Spinosaurus* is the first and only giant theropod known with specialised semiaquatic adaptations. We scanned the cast material housed in the Natural History Museum of Milan, as well as new bones associated with it and recently recovered at the type locality. Consequently, we have now obtained a new and more accurate reconstruction of the pes of this enigmatic dinosaur. Our preliminary results confirm the presence of fleshy lobes and interdigital webbing that would have enhanced foot-propelled swimming, and walking on soft and muddy substrates.

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## Ricostruzione paleoecologica della facies a *Pinna nobilis* nel Gelasiano del Torrente Stirone (Piacenza)

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Gli affioramenti Plio-pleistocenici lungo il corso del torrente Stirone (Parma-Piacenza) sono oggetto di studio dagli anni '50. Questo lavoro si focalizza su un tratto di argine in cui affiorano sedimenti di età gelasiana contenenti abbondanti resti di molluschi bivalvi del genere *Pinna* in posizione di vita (Fig. 1), già riportati in letteratura ma non adeguatamente studiati. Essi sono indicativi di particolari condizioni paleoecologiche, in quanto *Pinna* vive in ambiente fotico, di mare basso e associato a *Posidonia oceanica*, *Cymodocea nodosa*, ed in genere alle fanerogame marine.

Al fine di ricostruire e interpretare in chiave paleoecologica il sito di studio, si è proceduto con l'analisi sedimentologica e tassonomica delle associazioni a molluschi (frazione ghiaia), compresa l'identificazione specifica degli esemplari del genere *Pinna*, e a foraminiferi bentonici (frazione sabbia medio-fine). Il campionamento (44°50'39.3"N, 9°58'59.9"E, 6 repliche da 2 l ciascuna) è avvenuto sulla sinistra orografica del torrente Stirone, nei pressi della località di Scipione Ponte (PR), in un tratto del torrente disposto circa W-E. Il banco contenente gli esemplari di *Pinna* ha una potenza di circa 10 m e immerge debolmente verso NE: le sei repliche sono state campionate spostandosi lateralmente di 100 m, quindi coprono tutta la potenza e comprendono i sedimenti associati a *Pinna*, sia laddove questa è abbondante ma anche dove è più scarsa.

Sulla base delle caratteristiche morfologiche dei gusci, la forma dell'umbone e le ornamentazioni, è stato possibile identificare la specie di *Pinna* come *Pinna nobilis* Linnaeus, 1758, a discapito di altri



Fig. 1 - *Pinna nobilis* in posizione di vita affiorante nel sito indagato

candidati quali *Pinna rudis* Linnaeus, 1758 e *Atrina fragilis* Pennant, 1777 (sinonimi *Atrina pectinata* o *Pinna pectinata*). I sedimenti che compongono l'affioramento sono sabbie fangose, più o meno grossolane, che si inseriscono perfettamente nel contesto ecologico e sedimentologico dell'ambiente infralitorale colonizzato da fanerogame marine e da *P. nobilis*. La malacofauna associata (57 specie di molluschi, di cui 21 gasteropodi, 34 bivalvi e 2 scafopodi) è ben conservata (indici di conservazione 3, 4) e rappresentativa di popolazione, tale da poter sostenere che la malacofauna osservata e ricostruita sia autoctona. Venti specie sono attribuite a biocenosi AP e HP, 8 specie sono attribuite alla biocenosi SFBC (di cui due caratteristiche esclusive). È possibile fare una distinzione tra quelle che sono presenti in concomitanza solo di *P. oceanica*, solo di *C. nodosa* o con entrambe: emerge che 26,30 % è associato a *P. oceanica*, il 7,0 % viene attribuito a praterie a *C. nodosa*, mentre il 31,6 % delle specie è presente in concomitanza con entrambe le fanerogame. Sono riportate anche molte specie indicative di piccoli substrati solidi, specie che sono facilmente contestualizzabili in un ambiente che offre appigli adatti all'insediamento, siano essi gusci di altri esseri viventi, piccole rocce o alghe calcaree, oppure proprio foglie e rizomi di fanerogame. Tra i foraminiferi bentonici, sono stati estratti 558 individui appartenenti a 42 specie: spiccano 6 specie che rappresentano il 47,7 % in abbondanza di tutti gli individui estratti, specie epifite correlate a fanerogame marine. Pertanto, è ragionevole concludere che la facies a *P. nobilis* che affiora lungo il torrente Stirone riflette le condizioni di un fondale marino poco profondo, con biocenosi proprie dell'infralitorale e a fanerogame (probabilmente *P. oceanica*), fondale caratterizzato da un mosaico con aree più o meno floride di copertura vegetale, testimoniate dalla presenza più o meno abbondante di *P. nobilis* in situ.

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## Paleofuturo a sud. Sei lustri tra i fossili "maestri muti"

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La valorizzazione del patrimonio geopaleontologico è un possibile cammino di ricerca da caratterizzare territorialmente incominciando prima di tutto dal mondo della scuola attraverso un approccio interdisciplinare orientato ad una progettazione interculturale.

Il Sannio fossilifero, riscoperto grazie al ritrovamento di *Scipionyx samniticus* viene inquadrato nel P.T.C.P. (Piani Territoriali di Coordinamento Provinciale) della provincia di Benevento nell'ambito dei distretti paleontologici dove sono sorti musei nell'ultimo ventennio: Benevento, Montefalcone di Valfortore, Baselice e Pietraroja. Sono luoghi che hanno significativamente contribuito alla divulgazione di questo patrimonio che viene proposto sul territorio come un "viaggio a ritroso nel tempo".

In siffatto contesto si prospetta un "percorso" finalizzato a rilanciare il parco geopaleontologico di Pietraroja nell'ottica dei geoparchi Unesco traendo spunto dai numerosi progetti e concorsi che la Onlus Un Futuro a Sud ha organizzato e svolto nelle scuole con continuità nel corso dell'ultimo trentennio grazie ai patrocini della Provincia di Benevento, del comune di Pietraroja e dell'Ufficio Scolastico Provinciale di Benevento e la partecipazione di docenti delle facoltà di Scienze delle Università del Sannio e della Federico II di Napoli, dell'Ordine dei Geologi della Campania, di paleontologi, paleoartisti, litografi e docenti di scuola. Seminare lo studio della geopaleontologia nella programmazione didattica curriculare ed extracurriculare delle scuole di ogni ordine e grado della provincia di Benevento insieme ai C.P.I.A. (Centri Provinciali Istruzione Adulti), è un aspetto importante per traghettare le conoscenze verso le competenze al fine di sviluppare una cittadinanza attiva e consapevole che è prerogativa irrinunciabile ad una comunità che desidera vivere il geoparco.

La divulgazione delle inter-connessioni tra litosfera e biosfera impone lo studio di molteplici conoscenze che necessitano la valorizzazione di un patrimonio professionale ad oggi inespresso e da intercettare.

L'auspicio è che si rafforzi la consapevolezza del potenziale e del valore di luoghi e risorse "a chilometro zero" da riscoprire con occhi nuovi.

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## Brachiopods distribution and facies architecture in a composite mud mound from the Viséan of Derbyshire, UK

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Mud mounds are a common feature of Mississippian carbonate platforms (e.g. Lees & Miller, 1995; Gutteridge, 1995). A very good example of a Type 3 (crinoid-brachiopod-fenestrate bryozoan buildup) Mississippian buildup (Bridges et al., 1995) crops out along the southern edge of the Peak District, near the village of Monyash (Derbyshire, UK), at the top of the Viséan Monsal Dale Limestone Formation (Gutteridge, 1991).

