XXIV Edition of the "Giornate di Paleontologia"

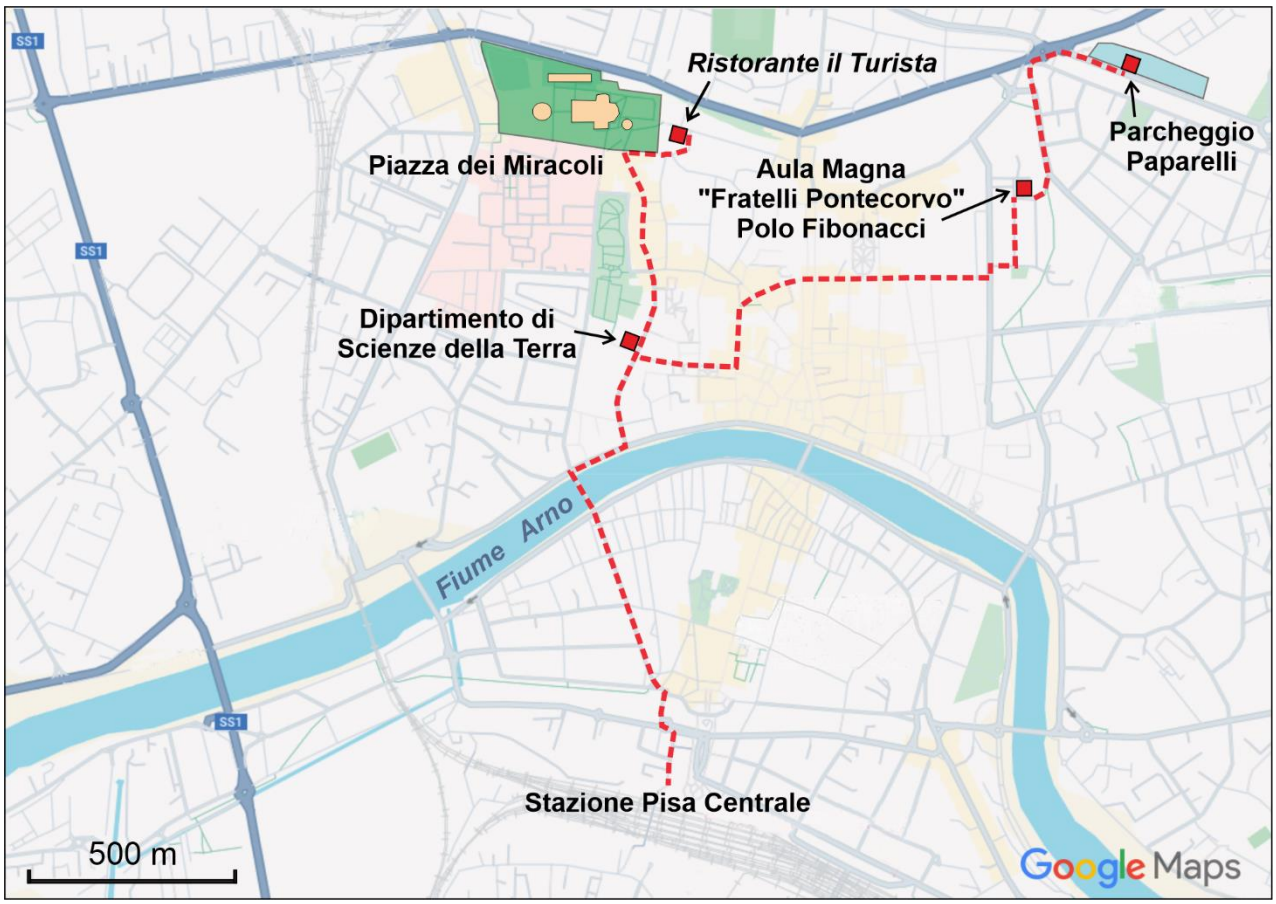
Pisa, (4) 5-7 June 2024

ABSTRACT BOOK

Edited by
Giovanni Bianucci, Marco Merella & Alberto Collareta

CONFERENCE LOCATIONS

The XXIV Edition of the Paleodays will take place in the Aula Magna "Fratelli Pontecorvo" (Building "E" of the Fibonacci Centre, via Filippo Buonarroti 4, 56127 Pisa) and the Department of Earth Sciences (via Santa Maria 53, 56126 Pisa) of the University of Pisa.



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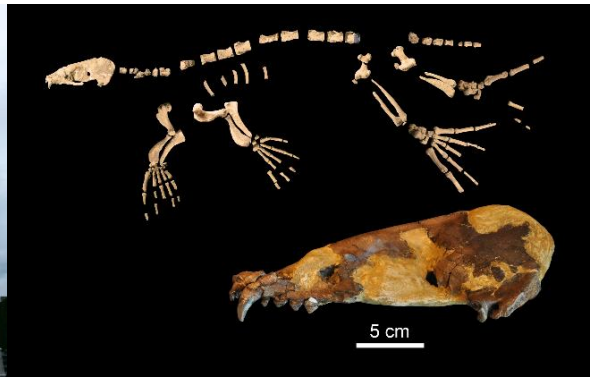
ABOUT THE PALEODAYS 2024 LOGO

The Paleodays 2024 logo features the silhouettes of the main buildings of the UNESCO World Heritage Site of Piazza dei Miracoli in Pisa (namely the Leaning Tower, the Cathedral and the Baptistery) as well as of the holotype skeleton of *Pliophoca etrusca*, an extinct monk seal relative from the Tuscan Pliocene.

The exceptional skeleton of the *Pliophoca etrusca* holotype was discovered by Antonio Di Paco, a passionate fossil hunter, at the beginning of the 20th century near Orciano Pisano, an important paleontological locality of Tuscany – one that over the last two centuries has yielded abundant and remarkable finds of fossil remains of Pliocene marine vertebrates. The specimen was acquired by the Museum of Geology and Paleontology of the University of Pisa (which subsequently became part of the university's Natural History Museum) and then described in detail in 1902 by Riccardo Ugolini, who referred it to the extant Mediterranean monk seal *Monachus monachus*. Forty years later, Giulio Tavani assigned this skeleton to a new genus and species of pinniped, which he named *Pliophoca etrusca*. The validity of Tavani's genus and species was confirmed in a recent revision resulting from the collaboration between the paleontologists from the universities of Pisa and San Diego (USA).

Pliophoca marks one of the last stages of the evolutionary history of a lineage of pinnipeds, the phocid Monachinae, which originated at the beginning of the Miocene in the Mediterranean Sea, where they survive today with only a handful of individuals. This fossil is one of the most complete pinniped skeletons to have ever been found worldwide: it preserves the skull, vertebral column, ribs and limbs - an extraordinary condition considering that seal fossils are generally represented by fragmentary skeletal remains.

Pliophoca is an important testament to the sea that submerged a large part of western Tuscany during the Pliocene. Here, the sands and clays were deposited which today cover a large part of the Tuscan hills, the latter being famous for their extraordinary fossil content since Leonardo da Vinci and Nicola Stenone. This marine scenario is reconstructed in one of the exhibits of the Natural History Museum of the University of Pisa in Calci (PI), where the *Pliophoca* skeleton and a life-size reconstruction thereof are on display.



PREFACE

After more than forty years, the Italian paleontologists will meet again in Pisa on the occasion of the XXIV Edition of the "Giornate di Paleontologia" - Paleodays 2024. This edition promises to be a record-breaking one: at the time of writing, participants are approaching the exceptional number of 190. It is the sign of a vital, attractive, and rapidly growing community which bodes well for the future of Paleontology at a national level.

With an invited talk, 95 oral presentations and 69 posters, the scientific sessions of this congress will provide a comprehensive overview of the many and diverse research directions of the Italian paleontological community. This volume collects the abstracts of such contributions, which collectively depict a 360-degree investigation of the History of Life on our planet as told by fossils.

It is a great honor for us to host the Società Paleontologica Italiana in the town of Pisa, whose university has a history of studies and research in the paleontological field that can be traced back to the early days of its Natural History Museum in the 16th century. We hope that the Paleodays 2024 will represent a welcoming setting for rich, frank and serene discussion for all participants, as well as an opportunity for further growth and strengthening for the entire Italian paleontological community.

Giovanni Bianucci, Marco Merella & Alberto Collareta
University of Pisa

General Index

XXIV Edition of the "Giornate di Paleontologia"

Pisa, (4) 5-7 June 2024

INVITED TALK
Abstract

Walking around Gondwana, searching for fossil tetrapod tracks. A contribution to the formation and growth of vertebrate ichnology schools in Italy and Brazil

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Here, I summarize the results of my lifelong research, which developed mainly in the field of tetrapod ichnology and in the Gondwanan continents. In 1975, when I was professor of Earth Sciences at the Federal University of Paraná, Brazil, colleagues informed me that there were no fossil tracks all over the country. However, in the same year, I rediscovered the location of the Paraíba trackways and, with informal collaborators, dug out many new ones. Subsequently, I detected thousands of tracks in the Lower Cretaceous Botucatu Formation in 1976, and those of the Caiuá Group in 1977. In 1980, I found dinosaur tracks in the Marajó sub-basin, and others along the banks of the Tocantins River in Amazonia. I then began visiting all the Phanerozoic basins of Brazil in search of tracks and bones. I visited dozens of them, from the graben of Tacutu (Roraima), in the extreme north of Amazonia, to the extreme south of the country, at the Chuí.

During these expeditions, often by canoe on Amazon or also on horseback in arid and very hot caatingas of the Northeast, at times I found myself in every kind of adventure, even with bandits, caimans, crocodiles and piranhas. However, I've seen and discovered wonderful things. I also worked in ichnology and herpetology in Italy and several other countries in six continents.

An important moment was the preparation of the "Glossary and Manual of Tetrapod Footprint Palaeoichnology", and I am currently taking part in preparing an updated version thereof. In the 1980s, I started working in all countries of South America, in view of the preparation of the "Annotated Atlas of South American Tetrapod Footprints, etc."

Some 90 expeditions in Gondwanan continents over 50 years (1973-2024) contributed to disclose to the world the ichnological treasures of Brazil, South America, and many other countries.

What I appreciate most about my scientific life is having taught to many young researchers (in Italy, Brazil, Australia and other countries) to work with fossil tracks; and having contributed to form schools of tetrapod ichnology in some such countries, especially in Brazil and Italy.

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PRESENTATIONS
Abstracts

Calcareous plankton and bio-geochemical climate signals at the Monte San Nicola type-section (Sicily)

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We present a high-resolution multiproxy study based on micropaleontological data (calcareous plankton), organic geochemical (alkenones) and planktonic $\delta^{18}O$ records, to unravel changes in paleotemperature and paleoproductivity during the Plio-Pleistocene transition (PPt) in the Mediterranean Sea. The PPt is located between the end of the Mid-Piacenzian Warm Period (~3 Ma) and the progressive intensification of the North Hemisphere Glaciation (iNHG). In this framework and as part of the GELSTRAT project (Head and Caruso, 2022), we analyzed the Monte San Nicola type-section (MSN_{t-s}), the reference record for the Gelasian Global Stratotype Section and Point (GSSP)(2.58 Ma).

Our biotic and abiotic proxies indicate that the investigated interval spans from ~2.7 to 2.5 Ma and includes several glacial-interglacial cycles, corresponding to the Marine Isotopic Stages (MIS) G4 to 100, well correlated with Mediterranean and extra-Mediterranean records. Calcareous plankton, alkenone-based SST and $\delta^{18}O$ records indicate that from MIS G4 to G1 the glacial-interglacial variability was rather weak. A distinct amplitude increase of the obliquity cycles is recorded starting from MIS 104 upwards which traces signals of iNHG slightly below the GSSP, located within MIS 103. Evidence of weak glacial conditions developed during MIS 102, likely reflecting interference between obliquity and insolation. Change in the abundance of some key calcareous plankton taxa, coupled with increase of C_{37} alkenones, marks the precession-related sapropelic layers A2-A5 and indicate increases in productivity in surface water and likely enhanced organic matter preservation at the sea bottom during sapropel deposition. Our results reveal that superimposed to orbital cycles, a clear millennial-scale variability occurs during the glacial periods prior to MIS 100. The overall results contribute to frame the Gelasian GSSP within a global climatostratigraphic evolution, enhancing its correlation on a wide scale.

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Application of flipped learning to museum activities starting from Poggio Rosso's "Hyenas' den" from the Pleistocene of Upper Valdarno

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Bringing people, especially the youth, closer to collections has always been a primary objective of museum institutions. Innovations in teaching techniques and advanced visual technologies are increasingly familiar to children and allow them to experiment learning with a more interactive and engaging approach.
Here we describe an educational laboratory based on the Pleistocene fossil accumulation informally known as the "Hyenas' den", exhibited at the Museo di Storia Naturale, Geologia e Paleontologia of Florence (MNHF), Italy. This accumulation hosts, in about 3 m^2, bones belonging to ten different species of fossil mammals (e.g. *Eucladoceros dicranios, Equus stenonis, Homotherium latidens*). The aim of the flipped-learning laboratory activity, called "Mistero al museo - Indaghiamo l'ambiente toscano di due milioni di anni fa" is to help young visitors to understand how the bone accumulation was formed and why. The target is children aged 6 to 11, who are guided in the discovery just like in a true crime story, with a parallel between the profession of the detective and that of a paleontologist. The children, divided into small groups and with the guidance of the educators and color-based graphic supports, have to compare the bones occurring in the Hyenas' den with the specimens on display in the museum, in order to identify the corresponding species. This task activates their curiosity and allows them to independently explore the museum to find the information necessary to solve the game. Once all the species are identified, and the provided "detective cards" are filled, each group has the opportunity to present its theory on the nature of the fossil accumulation and what happened two million years ago, putting into practice an active learning approach, thus stimulating curiosity about the topic and scientific reasoning, fundamental values that we hope to pass on to new generations.

Paleoceanographic changes provided by foraminiferal and XRF data across the OAE 2 at Southern High Latitudes (IODP Sites U1513 and U1516, SW Australia)

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The Cenomanian-Turonian Oceanic Anoxic Event (OAE 2) is the greatest global environmental perturbation in the Late Mesozoic that also affected marine biota. International Ocean Discovery Program (IODP) Sites U1513 and U1516 in the Mentelle Basin (SW Australia) document a continuous foraminiferal record suitable to reconstruct the paleoenvironmental conditions in the water column and at the seafloor.

Below and in the lower part of the OAE 2, the foraminiferal assemblage shows low species diversity and is dominated by the opportunistic taxa *Gavelinella*, *Gyroidinoides*, *Stensioeina*, *Microhedbergella* and *Muricohedbergella*. XRF data show an increase in terrigenous input and more humid conditions, with the exception of a short interval characterized by a peak in Zr/Rb ratios that indicates a drier environment. The unique occurrence of *Stensioeina truncata* and a slightly increase in epi-infaunal taxa indicate an improvement of seafloor conditions that might correspond to the Plenus Cold Event (PCE) at high latitudes. An interval of low $CaCO_3$ content within the OAE 2 interval dominated by radiolarians identifies an extremely eutrophic environment with suboxic conditions marked by a sharply increase in rainfalls and riverine discharge causing a shoaling of the CCD. However, Site U1516 shows few samples with the occurrence of diversified benthic and planktonic foraminifera indicating an improvement of environmental conditions.

Above this interval, a different benthic foraminiferal assemblage characterizes both sites with the occurrence of *Conorboides claytonensis*, an increase in agglutinated taxa and in *Praebulimina elata*. The major diversification of planktonic foraminifera from surface to thermocline dwellers occurs in the uppermost part of OAE 2, indicating the emplacement of a stratified water column in a mesotrophic regime and dysoxic conditions, but with a slower recovery at Site U1516 and a turnover towards more eutrophic conditions in the Turonian.

The Permian timescale: progress and challenges

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After several years as a voting member of the Subcommission on Permian Stratigraphy (SPS) of the International Commission on Stratigraphy (ICS) of the IUGS, and at the end of my term as SPS Chair, I thought it was time to give an overview of the processes (sometimes debated) that govern the selection of Global Stratotype Sections and Points (GSSPs) and offer a snapshot on the present state and future of the Permian timescale.

The Permian, the last 47 myr of the Palaeozoic Era, is a very interesting period starting with the main phase of the Gondwana Glaciation and the assembly of Pangaea, and ending with the greatest mass extinction of the Phanerozoic, through a series of complex and dynamic events. Framing these events with a timescale is thus crucial for understanding the biotic and geologic evolution of the Earth at the end of this Era.

In the nearly two centuries of work after Murchison in 1841 coined the term Permian for strata in the Russian Urals, the Permian chronostratigraphic scale was developed and currently comprises nine stages in three series: Asselian, Sakmarian, Artinskian and Kungurian in the Cisuralian (Lower Permian); Roadian, Wordian and Capitanian in the Guadalupian (Middle Permian); Wuchiapingian and Changhsingian in the Lopingian (Upper Permian). All GSSPs have been ratified, except for one, the Kungurian, and all use conodont evolutionary events as the primary tool of correlation. A candidate for the Kungurian has already been selected at Rockland, Nevada, so the temporal ordering of the events in the Permian has the potential to be achieved.

However, the scale is not perfect. The base-Wuchiapingian GSSP had to be revised because of the flooding of the original section by the construction of a dam (Shen et al., 2024), and recent research revealed several problems for both the Roadian and Wordian GSSPs (Henderson, 2024), although these stages are long and widely used.

So even if the future development of the Permian timescale should focus on finer temporal subdivision and on correlation using multiple tools (radioisotopic, magnetostratigraphic and chemostratigraphic), some stage bases need to be rediscussed and revised.

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The first articulated skeleton of *Eucyon monticinensis* from the latest Miocene of Verduno (Piedmont, Italy)

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Eucyon is a genus of jackal-sized canids considered among the earliest members of the tribe Canini. Its first occurrence is recorded in the Clarendonian (Late Miocene; 10–9 Ma) of North America with the species *Eucyon davisi*. From a biogeographical perspective, soon after its origin in North America (Tedford et al., 2009), *Eucyon* dispersed towards the Old World during the latest Miocene, in particular to Central Asia, Europe, and Africa. Although the genus did not survive beyond the late Hemphillian in North America (where it probably gave rise to the first representatives of *Canis*), it reached a relatively high diversity in the Pliocene of Eurasia, surviving until the Early Pleistocene (Sotnikova & Rook, 2010). Amongst all the records of *Eucyon*, very few include complete cranial remains and even fewer include articulated skeletons or skeletal parts (in this context, an exceptional skeleton of *E. davisi* from Arizona stands out; Tedford et al., 2009).