The buildup is a complex structure, which originates from the juxtaposition of several smaller mounds and comprises a complex set of core-, flank- and intermound facies. In particular, there are different sets of massive mound cores surrounded by poorly to well-bedded flank facies; these sets are both adjacent to each other and vertically stacked to form a composite buildup. The mud mound cores predominantly consist of leiolitic to clotted peloidal carbonate mud with common fenestrate bryozoans, rare fistuliporid bryozoans, brachiopods, crinoids and abundant early marine radial fibrous calcite cement in primary growth framework porosity. Bryozoans are widespread in the cores, forming a rigid framework with their branches. The mound extends laterally for



several hundreds of metres and is up to 20 m thick, suggesting mainly laterally accretion due to relatively shallow depths (Gutteridge, 1995).

Brachiopods are widespread in the mound cores and occur in isolated high-diversity concentrations. These concentrations were previously considered to be life assemblages in "pockets" scoured by storm currents (Gutteridge, 1990). New field data allowed revising this hypothesis as no sign of erosion is present at the base of the brachiopod concentrations. Brachiopods also occur in neighbourhood assemblages in the flank facies, which are otherwise dominated by large crinoids. Brachiopods from core concentrations and flank facies are similar and comprise free-living seminfaunal productids (*Antiquatonia*, *Dictyoclostus*, *Echinoconchus*, *Krotovia*), pedicle-attached terebratulids (*Girtyella*, *Hartella*) and rhyconellids (*Pleuropugnoides*) and free living spiriferids (*Phricodothyris*, *Latibrachythyris*). Seminfaunal productids, in particular species of the genera *Antiquatonia* and *Dityoclostus*, are dominant and reach a larger size than the other taxa, suggesting sparse food resources.

The next steps of the research will focus on unravelling what controlled brachiopod distribution in the mound and why productids - usually adapted to soft substrates - dominated the mound cores that were likely to be a hard substrate-bryozoan framework.

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## An enigmatic Diapsid reptile from the Middle Triassic of England

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Lepidosauromorpha is an extinct clade of diapsid reptiles basal to the extant, widespread Lepidosauria (Rhynchocephalia and Squamata), but its origins are poorly constrained (Evans, 2003; Evans and Jones, 2010). The oldest known taxa belonging to Lepidosauromorpha have been found in Early Triassic rocks of South Africa and Europe, while the first lepidosaurs are Middle Triassic in age (Carroll, 1975; Benton, 1985; Evans, 1991; Waldman & Evans, 1994; Renesto & Posenato, 2003; Evans & Borsuk-Białynicka, 2009; Jones et al., 2013; Schoch & Sues, 2018; Simões et al., 2018).

This work presents a previously undescribed reptile specimen from the Middle Triassic Otter sandstone, outcropping in south-western England, renowned for its vertebrate fossil content including fishes, temnospondyl amphibians and various diapsid reptiles that lived in a fluvial environment (Spencer & Isaac, 1983; Benton, 1997; Spencer & Storrs, 2002; Zaher et al., 2018; Coram et al., in press). The specimen is described from an incomplete but mostly articulated skeleton, comprising a badly damaged skull, vertebral column (19-21 pre-sacrals are preserved), pectoral girdle, ribs and the right forelimb. In order to study the specimen, CT scanning was used to derive a 3D model of the skeleton, revealing delicate anatomical details otherwise buried in the sandstone matrix. This reptile is characterized by a primitively high maxilla without a prominent nasal process, quadrate with a lateral conch, low jugal with small posterior process, conical teeth with pleurodont implantation, high coronoid process, notochordal vertebrae, long humerus with an entepicondylar foramen, rod-like clavicles, T-shaped interclavicle and a ventrolateral process of the scapulo-coracoid. Skull material is abundant, but damaged to the point that most of the skull's characters are lost. Phylogenetic analyses including Lepidosauromorpha usually are weakly supported and unresolved due to important percentages of missing data; nonetheless, all retrieved cranial and post-cranial characters of the specimen fully support an inclusion in the clade Neodiapsida (Benton, 1985). Strong evidence, including the pleurodont dentition, quadrate conch, notochordal vertebrae, cervical vertebrae shorter than dorsals and single headed ribs, advocate an inclusion in Lepidosauromorpha, although its characters are not typical of lepidosauromorph clades like Kuehneosauridae or Younginiformes; furthermore, there is no data supporting an inclusion in Lepidosauria. Morphological comparisons with other similar taxa have evidenced notable differences and, after further study, a new taxon will probably have to be erected for the specimen.

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## Paleo-environmental reconstruction of the upper unit of the Rosso Ammonitico Veronese of the Castione quarries

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In this work we perform a palaeoecological analysis of the taxa studied and discussed in the bachelor thesis "*Il Rosso Ammonitico Veronese nella città di Trento e studio della collezione Mazzucchi di Castione*" (Filosi, 2018), where the main purpose was the taxonomic identification of the specimens of the Mazzucchi collection housed in the MUSE (Trento, Italy); the collection consists of ammonites collected from the quarries of Castione, in particular from the lithological unit "A" of the Rosso Ammonitico Veronese Formation (Kimmeridgian - Tironian) (Sarti, 1993, 2003). We obtained numerous information that allowed us to reconstruct the palaeoenvironment of the studied taxa: we identified 34 specimens of the collection belonging to 5 different families of ammonites (Aspidoceratidae, Lytoceratidae, Ataxioceratidae, Phylloceratida e Perisphinctidae), we analysed the relative abundance of the identified species and the sedimentology of the unit. Further systematic researches were undertaken on new possible species found in the same collection (specimens of the genus *Trenerites* sp. cfr *Trenerites evolutus*). We also made a comparison using literature data with outcrops of the same unit in the surrounding regions (Lombardia, Trentino-Alto Adige and Veneto), to integrate and to correlate the palaeoenvironmental reconstruction using the recovered taxa and the sedimentology.

Our results seem to support previous hypotheses of an open sea environment with the deposition of pelagic sediments (Petti et al., 2011), marked by the alternation between high and low sedimentation rates that resulted in a different preservation of the fossil remains buried in those sediments.

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## Ricostruzioni paleoecologiche e paleoambientali dell'evoluzione di una struttura tabulare nell'area del Malta Plateau durante il tardo Quaternario tramite lo studio delle associazioni a foraminiferi bentonici

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Il Malta Plateau è un'area di particolare interesse in quanto soggetta a fenomeni di fuoriuscita di gas che portano alla formazione di vulcani di fango. Inoltre, nell'area è stata riscontrata la presenza di strutture tabulari rilevate rispetto al fondale, che sono l'oggetto di studio di questo lavoro. Precedenti studi hanno fornito una descrizione morfologica di una di queste strutture (Savini et al., 2009) e della sua evoluzione grazie ad analisi paleontologiche, sedimentologiche e mineralogiche (Bracchi et al., 2019). Questo lavoro propone una descrizione quantitativa delle associazioni a foraminiferi bentonici lungo una successione di sedimenti al fine di ricostruire l'evoluzione paleoambientale di questa struttura tabulare.

La carota MV02\_GC01 (36°34.2147'N; 14°30.2232'E), di lunghezza 176 cm, è stata campionata lungo il fianco della struttura tabula-

re a 141 m di profondità. La carota è caratterizzata nella sezione inferiore (da -176 a -76 cm) da biocostruzioni ad alghe calcaree e nella sezione superiore (da -76 a 0 cm) da depositi di fango fine. Per l'analisi micropaleontologica, 17 campioni sono stati prelevati ogni 10 cm per tutta la lunghezza della carota. Per ogni campione, 3 g di sedimento sono stati setacciati a umido con setaccio a maglia 125 µm e quartati. I foraminiferi bentonici sono stati raccolti tramite picking manuale, identificati e contati, mentre i foraminiferi planctonici sono stati contati per ottenere una stima di paleo-profondità.

In totale sono stati identificati 7218 foraminiferi bentonici appartenenti a 70 specie. In base alle loro caratteristiche ambientali, sono stati raggruppati in quattro categorie ecologiche, di cui è stata calcolata l'abbondanza relativa: trasportati, lagunari, marini ed epifiti.

La variazione lungo la carota di queste categorie è qui riportata e rappresentata in Figura 1:

- **Trasportati:** gruppo composto da Miliolidi rielaborati, *Ammonia beccarii* ed *Elphidium crispum*. Questi individui sono caratterizzati da una colorazione alterata e da gusci intensamente abrasi. Partendo dalla base della carota, si possono individuare due o tre fasi di diminuzione dell'abbondanza relativa. Questo gruppo, in gran parte presente nella sezione inferiore della carota, con un valore massimo di 37,8% a -160 cm, poi diminuisce fino a -80 cm, dove si identifica un altro picco di 33,04%; infine, l'abbondanza diminuisce di nuovo andando verso il top della successione, raggiungendo il valore 0% a -10 cm.
- **Lagunari:** gruppo composto da *Haynesina depressula*, *H. germanica*, *Pararotalia* spp., *Ammonia tepida*, *Elphidium granosum* e *E. translucens*; questa categoria ha un'abbondanza relativa costante lungo la successione con valori tra il 10 e il 15%, con un massimo di 22,9% a -30 cm.
- **Marini:** gruppo composto da Miliolidi (in situ, piccoli, bianchi e con un guscio ben conservato), *Bolivina* spp., *Cassidulina carinata*, *Globocassidulina subglobosa*, *Bulimina* spp., *Uvigerina* spp., *Valvulineria* spp., *Discorbis* spp., *Cibicides refulgens* e *Nonion* spp.; l'abbondanza relativa di questa categoria presenta un trend d'incremento dal basso verso l'alto, con un valore massimo di 70% a -20 cm.
- **Epifiti:** gruppo composto da *Textularia* spp., *Reussella spinulosa*, *Neoconorbina terquemi*, *Rosalina* spp. ed *Asterigerinata mamilla*; questa categoria è strettamente connessa a quella dei marini sulla base del significato ecologico. Infatti, la maggior parte degli epifiti identificati è associata, nel Mar Mediterraneo, a condizioni ambientali strettamente marine con la presenza di *Posidonia oceanica*. L'abbondanza relativa di questa categoria presenta un trend d'incremento dal basso verso l'alto, con un pronunciato picco del 33% a -60 cm.

Il rapporto foraminiferi planctonici vs foraminiferi bentonici (%P) corretto per le specie infaunali, espresso come percentuale (van der Zwaan et al., 1990) presenta valori particolarmente elevati nella sezione inferiore della carota, con valori attorno all' 80% tra -150 a -90 cm e con un massimo di 84% a -140 cm. A partire da -90 cm, il rapporto inizia a diminuire verso la parte superiore della successione, con un importante incremento negli ultimi due campioni.

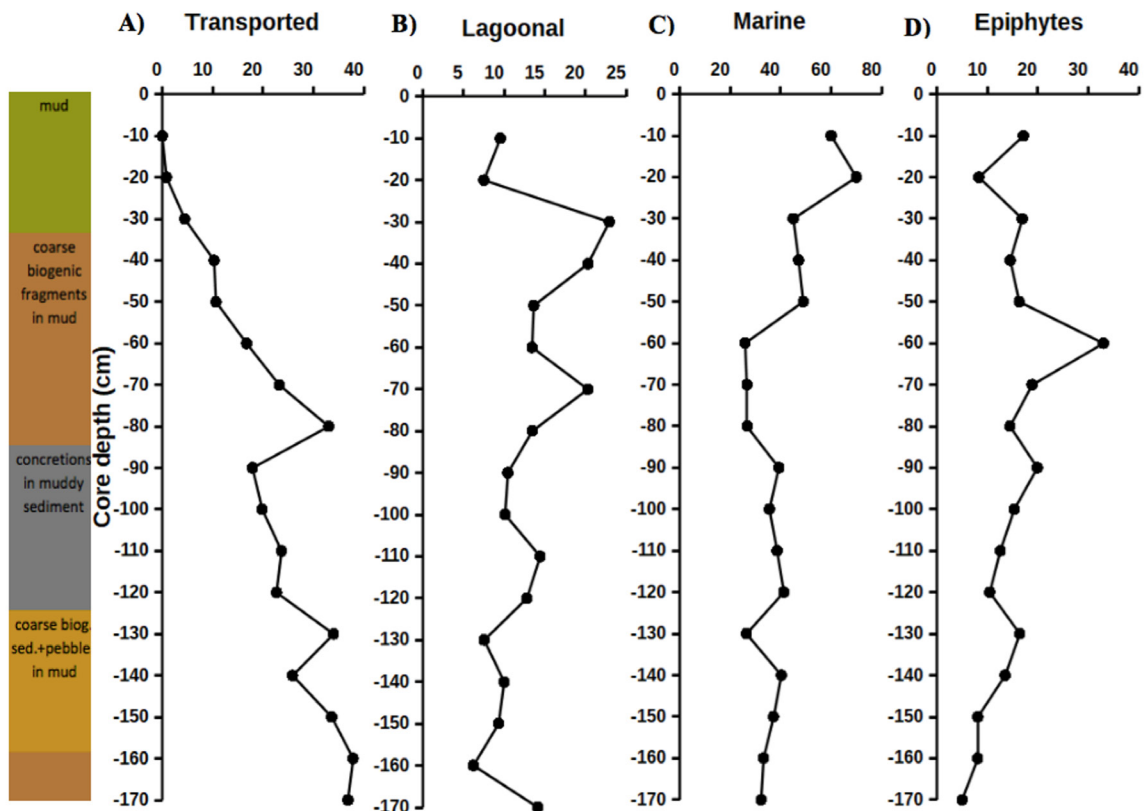


Fig. 1 - Grafici della variazione dell'abbondanza relativa delle quattro categorie ecologiche lungo la carota schematizzata a sinistra (A: trasportati; B: lagunari; C: marini; D: epifiti) lungo la successione sedimentaria espressa come percentuale (%)

La variazione dell'abbondanza relativa delle categorie ecologiche è stata interpretata come un ciclo di trasgressione dall'Ultimo Massimo Glaciale o da fasi glaciali precedenti. La diminuzione dell'abbondanza degli individui trasportati verso l'alto, accoppiata all'incremento dell'abbondanza dei marini e degli epifiti suggerisce un trend di approfondimento nel tempo. Questi risultati sono in accordo con i dati di Bracchi et al. (2019), sebbene gli alti valori dell'indice %P nella sezione più bassa della carota siano ancora oggetto di discussione. Questi possono derivare da: un'intensa attività erosiva durante le fasi glaciali, la migrazione verticale di materiale più antico in corrispondenza di possibili fuoriuscite di gas e fluidi o particolari condizioni paleoecologiche che hanno favorito il proliferare dei foraminiferi planctonici in condizioni di mare basso.

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## ***Mutoviaspermum krassilovii* gen. et. sp. nov., a peculiar ovuliferous compound conifer cone from the Lopingian (late Permian) of European Russia (Vologda region)**

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Late Permian Voltziales are interpreted to have given rise to most extant conifer families, although their origin and evolutionary relationships are still poorly understood. The recent discovery of female reproductive organs in anatomical connection with *Quadrocladus*-like leaves from the well-known Mutovino (=Isady) locality (European Russia) rekindles the discussion on the origin and evolution of late Permian conifers. The Poldarsa Formation (Kichuga Member) yielded a diverse Lopingian (260–251 Ma; upper Permian) flora, which includes some very peculiar ovuliferous compound cones. The micromorphology of eight specimens of dispersed ovuliferous compound cones in organic connection with conifer shoot fragments are here described. Their relationships are tested in a phylogenetic analysis as well. *Mutoviaspermum krassilovii* gen. et. sp. nov. is characterized by a stout main axis with helically arranged polysperms (sensu Meyen 1987) protected by coriaceous bracts. The polysperms are characterized by a peltate structure with a whorl of segments, fused near the stalk, in the basal part and with a seed scar on each segment. The anatomical connection between *Mutoviaspermum krassilovii* and *Quadrocladus*-like leaves provide the basis for re-assessing the botanical affinities of these taxa. A morphological phylogenetic supports the placement of *Mutoviaspermum* as an early diverging genus within the conifer order Voltziales. However, a precise relationship of this genus with other early conifers remains uncertain. Results of this analysis underline not only the ambiguous position of *Quadrocladus* but highlights also its complex and poorly understood relationship within the diverse Permian conifers.