In this study we report on a well-preserved articulated partial skeleton of *Eucyon monticinensis* from the late Messinian of Verduno (Piedmont, Italy), representing the most complete finding of *Eucyon* in Europe discovered to date. We characterized the morphology of this outstanding specimen through a comprehensive analysis including μCT-based images revealing its internal anatomy. Additionally, we compared it with all known *Eucyon* samples from all over the world and we performed a phylogenetic analysis based on cranial and postcranial characters to assess its relationships with extinct and extant Canini.

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Anisian Ammonoids from the Hallstatt Limestone of Desli Çaira (Dobrogea, Romania): faunal composition and preliminary taxonomic results

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Deşli Caira section in northern Dobrogea (Romania) is one of the key sections for the definition of the Global Boundary Stratotype Section and Point (GSSP) of the Anisian stage of the Middle Triassic series, one of the Triassic GSSPs that has still to be defined. One of the main strong points of this section is its rich ammonoid record, spanning from the Late Olenekian to the Early Anisian. The locality has been under study for more than 30 years by one of us (EG), who devoted most of his life to collect ammonoids from this site. This collection has been integrated by new samplings carried out in 2023 and now consists of 698 specimens, mostly collected with a bed-by-bed approach. The ammonoids were collected from 15 levels of a 30 m thick succession of Hallstatt Limestone. The ammonoid taphonomy do not display significant variation along the section. The specimens do not show any evidence of reworking, based the method by Fernandez Lopez (1984). The most common preservation is as hollow phragmocones (Seilacher et al., 1977), filled by sediment and cement. Ammonoid faunas are dominated by *Leiostraca*, as usual in the
Ammonitico Rosso facies, such has Megaphyllitoidea, Sturiidae, Gymnitidae, Cladiscitidae and Phyllocertoidea. Trachiostraca are represented by Ceratoidea. The ongoing research is focused on the Aegean (Early Anisian) faunas. These include some taxa reported in Chios (Greece), the type locality of the Aegean substage (Assereto, 1974), such as *Paracrochordiceras denseplicatum*, *Aegeiceras ugra* and *Leiophyllites pseudopradyumna* and some taxa not documented at Chios, such *as Stenopopanoceras transiens*, *L. pradyumna* and a new genus of Cladiscitidae. In the upper part of the section, the occurrence of Acrochordiceras is potentially useful to mark the Aegean/Bithynian boundary.

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Artificial Intelligence application to the identification of fossil shark teeth using Convolutional Neural Networks

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Artificial Intelligence is impacting all the fields of knowledge. Deep Learning paradigm (LeCun, 2015) in particular makes possible to develop data analysis tools that support subject matter experts in different fields such as Medicine (D'Andrea, 2023), up to Egyptian hieroglyphs recognition (Guidi, 2023). This trend is now also observed in Paleontology (Yu, 2023).

The purpose of this study was to determine if Convolutional Neural Networks (CNNs), a class of Deep Learning algorithms designed specifically for computer vision applications, could correctly categorize photographs of fossil shark teeth that were gathered from online datasets as well as from the authors' experience on Peruvian Miocene and Italian Pliocene fossil assemblages, in particular from the paleoichthyological collection of the G.A.M.P.S. Geopaleontological Museum (Italy). The shark taxa allocated in the final dataset (over one thousand of images) include both extinct and extant genera, namely: *Carcharhinus*, *Carcharias*, *Carcharocles*, *Chlamydoselachus*, *Cosmopolitodus*, *Galeocerdo*, *Hemipristis*, *Notorynchus*, *Prionace* and *Squatina*. We created and trained a CNN, to recognize images with a single shark tooth, obtaining a 5 fold cross validated mean accuracy of 85%. We introduced explainability of the results leveraging on SHAP (SHapley Additive exPlanations), a game theoretic approach to explain the output of any machine learning model (Lundberg, 2017).

The project aims to show how Deep Learning can be used to create tools to support research in the paleontological field.

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The Coralligenous reef: from Holocene inception to ongoing deep demise along the SE Sicilian shelf

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Coralligenous algal reefs (C) stand as a priority habitat of the Mediterranean region. They are Holocene biogenic rocks that record the natural environmental history of the continental shelves and their recent human-induced impacts.

In the framework of the project "CRESCIBLUREEF", we investigated the complex interplay of the geological and oceanographic controls on the biological processes that shaped the development of C reefs. The inception and evolution of C offshore Marzamemi (SE, Sicily) is tied to its regional tectonic and climatic history. Vertical tectonic movements combined with eustatism generated a flight of four submerged terraces, identified in a high-resolution bathymetric map. C build-ups are unevenly distributed as clusters of discrete columns or dm-sized hybrid banks down to 45 m of water depth (wd), also on inherited topographies, whereas between 45 and 65 m wd, only patches of discrete columns occur. Between 65 and 80 m wd, fine sedimentation and turbidity hamper C development, while build-ups occur again below 80 m wd, in correspondence of a submerged terrace, often as groups of isolated columns.

We collected four build-ups at 36, 37, 47.7 and 85 m wd, respectively. The complete analysis of their living associations and their internal structure, composition, density and radiocarbon age provided a full array of data about the Holocene timing of C inception, its paleodepth and style of development along the shelf. The deepest sample at 85 m is presently affected by fine sedimentation and the sclerobiont living association consists mainly of annelids and bryozoans, with sponges dominating biomass. Few crustose calcareous algae persist at this considerable depth and suboptimal water transparency. On the contrary, the internal composition of all sampled build-ups is dominated by coralline algae. The striking shift in the primary habitat formers of deep build-ups poses a problem with the identification of C in these deep and animal-dominated instances.

Will Artificial Intelligence replace palaeontologists? Performance analysis of the first generative AI system trained with palaeontology data (GeologyOracle)

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Artificial intelligence systems based on the Generative Pre-trained Transformer (GPT) model have shown revolutionary capabilities in generating scientific text, revolutionizing the way scientists research and teach. However, there is a notable lack of general AI systems specifically designed for geosciences, and the effectiveness of GPT technology has not been tested in palaeontology. To fill these gaps, we developed a new artificial intelligence system (GeologyOracle) built on the GPT-4 model and trained on Earth science data, with specific emphasis on palaeontological datasets. GeologyOracle is designed to simulate a conversation with a geologist, capable of analyzing palaeontological data sets, proposing new palaeobiological hypotheses, explaining palaeoecological concepts, and suggesting the location of new fossil sites. To evaluate the performance of GeologyOracle, the system was tested with 152 questions provided and rated by a panel of geoscience scholars on a scale of 0 to 10. Performance analysis showed that 79% of responses scored at or above the passing score of 5, with a trend towards providing high-quality responses (mean: 6.7; median: 7; interquartile range: 5-9). The results demonstrate that GeologyOracle is effective in performing complex palaeontology tasks, such as identifying fossils, as well as interpreting fossil-bearing outcrops and palaeoecological data. The performance of the AI system may be comparable to that of trained palaeontology experts, suggesting the potential of GeologyOracle as an assistant in various palaeontology fields, including ichnology, micropalaeontology, palaeobotany, among others. While AI cannot replace human palaeontologists, it offers significant potential to accelerate scientific discovery, automate palaeontological research, and assist educators, students and geotourists. To encourage discussion about the relationship between AI and palaeontology, a beta version of GeologyOracle will be freely available for the participants of the PaleoDays 2024 congress at www.geologyoracle.com (Baucon, 2024).

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CT investigation on four coralligenous build-ups from Marzamemi, Sicily

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Crustose coralline algae form coralligenous build-ups, one of the most significant ecosystems in the Mediterranean shelf. These bio-geological structures provide habitat for a diverse array of epi- and infaunal communities, which compete for space, influencing either reef growth or structural integrity through bio-erosive activities. Investigating the correlation between the algal framework and the associated communities holds paramount significance for ecological, palaeoecological and monitoring objectives. Within this context, the CRESCIBLUREEF project is focused on investigating coralligenous reefs off the coast of Marzamemi, Southeast Sicily.

Four build-ups have been collected at 36, 37, 47.7 and 85 metres depth and from different shelf environments. Here we present a Computer-Tomography (CT) scanning to reconstruct the internal structure of the four build-ups, and to assess their variation in density. The CT analysis categorised the framework into four density categories: Low, Medium, High and Ultra-High. Subsequently, the build-ups were cut, and the categories were visually validated by observations and thin sections. The total porosity of the structures was calculated by analysing their cavities, both primary or due to taphonomic processes.

The findings reveal a conspicuous porosity throughout the structures. Additionally, a depth-dependent gradient in structural density of the framework was observed, with deeper build-ups exhibiting higher percentages of hard material compared to shallower ones. These observations suggest a relationship between the build-up age and its density, indicating a trend of increasing density with present seawater depth and possibly with their age.

The highly-resolved analysis underscores the intricate growth patterns of the build-ups. Understanding the structural characteristics, including density and porosity, could offer valuable insights into palaeoenvironmental considerations and serve as a potential framework for analysing and interpreting more ancient, fossil, biogenic framework.

The body shape of *Perucetus colossus*, the extremely heavy basilosaurid from the middle Eocene of Peru

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The basilosaurid cetacean *Perucetus colossus*, recently described from the middle Eocene (ca. 40-38 Ma) of the Pisco Basin, Peru, has garnered great attention for its remarkable body mass (Bianucci et al., 2023). The analysis of its holotype - a partial skeleton comprising 13 vertebrae, 4 ribs, and the right innominate - hints at a staggering total skeleton mass of ca. 5–8 t, at least twice that of the largest living animal, the blue whale. This suggests a body mass for *Perucetus* between 85 and 340 t, making it a contender for the title of the heaviest animal ever.

Assuming neutral buoyancy, the estimated medial body mass of *Perucetus* allows its body volume to be estimated at 180 m^3. Comparison with the 3D body shapes of extant marine mammals, scaled to *Perucetus* median length estimate, points to a striking resemblance to the West Indian manatee *Trichechus manatus*. This basic analysis reinforces our previous interpretation of *Perucetus* as a benthic feeder inhabiting hydrodynamic coastal environments.

Newly discovered ribs from the holotype allowed to reconstruct the maximum cross-section of the ribcage of *Perucetus*. The cross-sectional surface area estimated from a 3D model of a double-headed rib from the central portion of the thorax is approximately 1.4 m^2, notably smaller than our volumetric reconstruction above. However, it is crucial to note that this area represents only a fraction of the total cross-sectional surface area of the body. Indeed, in the extant *Tursiops truncatus*, the ribcage's cross-sectional surface area at a similar anteroposterior level accounts for only 40% of the entire body's cross-section. Moreover, it is likely that *Perucetus* had a greater volume of blubber and muscle tissue around the ribcage compared to the bottlenose dolphin. Therefore, the use of ribs to reconstruct the body shape of *Perucetus* requires caution.

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Spinosaurus aegyptiacus: resolving weighty matters

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Body size and body mass can give important hints on the ecology, behaviour, physiology and biomechanics of extinct organisms (e.g., Romano et al., 2023). Therefore, applying methods for obtaining precise and reliable estimates is essential. This is particularly true for tetrapods with unique anatomical blueprints and no modern-day ecological and morphological equivalents.

Here, we present the preliminary results of body size estimates of the *Spinosaurus aegyptiacus* specimen FSAC-KK 11888 (see e.g. Ibrahim et al., 2020) and compare it to other large theropods. Previous attempts to estimate the body mass in large-bodied, bipedal theropod dinosaurs have yielded a wide range of values with little consensus. By deploying 3D skeletal reconstructions based on bones digitized via X-ray computed tomography scanning and photogrammetry, as well as high-precision digitally sculpted flesh models, we obtained the most parsimonious estimates for this animal. In addition to the novel body size conclusions, our results support a water-loving ecology for the cryptic theropod dinosaur *Spinosaurus aegyptiacus*.

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A new Pliocene gray whale from Piedmont, northwestern Italy

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A new partial gray whale skull was found in the paleontological collection of the University of Turin. It includes the posterior and ventral portions of the cranium and fragments of the posterior portions of the right and left mandibular rami. The locality of the discovery is unknown, but the associated sediment allows to infer that it was collected from the Sabbie d'Asti Formation, hence a geological age of about 3.8-3 Ma. The neurocranium includes a partial periotic that was CT-scanned and 3D-modeled, which revealed characters compatible with an assignment to Eschrichtiidae. The exoccipital protrudes posterolaterally with its posteroexternal corner like in Eschrichtiidae and Cetotheriidae s.s. The posterior portions of the mandibular rami show that the articular surface of the mandibular condyle faces posterodorsally, and the angular process is well-developed and protrudes ventrally and posteriorly, thus resembling very closely the morphology observed in *Eschrichtius robustus* and *Eschrichtioides gastaldii*. These characters support the inclusion of this specimen in Eschrichtiidae, but morphological differences observed in several skull and mandibular districts suggest that it represents a new eschrichtiid taxon. This specimen is the second eschrichtiid to be found in the Tertiary Piedmont Basin, suggesting that eschrichtiids were steadily present in the mid-Pliocene of the Mediterranean. This discovery raises questions about possible mysticete niche differentiations in the food web of the Pliocene Mediterranean basin given the extraordinary baleen whale diversity testified by the regional fossil record from this epoch.

The new palaeontological and archaeological research at the Büs dei Lader (Prevalle, Brescia)

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In March 2023, under the direction of the Soprintendenza ABAP-BG-BS, new research began in the cave "Büs dei Lader" (Prevalle, Brescia), a small cavity that extends for about ten metres in length and is just over two metres wide at its widest point. The focus of the new work was the verification of the presence of residual deposits of palaeontological and archaeological interest after the excavations carried out in 1930 and 1956, conducted respectively by Prof. G. M. Ghidini and by the Gruppo Grotte Prevalle. The latter led to the discovery of abundant faunal finds and a single backed point, reported by P. Biagi in the 1976, dated to the Gravettian/Epigravettian. However, the excavation methodologies adopted at the time did not allow the stratigraphic association between these finds to be verified. The only dating available comes from a charcoal sample collected from the section by Biagi in the 2000 and dated to 17040±80 BP.

The recent checks involved both the external deposit and the internal portion of the small cavity, where strips of deposit not disturbed by previous excavations were preserved. The excavation inside the cavity allowed us to identify a stratigraphic sequence of great interest consisting of a sedimentary deposit characterized by a yellow silty matrix with local sub-angular carbonate clasts and rare small sub-rounded ferrous clasts residual from ancient palaeosols. The deposit was cemented to the walls, sometimes weakly and sometimes tenaciously. Mostly the deposit consisted of small portions distributed along the walls of the cavity, which did not exceed 10-15 cm in thickness and one metre in vertical development. The material is both macro- and micro-mammals, very abundant, and indicated continental climatic phases, mostly dry, which favoured the establishment of a steppe environment. Some flint flakes of difficult chrono-cultural attribution were also found.

Much ado about Linda: revision and valorisation of the fossil fauna from the Farneta Faunal Unit in its type area

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In September 2022, during the re-organization of fossil deposits of the Museum of Geology and Palaeontology of Florence (MNH), an unexpected crate resurfaced. It contained fossil bones and teeth of numerous vertebrate taxa, labelled to be excavated in association with the *Mammuthus meridionalis* skeleton displayed in the museum, nicknamed as "Linda". The excavation took place in the small village Farneta (Tuscany, Italy), that also names the faunal unit (F.U.) of the Villafranchian Mammal Age. Historically, the Farneta F.U. includes collections from several other localities, e.g., Pietrafitta, Monte Argentario, Selvella. The material requires a general revision. Starting from the digitization of the collections different research groups are involved in the study of the recovered taxa including cervids (*Pseudodama farnetensis* and *Praemegaceros obscurus*), bovids (*Leptobos* sp. and *Eobison degiulii*) and equids, whose identification has varied in the past from the original two species (*Equus stenonis* and *E. stehlini*; Azzaroli, 1983) to one (*E.* cf. *stenonis*; De Giuli, 1986), to again two species (*E. altidens* and *E. suessenbornensis*; Alberdi & Palombo, 2013). Such inconsistencies occur for most of the material. The revision will be at the base of a valorisation project that will make accessible this important late Villafranchian mammal assemblage to the public as well as to specialists in the field.

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Geochemical and mineralogical signatures imply a broad spectrum of taphonomic processes for marine mammalian bones from the Miocene and Pliocene of Tuscany

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The Neogene marine successions of Tuscany host numerous fossils of mysticetes, odontocetes and sirenians. Mammalian bones are highly sensitive to the surrounding environment, especially post-mortem. The highly diverse palaeoenvironments (from deltaic to slope) of the Neogene basins of Tuscany provides an ideal scenario for investigating the manifold taphonomic processes that affect marine mammal skeletons in different depositional settings and entombing sediments, where the biostratinomic and diagenetic agents at play are also diverse (Bosio et al. 2021b).

Small fragments of bones (mostly ribs) and the embedding sediment were collected from cetacean (both mysticete and odontocete) and sirenian skeletons at Ponsano, Arcille, Lucciolabella, Monterotondo, Riparbella, Asciano Senese, Castelfiorentino, Empoli, Spicchio and Certaldo. A detailed microscopical and compositional characterization of the fossils was carried out via optical microscopy, SEM-EDS, EPMA and LA-ICP-MS.

The bones exhibit a plethora of taphonomic signatures. The color of bones varies from grey to brown to dark amber to red, the latter being related to the presence of Fe-oxides and Fe-sulfides. The presence of "type B" microborings witnesses to the bacterial activity related to sulphate-reduction processes (Bosio et al. 2021a). The bad preservation of the cortical tissue, together with microcracks and fractures, dissolution marks, algal perforations and frequent microborings indicate a long exposure at the seafloor before the eventual burial. Secondary cements such as calcite and barite are also present in some specimens, implying that late diagenetic processes were also relevant. Our study supports the notion that a rapid burial may not be an essential factor leading to fossil preservation.

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Infestation of plant fossils with fungi – a case study from the Museum of Nature South Tyrol

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Fungal infestation is a serious threat to fossils in museum collections, yet little research has been carried out on this critical issue to date. Fungi can cause both mechanical and chemical damage by penetrating the fossils and depositing harmful substances (i.e. organic acids) on the fossils and the surrounding sediment. Due to the discovery of fungal infestation in several specimens, the South Tyrol Museum of Nature has started a research project dealing with fungal infestation of plant fossils. The aims of this project are (1) to establish a protocol for the early detection of fungi on fossils; and (2) to understand the effects of fungal infestation on the long-term preservation of fossils, as eradication is usually not possible. Here, we report on the first phase of the project, which involved a systematic assessment of the museum's plant fossil collection. The collection was divided into sub-collections according to origin and date of acquisition, with the oldest specimens dating back to 1995 and the first major acquisition from 2000. At least 30 specimens from each sub-collection were carefully examined under a stereo-microscope to determine the presence, location, color, and type of fungal attack, as well as the type of substrate affected. We found that the predominant infestation occurred on specimens added to the museum's main repository between 2003 and 2005. Patches of fungal growth on these specimens are mostly whitish mycelia with a loosely net-like structure; they are predominantly found on rock substrates. Pieces of the mycelia were taken into culture to identify the fungal species involved by morphological characterization and DNA sequencing of the ITS1-5.8S-ITS2 region. The identification of the fungal taxa involved in the infestation will enable the development of targeted treatment strategies and contribute to the long-term conservation of the collection.