## **I resti fossili di Pietraroja presenti nelle collezioni paleontologiche del Museo di Storia Naturale dell'Università di Firenze**

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La Civita di Pietraroja nella provincia di Benevento figura per la prima volta nella letteratura scientifica alla fine del XVIII con una menzione da parte del geologo e naturalista Scipione Breislak, che già fece cenno all'ottimo stato di conservazione dei resti che vi si ritrovavano, caratteristica che, nel tempo, ha fatto avvicinare il sito a Fossil-Lagerstätte del calibro di Bolca e Solnhofen. Da allora le ricerche si sono susseguite con continuità per studiarne i reperti, e sono state coronate dalla scoperta dei resti di *Scipionix samniticus*, il primo dinosauro mai ritrovato in Italia, che nel 1998 diede lustro e notorietà al sito a livello sia nazionale che internazionale conquistandosi la copertina della prestigiosa rivista Nature. Nella comunicazione proposta, conseguente a un lavoro di Tesi triennale, viene inquadrato lo svilupparsi degli studi dei "calcarei a ittioliti" di Pietraroja dagli studi di Nicola Covelli fino a quelli di Cristiano Dal Sasso, con un quadro aggiornato sulle ipotesi inerenti la datazione e l'interpretazione geologica della formazione del giacimento fossilifero. In questo quadro sono riportati i dati prodotti dal primo studio dei campioni presenti nelle collezioni paleontologiche del Museo di Storia Naturale di Firenze, in larga parte precedentemente mai analizzati eccezion fatta per quelli



curati nel XIX secolo dal Professor Iginio Cocchi, che ha portato alla loro identificazione a livello tassonomico come appartenenti per la maggior parte al genere estinto di pesci fossili *Clupavus*, al loro conseguente inserimento nel catalogo digitale del Museo e alla produzione di un archivio fotografico.

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## The 3D model of *Scipionyx samniticus*: an educational tool to learn the anatomy of a dinosaur

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Working together, palaeontologists and artists can reconstruct the appearance of organisms that lived millions of years ago by studying, drawing and sculpting, and also thanks to the powerful tools provided by new 3D technologies. Among non-avian dinosaurs, the most suitable candidate to be represented by a 3D anatomical model, including soft-tissue anatomy, is *Scipionyx samniticus* (popularly dubbed "Ciro"), a tiny specimen discovered at Pietraroja (southern Italy) in 1980. It represents one of the most relevant finds in the history of palaeontology due to its unique state of preservation, including soft-tissue remains which are still in anatomical position (Dal Sasso & Signore, 1998). In 2011, a detailed monograph was published (Dal Sasso & Maganuco, 2011), providing the most complete anatomical database on a dinosaur. Descriptions of the whole osteology and soft-tissue anatomy were coupled with a huge amount of photographs, labelled line drawings, skeletal reconstructions and in-vivo restorations. The ontogenetic stage and the relative position of the food remains in the digestive apparatus were also documented. Here we propose an interactive 3D reconstruction of *Scipionyx*, digitally modeled and painted using the software ZBrush and animated in Blender, summarizing the data published in the 2011 monograph. The reconstruction allows the user (1) to view size and position of the known soft-tissues of the dinosaur (e.g., articular cartilages, tracheal rings, oesophageal remains, blood-rich organs, intestine, hindlimb muscles, and horny manual claws); (2) to highlight some early ontogenetic features of the individual (e.g., frontoparietal fontanelle, large size of the orbits, abdominal space for the yolk-sac); (3) to show the feeding chronology. The 3D model of *Scipionyx* is also suitable for three additional purposes: to realize a virtual animation, which allows scientists to study and represent the animals of the past just like living animals; to 3D-print a scale anatomical model of the animal, useful for teaching purposes and for museum display; to calculate a more accurate volume and body mass estimate of the individual, for study purposes. In conclusion, the 3D reconstruction of *Scipionyx* presented herein is designed to be a useful, interactive, and versatile educational tool for teachers, students, museum's visitors and all people interested in learning about the anatomy of dinosaurs; it is accessible to a wide audience in different ways; it is easily modifiable to include additional educational contents; it is easily updatable in case of new discoveries and/or revised interpretations; and it provides new information about the body mass of the individual.

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## Taking the stock about Cessaniti: 10 years of researches on a key site for the Late Miocene of the central Mediterranean area

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During Miocene, the paleogeography of central Mediterranean underwent significant modifications. The sedimentary basin of Capo Vaticano/Monte Poro, located in the south-western sector of the Calabria-Peloritani Arc, have a strategic position and released a very interesting record of marine and continental fossils.

The late Miocene succession of Capo Vaticano/Monte Poro (Fig. 1) overlies a Paleozoic crystalline substratum, and outcrops with different thickness and facies throughout the area (Nicotera, 1959). At Cava Gentile (Cessaniti), the late Miocene succession is complete and reaches its maximum thickness (Fig. 2) (Neri et al., 2005; Gramigna et al., 2008; Marra et al., 2017).

Cessaniti is known since the XIX century for the impressive abundance of *Clypeaster* and their remarkable preservation. In addition to the rich echinoid fauna (Checchia Rispoli, 1925), the site released abundant remains of marine mammals, mainly Sirenians and subordinately Cetaceans, (Neviani, 1886; Moncharmont Zei & Moncharmont, 1987; Carone & Domning, 2007; Guido et al., 2012; Carone et al., 2013; Carone & Marra, 2014; Marra et al., 2016). The occurrence of land mammals at Cessaniti has been firstly noticed



by Ferretti et al. (2003), which described and determined the *Stegotetabelodon* cf. *syrticus*, a proboscidean of Afro-Arabian affinities.

A new impulse to studies on the mammal association from Cessaniti started over in 2008, under the scientific direction of the present authors. Ten years later, almost all the mammals have been determined, described, and related to a new stratigraphical framework (Marra et al., 2011; Carone et al., 2013; Carone & Marra, 2014; Marra et al., 2016; Marra et al., 2017; Marra, 2018). Marra et al. (2017) recognised in the Gentile's quarry succession soils and fluvial deposits in the "Clypeaster sandstones" (FL1 to FL3 in Fig. 2), probably due to temporary falls in sea level during the transgression, controlled by tectonics. Moreover, the Authors dated the succession (from LG to the top of SH4, Fig. 2) between 8.1 and 7.2 ma.

The abundant record of *Metaxytherium serresii* confirmed the reduction of the body size of the species with respect to the ancestor *M. medium* and demonstrated a broad intraspecific variability (Carone et al., 2013). Cetaceans are represented by Physiteroidea indet. (Marra et al. 2016) and few remains of other Odontocetes indet.; also, few remains of Mysticetes have been attributed to *Heterocetus* cf. *guiscardii* (Carone & Marra 2014).

New finds of *Stegotetabelodon syrticus* confirmed the attribution to the Afro-Arabian species and

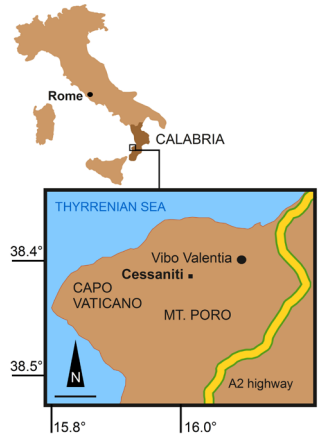


Fig. 1 - Geographical position of the sites quoted in the text

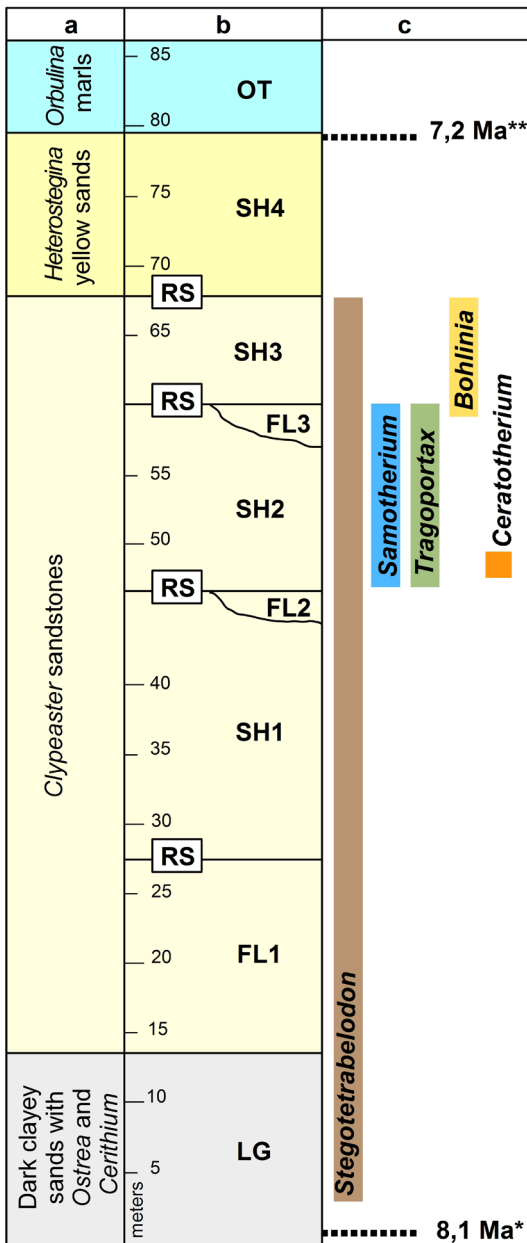


Fig. 2 - Simplified stratigraphy of Cava Gentile at Cessaniti. a) informal stratigraphy; b) revised stratigraphy according to Marra et al. (2017): LG, Lagoonal; FL, fluvial; SH, shoreface; OT offshore transition; RS, Ravinement surfaces; c) mammalian taxa occurrence

extended the occurrence of the taxon also in the lagoonal deposits (LG in Fig. 2), suggesting a long persistence in the area (Ferretti et al., 2017).

The Giraffid remains have been attributed to *Bohlinia attica* and *Samotherium boissieri*, two species common in the Pikermian biome, a mammal association of savannah-like environment typical of the Greco-Iranian bioprovince (Marra et al., 2011).

The medium sized bovid remains have been identified as *Tragoportax* cf. *rugosifrons*, a boselaphine bovid belonging to a genus widespread in Eurasia and Africa during the late Miocene (Marra, 2018). A small sized bovid, still undetermined, also occurs in the association.

The morphological characters of Rhinocerotidae remains allowed the proposal of a new species related to the African genera *Diceros* and *Ceratotherium*, and recently attributed to the new species of '*Ceratotherium*' *adventitius* (Pandolfi et al., 2019).

Isolated limb bones seem attributable to an Antracotherid and are still under study.

The land mammals from Cessaniti include North African and Pikermian species. This peculiar bioprovince can be the result of stable land connections with Africa when the Pikermian biome expanded its geographical range including the northern part of the continent (Marra et al., 2011; 2017).

The pending taxonomic attributions, and the continuous ongoing field activities are intriguing premises for the prosecution of the researches at Cessaniti, and for our understanding of its relevance in deciphering the paleogeographic evolution of the central Mediterranean at the end of Miocene.

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## La valenza strategica dei geositi per la valorizzazione del territorio

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L'obiettivo della ricerca è l'individuazione e la sperimentazione di strumenti e metodi per la valorizzazione del patrimonio geologico. Il patrimonio geologico di una determinata area comprende tutti i beni naturali in cui la componente geologica costituisce l'interesse prevalente. Il paesaggio, inteso come bene naturale, può essere osservato e valutato mediante due tipi di approcci: il primo è sicuramente quello che si basa sull'ammirazione della bellezza naturale del bene, approccio soggettivo. Il secondo è quello scientifico-culturale, basato sulla conoscenza del bene (Panizza, 1999).

L'integrazione dei due approcci è l'obiettivo che può portare ad avere una visione completa del patrimonio geologico. Due sono gli elementi fondamentali sui quali si basa il passaggio dal concetto astratto di patrimonio geologico alla sua visione concreta: l'attribuzione di un "valore" ai siti geologici e la gestione dei dati relativi. La valorizzazione dei geo-siti deve basarsi soprattutto su un processo di comunicazione e di interpretazione che deve portare l'utente a guardare con occhi diversi ciò che lo circonda. Un progetto di valorizzazione deve essere concepito come la spiegazione di un racconto che offre al visitatore nuovi percorsi di conoscenza e di scoperta che lo portano a condividere il valore di un territorio. In questo contesto i geo-siti giocano un ruolo importante e rappresentano un valore aggiunto alle opzioni di sviluppo dell'economia locale. Al fine di valutare esperienze di geo-conservazione anche in altre aree europee è stata presa in esame anche l'esperienza realizzata all'Arcipelago delle Azzorre, che presenta una ricca e vasta geo-diversità e un importante patrimonio geologico (Avila et al., 2016).

Queste isole rappresentano un ottimo esempio di conservazione dell'ambiente geologico poiché nel 2013 sono state il primo arcipelago ad essere incluso nella rete Europea e mondiale dei Geo-parchi riconosciuto dall'UNESCO. La gestione dei geo-siti paleontologici, la loro organizzazione e le metodologie che devono essere utilizzate per salvaguardare l'integrità dei fossili e sottolinearne il valore scientifico costituiscono un unicum nell'ambito della gestione e della valorizzazione dei geo-siti poiché ogni singola attività che viene svolta in un giacimento fossilifero ricopre un'importanza fondamentale per la riuscita del lavoro di estrazione, recupero dei reperti e poi della loro fruizione (Broglia, 1995).

Tuttavia, anche in quest'ambito, è stata riscontrata una carenza nella conoscenza da parte delle popolazioni locali. Infatti, in molte zone alcuni reperti sono andati perduti in circostanze "misteriose" e di essi sono rimaste solo fotografie che non permettono una adeguata classificazione ed interpretazione tassonomica.

Anche nell'area del parco geopaleontologico di Pietraroja, la geo-conservazione dell'area non sempre è stata ottimale e solo recentemente sono stati messi in atto alcuni progetti di valorizzazione. L'istituzione di un ente di protezione Geopaleontologico nell'area era prevista fin dal 2000, quando viene emanata la legge n° 388 del 23 dicembre, che nel dare atto dell'esigenza di conservare e valorizzare i siti geologici, paleontologici, naturalistici e paesaggistici, reca norme per l'istituzione e la gestione dell'ente geopaleontologico di Pietraroja, istituito poi, però, 17 anni dopo con il decreto del 28 Dicembre 2017.

Altro aspetto importante è quello economico, legato soprattutto all'incremento dei flussi turistici in queste aree. Infatti, accanto a siti più noti come Pietraroja, abbiamo siti minori come Baselice, Vitulano, Cerreto Sannita, Telese o la stessa Pietraroja scarsamente raggiunti dai flussi turistici ma che possono divenire un esempio di turismo eco-sostenibile.

Le opportunità offerte dal territorio della Campania sotto l'aspetto geo-turistico sono enormi grazie alla grande varietà geologica dei paesaggi che il nostro territorio ha da offrire (Ruggiero et al., 2003; Amore & Ciarcia, 2016).