Toward a comprehensive palaeogeographic reconstruction of the Paleogene foredeep basin in the Provençal Domain

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The Paleogene sedimentary succession of the Provençal domain, cropping out along the Maritime Alps, is composed by a deepening-upward sequence that starts from paralic to shoreface deposits and ends with relatively deep flyschoid units. Despite the relatively monotonous character of the succession, each locality investigated within a ten kilometers radius from Ventimiglia displays a specific set of characters that makes each one unique and rather different from the others. Some successions show the transgression sequence that starts from shoreface deposits (e.g., near the Sealza village) whilst others start with paralic to continental *Microcodium-Taenidium* facies (e.g., near the Olivetta San Michele village) and others with open marine settings (near the Capo Mortola promontory). In some cases, the fossil associations are so diverse that some taxa dominate in a certain locality and are very rare to absent in others nearby. Some localities are rich in resedimented deposits, others show in situ material only.

Within this framework, a detailed study of the successions permitted a rather comprehensive reconstruction of the possible paleogeographic setting that could constrain all data. The paleogeography proposed is characterized by a very active riverine system that controlled both water turbidity and sedimentary rate; this had a clear impact on the benthic community, especially on the symbiont-bearing taxa. The ramp was relatively wide to permit current-driven sediment distribution, therefore differentiating muddier vs. sandy seafloors and nutrient-rich from nutrient-depleted surface waters. Lastly, the tectonic regime kept the entire system extremely unstable and affected abruptly the sedimentation rate.

An unusual archosaur dentary from the Lower Cretaceous of Teruel, Spain

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This study focuses on an enigmatic small archosaur dentary recovered in the Barremian (Lower Cretaceous) El Castellar Formation, in Galve, Teruel Province, North-East Spain. This formation comprises an alternation of marly limestones and limestones deposited in a lacustrine environment. The fossil was recovered in the Cuesta Corrales 2 locality, an eggshell accumulation assemblage found in the marly limestones, type locality of the oospecies *Guegoolithus turolensis* and the dryolestian mammal *Crussafontia amoe*.

Here, we present a 3D reconstruction of the specimen after a micro-CT scan acquisition. The 3D models are complemented with BSE-SEM images acquired in TOPO mode with an environmental SEM. The fossil consists of the mesial-most portion of a left dentary (total preserved length: 5 cm) whose distal end is missing due to taphonomic fragmentation. Otherwise, the preservation state is good, albeit numerous fractures are visible.

The dentary is labio-lingually slender, the symphyseal region is small, and there is a large Meckelian canal. The anterior part is dorsoventrally enlarged, and the 1st dental alveolus seems to be procumbent. Seven total tooth positions are visible, with a variable distance between the alveoli. Only two teeth are preserved, in the 3rd and 4th alveoli, respectively. They are complete, but present damaged enamel, making it impossible to identify eventual denticles. Both are compressed labio-lingually. The 3rd tooth is 1.5 times higher than the 4th, and has an asymmetric lanceolate morphology. The 4th is triangular, with a partially preserved thin enamel layer.

The labio-lingually compressed teeth with thin enamel, together with a gracile dentary with a small symphyseal surface, are compatible with a maniraptorian dinosaur. Further analysis is needed to achieve a more precise classification. The unusual combination of characters has never been reported in any archosaur from the Lower Cretaceous of the Iberian Peninsula, suggesting that the studied specimen may represent a new taxon.

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Going deeper: the Ypresian fish-bearing *Lagerstätte* of Sòlteri (Trento, northern Italy)

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A Ypresian fish-bearing site has been discovered in the late '70s at Sòlteri (Trento, northern Italy; Venzo et al., 1986), but its peculiar ichthyofauna, dominated by deep-water bony fishes, remained virtually unexplored for decades despite its potential interest. In fact, it represents the nearly coeval bathyal equivalent of the Pesciara and Monte Postale of Bolca *Lagerstätten* (Verona province, northeastern Italy), worldwide known for their extremely abundant and diversified, shallow coral reef-associated fish fauna. Our ongoing studies aimed i) at detailing the stratigraphical position of the site and establishing its precise chronological relationship with Bolca, and ii) at analysing the low-diversified ichthyofauna, represented by nearly 250 specimens in various degree of preservation. The fish assemblage reflects a meso-bathypelagic ecosystem including Stomiiforms (Gonostomatidae and Phosichthyidae), Myctophiforms (Myctophidae) and Percomorphs (Gempylidae and Stromateoidei), most of them represented by new, so far undescribed taxa. Sòlteri is of extreme relevance not only because it is one of the most ancient Cenozoic deep-water *Lagerstätten* ever found, but it also gives us a unique opportunity in paralleling the Bolca's biota in order to reconstruct the paleoenvironmental and paleoclimatic responses of the Tethyan fish communities during the demise of the EECO, the longest warm phase of the entire Cenozoic.

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Il progetto PRIN "REMEPP": Risposta del plancton calcareo del Mediterraneo alla variabilità della CO_2 durante alcuni intervalli del Plio/Pleistocene

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Il Mediterraneo è un'area di particolare interesse poiché è particolarmente esposto ai rischi naturali, in termini di desertificazione, acidificazione delle masse d'acqua e perdita di biodiversità. Il progetto REMEPP mira a ricostruire gli effetti della CO_2 sulla produttività globale del plancton calcareo in alcuni intervalli chiave del Neogene e del Quaternario, in cui si sono verificate forti variazioni climatiche. Le successioni selezionate ricoprono gli intervalli stratigrafici compresi tra 5.2-4.85 Ma (EZWP), 2.95-3.3Ma (PWP) e 2.7-2.4 Ma (PPT), ed affiorano nelle famose successioni di Eraclea Minoa/Capo Bianco, Punta di Maiata, Punta Piccola e Monte S. Nicola. Queste successioni, in cui sono stati definiti i GSSP del Messiniano/Zancleano, Zancleano/Piacenziano e Piacenziano/Gelasiano, sono astro-bio-magneto-cronologicamente ben calibrate. In particolare, questi intervalli sono caratterizzati da forti cambiamenti nelle associazioni a microfossili calcarei indotte dai cicli astronomici. Per poter comprendere in modo approfondito i meccanismi di controllo delle variazioni climatiche verrà utilizzato un approccio multidisciplinare, eseguendo analisi quantitative sui microfossili calcarei, analisi sugli isotopi stabili ($\delta^{18}O$, $\delta^{13}C$ e $\delta^{11}B$) ed utilizzando gli alchenoni per stimare le paleotemperature delle acque superficiali, oltre che come proxy della produttività marina. La grande sensibilità del Mare Mediterraneo alle variazioni climatiche e il segnale immagazzinato in questi archivi sedimentari naturali saranno fondamentali per caratterizzare e quantificare per la prima volta i livelli di CO_2 e comprendere come i microfossili calcarei abbiano risposto a queste variazioni.

Paleoclimatic reconstruction based on calcareous nannofossil assemblages at the Late Pleistocene-Holocene transition in the Northern Ionian Sea

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The interval between the Late Pleistocene (20.7 ky BP) and the Early Holocene (10.5 ky BP) was investigated through high-resolution quantitative analyses on calcareous nannofossil assemblages of the ND14Mbis sediment core. The core was collected in the Northeastern Ionian Sea at 665 m of water depth (Next-Data 2014 cruise). It is 332 cm long, and we investigated the interval comprised between 132 and 332 cm. The chronology based on 10 radiocarbon ^{14}C AMS measurements (Checa et al., 2020), indicates an extrapolated age of 20.66 kyrs BP at the bottom. The micropaleontological data were associated with XRF core-scan and $\delta^{18}O$ data on *Globigerinoides ruber* (white) records, from the same core and literature data (Columbu et al., 2022). *Emiliania huxleyi* > 4 μm, Total *Gephyrocapsa* and holococcoliths pointed out colder intervals (e.g. Heinrich Stadial HS1 and Younger Dryas). Warm Water Group (WWG) and holococcoliths described the onset of slightly warmer climatic conditions only during the late Bølling-Allerød. *Helicosphaera carteri* and reworked specimens responded to continental runoff.

We were also able to highlight the bipartition of the HS1 (HS1-a, HS1-b) with a transition phase (HS1-t). Lastly, calcareous nannofossil assemblages and XRF data (Ca/Ti, K/Al ratios) highlighted two sharp events of sea level rise (Meltwater pulses 1A and 1B timing).

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Studio stratigrafico e paleontologico della sezione di Spicchio (Empoli, FI)

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Vengono presentati i dati preliminari dello studio stratigrafico dei depositi della Formazione di Villamagna, affioranti a Spicchio (Empoli, Toscana). Lo studio è stato svolto nell'ambito del Progetto CARG Foglio Geologico n. 274 Empoli.

La sezione (20 m ca.) è costituita da silt, silt argillosi e sabbie fossiliferi ricchi, nella parte alta, in materia organica vegetale.

Nelle litologie più fini della parte bassa e intermedia della sezione i microfossili indicano un ambiente marino neritico interno. Nei foraminiferi il rapporto plancton/benthos è < 0,1 e le associazioni sono costituite per lo più da esemplari di *Nonion*, *Ammonia*, *Elphidium* e miliolidi. Gli ostracodi sono rappresentati da *Cytheridea*, *Aurila*, *Palmoconcha*, *Ruggieria tetraptera* e rari *Leptocythere bacescoi*. Il nannoplancton consiste, tra gli altri, di *Helicosphaera selli*, *Pseudoemiliania lacunosa* e *Discoaster surculus*. Nelle porzioni più sabbiose si ritrovano resti disarticolati dei bivalvi *Cerastoderma*, Veneroidae, Pectinidae e *Pelecyora gigas* in posizione di vita, oltre che vertebrati come un misticeto indeterminato e la tartaruga dal guscio molle *Trionyx*. Nella parte alta della sezione le microfaune oligotipiche indicano un ambiente paralico. La successione è chiusa da depositi marini prossimali a microfossili, molluschi (*Solen*, *Cerastoderma* e *Cerithium*) e balanidi.

La presenza di *Pseudoemiliania lacunosa*, l'assenza di *Reticulofenestra pseudoumbilica* e di sphenoliti consentono di attribuire la base della successione quantomeno alla Zona MNN15 di Di Stefano et al. (2023) (Zancleano p.p.-Piacenziano p.p.). Questo dato è confermato dalla presenza di *Ruggieria tetraptera* (Miocene-Pliocene) e di *Leptocythere bacescoi* che compare alla base dello Zancleano (Guernet, 2005). La presenza di *Pelecyora gigas* suggerisce inoltre un'età non più recente del Piacenziano medio, ca. 3 Ma (Monegatti & Raffi, 2001).

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Synchrotron light reveals the identity of two hominin teeth from Olduvai Gorge (Tanzania)

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In recent years, two hominin teeth were discovered by the Tanzania Human Origins Research (THOR) project at Olduvai Gorge, in northern Tanzania. Specimen OH 30B was discovered in 2021 in the Maiko Gully at the famous Frida Leakey Korongo (FLK) site, specifically in geological locality 45c (Hay, 1976), very close to where OH 30 was found in 1969 (Leakey, 1971). In fact, OH 30B represents the antimere of the lower left first molar of OH 30. The stratigraphic position of OH 30B (lowermost Bed II) suggests an age of ca. 1.8–1.7 Ma. Specimen OH 92 was discovered in 2019 during surface surveys in the Bell's Korongo (BK) area, in a small erosional channel at the base of a hill in BK East. The latter outcrop includes, from bottom to top, Upper Bed II, Bed III, and the Ndutu Beds; therefore, OH 92 could come from any of these beds, although its taphonomic features point towards a possible origin from Upper Bed II.

For the first time on Olduvai hominin remains, both teeth were analyzed through synchrotron microtomography at the European Synchrotron Radiation Facility in Grenoble. Their morphology differs significantly at both the enamel-dentine junction and the outer enamel surface. Some of the differences between the two teeth are likely to represent metameric differences in the tooth row as OH 30B has been identified as a lower right first molar and OH 92 as either a lower right second or third molar. Despite these differences, our quantitative analyses point toward a reliable attribution of both teeth to the genus *Paranthropus*, whose record of lower molars at Olduvai Gorge is therefore significantly expanded by our discoveries.

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Evaporite minerals: new frontiers in biomineralization studies

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The presence of biological activity and breakdown products can have a significant role in the complexity of crystal formation as observed in the case of calcium carbonate precipitation (Riding 2000). In the recent years, new studies on calcium sulphate (*e.g.*, gypsum) suggested that gypsum precipitation can be related to microbiological activities. The biotic mediation is mainly suggested by the low-salinity values recorded in fluid inclusions (FIs) trapped within the crystals. Supplementary evidence for biogeochemical activity comes from the study of molecular fossils (*i.e.*, hydrocarbons, alcohols) extracted from gypsum layers and marl interbeds of the Primary Lower Gypsum unit (Natalicchio et al., 2021). As result of that, to better understand the gypsum precipitation trigged by microbiological activity, it is necessary to investigate which mechanism of biomineralization is involved. The mineral bio-nucleation of the minerals can be: 1) controlled directly by the organisms; 2) induced by metabolic activities of microbial communities; or 3) influenced by organic templates. Research on biomineralization is in continuous evolution and the finding of new bio-products are fundamental in the study of biological evolution and the geological processes linked to the organism development.

The focus of this research is to open new frontiers in biomineralization studies investigating the main evaporite minerals located in the Calabria region (Southern Italy) to clarify the role of microbiological activity in gypsum crystal precipitation and also their potential contributes to the formation of halite crystals.

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New perspectives on the palaeobiogeography of the Plio-Pleistocene European equids and on the *Equus* Datum

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The *Equus* Datum has usually been interpreted as one of the most important biochronologic event for the faunal turnover at the beginning of the Pleistocene, identified as the dispersal of the monodactyl horses from North America in Eurasia at ca. 2.6 Ma.
The oldest European species is considered *Equus livenzovensis* but, however, another relevant species has not been investigated deeply, *Equus major*. Indeed, despite its description at the end of the XIX Century, the alpha-taxonomy, paleobiogeography and biochronology of *E. major* remained obscure and ill-defined, leaving a gap in the evolutionary history of the Eurasian Palearctic Early Pleistocene *Equus* species.
Here, we present the latest results on the Early Pleistocene *E. major* samples from Pardines and Senèze which have provided i) a clarified taxonomic and evolutionary status of *E. major* related to the Early and Middle Pleistocene European stenonid fossil *Equus* species, ii) new insights on its paleoecology through mesowear and body mass estimates, and iii) a new palaeobiogeographic distribution closely related to the European paleoclimatic conditions during the Early Pleistocene.
These new outcomes help to better understand *E. major*, leading to the interpretation that it was the largest Early Pleistocene *Equus* in Europe, it had a browse-dominated to mixed-feeding diet and was well adapted to humid and forested parts of Europe during the earliest Pleistocene.
Eventually, the comparison of the new paleobiogeography of the European Early Pleistocene *Equus* species with the European paleoclimatic conditions between 2.6 – 1.8 Ma provides a new perspective in understanding the distribution in time and space of early *Equus* species in Western Eurasia at the onset of the Quaternary.

Dancing towards the end – Ecological oscillations in coral reefs prior to the Messinian Salinity Crisis (Rosignano Limestone, Acquabona, Livorno, Tuscany)

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During the Oligocene and the earliest Miocene, the Mediterranean was a large seaway connecting the Atlantic and Indo-Pacific oceans, housing a wide variety of coral species and many reefs. By the end of the Miocene it had become a restricted basin and when, during the Pliocene, it once again connected to the Atlantic, the environment was no longer suitable for the development of large shallow-water coral reefs.

The reefs of the lower Messinian Rosignano Limestone (Tuscany) represent the latest and northernmost large structures of their kind. Having developed at the edge of the coral ecological niche, they can provide invaluable information. A detailed microfacies analysis of the largest of these structures, outcropping at Acquabona, is performed. Four facies are recognized: a coral boundstone, a coralline algal rudstone, a serpulid packstone to floatstone, and a stromatolitic packstone. The succession displays a progression towards more stressful environmental conditions, culminating in the stromatolitic packstone that testifies to the establishment of a microbial carbonate factory. Environmental conditions barely suitable for the development of coral reefs were already present at the beginning of the succession, as demonstrated by the composition of the boundstone. The overall skeletal assemblage displays higher amounts of heterotrophs in comparison to other Upper Miocene reefs developed south of Acquabona. Most of the observed coral colonies feature encrustations by coralline algae and encrusting foraminifera (mainly nubeculariids but also acervulinids). The frequency of these encrustations is distinctly larger in comparison to other Upper Miocene coral-reefs developed in more favorable conditions. The progressive environmental deterioration is paired with the reduction in the richness of the skeletal assemblage and the concomitant increase of groups of carbonate-producers better suited than corals to deal with stressful conditions.

When the Acquabona reef is compared with other Miocene coral reefs, it becomes evident what signs point towards the impending collapse of these bioconstructions.

The miniature fish *Habroichthys* from new sites of the Middle Triassic of Western Tethys (Dolomites, Slovenia, and Lombardy)

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Middle Triassic marine fish faunas often show a predominance of Peltopleuriformes, a group of small fishes characterized by marked sexual dimorphism and high specific variability. The iconic miniature fish *Habroichthys* Brough, 1939 (Actinopterygii; Peltopleuriformes) is well known from the Middle Triassic, from the Western Tethys to southern China basins. New *Habroichthys* material from recently discovered Alpine localities allows us to expand our general knowledge on this genus. At least two new species are present within a single thin bed in the late Ladinian Pelsa-Vazzoler Lagerstätte (Mt. Pelsa, Dolomites, Italy). Here, an abundant fish fauna was discovered in deposits representing a small intraplatform basin at the upper part of the Sciliar Formation. This fish deposit, together with plentiful silicified invertebrates, terrestrial plants, and rare insects, is proving to be a very promising window into the biota of the Middle Triassic. New *Habroichthys* specimens from the early Ladinian Cunardo Formation of Valcuvia (Lombardy, Italy) and from various Anisian sites in the Kamnik-Savinja Alps (Slovenia) are also currently being studied. The latter come mainly from the Strelovec Formation which was deposited in a restricted intraplatform basin formed by the dismemberment of the Anisian Serla Dolomite carbonate platform. They extend the Western Tethys stratigraphic range of *Habroichthys* at least to the Pelsonian (Anisian). The systematic study confirms that the number of deepened flank scales, in combination with the scale-row of insertion of the pelvic, dorsal, and anal fins, are the most prominent characters to distinguish *Habroichthys* species.