Negli ultimi anni si è compreso che la valorizzazione dei geo-siti deve andare oltre la semplice tutela e salvaguardia degli aspetti geologici ed ecologici, allargando il proprio campo di azione anche ad aspetti storici, culturali ed economici legati al geo-sito da salvaguardare. Si è infatti compreso come sia possibile interconnettere la valorizzazione di siti di interesse geologico con le caratteristiche storiche o archeologiche di un territorio. Ad esempio, facendo riferimento al patrimonio geo-industriale l'opinione pubblica dei paesi industrializzati ha preso via via coscienza del valore economico, sociale e scientifico di tali risorse o beni naturali (Del Prete, 2011).

Una migliore gestione del patrimonio geologico, e paleontologico in particolare, passa attraverso una maggiore consapevolezza

delle popolazioni locali nonché attraverso una divulgazione capillare e attraverso una forte identità professionale del geologo ed il riconoscimento del suo fondamentale ruolo nei diversi processi di organizzazione, valorizzazione e tutela dei geo-siti.

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## I coccoliti come indicatori dei cambiamenti paleoceanografici connessi alle variazioni paleoclimatiche del Quaternario

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La storia del nostro Pianeta è caratterizzata da sempre da variazioni delle sue condizioni climatiche; alcune si sviluppano su una scala temporale molto lunga, dell'ordine di migliaia, centinaia di migliaia o milioni di anni, altre, più brevi, presentano scale secolari o decennali. Le oscillazioni climatiche possono essere di carattere ciclico e possono essere causate dal variare, nel tempo, di fattori naturali, come i moti millenari della Terra o da fattori presenti all'interno del sistema climatico stesso: nell'atmosfera, nell'idrosfera, nella biosfera, nella criosfera e nella litosfera. Le variazioni climatiche più significative sono quelle che si sono verificate al passaggio da una fase glaciale ad una caratterizzata da condizioni interglaciali e viceversa. Lo studio di queste variazioni è importante per meglio capire le relazioni esistenti tra il clima e alcuni fattori ambientali. Il Mar Mediterraneo rappresenta, a questo scopo, un'area chiave poiché opera come una sorta di oceano in miniatura e di conseguenza è un luogo adatto sia per testare i processi oceanografici sia per raccogliere dati sulla risposta degli ecosistemi marini alle variazioni climatiche avvenute nel passato e per mettere, quindi, a punto schemi eco-stratigrafici per il plancton calcareo durante il tardo Quaternario. Il Mar Mediterraneo è un mare caratterizzato da un sistema di circolazione, a grande scala, di tipo anti-estuarino semi-chiuso che può essere diviso in due sottobacini, il Mediterraneo occidentale e orientale, rispettivamente a ovest e a est dello stretto di Sicilia (Pinardi et al., 2015). Le variazioni climatiche che hanno caratterizzato il Quaternario sono state registrate dalle associazioni planctoniche che sono largamente utilizzate nelle ricostruzioni paleoceanografiche e che sono caratterizzate dalla presenza, al loro interno, di organismi chiamati coccolitoforidi, uno dei principali gruppi di phytoplankton marino e tra i migliori proxy paleoceanografici. I coccolitoforidi sono un importante gruppo di alghe unicellulari planctoniche, che producono delle piccole piastre di carbonato di calcio chiamate coccoliti. Essi sono sensibili indicatori ambientali perché dipendono da fattori quali la temperatura, la salinità, la disponibilità di nutrienti e di luce solare (Baumann & Freitag, 2004). Essi sono anche i maggiori produttori di dimetil solfuro, un gas che è ritenuto contribuisca ad incrementare l'effetto serra, quindi le loro variazioni di abbondanza nelle associazioni planctoniche oltre a poter essere considerate come una risposta ai cambiamenti climatici del passato, hanno anche effetti diretti sul clima. I coccoliti sono abbondanti nei sedimenti di mare profondo, depositi al di sopra della profondità di compensazione della calcite (CCD) e conservano, generalmente, la composizione delle comunità della zona fotica sovrastante (Bown 1998). Dopo la fine dell'ultima glaciazione quaternaria il clima della Terra non è rimasto invariato ma, pur essendo caratterizzato da condizioni globali tipiche di una fase interglaciale, ha subito numerose oscillazioni. Oggi viviamo in una fase di forte riscaldamento con impatti diffusi sia sui sistemi umani sia su quelli naturali. I valori medi delle temperature, in atmosfera e nelle acque oceaniche, mostrano un continuo incremento, la quantità delle precipitazioni nevose e l'estensione delle calotte glaciali registrano, invece, significative diminuzioni; si assiste, inoltre, ad un innalzamento globale del livello del mare e ad un aumento delle emissioni di gas serra in atmosfera. Ciò ha portato a elevate concentrazioni, in atmosfera, di anidride carbonica, metano e protossido di azoto che costituiscono, molto probabilmente, la principale causa del riscaldamento globale osservato sin dalla metà del 20° secolo (Ruddiman, 2008). Per meglio gestire e per rallentare il riscaldamento climatico in atto occorre migliorare le conoscenze degli ecosistemi marini; soprattutto è importante comprendere a pieno quali sono le risorse ancora disponibili, la vulnerabilità dell'area mediterranea e le sue capacità di resilienza rispetto alle pressioni, naturali e umane, su di essa esercitate. Inoltre, è necessario mettere a punto per le aree costiere piani di protezione e mitigazione dai rischi connessi alle variazioni climatiche globali a cui queste aree sono più esposte. La ricostruzione dei climi del passato è, dunque, fondamentale per poter distinguere le variazioni naturali del clima dalle variazioni causate dall'impatto delle attività umane sul sistema climatico terrestre; tali ricostruzioni sono possibili grazie allo studio dei proxy climatici, che consentono di ottenere ricostruzioni paleoclimatiche e paleoambientali dettagliate. Lo studio dei coccoliti in particolare è perciò utile per acquisire dati sulle variazioni climatiche del passato e per poter effettuare congetture sull'evoluzione futura del sistema climatico terrestre più attendibili. Un'accurata previsione dei futuri scenari è fondamentale per consentire una pianificazione più attenta; tale pianificazione deve essere basata su interventi più severi per quanto riguarda l'uso dei combustibili fossili ma anche su una gestione integrata delle aree marine costiere, basata su una maggiore attenzione all'utilizzo delle risorse marine e sulla tutela e la valorizzazione del patrimonio marino e costiero mediante la promozione di un turismo eco-sostenibile.

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## Apulia dinosaur footprints: state of the art and future perspectives

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In 1999, with the discovery of thousands of dinosaur footprints in an abandoned limestone quarry near Altamura (Murge area, southern Italy), the interest of the scientific community toward the dinosaur ichnological record in Apulia started, and in the following twenty years, several other dinosaur tracksites were discovered in the region (Nicosia et al., 2000; Conti et al., 2005; Petti et al., 2008; Sacchi et al., 2009; Petti et al., 2010; Petruzzelli et al., 2011; Mastronuzzi et al., 2015).

Track-bearing formations (Calcare di Bari and Calcare di Altamura) range from Early to Late Cretaceous and are mainly made of peritidal facies. A high palaeobiodiversity was assessed through the study of dinosaur tracks. The discovered ichnoassemblages indeed testify to the presence of small to medium sized theropods, sauropods, ankylosaurs and hadrosaurs.

In spite of the growing number of trampled horizons, studies are still in an embryonic phase for some of the discovered ichnosites. In the Murge area they regard only sites in the area of Altamura (Nicosia et al., 2000), Bisceglie (Sacchi et al., 2009; Petti et al., 2010) and Molfetta (Fanti et al., 2014; Petruzzelli, 2017; Petti et al., 2018).