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Mary Anning, Georges Cuvier and Camillo Ranzani: ichthyosaurus across Europe

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While selecting a number of specimens for a new exhibition in the Diplodocus Hall, the museum staff choose a series of historical ichthyosaurus casts dating back to the XIX century. The original labels were taxonomically out of date, and the subsequent research led to the discovery a very intriguing story that linked first female palaeontologist Mary Anning (1799-1847), French palaeontologist Georges Cuvier (1769-1832) and abbot Camillo Ranzani (1775-1841), professor and director of the Natural History Museum in Bologna.

By 1819 Mary Anning, who was already known internationally for having discovered remarkable specimens of ichthyosaurus and plesiosaurus, was experiencing great financial difficulties. Liutenant-Colonel Birch (1768-1829), one of her major customers, decided to sell part of his collection of Lyme Regis fossils to finance Anning's future work. The auction took place in London in 1820 and palaeontologist Cuvier bought a selection of five specimens for Paris Museum of Natural History, where they still are on display today (Vincent et al., 2014).

Meanwhile, from 1803 to 1841 Camillo Ranzani held the Natural History course in Bologna and, at the beginning of XIX century, he took charge of bringing back to Italy the natural history collections stolen during the Napoleon occupation. In doing so, he became acquainted with Georges Cuvier and his family (Canadelli and Tonetti, 2022), was hosted in Paris, and Cuvier came to Bologna and visited the University collections. It comes with no surprise that Cuvier offered to make some casts of the new purchase of British reptiles and arranged them to be sent to Bologna. As a result, four cast of ichthyosaur remains, excavated by Mary Anning, arrived in Bologna in 1823.

But the story is not yet finished: in 2014, Vincent et al. reconstructed the story of the specimens up to the Paris Museum, but one of the casts hosted in Bologna looks "more complete" than Paris original.

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Exploring the Biomechanics of Cranial Pneumatization in Cave and Brown Bears

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Cave bears (*Ursus spelaeus*) are among the best representative of the carnivorous megafauna of the Late Pleistocene since their remains are commonly found in cave deposits throughout Europe. Cave bears can be easily recognised by a characteristic great domed head, with a steep frontal forehead and enlarged zygomatic arches. Moreover, cave bears possessed a greater cranial pneumatization than brown bears, with sinuses surrounding the frontal and dorsal regions of the brain, even developing within the zygomatic arches. The function of such a great cranial pneumatization is a subject of debate in the palaeontological community, with hypothesised functions bound to the herbivorous diet or hibernation (Pérez-Ramos et al., 2020).

Here we present the preliminary results of Finite Element Analyses (FEA) conducted on the 3D models of the cave and brown bear skulls. The potential of FEA is to generate simulations that allow identifying loadings and stress concentration areas on 3D objects. The study aims to test the hypothesis that the cranial pneumatization observed in cave bears is an adaptation to bear the stresses of a diet based on tough food. FEA allows us to compare how cranial pneumatization acts in redistributing the stresses generated during bites and compare the results obtained with the cave and brown bear skulls. The analyses were also extended to survey the cranial structure in function of ontogenetic development, sexual dimorphism and intraspecific variability. The comparison between the "speloid" and the "arctoid" morphology may provide insights to better understand the ecology and evolution of *U. spelaeus*.

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Impatto del genere *Amphistegina* sull'associazione a foraminiferi bentonici delle Isole Pelagie, un esempio di invasione nel Mediterraneo Centrale

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Negli ultimi anni il Mare Mediterraneo è sempre più soggetto alla colonizzazione di organismi marini non-indigeni, molti dei quali migrano attraverso il Canale di Suez. La sua apertura, avvenuta nel 1869, ha rimesso in comunicazione dopo milioni di anni due differenti province biogeografiche, facilitando la migrazione di oltre 600 specie non-indigene, alcune delle quali stanno causando seri rischi alla biodiversità nativa.

In questo studio vengono presentati i risultati delle analisi a foraminiferi bentonici di campioni di alghe e sedimento prelevati intorno alle Isole Pelagie (Lampedusa e Linosa) nel 2014. Queste isole, a partire dal 2005 (anno della prima segnalazione), stanno subendo l'invasione della specie non-indigena indo-pacifica *Amphistegina lobifera* Larsen.

I dati raccolti sono stati confrontati con quelli dei campionamenti effettuati nel 2005 e nel 2009, evidenziando come nella maggior parte dei casi *A. lobifera* è aumentata in abbondanza e domina le associazioni, raggiungendo percentuali superiori al 50% a fronte di una drastica diminuzione delle specie native. I suoi resti carbonatici accumulati sul fondale di isole di origine vulcanica come Linosa stanno progressivamente cambiando la composizione dei sedimenti marini e per la prima volta stanno dando origine anche ad accumuli nell'ambiente costiero, all'interno di pozze riempite durante le mareggiate, come avviene negli atolli dell'Indo-Pacifico.

Questi risultati mostrano come in pochi anni alcuni foraminiferi non-indigeni siano stati capaci di colonizzare massivamente nuovi ambienti modificandone la biodiversità nativa ed influenzando i processi sedimentari.

Middle Aalenian ammonite chrononostratigraphy and cyclostratigraphy in the Marche Apennines (central Italy): the "Neroniad Level"

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The Aalenian chrono and cyclostratigraphic description in the Bugarone Inferiore Formation type locality (Cresta, 1988) and related sections on the Monte Nerone pelagic platform (Cresta et alii, 1995) are presented. The distribution of ammonites biohorizons sampled on the Bugarone quarry front (Cresta et al., 2002) has allowed to identify and chronostratigraphically frame a "cyclical" lithostratigraphic event in the Murchisonae Zone, here called "Neroniad Level". Its recognition on the Monti della Rossa in the Cava Fiaoni section (Vallemontagnana) is highlighted.

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Paleontological and Taphonomic Study of the Middle and Upper Jurassic Succession of Borgo Regalmici, Palermo (Sicily)

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Following Gemmellaro's pioneering paleontological studies in 1874, the pelagic Jurassic successions of Sicily have been extensively investigated from a sedimentological and stratigraphic perspective since the 1960s (Wendt, 1963). Recently, attention has shifted towards scattered carbonate blocks exposed in central-western Sicily, located between the Madonie and the Sicani Mountains. In these areas, several allochthonous pelagic carbonate units of Jurassic and Cretaceous age crop out as isolated limestone blocks in three main locations: Borgo Regalmici, Roccapalumba and Vicari. Noteworthy sections are exposed at Borgo Regalmici, where Gemmellaro (1874, 1882) described an ammonite association consisting of few species all referable to the Oxfordian: *Holcophylloceras zignodianum*, d'Orbigny 1848, *Taramelliceras* (*Proscaphites*) *anar*, Oppel 1863, *Passendorferia* (*Passendorferia*) *regalmicensis*, Gemmellaro 1874, *Gregoryceras fouquei*, Kilian 1889, and *Physodoceras insulanum*, Gemmellaro 1874.

The present study aims to provide a detailed description of the sedimentology and ammonite biostratigraphy of the Middle to Upper Jurassic sediments exposed in this section, and to highlight the presence of any significant stratigraphic discontinuities already identified in the contemporaneous successions outcropping in Western Sicily.

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Mechanical performance indicates niche partitioning in Late Cretaceous marine reptiles from the Western Interior Seaway

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The coexistence of sympatric predatory marine reptiles in the Western Interior Seaway (WIS) during the Late Cretaceous suggests ecological partitioning of higher trophic niches.

Previous studies have used dental morphology and microwear as proxies for the feeding habits of marine reptiles. However, teeth are only a fraction of the feeding apparatus. Assessment of paleoecological diversity in extinct predators also requires biomechanical simulations, to characterise performance.

Here, we performed the first, large-scale, comparative study on WIS marine reptile jaw performance using high-definition 3D models and muscle-driven finite element analyses (FEA). The jaws of mosasaurids and polycotylid plesiosaurians from the Campanian-Maastrichtian of North America were digitized and, for comparative purposes, mosasaur jaws were modelled with a fused symphysis and immobile intramandibular joint, forming a single functional element. Muscle insertions were identified to reconstruct jaw adductor muscles and assess respective muscle and bite force. We used Metafor to simulate realistic, muscle traction dynamics during biting, including simulations at different opening angles and biting locations.

Results reveal clear differences in biomechanical performances between the gracile jaws of polycotylids and other more robust mosasaurids. High deformation values in polycotylids indicate that maximum bite force was not exerted, suggesting other feeding strategies (e.g., snapping and swallowing). Moreover, polycotylids and some mosasaurid taxa (e.g., *Jormungandr*) appear better adapted to bite at wider gape angles, whereas mosasaurids with higher mechanical efficiency (e.g., *Mosasaurus*) appear better suited to take on large items with powerful bites. Our realistic biomechanical simulations numerically confirm previous hypotheses based on dental crown shape and wear, providing a unified canvas and protocol to assess niche partitioning in sympatric marine reptiles from well-sampled regions.

A story of fitness and phenotypes in a 2-million-year long fossil record

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Natural selection can be quantified and modelled as statistical associations between fitness and phenotypes. However, successfully operationalizing the study of selection using data from the fossil record is challenging despite the valuable insights it offers into long-term phenotypic evolution. Estimating fitness components from fossil populations allows linking observed evolutionary patterns with past selective forces, but such data are often unavailable for most groups of organisms. Cheilostome bryozoans, a group of calcified colonial marine invertebrates with an exceptional fossil record, present a unique opportunity to overcome this challenge. Fecundity, measured as the density of skeletal brooding structures (i.e., ovicells) within a colony of genetically identical feeding modules (i.e., autozooids) can be used as a proxy for fitness. Using multiple fossil populations of closely related (four species of the genus *Microporella*) and non-related species (*Antarctothoa tongima*) of cheilostome bryozoans spanning more than 2 million years of the Pleistocene in the Wanganui Basin of New Zealand, we investigate multivariate signals of trait-fitness associations for two phenotypic traits: autozooid and ovicell size. Thus, we ask how trait-fitness associations vary across time, among species and lineages, and whether they can predict phenotypic evolutionary outcomes. We also explore how paleotemperature and its variability contribute to the substantial variation observed in each of the two quantitative traits and fecundity across different time intervals for all species.

The snail way to modern marine complexity
Part 2: the Ladinian rise

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After the end Permian-Triassic mass extinction (c. 252 Ma), leaving the global seafloor inhabited by a disaster fauna, two major recovery steps occurred during the Middle Triassic. Cumulative literature data from 37 formations, mainly from Europe, indicate that species richness of benthic invertebrates (S) increased exponentially during the Anisian (c. 245 Ma) and reached a plateau (S = 350-400) through to the early Ladinian (c. 240 Ma). The Anisian rise was driven by the gastropods and associated with the resurgence of tropical carbonate platforms. Benthic ecosystem were dominated by herbivores. A second, dramatic step is testified by S = 1429 recorded in the well-known San Cassiano Fm, cumulating species from 30 fossil localities collected and described since almost two centuries.

Here, we report on a diversity S = 104 among the silicified molluscs of the Pelsa/Vazzoler Lagerstätte, in a single late Ladinian locality of the Agordo Dolomites (northeastern Italy). The list includes one new family, three new genera and 21 new species. A comparative analysis indicates that diversity had already taken off in the Longobardian (c. 238-239 Ma), a prelude to the early Late Triassic San Cassiano peak (c. 233-236 Ma). Gastropods dominate late Ladinian-early Carnian assemblages as they do in modern tropical environments. Structural and functional analyses suggest that most of the new species were small-sized parasites and predators of scleractinian corals and sponges and that a few of them could actively seek for mobile preys. Active predation in its turn selected for complex ornaments of axial ribs and spiral cords with knobby intersections, an early aspect of the Mesozoic marine revolution. As a whole, the fossil record indicates that modern marine complexity is rooted in two hyperbolic Middle Triassic events of diversification, and that triggering mechanisms can be explained by a two-steps adaptive radiation under biotic control within tropical carbonate platforms.

Rediscovering the Tuscan Miocene otters: intraspecific variability and phylogenetic position

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Despite modern otters are found across the globe, their fossil history is limited, primarily documented by fragmented dentognathic remains. The uppermost Miocene sedimentary record from the Italian peri-Tyrrhenian areas, specifically Tuscany and Sardinia, reveals the presence of a distinctive and unique paleobiogeographic region. This region is distinguished for its vertebrate assemblage, showing unique characteristics that set it apart from the contemporary faunas of Europe and Africa. In this work we report and describe new dental remains of a medium-sized Lutrinae from the Late Miocene of Baccinello and Casteani (Tuscany), enriching the poor fossil record of the subfamily in Europe. *Tyrrhenolutra helbingi* is a poorly known species, described on few dental remains from the Baccinello mine. Due to its peculiar morphology, it has often been overlooked in scientific literature. The descriptions of the material stored at the Natural History Museum of Basel and the Museum of Geology and Paleontology of the University of Florence offer new insights on the morphology of this taxon. The comparative study of these findings highlights several morphological similarities between *T. helbingi* and *Paludolutra maremmana* that allow us to re-define these taxa as *Tyrrhenolutra maremmana* nov. comb. We carried out a total-evidence cladistic analysis seeking support to morphometric and morphological similarities between *T.* "*helbingi*" and "*P.*" *maremmana*. Our results support the synonymy, excluding a close relationship of *T. maremmana* with *Paludolutra* of Italy and Spain, as previously thought. Furthermore, we confirm a long-forgotten hypothesis identifying *Limnonyx* as the possible continental ancestor of *Tyrrhenolutra*.

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A bear under the microscope: preliminary results of palaeoecological reconstruction of *Indarctos anthracitis* based on dental microwear and Hunter-Schreger bands

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The occurrence of fossil carnivores in insular ecosystems, usually, is predominantly constituted by otters, whereas other carnivores are generally absent from endemic insular faunas (Lyras et al., 2010). The endemic Late Miocene Tusco-Sardinian fauna represents an exception to this rule due to the occurrence of the endemic bear *Indarctos anthracitis* (Weithofer 1888). This occurrence represents a uniqueness in the fossil record as insular records of bears are unknown in the fossil record. Here, we revise and describe the material attributed to *I. anthracitis* (never adequately revised since its first description).

In the late Miocene, the genus *Indarctos* has been reported in Eurasia, North Africa, and North America. The taxonomy of this genus was revised several times but there is no consensus about their phylogenetic relationships between its species and other ursids. The results of comparative morphological and morphometric analyses allow us to reaffirm the distinction of our fossils from the other *Indarctos*. *Indarctos anthracitis* probably originated from *Indarctos atticus*, a large sized species with Eurasian distribution, and went towards size reduction as a result of evolution in an impoverished and unbalanced insular environment. This partially disagrees with what is seen in modern populations of bears confined on islands, which are usually characterized by similar size (or even larger) to corresponding continental forms (Gordon, 1986).

Aiming to investigate the dietary ecology of this endemic carnivore we used two different proxies: dental microwear and Hunter-Schreger bands, both considered to be useful in palaeoecological characterization of fossil carnivores. Dental surfaces were sampled using 3D digital microscope Hirox (HX-2500) equipped with NPS confocal system. We compared dental microwear pattern of *I. anthracitis* with a database of modern ursids using MicroWeaR package for R studio. Despite the small sample size, the results help us to clarify how this enigmatic bear survived in an impoverished environment.

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Timing and patterns of the end-Triassic extinction in Tethyan carbonate platforms

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We present a detailed bio- and carbon-isotope stratigraphy of three southern Tethyan carbonate platform sections, Mt. Messapion (Greece), Valle Agricola and Mt. Sparagio (southern Italy) across the Triassic/Jurassic boundary (TJB). In these sections, carbonate platform sedimentation persists across the TJB with no compelling evidence of a significant hiatus, thus potentially preserving the most detailed record of the end-Triassic extinction (ETE) in shallow tropical ecosystems. As such, these records differ from the classical sections of the northern Tethyan Realm (i.e., Northern Calcareous Alps, NCA, Austria and Lombardy Basin, northern Italy), where the extinction of carbonate platform assemblages coincides with a facies change and to the demise of the carbonate platform.

In the studied sections, the ETE is documented by the disappearance of megalodontid bivalves and involutinid benthic foraminifera, i.e. the typical aragonitic Dachstein-type biota, within a positive $\delta^{13}C_{carb}$ excursion, and few meters below a positive peak that, according to our study, correlates with the P1 peak documented in the Malanotte Fm of the Lombardy Basin. By contrast, the extinction of the Dachstein-type biota in the NCA and Lombardy Basin coincides with a negative carbon-isotope excursion (CIE) that is generally correlated to the initial CIE of the reference sections.

The bio- and carbon-isotope correlation performed in this study implies that extinctions in southern Tethys postdated the initial CIE, and thus are delayed compared to the NCA and Lombardy Basin. We contend that this level represents the true extinction of the Dachstein-type biota, while the disappearance in sections at the northern Tethyan margin represents a pseudoextinction coinciding with the demise of the carbonate platform. As a consequence, sea-level changes and the perturbation of the carbon cycle recorded by the Initial CIE are excluded as possible killing mechanisms of the Dachstein-type biota at a global scale.

The conodont genus *Rhodesognathus* Bergström & Sweet, 1966 from the Late Ordovician of the United Arab Emirates

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The genus *Rhodesognathus* was introduced in 1966 by Bergström & Sweet with specimens recovered from the Middle Ordovician Lexington Limestone of eastern North America. The genus, reported also in the Middle-Late Ordovician of Wales and Sweden, was regarded as composed by a pair of ambalodiform elements, having in *Ambalodus elegans* Rhodes, 1953 its type species. Dzik (1989) figured (but not described) a septimembrate *Rhodesognathus*, whose apparatus was regarded as "closely similar to that of *Amorphognathus*", the genus on which the biostratigraphic subdivision of the Late Ordovician is funded. However, a clear boundary between the two genera was never established.

A moderately abundant conodont fauna from the Ayim Member of the Rann Formation of the United Arab Emirates produced an exceptional well-preserved fauna with associations in some levels of the sole genus *Rhodesognathus*, allowing the first reliable reconstruction of the apparatus. A new diagnosis is provided, and a septimembrate apparatus architecture is described. Ambalodiform P elements bear the lateral process in continuity with the tooth immediately anterior to the cusp, being Pa and Pb elements characterized by the presence, on the outer posterior process of the P elements, of a lateral expansion that is denticulate in the Pa elements, non-denticulate in the Pb elements. The M element is represented by a holodontiform element equipped with a typical reclined cusp. The Sa, Sb, Sc and Sd elements constitute a transitional series of S elements that are completely indistinguishable from the corresponding elements found in *Amorphognathus*. Keys to distinction with the genera *Baltoniodus* and *Amorphognathus* are provided. The M element of *Rhodesognathus*, with the characteristic reclined cusp, is identified as the diagnostic element of the genus. The M element is diagnostic also in the genus *Amorphognathus*, and some holodontiform elements of *Rhodesognathus* have been erroneously attributed to *A. tvaerensis* and/or *A. superbus* in the literature, thus deriving an incorrect age. The new reconstruction of *Rhodesognathus* proposed herein urges a revision of the genus *Amorphognathus* and a careful check of previous age attribution in the Middle-Late Ordovician.

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The enigmatic "palaeoniscoid" fishes from the Lower Jurassic (Sinemurian) of the Southern Alps (Osteno, Como, Italy)

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Palaeoniscoids (or Palaeonisciformes) are an extinct group of actinopterygian fishes present from the Late Silurian to the Late Cretaceous which have posed taxonomic challenges due to their conservative body shape and similar, "primitive", skull anatomy. In the early to mid-20th century, Palaeonisciformes became a wastebasket taxon, grouping early members of several actinopterygian lineages thus complicating their taxonomic status. The recent establishment of Palaeoniscimorpha, a monophyletic clade which includes several taxa classically referred to Palaeonisciformes, sets the foundation for further evaluations of the included taxa (Lund et al., 1995; Schultze et al., 2021). The only known Jurassic "palaeoniscoids" in the Southern Alps are four specimens recovered from the Sinemurian Osteno Quarry (Lugano Lake, Como, Italy) by the Museo di Storia Naturale di Milano in the late 1900s. These specimens were briefly described by Duffin & Patterson (1993), who highlighted the similarities between them and two Jurassic taxa from Lyme Regis (Dorset, UK), pointing out the connection between the English and the Italian ichthyofauna. However, the taxonomic attributions provided by Duffin & Patterson (1993) appear not fully supported. For example, the attribution of some specimens from Osteno to the Lyme Regis taxa *Coccolepis liassica* and *Cosmolepis ornatus* were only based on non-reliable taxonomic features within Palaeoniscimorpha, like squamation morphology and ornamentation. Moreover, important characteristics such as skull and fin anatomies have been overlooked, suggesting the need of revision. The reassessment of taxonomy and systematic position of the Osteno palaeoniscoids will provide new insights into the biodiversity and the evolution of Liassic ichthyofaunas, clarifying the similarities and differences between the historically neglected Osteno fauna and the coeval one of Lyme Regis.

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Analysis of the frontal sinus of Early Pleistocene Canids

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This study took in consideration the analysis of the frontal sinus of some fossil species of the genus *Canis* (Mammalia, Canidae). The frontal sinuses are cranial cavities within the frontal bone, whose origin and evolutionary significance are still poorly understood and debated even in extant canids. Starting from a previously published paper on the development of the frontal sinus in the genus *Eucyon* (Frosali et al., 2023), and thanks to the Travel Grant won last year by the first author (S.F.), we reconstructed and analyzed these paranasal cavities in new samples of extant and fossil canids, trying to discern the paleoecological and phylogenetic impact of their shape and dimensions. According to the more widely accepted hypothesis, the function, morphology and size of the frontal sinus are linked to the dietary preferences and biomechanics of feeding. Indeed, their inflated shapes allow dispersing the stresses during hunting and feeding as in durofagous species (e.g., hyenas), in which the frontal sinus expands greatly caudally up to the level of the sagittal crest toward the occipital.

The analysis, based on Virtual Paleontology techniques, tried to highlight the similarities between a few Early Pleistocene species of the genus *Canis* and other extant species of the family Canidae. Albeit the study is still ongoing, first evidence that can be noticed is that among the roughly contemporaneous fossil species, there is a wide variety of morphology and dimensions of the frontal sinus, probably implying complex phylogenetic relationships between these species and different paleoecological adaptations.

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Taxonomic Diversity of Fossil Vertebrates from the Quaternary Deposits of the Karst Pit of Cà Negra (Croatia)

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In 1932, quarrying operations in an active chalk quarry named Cà Negra (in the Gulf of Piran, Croazia), revealed a karst sinkhole containing countless fossil specimens of macro- and micromammals. About 20,000 fossil specimens were collected and initially classified by Franco Anelli, a speleologist who was working on Italian Cave Registry. His studies were interrupted in 1939 due to the outbreak of World War II. Carefully packed in newspapers, the specimens were sent to Bologna, where they remained unstudied to these days. As the site is no longer accessible due to massive quarrying activities, data housed in Bologna represent a pivotal tool to infer palaeobiological data from this unique Quaternary site.

The Cà Negra sinkhole was 15 meters deep, an horizontal stratification revealing five distinct levels based on filling type could be distinguished, two of which bearing the majority of fossil remains. In addition to typical carnivores, large herbivores, and micromammals, non-mammalian microvertebrates such as amphibians (*Bufonidae*), reptiles (*Lacertidae*), fish (*Esocidae*), and birds (*Corvidae*) have also been identified. A comparison of the fauna identified at Cà Negra with other karst fossil deposits in the Istrian peninsula has revealed some fundamental differences, thus adding an unusual dimension to the site biodiversity. These differences consist in the absence of proboscideans, the presence of non-mammalian microvertebrates and the presence of the gastropod *Pomatias elegans*, a good palaeoenvironmental indicator.

Furthermore, of particular interest is the discovery of human remains, along with signs of manipulation such as cutmarks and fractured or burnt bones. These fossil specimens suggest direct involvement of *Homo* in the Quaternary ecosystem, opening new perspectives on his relationship with local fauna and evolutionary dynamics of the period.

The first *Osedax* traces on Miocene whale bone form the Northern Apennines, Italy

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Large cetaceans that after death sink to the deep-sea floor are usually colonized by a variety of organisms, forming the so-called whale-fall communities. A member of these communities is the bone-eating worm *Osedax*, a polychaete genus of the family Siboglinidae that uses a specialised root-tissue to penetrate the bones from which it gets nutrition through endosymbiotic bacteria. We studied a fragmentary long bone of an unidentified cetacean hosted at the Museum of the University of Modena and Reggio Emilia collected near Montegibbio (Modena, Italy) from Miocene marine sediments. A more precise dating of the associated sediments through calcareous nannofossils is ongoing. The bone, which shows signs of bioerosion on the outer surface, was analysed through 3D photogrammetry and micro-CT scanning to characterize the fossil traces and possibly understand which organism produced them. From an external view, the bone surface shows rounded to irregular pits, a few millimetres to 4 cm wide, where the compact bone has been removed exposing the cancellous bone. The smaller pits are isolated, while the bigger ones are merged one into the other. Although these traces on the surface appear similar to those produced by *Osedax* on modern bones, only small cavities with a single borehole reflect the shape of the root system of an individual animal and are of particular diagnostic value. Thanks to digital segmentation of the scan slices through the software Dragonfly, we isolated, measured and reconstructed the 3D morphology of single boreholes. We distinguished a variety of morphologies (from highly ramified to rounded shapes) and found similarities in size and shape with boreholes produced by modern *Osedax* species. Our finding represents the oldest fossil record of *Osedax* from the Mediterranean area, as it was previously only described from Piacenzian odontocete bones from Tuscany (Italy).

A regional synthesis from the Provençal Domain (western Tethys) on the response of marine calcifiers in shallow-water paleoenvironments across the Middle Eocene Climatic Optimum

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The sediments deposited during the Bartonian along the drowning ramp of the Provençal-Dauphinois Domain record the Middle Eocene Climatic Optimum (MECO), the prominent global warming event, centered at ~40 Ma and lasting ~400-600 kyrs. These successions offer the crucial opportunity to evaluate the resilience of foraminifera (both planktic and benthic, including larger foraminifera) based on their ecological reactions to the climatic disturbance. Our dataset come from three different successions (Sealza, Capo Mortola and Olivetta San Michele) that, despite being lithostratigraphically and biostratigraphically correlated, depict significant differences in terms of faunal distribution and depositional setting. Planktic foraminiferal assemblages differ in all the successions both in abundance and diversity, suggesting major differences in water circulation in these shallow-water settings. The variations in abundance of *Subbotina* and *Acarinina* appear controlled by both the MECO warming and by a moderate eutrophication related to the enhanced hydrological cycle. Benthic taxa fluctuations across the MECO are mostly comparable among the sections. The significant changes in the communities appears mainly influenced by the enhanced fluvial regime and related trophic state rather than by the temperature increase. This is particularly evident in larger foraminifera that reacted positively to the new trophic regime by increasing their abundance and diversity. Being shallow-water biota, they are better adapted to seasonal variations in salinity and temperature more than taxa living in deep-water settings and they are generally more resilient to long-term climatic perturbations. Nonetheless, their population shifts appear more directly impacted by the altered sedimentary rates and nutrient inputs, modulated by the enhanced hydrological cycle triggered by the warming event.

We can reconstruct paleoenvironment seasonality with brachiopods: insights from the modern *Calloria inconspicua* (Sowerby, 1846)

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Brachiopod shell is a valuable biogenic archive of seawater conditions for the Phanerozoic because they precipitate a carbonate shell that is rather resistant to diagenesis and can preserve its original chemical composition. The brachiopods lifetime can span from a few to several years, and the accretionary nature of the shell, coupled with the ability to measure isotopes in the shell with high spatial resolution ($\delta^{13}C$ and $\delta^{18}O$), has the potential to disclose seasonality of past seawater. To determine if, and how, employing shells as reliable archives of seasonal variation, we carried out a sclerochronological and sclerogeochemical study of the shell in the modern New Zealand brachiopod, *Calloria inconspicua* (Sowerby, 1846).

As well as employing the Spiral Deviation analysis to assess the ontogenetic age of individuals, we also analysed the shell growth lines pattern and the underlying microstructure. We complemented the analysis of morphological growth with measures of $\delta^{13}C$, $\delta^{18}O$ isotopic values collected with high spatial resolution along the shell and we related these with growth lines as well as with concurrent seasonal seawater isotope values. We observed that *C. inconspicua* changes the seasonal growth rate of shell during the ontogeny. The juvenile life stage is characterized by continuous growth of the shell during all the seasons, but later they preferentially expand their shell during the warm season, and show growth halts during the colder season. Therefore, the adult stage does not record the full seasonal variations, contrary to the juvenile shell growing continuously for the first two year after the settling and recording the full variation of $\delta^{18}O$ values caused by seasonal changes of seawater temperature. Consequently, errors in the estimation of mean paleotemperature may occur in those environments characterized by marked seasonality, because the seasonal growth biases the measurement of the $\delta^{18}O$ values depending on the portion of shell analysed.

Diatom seasonal laminations as paleoceanographic proxy: the case of the "El Padre" climatic mean state in the Upper Miocene Pisco Formation (Ica desert, Peru)

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To contribute data for climate modelling, we analysed laminated diatomites to unravel the ocean dynamic recorded by the Upper Miocene Pisco Formation. At the site of Cerro Los Quesos (CLQ), Ica Desert, Peru, we collected a 25 cm long seasonally laminated diatomitic sequence, dated between 6.93 and 6.71 Ma. Previous authors measured the SSTs of this time frame at Eastern Equatorial Pacific IODP Sites, pointing to an increase of SSTs during the time of deposition of the CLQ diatomites; these data were unexpected as diatomites are usually associated to cold surface waters. We solved this contrast as CLQ laminae are dominated by *Coscinodiscus*, a diatom genus belonging to the shade flora, meaning that it thrives at low light conditions at the thermocline, thus in a stratified water column. Higher SSTs imply a deeper-than-normal position of the thermocline (resulting in a dampened upwelling of nutrients) and a smaller T gradient between the Eastern and the West Pacific, a distinguishing feature of El Niño events. As *Coscinodiscus* dominates the whole diatomitic portion of CLQ, we concluded that El Niño-like settings persisted as a climate mean state for the entire deposition of this portion (Gariboldi et al., 2023). Some authors had recognised this same climatic condition for the Middle Pliocene Warm Period analysing geochemical proxies in core sediments and called it the "El Padre State". Yet, the validation of the existence of such climate mean state was lacking. The dominance of *Coscinodiscus* laminae and the scarcity of upwelling diatom genera in a period as warm as the Middle Pliocene provided the necessary evidence. This evidence revealed that El Padre was active during the Late Miocene in the Equatorial Pacific and promoted diatom laminae as proxy to further investigate it in the Middle Pliocene Warm period. Models suggest that the modern raise of global T implies a reestablishment of El Padre in the future, causing more frequent floods and droughts in the Americas.

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The Messinian entomofauna from Monte Castellaro (Pesaro, Italy)

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The paleontological deposit of Monte Castellaro, known since the 18th century, is located in the San Bartolo Natural Park, about 3 km from Pesaro. Here, abundant fish, leaves, and insect fossils were retrieved, along with few terrestrial vertebrates, from the Messinian bituminous marls of the Gessoso-Solfifera Group (Late Miocene; Bedosti, 1975; Bedosti, 2016). A rich entomofauna is present in one horizon, known in the literature as "Strato degli insetti" ("insect layer"; Sorbini, 1987), approximately 15 cm thick, consisting of alternating thin light and dark laminae. The likely rapid burial, absence of bioturbation, and anoxic conditions of the seabed led to the preservation of even the most delicate parts of the insects. A preliminary examination of the entire fossil entomofauna allowed for the identification of 12 orders, 24 families, and 34 genera, which makes Monte Castellaro one of the most important insect deposits of the Late Miocene of Europe. The association is dominated by nematoceran dipterans, hemipterans, adult odonates, and hymenopterans. Between 1986 and 2006, several studies on dipterans and dragonflies were published by the first author, which allowed for the identification of numerous new taxa. Among these, the type specimen of the damselfly *Italolestes stroppai* (Nel et al. 2005) was recently selected as the representative fossil of the Marche region within the "Fossili Regionali" initiative promoted by PAiP-SPI. Although the studies conducted so far allowed for some preliminary hypotheses about the environmental conditions during the deposition of the bituminous marls, for a reliable paleoclimatic reconstruction that would account the presence of temperate and thermophilic taxa, an examination of all the insect orders discovered in the Monte Castellaro section is necessary, along with a thorough study of the ichthyofauna, the macroflora, the pollen, and the bird and mammal remains from this unique site.

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The Quebrada des Aracas tracksite reveals giant theropod tracks from the Chacarilla Fm. (Jurassic-Cretaceous, NE Chile)

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Despite the potentially rich Mesozoic formations, the Chilean dinosaur track record is understudied (Yurac et al., 2022) and vague in its chronostratigraphic position. The updated record for the tracksite is now of 94 measurable tracks, assigned to five different morphotypes: Morphotype I was classified as *Parabrontopodus*-like. The remaining four morphotypes have been related to theropods. In particular, Morphotype II tracks, with their foot length longer than 50 cm, are among the largest ever recorded for theropods in South America. Ichnotaxonomically, it shows strong affinities with *Abelichnus astigerrae* (Calvo, 1991), but since we couldn't access to the original material, Morphotype II is attributed to cf. *Abelichnus*. The number of possible producers of this size in the time interval of the Chacarilla Fm. is limited, and, like the previous interpretation of Calvo (1991), the trackmaker is a large carchadontosaurid. Morphotype III shows theropod affinities but no similarities with known ichnotaxa. Morphotypes IV and V were classified as Grallatoridae and *Kayentapus*-like, respectively. This work provides new insights on palaeoecology and dinosaur biodiversity for Gondwana during the Jurassic-Cretaceous.

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Probability distribution and palaeoecological preference of cave lions *(Panthera spelaea*) in Europe during MIS5-3

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The cave lion, *Panthera spelaea,* is one of the most iconic Eurasian species of the Late Pleistocene. Skeletal remains of this species are well represented in the fossil record and depicted in cave paintings and artefacts. Additionally, genetic analyses revealed the evolutionary relationships of extinct and extant populations of all lions. However, the species' climatic constraints and information regarding the environments inhabited by the species compared to modern lions remain unknown.

In our analysis, we focused on European cave lions from the Late Pleistocene period (MIS 5-3). We carefully selected sites where lion remains have been directly radiocarbon dated or where localities have a fixed chronology within the specified timeframe, resulting in a final dataset of about 100 European sites. By correlating the species' occurrences and its maximum entropy probability distribution, with the 19 estimated raster maps available from the PaleoClim project, which provides climatic variables estimated for past ages, along with a rectified world digital elevation model in R, we calculated the climatic constraints for the lion population in Europe. Furthermore, we inferred environmental strata and zones (EnZ) matching the lion's distribution.

Cave lions showed a preference for "cold and wet" and "cold temperate and moist" EnZ, with a strong preference for the latter, mainly occupying the central European lowlands.

Studio ad alta risoluzione del sapropel "Nicola Bed" (2.59 Ma) affiorante a Monte San Nicola – (Sicilia)

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In questo lavoro vengono presentati i primi risultati di uno studio ad alta risoluzione del sapropel A5 (2.59 Ma, MIS 103), conosciuto in letteratura come Nicola bed ed affiorante nella successione di Monte San Nicola (Sicilia). In particolare, il sapropel è stato campionato nella sezione "Mandorlo", localizzata 400 m NW rispetto al GSSP del Gelasiano. Il campionamento è stato effettuato pulendo la parte affiorante con uno scavo di oltre un metro di profondità ed utilizzando una resina bicomponente per cementare la roccia; successivamente la roccia è stata tagliata con una sega circolare. Questa tecnica ha permesso di estrarre una carota di 45 cm, che in laboratorio è stata campionata ogni centimetro (Radmacher et al., 2023). In totale sono stati analizzati 41 campioni.
Questo studio rientra nel progetto "GELSTRAT" utile ad acquisire dati sul GSSP del Gelasiano e nel progetto di ricerca PRIN 2022 PNRR "ReMePP".
Nei 41 campioni è stata analizzata l'associazione a foraminiferi e gli isotopi stabili di Carbonio ed Ossigeno. Il sapropel si può suddividere in tre parti, con differenti caratteristiche sedimentologiche, micropaleontologiche e geochimiche che evidenziano forti oscillazioni ambientali durante la deposizione.
La parte inferiore è laminata e ricca di specie calde (*Globigerinoides ruber*); la parte centrale è caratterizzata da valori più bassi del $d^{13}C$, fortemente bioturbata da *Chondrites* e *Planolites* e valori del $d^{18}O$ che indicano forti influssi di acqua dolce. La parte alta è caratterizzata da una minore bioturbazione e da valori più stabili del $d^{18}O$.