The presence of dinosaur footprints in the Apulian Carbonate Platform clashes with a continuous marine environment scenario and thus can reveal a wealth of palaeobiological and palaeoenvironmental evidences that have important implications on the palaeographic reconstructions of the Southern Tethys region.

A large-scale scientific project on the important and well-known Altamura tracksite is starting. Studies on the Apulian footprints could also contribute to our knowledge on some neglected topics, such as their in-situ preservation and their use in public awareness of science and divulgation of the geo-palaeontological culture.

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## Neoselachians Synchodontiformes from Mt Nerone area (Umbria-Marche Apennine, Italy) throw new light on the Jurassic pelagic carbonate platform palaeoecology

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The Mt Nerone Pelagic Carbonate Platform (PCP) is proving to be a feasible observatory for a more inclusive understanding of the vertebrate/invertebrate palaeocommunities that inhabited the Jurassic sea of the Umbria-Marche-Sabina Domain. While the invertebrate fauna from Mt Nerone area has been largely studied in the past, formal descriptions of the vertebrate record were virtually lacking, being represented only by a probable ichthyosaur rib. More recently, a renewed interest has been focused on the highly fragmentary vertebrate remains of the region. As a result, an articulated dentition and some other tooth fragments of hybodont sharks referred to *Asteracanthus* cf. *A. magnus*, and several teeth of neoginglymodian actinopterygians with a greater affinity to the genus *Scheenstia*, have been described. These taxa indicate diverse durophagous ecological niches in the PCP-basin system of Mt Nerone, most likely triggered by the abundant invertebrate fauna inhabiting the structural high. Other shark remains enrich the vertebrate record from the area and are here presented. The new material, referred to Neoselachians Synchodontiformes and showing some affinities with the mono-generic family Orthacodontidae, is represented by slender and piercing teeth, with sharp cutting edges, indicating a tearing-type dentition. This dental type characterizes fishes dwelling in different environments, from the coastal to the epi-pelagic and pelagic domain. The neoselachians here reported most likely were active pelagic predators, catching on fishes, smaller sharks and probably cephalopods on mid- to surface water, on and surrounding the morphostructural highs. The new material introduces an additional trophic level and enhance our understanding of the Jurassic palaeobiology and palaeoecology of the Umbria-Marche Domain.

## I Geositi del Matese: proposte di tutela e valorizzazione

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Una ricerca, iniziata nel 2000, ha portato alla individuazione nell'area del Matese di 30 siti di interesse geo-ambientale (Amore et al., 2004, Ruggiero et al., 2003), di essi 18, a valenza almeno regionale, sono stati inseriti nel database nazionale dell'APAT (Taddei et al., 2004). I geositi individuati presentano un interesse scientifico primario di tipo: geomorfologico (8 siti), stratigrafico (5), paleontologico (3), geologico strutturale (1) e geominerario (1). Per alcuni di essi sono state avanzate proposte di valorizzazione, come la realizzazione di musei a cielo aperto in cave abbandonate o la sistemazione di siti in passato sedi di importanti attività estrattive o industriali, come esempi di archeologia industriale. Fra i vari siti censiti è da segnalare indubbiamente l'area di Pietraroja-Le Cavere (Parco Geopaleontologico), famosa nel mondo per il rinvenimento di pesci, anfibi e rettili fossili in uno straordinario stato di conservazione. Qui è stato ritrovato il primo dinosauro italiano, un esemplare di *Scipionyx samniticus*. Di grande interesse scientifico, didattico e paesaggistico è anche il Lago del Matese, splendido lago tettono-carsico e principale meta turistica dell'area. Nell'intero territorio del Matese le acque hanno un ruolo di primo piano, almeno altri tre dei geositi individuati sono intensamente legati alla loro attività: Ponte Lavello con le sue marmitte dei giganti e la spettacolare forra scavata dalle acque del Torrente Titerno; il Lago di Gallo legato allo sbarramento del Fiume Sava ed infine Lete-Centrale Elettrica dove, in un ambiente di grande valore naturalistico e paesaggistico percorso dal Fiume Lete, si è proposto di valorizzare la vecchia Centrale Elettrica, come esempio di archeologia industriale. Infine, ubicata nei pressi dell'abitato di Pietraroja, vi è Cava Canale, una cava abbandonata caratterizzata da un interesse scientifico primario di tipo geologico stratigrafico e secondario di tipo paleontologico e geomorfologico. Il materiale che veniva estratto è una calcarenite bioclastica miocenica appartenente alla Formazione di Cusano. I tagli mostrano delle situazioni molto interessanti, come ad esempio la trasgressione, in tre dimensioni e, in splendida esposizione, dei depositi del Burdigaliano superiore - Langhiano (Formazione di Cusano) sui calcari del Cretacico inferiore, interessati da evidenti bioerosioni. Ben esposto è anche il passaggio stratigrafico tra le calcareniti del Cusano e i calcari marnosi e marne della Formazione di Longano (Serravalliano - Tortoniano). Nei dintorni, in particolare nella cava di argilla situata di fronte a Cava Canale, affiorano estesamente le argille marnose, marne argillose e arenarie della Formazione di Pietraroja (Tortoniano). Queste tre formazioni sono state osservate e descritte da Selli nel suo importante lavoro sul Miocene dell'Italia meridionale (Selli, 1957). Sulle superfici rocciose, tagliate con il filo elicoidale, si possono osservare numerosi resti fossili: rodoliti, briozoi, pettinidi, ostreidi, balanidi, denti di pesci, etc. La cava si trova a poche centinaia di metri dal giacimento cretacico di "Pietraroja - Le Cavere".

Altro sito molto interessante è rappresentato dalle Regie Piane in cui affiorano i calcari del Cretacico con livelli di bauxite, in cui sono state aperte delle miniere. Segue, bene esposta tutta la successione fino alle calcilutiti del Longano. Gli scopi principali di tale progetto sono stati quelli di sensibilizzare le popolazioni locali, e soprattutto le scuole, sulla importanza di proteggere l'ambiente in tutte le sue componenti, anche quella abiotica, e di contribuire allo sviluppo socioeconomico del territorio. Infatti, nonostante il grande valore naturalistico, questa zona dell'Appennino meridionale appare marginale rispetto ai grandi flussi turistici che caratterizzano le coste campane e le città d'arte come Napoli, Caserta e Pompei.

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## The Geology of Civita di Pietraroja (Southern Italy) Stratigraphic and micropaleontological analysis

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The Civita di Pietraroja is located on top of a relief of the E-W trending Matese Group, at the border of the Campania Apennine Chain. The Matese Group is made up of Mesozoic calcareous successions linked to a platform or a border of platform of the South-Apennine Platform Unit (D'Argenio et al., 1973; Mostardini & Merlini, 1986; Pescatore et al., 1996). During the Neogene time this unit has been involved in the Adriatic trending thrust sheets (Late Miocene – Early Pliocene) of the developing chain. Subsequently (Late Pliocene - Pleistocene), normal faults led to the rising of this sector of the southern Apennine chain.

The relief of the *Civita di Pietraroja* is an eastern dipping monocline bordered toward south and north by east-west trending normal faults while toward east and west by north-south trending normal faults. The monocline is constituted by the Mesozoic calcareous succession followed, in discontinuity, by the Miocene from calcareous (Cusano and Longano Formations) to silici-clastic succession (Pietraroja Formation).