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Aluminosilicate biomineralization in an arsenopyrite cave

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Aluminosilicate biomineralization is a complex process that involves different stages of metal–microbe interactions, metal substitution, and crystallization (Konhauser & Urrutia, 1999; Sánchez-España et al., 2017). Depending on water chemistry and the bacterial species involved in the biomineralization process, aluminosilicate of bacterial origin can show different morphologies, from amorphous to submicrometric to nanometric in size, and exhibits a variable composition (e.g., kaolinite-like, halloysite-like, nontronitic, and chloritic). The role of bacteria nucleating authigenic aluminosilicates has been reported in lake sediments and rivers. Moreover, the formation of amorphous aluminosilicates around cells of *Bacillus subtilis* was observed by Fein et al. (2002). These so-called bio-clays form under both experimental and natural conditions, but until now they are not described forming bioconstruction-like bodies.

Here, we describe an unusual dendritic fabric forming in a natural environment, inside the Macariace arsenopyrite mine, near the Mammola village (Southern Calabria, Italy). These fruticose structures develop in a decimetric fracture of the cave wall characterized by sub-photic conditions. They are white in color and formed by an intricate frame of millimetric convolute tubular structures. Micromorphological and biogeochemical/mineralogical data of optical microscopy observations, scanning and transmission electron microscopy characterization, X-ray powder diffraction analyses, energy-dispersive spectroscopy microanalyses, thermal analysis and UV-Epifluorescence observations confirm the aluminosilicate nature of these structures and suggest unusual biomineralization processes involved in their deposition.

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Sus arvernensis (Croizet & Jobert, 1828) (Suidae, Mammalia) from the Pliocene of Hungary

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Sus arvernensis (Croizet & Jobert, 1828) is a Pliocene species that occupies a key position in the evolution of suids (Suidae, Artiodactyla, Mammalia) in Eurasia, and besides it is considered important for biochronological correlations and paleoecological inference. However, our knowledge on *S. arvernensis* is largely based on fossil remains from southwestern Europe, as exemplified by the abundant sample recovered from the RDB Quarry at Villafranca d'Asti (Piedmont, northern Italy) (Iannucci, 2024).

Here, I present an updated overview of the Hungarian fossil record of *S. arvernensis*. The species was previously reported from only two Hungarian localities, Gödöllő (Pest) and Süttő (Komárom-Esztergom) (Mottl, 1939; Jánossy, 1986), and the latter occurrence has even been questioned (Pickford & Obada, 2016).

Here, I confirm the presence of the species from Gödöllő and Süttő, and I describe more material from Beremend (Baranya) and Kisláng (Fejér). Collectively, the results of the revision carried out herein reveal a relatively widespread distribution of *S. arvernensis* in Hungary, hence providing an important link from the eastern to western European fossil record of the species. Apart from Gödöllő, all the other Hungarian localities (Beremend, Kisláng, and Süttő) yielded chronologically heterogeneous faunas spanning in age from the Pliocene to the Pleistocene, and the presence of the Ruscinian to early Villafranchian *S. arvernensis* contributes to their biochronological characterization.

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New insights into the filter feeding in Aegirocassisinae

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Radiodonts were a group of extremely successful large nektonic arthropods which proliferated in the Cambrian, with forms such as the iconic *Anomalocaris canadensis* (Whiteaves, 1892), only to become extinct in the Devonian. One of the keys to their success was the evolutionary plasticity of their frontal feeding appendages, which allowed them to conquer many ecological niches, including the evolution of giant filter feeders, the Aegirocassisinae (Potin et al., 2023), in the Ordovician (Van Roy et al., 2015; De Vivo et al., 2021; Potin & Daley, 2023).

Here we present the first evidence for a new interpretation of the filtering mechanism in Aegirocassisinae, thanks to a new fossil, the specimen DDMP 0012, belonging to the species *Pseudoangustidontus izdigua* (Potin et al., 2023). The specimen consists of two partially overlapped frontal appendages of the same individual, one open and the other closed. The open appendage (the only open one among all the fossils of Aegirocassisinae hitherto known) shows podomeres interspaced with arthrodial membranes forming a fan-like structure. The specimen allowed us to perform 3-D kinematic analyses using Blender. Our results show that feeding was performed through the formation of a basket made by the endites of the two appendages in conjunction, resembling the filter feeding gills of basking sharks, providing a new perspective on plankton-feeding radiodonts.

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A Kungurian (early Permian) flora from the Southern Alps (Northern Italy) yielding cuticles

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The Athesian Volcanic Group (AG) represents the most extensive Permian volcanic succession in Europa. The volcanic activity alternated with periods of quiescence, during which continental deposits formed. The fluvial-lacustrine sedimentary layers of the AG yielded diverse plant fossils, palynomorphs, tetrapod footprints, and other ichnofossils, permitting to reconstruct rich and complex ecosystems. Among the fluvio-lacustrine intercalations of the Athesian Volcanic District, Gorl stands out as one of the less explored outcrops. At Gorl, the Guncina/Guntschna Formation covers the rhyodacitic ignimbrites of the Gargazzone/Gargazon Formation with breccias and conglomerates, overlain by a 20 m thick fine- to coarse-sandstone succession, organized in massive to horizontally laminated beds. The exposed succession is overlain by rhyolitic lavas belonging to the Andriano/Andrian Formation. The plant fossils recovered from the Gorl succession are very fragmented but occasionally exceptionally well-preserved with cuticle. The morphological and cuticular analyses confirm the presence of some seed ferns (*Lodevia*, *Peltaspermum*, *Sphenopteris*), ginkgophytes (*Sphenobaiera*), and conifers (*Collia geinitzii*, *Feysia*, *Hermitia*) for the Southern Alps. The cuticular analyses permitted, however, also the description of a leaf fragment putatively assigned to *Germaropteris martinsii*, and several different types of conifer shoots and dwarf shoots (Conifer morphotypes 1-3, Dwarf shoot 1-2). The cuticle of *Collia geinitzii* is described for the first time. Palynological studies integrate the floral composition, adding some more humid elements to the flora (lycophytes, ferns, cordaites), and increases the diversity of the seed ferns and conifers. The palynofacies analyses permit to reconstruct a near-shore depositional lacustrine environment with a fluctuating lake level. The exceptionally well-preserved cuticles even demonstrate plant-animal interactions such as traces from piercing and sucking.

Neogene-Quaternary planktonic foraminiferal diversity in the Mediterranean area

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The Neogene and Quaternary periods are characterised by several oscillations in climate and related turns in fossils community, and planktonic Foraminifera represent a significant tool to monitor these climatic changes.

In particular, the planktonic foraminiferal populations of the Mediterranean area show pronounced oscillations on a variety from Milankovitch to million-year timescale. Analysis on mediterranean planktonic foraminiferal datasets have been performed on land and deep marine successions just listed on Lirer et al. (2019), and calibrated vs the Geological Time Scale 2020. Data revealed a progressive long term trend in planktonic foraminiferal diversity, increasing from ca. 20 Ma up to 6.60 Ma. In particular, four main increases in turnover and/or diversity signal occur during the Miocene and they realized at 21.8 Ma (Aquitanian), 15.10 Ma (Middle Miocene), 11.30 Ma (early Tortonian) and 7.20 Ma (early Messinian). Contrarily, after the Plio-Pleistocene reflooding, planktonic foraminiferal diversity shows an almost flat trend, punctuated by weak increases in turnover and/or diversity centred at 4.20 Ma (middle Zanclean), 3.50 Ma (early Piacenzian), 2.60 Ma (early Gelasian), 2.0 Ma (upper Gelasian) and 0.30 Ma (upper Chibanian).

Moreover, during the Neogene-Quaternary interval the innovation and disappearance rates in planktonic foraminifera show strong fluctuations and distinct maxima. Four main innovation rates occur during the Miocene: i) lower Aquitanian, ii) Langhian, iii) upper Serravallian-lowermost Tortonian and iv) upper Tortonian-lowermost Messinian. Last innovation rates occur during the Plio-Pleistocene but the rates are lower than in Miocene.

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Paleoenvironmental insights on the earliest hominin dispersal into Europe: stable isotope analysis on the large mammal assemblage of Pirro Nord (Early Pleistocene, Apulia)

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The use of stable isotopic proxies on mammalian fauna to investigate paleoenvironmental conditions of early hominin-bearing sites has been widely employed in the Plio-Pleistocene of East Africa, as evidenced by several studies. On the contrary, the utilization of this methodology resulted underemployed in studies on Early Pleistocene hominin-bearing sites in Western Europe.

We present here new stable carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) data from the large mammal assemblage from Pirro Nord Early Paleolithic site, in which one of the oldest hominin records in Western Europe is reported. Our study is based on sampling and measuring a hundred bulk enamel (bioapatite) samples of different genera (*Homotherium, Pachycrocuta, Ursus, Canis, Xenocyon, Bison, Stephanorhinus, Equus*, and *Pseudodama*).

Previous reconstructions of paleoenvironmental conditions at Pirro Nord primarily based on microvertebrates, suggested a diverse environment with open dry areas and scattered forest patches. These conditions were indicative of a slightly colder climate with more precipitation compared to present day.

Our data aligns with the idea of open and dry environments at Pirro Nord, with the majority of ungulates exhibiting a grazing behavior. Notably, *Stephanorhinus* displayed an extremely grazer-centric diet. Differences between $\delta^{18}O$ values from non-obligate and obligate drinkers are here considered as a proxy to estimate aridity in the area surrounding Pirro Nord. Although a larger number of samples (and taxa) would be desirable, our first results suggest systems with low or very low aridity. Among carnivores, the high $\delta^{13}C$ values for *Pachycrocuta* may be the effect of a significant intake of scavenging diet and the incorporation of ^{13}C into the digestive system through bone biting. The low-moderate $\delta^{13}C$ values observed in *Ursus* are likely associated with an omnivorous diet and, potentially, the absence of urea recycling during hibernation. Notably, the substantially lower $\delta^{13}C$ values in *Homotherium*, in stark contrast with those recorded for this taxon in African sites, may provide first evidence of prey consumption on browser species. This finding underscores the adaptability of this taxon which probably was one of the main competitors of early hominins for meat resources.

Esemplare giovanile di *Cymbospondylus buchseri* e nuovi resti di *Besanosaurus leptorhynchus* nella Collezione di Geologia "Museo Giovanni Capellini" di Bologna

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Nel contesto di un progetto di valorizzazione dei reperti storici custoditi nella Collezione di Geologia "Museo Giovanni Capellini" di Bologna sono stati restaurati e studiati 28 reperti provenienti dai Giacimenti di Besano - Monte San Giorgio. Le lastre, solo parzialmente catalogate negli anni '90 del secolo scorso, giunsero a Bologna nel 1925 tramite Michele Gortani che attribuì sommariamente i fossili in esse contenuti a *Mixosaurus cornalianus*. Tra questi reperti sono di particolare interesse i campioni MGGC 10320 e MGGC 10326, che contengono rispettivamente i resti di un cranio e porzioni di scheletro assiale di vertebrato. Il reperto MGGC 10320 si presenta come una lastra a scisti bituminosi di dimensioni 11x15 cm contenente i resti disarticolati di diverse ossa frammentate di vertebrato e ossa di dimensioni maggiori sovrapposte ad essi. L'elemento più diagnostico è un osso di lunghezza 11 cm e larghezza 2 cm, che presenta una particolare ornamentazione striata sulla superficie e identificato come porzione di una costola di un vertebrato di grandi dimensioni. Dal confronto con i reperti del Museo Civico di Scienze Naturali di Milano sono state trovate congruenze con le costole appartenenti all'olotipo, e unico esemplare, di *Besanosaurus leptorhynchus*. Il reperto MGGC 10326 consiste in una lastra a scisti bituminosi, di dimensioni 24x10,7 cm, contenente i resti in vista laterale destra di un cranio in connessione anatomica parziale attribuito a *Cymbospondylus buchseri*. L'orbita risulta schiacciata dorsoventralmente e ha dimensioni minute. MGGC 10326 presenta una spiccata eterodontia con i denti che mostrano una tendenza di irrobustimento partendo dalla porzione distale del rostro e finendo nella porzione finale dei rami mandibolari e mascellari. Le ridotte dimensioni, più del 50% in meno, fanno pensare che si tratti di un esemplare giovanile in quanto della specie *C. buchseri* ne sono stati ritrovati solo esemplari adulti, conservati a Zurigo, che raggiungono i 6 m di lunghezza stimati. La scoperta di un esemplare giovanile può aprire la strada a studi ontogenetici della specie. Questi due esemplari arricchiscono le importanti faune di Besano.

Eocene-Miocene biostratigraphic markers of the Pisco Basin, Peru

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The East Pisco Basin is world reknown for its exceptionally rich and well preserved assemblage of marine vertebrate fossils ranging from the middle Eocene to the upper Miocene. The strata hosting such fossils have been the object of investigation by our research group for the last 10 years, building on previous stratigraphic schemes. Following a sequence-stratigraphic approach, unconformity surfaces were identified on the field and mapped (DiCelma et al., 2017). Such unconformities bound the main stratigraphic sequences or alloformations named, from older to younger, the Paracas, Otuma, Chilcatay and Pisco formations. Minor unconformities allowed identification of cyclical units within each sequence and integration of biostratigraphic and tephrochronologic age determinations provided the chronological constrain (Gariboldi et al., 2017; Malinverno et al., 2021).

Here we summarise the biostratigraphic characterisation of each stratigraphic unit and sub-unit: benthic foraminifera, calcareous nannofossils, diatoms and silicoflagellates are alternatively significant in different climatic and environmental contexts and provide key marker species useful for global and local correlation. We also provide new data from key outcrops that allow refing our dating of the East Pisco Basin.

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Dynamic responses of calcareous plankton in the Ligurian Sea across the last 28ka: insights into paleoclimatic and paleoceanographic changes

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During the late Quaternary period, glacial-interglacial cycles, caused by periodic changes in Earth's orbital parameters, have consistently conditioned the composition and dynamics of land and sea ecosystems. These significant climate shifts, like the Younger Dryas, Bølling-Allerød, and Heinrich events, which have had worldwide effects, are also well-documented in the Mediterranean Sea.
The Mediterranean Sea, located at mid-latitudes, is responsive to climate variations, influenced by both polar and equatorial dynamics. This research introduces the initial reconstruction of paleoceanographic conditions on a centennial scale during the last deglaciation in the Eastern Ligurian Sea, near the Italian coastline in the Western Mediterranean. This region provides a distinctive setting for detailed reconstructions of past climates and ocean conditions, housing both surface (Modified Atlantic Water; MAW) and subsurface (Levantine Intermediate Water; LIW and Tyrrhenian Intermediate Water; TIW) water masses, that carry signals from the Atlantic and the Eastern Mediterranean. To reconstruct the major events of the last 28ka in the Ligurian Sea, the 320cm sediment core NDT_22_2016, drilled at a depth of 436m aboard R/V Minerva Uno of CNR, was studied using geochemical proxies and calcareous plankton assemblages (planktic foraminifera and coccolithophores)
Analysis of planktic foraminifera assemblages, reworked coccoliths, and XRF data revealed fluctuations in climate during the last glacial period, chronologically correlated to western and eastern Mediterranean sectors. Planktic foraminifera also suggests colder conditions in the Ligurian Sea compared to the southwestern Mediterranean, showing pronounced seasonality, particularly evident during Heinrich and Heinrich-like events.
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A journey through marine geobiological archives: potential environmental proxies in Coralligenous build-ups

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Among the bioconstructed habitats of the Mediterranean Sea, Coralligenous is undoubtedly the most important ecosystem because of its extent and complexity. Coralligenous is a heterogeneous habitat, a prominent geobiological system and a unique hot spot of biodiversity (Cipriani et al., 2024). Nevertheless, these build-ups are characterized by a low accretion rate and a high sensitivity to natural and anthropic impacts. For these reasons, Coralligenous has since long time been the object of special interest by the UNEP RAC/SPA and considered among the priority habitats for monitoring and conservation by the EU.

The geochemical analysis of the main skeletal and non-skeletal carbonate components of coralligenous bioconstructions and the comparison of the data with surrounding marine water allows to investigate the balance between reef status and environmental parameters and to identify possible proxies for short- and long-term environmental studies. This approach highlights a relationship between the chemical composition of the minerals and the waters in which they form, especially in terms of trace elements. Furthermore, the carbonates revealed positive anomalies in heavy metals also found in bioconstructions' surrounding waters. Such enrichments could result from pollutants introduced into the marine system by human activities and recorded by the components of the bioconstructions. This data, although preliminary, allows to consider coralligenous build-ups as environmental recorders of marine conditions under natural changes and anthropic disturbance, enabling the reconstruction of the evolution of the marine environment over time.

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A *Kolpochoerus* skull (Mammalia, Suidae) from the Buia site (Lower Pleistocene, Danakil, Eritrea): Virtual Paleontology applications for taphonomic analyses

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The rich collection of fossil pigs from Buia (Eritrea, Early Pleistocene) (Medin et al. 2015) preserves a muzzle of *Kolpochoerus majus* (UA-20) with the occurrence of clear bite marks on the dorsal surface. This led us to attempt to investigate on the possible trackmaker. To do this, we considered two predator taxa present in the area about 1 Ma ago (*Crocodylus niloticus* and *Crocuta crocuta*; Delfino et al., 2004), as well as those who still potentially prey on African suids. Considering a functional bite of carnivore on a prey (regardless of hunting or scavenging), the distance between couples of bite marks documents the trace of a functional pair of teeth impressed on the bone during the bite action. As such, it is comparable to the intercanine distance between upper canines. Morphological and morphometric characterization of the UA-20 bite marks allowed us a preliminary discrimination between the considered taxa. Particularly *C. crocuta*, *H. hyaena*, *P. brunnea*, *A. jubatus*, and *C. niloticus* displayed comparable dimension with the bite marks distance in the investigated specimen. Further anatomical, biomechanical, and ecological considerations led us to exclude the extant *C. niloticus*, *A. jubatus,* and *P. brunnea,* as well as the fossil *Crocuta ultra* and *Hyaena makapani*. Of the remaining taxa, between *C. crocuta* and *H. hyaena*, it is difficult to conclusively determine which left marks. However, there are some independent considerations (e.g., prey preference, hunting strategy, etc.) favoring the identification of *Crocuta crocuta* as the most probable responsible for inflicting the bite.

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An overview of the late Early Pleistocene to Middle Pleistocene hippopotamuses from the Italian Peninsula

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The hippopotamuses dispersed in Europe during middle Villafranchian around 2.2 Ma, recently defined as "Hippo event". Despite the prolonged presence of this group in Europe, hippopotamuses are relatively scarce and are represented by isolated and fragmentary fossils, with only a few nearly complete skeletons found in lacustrine or fluvial deposits.

Although there are still conflicting opinions about the systematics and evolution of this group, the majority of the authors agrees with the identification of only two species, *Hippopotamus antiquus* and *Hippopotamus amphibius*, excluding the islands. Similarly, the timing of the dispersal of the modern hippopotamuses has long been disputed too. Recently, the reassessment of the stratigraphic setting and geological data of the skull from Cava Montanari (Rome, Italy) reinforced the hypothesis of a Middle Pleistocene dispersal (ca. MIS 13) for *H. amphibius*.

Here, the hippopotamus fossils from a number of Italian Peninsula sites chronologically referred from the late Early Pleistocene to the Middle Pleistocene have been studied, including well-known specimens from the literature as well as fossils presented here for the first time. The results provide an updated overview of Italian hippopotamuses, with a focus on *H. antiquus*-*H. amphibius* transition occurred during the mid-Middle Pleistocene. By studying a large sample, it was possible test the validity of the arrangement of the enamel ridges of the external surface of the lower canines as a diagnostic character for hippopotamuses, confirming its value for specific identifications. Finally, size variability during the Middle Pleistocene was investigated through biometric comparisons, confirming that *H. antiquus* typically exhibited larger dimensions compared to *H. amphibius*.

Progression and decline of the harbours at the Elaiussa Sebaste archaeological site (South-Eastern Turkey) from the late Hellenistic age until the Early Byzantine period

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Geoarchaeological study of the Mediterranean ancient harbours has been developed and well defined over at least the last two decades as they represent very important geoarchaeological and geochemical archives very useful in paleogeographical reconstructions of past environmental changes (Marriner *et al*., 2014). The ancient city of Elaiussa Sebaste, currently Ayaş, is located on the south-eastern coast of Turkey, about 60 km to the west of the modern city of Mersin. It was one of the main trading harbours of the Mediterranean, growing in the Augustan period and maintaining its prestige until the early Byzantine era. The Arab invasion, which occurred in the 7th century CE, marked its definitive abandonment (Equini Schneider, 2003). A very prominent historical topic concerns the paleoenvironmental evolution of the northern and southern harbours of Elaiussa Sebaste, including their decline and burial.

A wide interdisciplinary study analysed 6 cores drilled in the current plains, which correspond to the setting of the two former harbour basins. The geoelectrical study, integrated with borehole stratigraphies and limestone outcrops, allowed us to reconstruct the geometry of the carbonate bedrock that constitutes the accumulation base of the marine sediments. In the north harbour, the morphology of the seabed reveals the presence of two depocentres both reaching a depth of 15 m. Using radiocarbon dating, we observed that sediments deposited in a time range spanning from the 8nd century BCE to the 6th century CE correspond to the development phases of the ancient town and its harbours. Sedimentology, micropalaeontology (foraminifers, ostracods), paleobotany (pollen, microcharcoals, plant macroremains) and Pb isotopes allowed us to provide the model of the environmental evolution recorded in both port basins. The main harbours development phase, marked by a change in Pb concentration, has been hypothesized during the period 140-220 CE. This aligns with historical sources which state the city developed in the middle Roman imperial period (Equini Schneider, 2003).

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From conservation to dissemination: Creating digital palaeontological collections at a Department of Earth Sciences and a major Natural History Museum (University of Pisa)

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As many other geological departments worldwide, the Department of Earth Sciences of the University of Pisa (=Dipartimento di Scienze della Terra dell'Università di Pisa; DSTUP) is home to a palaeontological teaching collection. Although the specimens that comprise this collection have no special museological relevance, their role in educating generations of students in natural and geological sciences is invaluable. The need for creating a digital version of the DSTUP collection was first felt strongly in 2020, when the COVID-19 pandemics caused all teaching activities to move online.

Another large, diverse, scientifically priceless palaeontological collection is housed in the Natural History Museum of the University of Pisa (=Museo di Storia Naturale dell'Università di Pisa; MSNUP). Highlights of this collection, which includes many holotypes, historical finds and otherwise unique specimens, are the Permo-Carboniferous flora, the Triassic vertebrate footprints and the Pleistocene terrestrial mammals from the Monti Pisani massif (Northern Apennines) as well as the marine mammals and fishes from the marine Miocene and Pliocene of Tuscany and a huge collection of ammonoids from central Italy (Apennines). The foremost importance of this collection has long led us to search for ways to create digital models of its most precious elements as a means of mitigating the corresponding palaeontological risk.

In the last few years, members of the palaeontological laboratories (PaleoLab) of the University of Pisa have been using the 3D technologies of 'virtual palaeontology' to (1) digitize the most relevant specimens from both collections, (2) create online archives, and (3) make the resulting models accessible and shareable with the broadest audience possible through social media profiles and internet browsers. 3D models were produced through structured-light scanning and digital photogrammetry, and then processed for post-production through the 3D software Blender whenever necessary. All the 3D scans were then gathered in the online repository Sketchfab, which was chosen for its user-friendly interface and common usage among museums and teaching institutions. The DSTUP and MSNUP Sketchfab accounts were linked to social media (Facebook and Instagram) profiles to promote the dissemination of the corresponding palaeontological collections. The first results of such an effort are very encouraging in terms of views and online interactions.

Variabilità climatica durante la stabilizzazione della calotta polare artica tra 2.59 e 2.4 Ma. Studio del limite Pliocene-Pleistocene a Monte San Nicola (Sicilia)

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Lo scopo di questo lavoro è stato quello di approfondire la variabilità climatica al passaggio Plio-Pleistocene nella successione di riferimento di Monte San Nicola (Gela), dove è stato definito il *Global Stratotype Section and Point* (GSSP) del Gelasiano. Lo studio ad alta risoluzione è stato effettuato sulle associazioni a foraminiferi planctonici e sugli isotopi stabili dell'ossigeno, studiando i campioni dalla sommità del sapropel A5 (Nicola Bed), nel quale è stato definito il GSSP del Gelasiano, sino al *Marine Isotope Stage* (MIS) 95. I dati delle fluttuazioni di abbondanza dei foraminiferi e delle oscillazioni degli isotopi stabili, trasformati in modello tempo, hanno permesso di identificare l'intervallo stratigrafico studiato compreso tra i MIS 103 e 95 (2.587 a 2.401 Ma). Le analisi hanno evidenziato come i cicli astronomici (obliquità, precessione ed eccentricità) abbiano controllato l'espansione della calotta polare artica, con la conseguente migrazione di specie polari nel Mar Mediterraneo. Questo evento è stato amplificato dalla chiusura dell'Istmo di Panama, culminato a 2.53 Ma. Le forzanti orbitali sono uno dei principali fattori che hanno controllato le variazioni climatiche e queste, a loro volta, influenzano lo sviluppo dei foraminiferi planctonici. La chiusura dell'Istmo di Panama, in concomitanza con la progressiva riduzione dell'eccentricità dell'orbita e della minore obliquità, ha prodotto una delle più importanti glaciazioni del Pleistocene tra i MIS 100 e 96, segnando la definitiva stabilizzazione della calotta polare artica passando da una condizione di GREENHOUSE (Piacenziano) ad una di ICEHOUSE (Pleistocene).

Delving into the Palaeontological Museum of Catania: the historical collections of Sicilian dwarf hippos

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The research of a palaeontologist extends far beyond fieldwork, since significant discoveries may originate from the study of ancient, overlooked collections tucked away in museum drawers that can hide important findings discoverable as in excavations of fossiliferous outcrops.
The vertebrate's section of the Palaeontological Museum of the University of Catania is a treasure trove of scientific value, hosting numerous almost unpublished collections of insular Quaternary mammals from Eastern Sicily among which those from Contrada Tabuna (Ragusa), Melilli (Siracusa) and Fondo di Serraci, (Catania). All these collections include numerous remains of *Hippopotamus* cf. *pentlandi*, an extinct dwarf hippo species adapted to island environments during the Middle-Late Pleistocene. This material comprises bones and teeth from the Aradas, Maugeri Patanè and Accordi collections, which represent an unexploited resource for scientific research (Aradas, 1864; Maugeri Patanè, 1936; Accordi, 1957).
One of the primary objectives of my PhD project is to reorganize, catalogue and digitalize the dwarf hippo's material, contributing to the creation of a comprehensive museum database. This will integrate bone finds with detailed photographic documentation promoting broader accessibility to the rich paleontological resources housed in the Palaeontological Museum of the University of Catania.
We expect that the re-discovery and examination of these three long-time unstudied, but important collections will shed new light on the taxonomy of the insular dwarf hippos of eastern Sicily, and on the evolution and ecological adaptations of this taxon.

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The biostratinomic analysis of a partial skeleton of Proboscidea from Pliocene marginal-marine deposits of the Valdelsa Basin (Tuscany, central Italy) reveals an unusual mode of barnacle preservation

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We provide a preliminary biostratinomic analysis of a partial skeleton of a proboscidean, consisting of nine postcranial bones (vertebrae and ribs), from Pliocene barrier island deposits of 'Cava La Serra' (Merella et al., 2023) in the Valdelsa Basin (San Miniato, PI; Italy). What is unique to these postcrania is that their cortical and – whenever exposed – spongy bone is encrusted by acorn barnacle shells, and secondarily by oyster valves. Recognized as belonging to the extant striped barnacle, *Amphibalanus amphitrite*, the cirripede shells occur both isolated and in clusters, and locally on each other, thus evoking various phases of barnacle growth. On the same bones, numerous *Anellusichnus*-like traces and other bone modifications resembling Palmer et al.'s (1993) 'epibiont shadows' are also pervasively present, which are also interpreted as due to acorn barnacle encrusters, as well as to the differential erosion of the bone (in the case of the 'epibiont shadows'). We hypothesize that the proboscidean carcass floated into a marginal-marine setting, where the bones were abraded and overturned many times, allowing for the settlement of different generations of barnacles. Considering the growth rates of *A. amphitrite*, the incomplete skeleton must have been exposed at the seafloor for a long time (several months to some years). In conclusion, our new find testifies to an unusual mode of barnacle preservation while providing new insights into the Pliocene depositional setting at 'Cava La Serra'.

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Bioturbations in the early Permian of Sesto/Sexten (Bolzano Province)

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In the northeastern Dolomites crops out the Sesto Conglomerate, a conglomeratic succession coeval with the Athesian Volcanic Group, although it is still unclear whether it corresponds to the entire lower Permian volcanic and volcanoclastic succession. Here we present the study of two slabs of Sesto Conglomerate yielding bioturbations. The bioturbation intensity is high (90%; BI=5-6) and the bioturbations are homogenously distributed. Based on shape, size, spatial orientation, sediment fill and wall structure the trace fossils were assigned mainly to the ichnogenus *Planolites*, characterised by mostly horizontal, straight, and unbranched burrows, reflecting feeding and dwelling behaviour of deposit and detritus feeders. The low diversity in the trace association indicates that the ecosystem was stressed, probably due to the activity of the supervolcano. However, the high bioturbation intensity implicates that during periods of more favourable environmental conditions, such as for example during periods of minor volcanic activity, where the sedimentation rates was slow, the organisms had enough time to bioturbate the substrate. During these periods freshwater habitats could form, characterized by low-energy conditions that permitted the accumulation of organic particles on the substrate-water interface. The bioturbators that colonized these areas were probably insects or wormlike animals that moved through the substrate in search of food. This is the so far easternmost occurrence of bioturbations influenced by the activity of the supervolcano as demonstrated by the affinity with the bioturbations in the supervolcano area, such as Gocciadoro and Silberhof (Baucon et al., 2024).

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A new census of the paleodiversity of the Villaggio del Pescatore lagerstätte (Campanian, Trieste)

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The Villaggio del Pescatore quarry (Duino-Aurisina, Trieste) is one of the most unique Italian fossil localities, known primarily for its exceptionally preserved hadrosauroid dinosaurs and crocodylomorphs dated to the early-middle Campanian. However, a large collection of plants, arthropods, other vertebrates and even coprolites, either housed at the Museo Civico di Storia Naturale of Trieste (MCSNT) or still *in situ*, remains undescribed or barely mentioned in the literature. An ongoing research project on the diversity of the site revealed about 50 overlooked specimens with significant features, which were the target of cleansing and microscopic photography at the MCSNT. A preliminary revision of this material revealed a surprisingly underestimated biodiversity. The megafloral remains are more abundant than expected, comprising articulated conifer shoots and small leaves of angiosperms. Large to small-sized arthropods are represented, including well-preserved decapods and even insects. Small, articulated teleosts were found among undiagnostic disarticulated remains. Some of the still *in situ* vertebrate material display diagnostic features of the hylaeochampsid *Acynodon adriaticus*, increasing the specimen count of this taxon to at least three individuals. A partial crocodylimorph jaw currently under preparation is not referable to *A. adriaticus*, revealing the occurrence of at least two suchian taxa at the site. Despite decades of research and pending new excavation activities at the quarry, this revision amplifies both known abundance and paleodiversity of the Villaggio del Pescatore. New findings are changing our understanding of the paleoenvironmental context and highlight the importance of ongoing studies of this fossil-lagerstätte.

A peritidal Burgess Shale-type fauna

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Burgess Shale-type (BST) faunas have proven critical for mapping the Cambrian assembly of animal-dominated ecosystems, but have so far only been reported from fully subaqueous deposits. Moreover, BST-fossils are often described without accompanying sedimentary and ichnological analyses or reference to their depositional context. Here we integrate evidence from ichnofossils, sedimentary features, and Small Carbonaceous Fossils (SCFs; Butterfield and Harvey, 2012) from the middle Cambrian (Late Guzhangian, Series 3) Pika Formation of Jasper National Park, Alberta (Canada), documenting a unique BST fauna occupying an offshore peritidal habitat. Finely laminated shales with mudcracks and dumbbell-shaped *Arthraria*-type burrows record a periodically emergent, likely dysoxic mudflat setting. This same facies yields priapulids, annelids, and wiwaxiids typical of deeper-marine sediments. Recovery of *Cirratuliformia*-like annelid chaetae further identifies the likely source of *Arthraria* burrows and associated faecal pellets. These findings show that Cambrian marine metazoans, including probable crown-group orders, ranged beyond permanently subaqueous deposits. The expanded palaeoenvironmental range of the BST taxa from the Pika biota denotes remarkably broad ecological tolerances, suggesting the existence of a previously cryptic guild of Cambrian "pioneer taxa". Their occupation of offshore peritidal ecologies may prelude to more extensive metazoan colonisation of high-energy, siliciclastic marginal marine environments.

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A new Lower Miocene odontocete assemblage from the Colle della Croce quarry (Feltre; Northeastern Italy), and a chronostratigraphic calibration of the Belluno Sandstone

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The Lower Miocene Libàno Sandstone of Veneto is historically known for being home to abundant finds of marine vertebrates, especially odontocetes, that have been collected and studied since the 18th century. The historical fossiliferous sites, stretching the Belluno area, expose coarse-grained sediments that could not be dated by biostratigraphic means as they are barren, and are loosely constrained to the Early Miocene. Here, we report an odontocete assemblage from the Colle della Croce quarry, a newly discovered locality near Feltre. The fine-grained sediments exposed in the quarry have been dated by calcareous nannoplankton biostratigraphy to the 20.89–19 Ma (latest Aquitanian to early Burdigalian) time interval.

A preliminary systematic assessment of the odontocetes from the new quarry reveals an assemblage characterized by good diversity and disparity: it includes squalodontids, a new squaloziphiid-like dolphin, a physeteroid, eurhinodelphinids, an odontocete possibly related to *Dalpiazina*, and additional material of basal delphinidans (a cranium with ear bones from this very site was described as belonging to *Kentriodon* sp. by Nobile et al., 2024).

Moreover, the marine vertebrate fossils from the Colle della Croce quarry also include sea turtles (Cheloniidae), bony fishes (Sparidae) and many different elasmobranch taxa.

The new odontocete assemblage from the Colle della Croce quarry is somewhat similar to the historical Belluno fossil fauna due to the shared occurrence of members of squalodontids, eurhinodelphinids, physeteroids and possibly dalpiazinids. Apparent idiosyncracies of the Colle della Croce quarry include the occurrence of a kentriodontid and a squaloziphid-like, whose absence from the Belluno fauna may be due to small differences in terms of age and palaeoenvironment (with the strata exposed in the vicinity of Feltre representing distal facies compared to the Belluno outcrops).

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Mario: the straight-tusked elephant from Contrada Calorie (Rotonda, Basilicata)

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We present the results of our recent analysis of the elephant skeleton discovered in 1982 at Contrada Calorie (Basilicata, Southern Italy). The skeleton comes from a sedimentary deposit dated to the early Middle Pleistocene (MIS13) (Cavinato et al., 2001; Robustelli et al., 2014). Although this specimen is very popular, having been on display in Rotonda (now in the recently renamed Museo Geo-Paleontologico e Archeologico "MUGEPA") since its discovery, and despite its previous citation in some scientific articles, the remains were never thoroughly studied. The dental and cranial traits of the Contrada Calorie elephant, dubbed "Mario," indicate that the skeleton belongs to a straight-tusked elephant, *Palaeoloxodon antiquus*. Based on the teeth in use and their wear stage, the individual was about 35 years old at the time of death. Body size was estimated combining the results obtained by applying different methodological approaches, indicating a shoulder height "in flesh" of about 3.9-4 m and a body mass of about 9.6-9.7 tons (Palombo et al., 2024). Although the Calorie elephant is not exceptionally large for its species, we inferred it to be male based on comparison with other Italian and European straight-tusked elephant specimens of known sex and age, considering that the Calorie elephant was not yet a fully grown animal (having the penultimate molar still in use) but displays quite large tusks. The detailed analysis of the skeleton's anatomy is still ongoing. The exceptional completeness of the skeleton and the geological age of the specimen, dated to the early Middle Pleistocene, which makes it the most complete skeleton of early *Palaeoloxodon antiquus* from Italy, will provide invaluable insights into the early evolution of straight-tusked elephants in Europe.