The ichthyolite limestones, considered for this study, crop out on the eastern side of the *Civita di Pietraroja*, and fall almost completely in the area of the Geopaleontological Park. They consist, from bottom to top, of three terms whose total thickness is about 40 m:

- 1) fine-grained limestones (mudstone, mudstone-wackstone) in thin, generally laminated and sometimes gradated layers in which fish specimens have been found (Bravi & Garassino, 1998) with typical lithofacies of intertidal and / or subtidal environment with restricted circulation;
- 2) medium to fine-grained limestone (packstone and wackstone) in thin, laminated and graded layers with lithofacies typical of a subtidal environment and characters indicating gravitational deposition; the geological field survey has highlighted a surface with channels filled by these calcareous-clastic deposits in progradation toward east and, according to a tabular geometry of the layers, they, probably, were deposited into a depressed area of the platform;
- 3) fine-grained limestones (mudstone) in laminated and sometimes graded thin layers in which nodules and bands of chert and centimetric layers more or less siccilized with desiccation structures are found. Furthermore, this term is characterized by thin layers ranging from millimetres to centimetres rich in organic matter and containing several remains of continental vertebrates and marine vertebrate and invertebrates (Bravi & Garassino, 1998; Dal Sasso & Signore, 1988). The lithofacies is typical of intertidal and subtidal environments with restricted circulation.

The micropaleontological analysis, above all on the calcareous nannoplankton, performed on samples collected from the studied succession, has highlighted the complete absence of species, confirming that the 1 and 3 successions are of shallow water while the 2 succession, of deeper environment, could be deposited in a depressed area located on the platform.

According to our data it is possible to reconstruct a paleomorphology of the area characterized by a platform with an irregular topographic surface with wide and probably confined depressions. The studied succession characterized by (1) deposits of low circulation environment then (2) of open circulation environment and again (3) of restricted circulation environment was deposited in one of these depressions.

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## Partial cranium of Propotamochoerus (Cetartiodactyla, Suidae) from the late Miocene of Northern Italy

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In this work we describe a partial cranium of a suid (Cetartiodactyla, Suidae) from the Messinian post-evaporitic deposits (5.55–5.40 Ma) of Verduno (Piedmont, NW Italy). The splanchnocranium from Verduno preserves almost complete upper tooth rows. The

specimen is characterized by a relatively small size, wide snout, weak development of upper canines, and absence of alveolar crest. The preserved third molar is fully erupted but virtually unworn. These features suggest that the individual should be considered a young adult female. The combination of morphological and morphometrical characters of the specimen allow us to assign it to the genus *Propotamochoerus* (Pilgrim, 1925).

Miocene Eurasian suids are commonly separated in two different lineages: *Microstonyx* / *Hippopotamodon* characterized by large sizes, and *Propotamochoerus* / *Korynochoerus* with smaller size. The relationships between these genera are still debated although some hypotheses have been proposed. While *Microstonyx* and *Hippopotamodon* are common in the Eurasian fossil record and well documented, the less abundant *Propotamochoerus* is a poorly known genus characterized by a rather heterogeneous hypodigm, so much that it was sometimes regarded to as a “wastebasket taxon” for a large amount of isolated Miocene suid remains, especially teeth. In Europe, two species belonging to this genus are currently recognized, *P. palaeochoerus* and *P. provincialis*, but the cranial anatomy of these taxa is practically unknown. Furthermore, several late-latest Miocene samples are referred to *P. hyotheroides* or *P. hysudricus*, although more recent studies attribute the same materials to *Propotamochoerus* sp. and suggest the existence of a possible new species. Besides the small endemic form *Eumaiiochoerus etruscus* from the Tusco-Sardinian bioprovince, the Miocene fossil record of suids in Italy is particularly poor. Scanty and isolated remains attributed to the genus *Propotamochoerus* are known from Emilia-Romagna, Tuscany, and Sicily. The fossil from Verduno represents the most complete and significant specimen referred to date to *Propotamochoerus* in the Italian Peninsula. Unfortunately, the lack of comparative material and the debated taxonomic status of *Propotamochoerus* do not allow us to interpret in much detail the specific status of the Verduno specimen, at least at this preliminary stage.

## Contrada Monticelli (Castellana Grotte, southern Italy): the southernmost occurrence of the early Middle Pleistocene *Dama cf. roberti* (Cervidae, Mammalia)

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In 1978, a deposit bearing abundant fossil vertebrate bones was discovered at Contrada Monticelli (Castellana Grotte, southern Italy) during building works (Luperto-Sinni & Colucci, 1985), within the Calcare di Altamura Formation (Upper Cretaceous). The collected fossils, including *Paleoloxodon antiquus*, *Stephanorhinus hundsheimensis*, equids, bovids, cervids and *Canis mosbachensis*, (Luperto Sinni & Colucci, 1985; Mazza & Varola, 1999; Mecozzi et al., 2017), provided important indications on the paleoenvironmental and paleoecological context of the Murge during the Middle Pleistocene. The deposit has been attributed to the early Galerian Mammal Age (0,6-0,4 Ma; Mecozzi et al., 2017). Currently, the fossils from Contrada Monticelli are stored at the Museum of Earth Sciences of the University of Bari. Among these, 12 fossil remains attributed to Cervidae have been selected for this study in order to refine their taxonomical identification. They are composed of 9 cranio-dental remains, 1 cervical vertebra and 2 right humera. Unfortunately, no antlers have been found. Morphological and biometric analyses were carried out allowing their attribution to the genus *Dama*. Overall, the conservation status is quite good, although some fossils show deformation, due to compression during the post-depositional phase. Most of the cranio-dental findings represents sub-adults and young individuals. A morphological and biometric comparison with fossil *Dama* from other Italian sites allowed to refer the remains of Contrada Monticelli to *Dama cf. roberti* Breda & Lister (2013). There is a certain variability in the morphological features as in other samples of *Dama roberti* from different European localities. Some characters are plesiomorphic within the group *Pseudodama-Dama* and are shared with the genus *Cervus*, evidencing a progressive and gradual differentiation of *Dama* from *Cervus*, in agreement with the previous studies (Breda, 2015). The recognition of the species *Dama cf. roberti* at Contrada Monticelli represents the southernmost evidence of this species in Italy and is consistent with the biochronological attribution of this site to the Isernia La Pineta Faunal Unit (FU) where this species has been recorded as well (Breda et al., 2015).

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## Gli anfibi e rettili gelasiani di Coste San Giacomo (Anagni, Italia)

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Il sito pleistocenico di Coste San Giacomo, localizzato nel Bacino di Anagni (Lazio meridionale), è ben conosciuto tra i paleontologi dei vertebrati per l'importante mammalofauna, datata a circa 2,1 milioni di anni (Pleistocene Inferiore; Gelasiano). Malgrado siano state identificate finora 32 specie di micro- e macromammiferi, nessuna analisi sistematica è stata finora condotta sui microvertebrati ectotermi.

Questo studio, basato su un campione di 83 resti fossili recuperati durante gli scavi condotti nel 2013, si incentra per la prima volta sugli anfibi e rettili provenienti dal sito di Coste San Giacomo. L'analisi dei resti ha permesso il riconoscimento di almeno tre taxa di anfibi e almeno altrettanti di rettili. Tra gli anfibi sono presenti resti di bufonidi indeterminati (*Bufo* indet.), rane verdi (*Pelophylax* sp.) e rane rosse (*Rana* sp.), anche se due diversi morfotipi degli ilei di quest'ultimo genere suggeriscono la possibile presenza di due distinte specie. I rettili includono due lucertole (*Lacertidae* indet. e *Pseudopus* sp.) e un serpente (*Natrix* sp.). La presenza di *Pseudopus* risulta particolarmente importante in quanto rappresenta l'unico ritrovamento certamente quaternario di questo anguine in Italia peninsulare.

I taxa identificati forniscono informazioni utili alla ricostruzione paleoambientale del sito di Coste San Giacomo. Gli anfibi e *Natrix*, in particolare, testimoniano un ambiente umido, in accordo con i dati forniti dalla sedimentologia e dal resto della fauna. L'unico rappresentante attuale del genere *Pseudopus*, *Pseudopus apodus*, abita ambienti relativamente aridi e rocciosi con abbondante copertura vegetale, ma una relazione con ambienti più umidi è stata suggerita per alcune specie estinte appartenenti allo stesso genere.



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