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Biotic replacement and evolutionary patterns in Miocene Rhinocerotidae from the Vallès-Penedès Basin (Catalonia, Spain)

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The Vallès-Penedès Basin (Catalonia, Spain) is a classical area for the study of the Miocene land mammal faunas and includes one of the densest and most continuous records in Eurasia. Furthermore, it is the type area for the Vallesian European land mammal age. The sedimentary infilling of this basin started in the Early Miocene and ended in the Late Miocene. The fossil record is represented by thousands of specimens, including Rhinocerotidae. Cranial and postcranial material belonging to this family was mainly published in the 1970s and no critical revision or description of new material has been so far conducted in the last decades. At the same time new specimens have been collected from the Vallès-Penedès Basin during recent excavations and in particular from the renowned macrosite of Abocador de Can Mata. Among others, it is here important to list hundreds of specimens including almost complete crania and mandibles with associated skeletons (total specimens including isolated postcranials ~900). Aceratheriini are the best documented group of the family, being represented by small and medium-sized browsing species with strong sexual dimorphism. Aceratheriini were gradually replaced by Rhinocerotini during the Late Miocene, with the occurrence of large-sized species. Changes in social behavior and rhinoceros population structure may also be inferred through time. The abundant and continuous record of Rhinocerotidae from Vallès-Penedès Basin represents a unique opportunity to understand the biotic replacement that occurred during the Miocene among Rhinocerotidae and to investigate the evolutionary trends and variability of the recognized species.

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The *Dama*-like deer from Pietrafitta (Umbria): preliminary analysis and comparisons with the material from Farneta (Tuscany)

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The paleontological site of Pietrafitta, located within the Tavernelle-Pietrafitta basin (Umbria), yields one of the richest Early Pleistocene (Calabrian) fossil vertebrate assemblages in Italy, composed by almost 40 different taxa. The assemblage is referred to the Farneta Faunal Unit (ca. 1.6–1.4 Ma) of the late Late Villafranchian. In this work we present a preliminary study of the medium-sized cervid sample from Pietrafitta, consisting of both craniodental and postcranial remains for a total of more than 300 fossils. Amongst the remains, it is noteworthy the presence of a partial neurocranium of a male individual preserving both antlers and of numerous postcranial remains probably referable to one or more skeletons, which were articulated at the time of discovery. The morphological analyses performed suggest the attribution of the sample to the group of Plio-Pleistocene *Dama*-like deer, hereby described as *Pseudodama*. Comparisons of the Pietrafitta medium-sized cervid sample to other Early Pleistocene samples from Europe, support its attribution to the most derived forms of the group (i.e., *Pseudodama farnetensis* and *Pseudodama vallonnetensis*). Further comparative analyses with the sample from the nearby locality of Farneta (Tuscany) including the type material of *P. farnetensis*, point toward an attribution of the Pietrafitta sample to the same species, in agreement with biochronological data. Additional analyses will enhance our understanding and provide deeper insights into the spatial and temporal distribution of this taxon, along with elucidating its phylogenetic relationships with other *Dama*-like deer.

Of bites and dogs: preliminary bite simulations in a fossil Canidae and insights on its palaeoecology

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Among Carnivora, a number of aspects concerning canid palaeoecology remains poorly investigated, despite their ecological impact as social predators. This is curious because their evolutionary history displays intriguing differences in feeding-related adaptations, although the family conservative morphology. To explore this topic, we digitally simulated the bite of the medium-sized fossil canid *Eucyon davisi* (Late Miocene-Early Pliocene) and the extant grey wolf (*Canis lupus*) using the Finite Elements Analysis (FEA). The aim of this study is to improve our knowledge on the feeding ecology of *E. davisi* through the comparison of its Von Mises stress distribution and bite force data with those of *C. lupus*. To perform the digital simulations, after extracting from CT-scans 3D models of cranium and teeth were imported within the FEA software Strand7 (www.strand7.com). The crania have been aligned with a surface model of the mandibles, and a series of preloaded truss elements simulated the elevator musculature. We simulated a bilateral canine bite, an unilateral carnassial bite, and an unilateral bite at the M1. The stress patterns across the three load cases in *C. lupus* and *E. davisi* reveal in the former an evident fall of the stress values at level of the frontals, suggesting a great influence of the cranial vault architecture in the stress dissipation during biting. Furthermore, the estimated bite force results significantly higher in *C. lupus* than in *E. davisi*, and this, possibly, hints a minor relevance of the bite in the fossil form. Consequently, the data obtained from the FE bite simulations support the ecological difference between *C. lupus*, thought as hypercarnivorous, and the mesocarnivorous *E. davisi*, as hypothesized in previous studies.

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"No est potestas super terram que comparetum ei" The giant ichthyosaur of the Severn Channel (SW England)

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Giant Late Triassic ichthyosaurs have been shrouded in mystery for more than two centuries. Due at large to their fragmentary fossil record, giant ichthyosaur palaeoecology, morphology and extinction are still a matter of important debate, making every new data crucial for the understanding of these past giants. We present the results of the latest studies on these marine reptiles, focusing on the morphology and bone histology of the newly described *Ichthyotitan severnensis* from the Rhaetian Westbury Formation of SW England (Lomax et al., 2024). Although the taxonomic assignment remains uncertain due to the incompleteness of the material, *Ichthyotitan severnensis* represents the first formally named giant ichthyosaur from the Rhaetian. The remains attributed to *I. severnensis* help us to reassess the size of ichthyosaurs in the latest Triassic, of which appears comparable to modern-day blue whales, indicating that extreme gigantism (length >25 m) evolved at least once outside of and long before Cetacea. The bone histology of *I. severnensis* confirms previous studies (Perillo & Sander, 2024) on the occurrence of an atypical histotype characterizing giant Late Triassic ichthyosaur lower jaws, probably linked to gigantism or to selective pressures in feeding. The case of *I. severnensis* highlights the crucial importance of collaboration between citizen scientists and palaeontologists for recovering new specimens, otherwise doomed to be lost. Finally, we address the need for further comparative studies with other ichthyopterigians and cetaceans to answer the many still open questions.

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The giant Pliocene cold-seep system of the Crotone Basin (South Italy)

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The Pliocene cold-seep system of the Crotone Basin (South Italy) represents a key site for dimension (350m long, 100m wide and 40m thick), outcropping exposure and quality. The associated deposits are characterized by a conduit facies made of authigenic calcite interpreted as previously active gas/fluid escape pipes and by a pavement facies, depicted as the surrounding early calcite-cemented bioclastic and siliciclastic sediments. Pavement facies are commonly colonized by chemosymbiotic and non-chemosymbiotic macrofauna (Lucinid and Solemyid bivalves, gastropods and serpulids). The conduit microfacies is characterized by the inward accretion of dark micritic laminae alternating with whitish sparitic layers. The micritic laminae show a microbial peloidal to dendrolitic fabric, which commonly incorporates planktonic foraminifera and coprolites, whereas the crystalline layers consist of microsparitic and sparitic crusts of prismatic zoned calcite crystals. The pavement facies shows more variability, because it is typified by laminated microbial boundstones, chemosymbiotic–bivalves packstone, foraminiferal packstone/wackestone and hybrid arenites. The stratigraphic constraint coupled with the foraminiferal assemblage (planktonic taxa) suggest a deep-water setting occasionally affected by siliciclastic sedimentary flows. The pavement facies also shows common brecciation features, suggesting the establishment of post-depositional overpressure conditions due to the early cementation of the conduits, which triggered localized rock failure. Stable isotope analysis of the different facies reveals overall negative $\delta^{13}C$ values (-6.8 to -37.4‰ Vienna PeeDee Belemnite), indicating the presence of a complex mixture of methane with other hydrocarbons consumed microbially via anaerobic oxidation of methane; whereas $\delta^{18}O$ values are relatively positive (0.0 to +3.4‰ Vienna PeeDee Belemnite) suggesting the possible dehydration of clay minerals and/or destabilization of gas hydrates.

Late Cretaceous paleoceanographic changes and onset of the Santonian cooling registered by planktonic foraminifera and stable isotopes at southern high latitudes

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The Cenomanian - Santonian sedimentary record recovered at IODP Expedition 369 Site U1513 in the Mentelle Basin (SE Indian Ocean, paleolatitude 60°S at 85 Ma) is studied to interpret the paleoceanographic evolution in the Southern Hemisphere. The changes in planktonic foraminiferal assemblage, considering depth ecology preferences of different species and surface and seafloor temperatures inferred from the stable isotopic values measured on foraminiferal tests, provide a valuable perspective on Late Cretaceous climate. The hothouse climate during the Turonian - Santonian, characterized by weak latitudinal temperature gradients and high atmospheric CO_2 concentrations, is followed by a progressive cooling during the Campanian. At Site U1513 the beginning of this climatic transition is recorded within the Santonian, as indicated by a ~1‰ increase in $d^{18}O$ values of planktonic foraminifera, suggesting a significant decline in surface water paleotemperatures of 4°C. The onset of cooling also recorded changes in the planktonic foraminiferal assemblages, including extinctions among surface (*Marginotruncana*) and deep (*Planoheterohelix papula*) dwellers, appearances (*Archaeoglobigerina cretacea*) and diversification of newly evolving taxa (*Globotruncana*), and changes from predominantly epifaunal oxic to infaunal dysoxic/suboxic taxa among co-occurring benthic foraminifera (Petrizzo et al., 2022).
The data presented here document an interval in the Santonian during which the rate of southern high latitude cooling increased. Both surface and bottom waters were affected, although the cooling signal is more evident in surface waters. This pattern of cooling is in agreement with model simulations and paleotemperature reconstructions, and ascribes the deterioration of the Late Cretaceous climate to decreased CO_2 in the atmosphere and changes in the oceanic circulation correlated with enhanced meridional circulation.

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A new fossil clarifies the anatomy and phylogenetic relationships of the Eocene gymnodont fish *Zignoichthys oblongus* (Zigno, 1874)

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Tetraodontiformes is a worldwide distributed order of marine fishes, known as puffers, ocean sunfishes, porcupine fishes, boxfishes, triggerfishes, filefishes and their allies, today including about 350 extant species in ten families that are characterised by extreme taxonomic and morphological diversity. Recent excavation at the Pesciara site of the Monte Bolca Lagerstätte (50 Ma, Veneto, Italy) yielded an extremely well-preserved specimen of the tetraodontiform fish *Zignoichthys oblongus* (Zigno, 1874). Due to its completeness and exceptional preservation, it has been possible to redescribe the morphology of the species and carry out solid phylogenetic analyses.
Zignoichthys oblongus displays a combination of features that clearly supports its assignment to the gymnodont suborder Tetraodontoidei. Analyses of this new fossil also demonstrates that the previous apparent absence of some plesiomorphic characters (e.g., spiny dorsal fin) was the result of taphonomic biases. Comparative morphological and phylogenetic analyses show the close relationship between *Zignoichthys oblongus* and the extant genus *Triodon*, supporting their sister-group relationship and basal position within the Tetraodontoidei. Some of the most salient morphological features observed in both *Z. oblongus* and *T. macropterus* are the presence of: fused dentaries, basisphenoid, urohyal, beryciform foramen, ribs, epineurals, structure of the caudal fin and spiny dorsal fin.

Eusuchian cranial remains provide new evidence of a diverse crocodyliform fauna form the Late Cretaceous of the southern Pyrenees

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Allodaposuchids were among the most common crocodyliforms in the Late Cretaceous of Europe. The clade, recently erected to include an abundant number of species described in the last decade, appears to have a remarkable diversity that generated systematic controversies. Here we performed analyses on two crocodyliform cranial remains from two lower Maastrichtian historical localities of the Tremp Group (Catalonia, Spain). One of the specimens, collected in the late 1950s in the Suterranya-Mina de lignite locality, is a fragment of the interorbital region that shows some important similarities with *Allodaposuchus subjuniperus*. Some already described isolated teeth (Martín Jiménez et al., 2017) could be assigned to the same specimen, reinforcing its taxonomic referral. The other specimen, the posterior fragmentary part of a skull from the Els Nerets locality, had been previously described as an allodaposuchid (Narvaez et al., 2017) and is here reviewed. Despite its small size, the skull bears some features that suggest it belonged to an adult individual and has some peculiar characters that do not allow to refer it to any known allodaposuchid taxon. Both the specimens are clearly distinct from *Allodaposuchus palustris*, which is already reported from the lower Maastrichtian transitional deposits of the Tremp Group and it was found also in Els Nerets (Blanco et al., 2020), in the same level of the skull fragment here reviewed. Therefore, this evidence suggests that several different species of allodaposuchids can be found in the lower Maastrichtian deposits of the Tremp Group.

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Gotta Score 'Em All: cladistic analysis of the First Generation of Pokémon as a powerful teaching tool

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Pocket monsters, more commonly known as Pokémon, are fictional 'creatures' conceived by Satoshi Tajiri, a Japanese video game developer. Since their inception in 1996, these "organisms" have captivated multiple generations of fans, propelling the Pokémon brand to become one of the most fortunate entities in the media franchise industry. This contribution adopts the perspective of a naturalist exploring a novel planet inhabited by entirely unique life forms, albeit bearing certain resemblances to Earth's organisms. In the absence of prior research and taxonomic classifications, the objective was to discern potential taxonomic characteristics and propose an initial phylogeny of the first generation of Pokémon based on the congruence of observed traits. The analysis of Pokémon phylogeny facilitates the understanding and exploration of various aspects of evolutionary processes, ranging from homologies to synapomorphies, autapomorphies, and evolutionary convergences likely influenced by shared environments. Among the diverse cladograms generated, the most methodologically and philosophically sound one is constructed solely on observable traits, supplemented by a few inferences drawn from existing knowledge of terrestrial organisms. Moreover, the analysis reveals that Pokémon game characters (i.e., moves, egg groups, abilities) were not conceived arbitrarily; rather, discernible patterns and congruences emerge, largely tied to ethological characteristics and habitats. Given Pokémon's immense popularity, particularly among younger audiences, this exercise underscores the potential of such endeavors in educational and popular realms. It serves to ignite enthusiasm for the science of systematics and appreciation for the richness and beauty of life's diversity and the natural sciences at large.

Opening a window on a Late Jurassic world: new iguanodontian dinosaurs from the Morrison Formation, Ten Sleep, Wyoming (U.S.A.)

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The Upper Jurassic Morrison Formation is one of the most famous dinosaur-bearing geological units around the globe. It represents a patchwork of seasonal wet-land paleoenvironments, deposited during the Kimmeridgian-Tithonian interval. Several dinosaur bone beds have been recovered in various localities, such as the famous Cleveland-Lloyd Quarry, where hundreds of skeletal remains have been unearthed. Most of these quarries, however, are saurischian-dominated assemblages, while ornithischian dinosaur findings are relatively rare. Iguanodontian dinosaurs are well known from the Morrison Formation, with three taxa being considered valid: *Uteodon aphanoecetes, Camptosaurus dispar* and *Dryosaurus* spp. Here we report for the first time multiple individuals of a dryomorphan iguanodontian dinosaur, recovered from a previously unreported multi-taxic bone bed in the Ten Sleep Area, northwestern Wyoming, and hosted at the American Museum of Natural History, NYC. The sample includes four size classes, with the largest individual being the most complete and including cranial, axial, and appendicular skeletal material. The smaller individuals are represented by appendicular material that overlaps with the largest individual, and do not present significant character variation in respect to the latter. The largest individual AMNH FARB 33170 is characterize ed by the following combination of characters: deltopectoral crest of humerus low, moderately bowed femoral shaft, pendant fourth trochanter located on the proximal half of the shaft, scar of the insertion of Musculus caudifemoralis longus separated from the fourth trochanter, expanded brevis shelf, post-pubic process narrow and dorsally deflected. This combination of characters is widespread within Dryomorpha but not consistent with the referral to any iguanodontian known in the Morrison Formation. Future research will clarify if the new reported material represents a new taxon or it is referable to already known species.

The genus *Propomatoceros* (Polychaete serpulidae): epibiotic/symbiotic relationships through time

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The genus *Propomatoceros* Ware, 1975 includes numerous species distributed from the Wordian-Upper Permian to the Middle Eocene. It is most frequent and abundant in the Mesozoic and especially in the Jurassic (Ippolitov et al., 2014).

Species have been found associated with organogenic substrata colonising during time a variety of hosts including sponges, ostreid, pectinid and trigoniid bivalves, gastropods, belemnites, ammonites, nautiloids, other serpulids, corals and crabs.

Different types of serpulid-host associations have been recognized: the most abundant ones correspond to post-mortem encrustation on molluscs and corals. In contrast, a symbiotic association has been postulated between some lower Cretaceous *Propomatoceros* species and coral colonies that may be regarded as a mutualism, with serpulid tubes bioimmured within corals (Garberoglio & Lazo, 2011). Analogously, a serpulid-crab species-specific relationship from middle Eocene can be interpreted as commensalism (Beschin et al., in press).

Inerestinlgy, *Propomatoceros* can be the host for other taxa as in the case of middle Jurassic tubes attached on oysters but in turn hosting bioclaustrated hydroids (Słowiński et al., 2020).

The symbiosis between *Propomatoceos* species and some colonised taxa (lower Cretaceous corals and Middle Eocene crabs) indicates that this genus established more complex relationships during its evolutive history.

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Central Mediterranean MIS 5 calcareous bioconstruction: a consortium of algal, metazoan, and microbial framebuilders (Capo Colonna - Crotone Basin - South Italy)

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The Last Interglacial (MIS 5) transgressive-regressive deposits of the marine terrace of Capo Colonna (Crotone Basin) provide fossil examples of infra/circa-littoral environments of the central Mediterranean, characterized by low-relief bioherms and biostromes dominated by calcareous red algae, analogous to the modern coralligenous and mäerl habitats respectively (Nalin and Massari, 2009; Bracchi et al., 2014).

The primary framework of the bioherms consists of laminar encrusting red algae acting as main framebuilders, with secondary bryozoans, foraminifera, and serpulids. The mäerl bed is composed of free-branched red algae rudstones. A variable amount of sandy bioclastic sediment is laterally interbedded with the bioconstructions and trapped in their cavities.

All bioconstruction subfacies and associated sediments are rich in microbial-mediated autochthonous micrite, with aphanitic, peloidal, clotted peloidal, and filamentous fabrics. Microbial micrite can also trap and bind variable amounts of grains or be a secondary component of detrital sediment with micritic rims around clasts. All these early lithified micrites show the typical nanostructure of microbial-mediated carbonates, rather than of an accumulation of mud particles, as they are made up of nanospheres coalescing into subhedral microcrystals, replacing microbial cells (found with different morphological types) and extracellular substances (Perri et al., 2012).

This implies the widespread presence of lithifying microbial biofilms that colonized both the bioconstruction cavities and the intergranular space of the associated sediment. These microbial communities, thanks to their metabolic processes mediating the precipitation of carbonates, contributed significantly to the early cementation of all the studied deposits.

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The giant hyena *Pachycrocuta brevirostris* foraging on seal: evidence from the late Early Pleistocene site of Cueva Victoria (Spain)

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Cueva Victoria is a cave located 3 km south of the Mar Menor lagoon, near the mining district of Cartagena (south-eastern Spain). Originally the cave was filled with breccia that was then partly removed during mining activities in the last century (García-Nos et al., 2023). The cave deposit has yielded fossil bones of more than 90 species of vertebrates. The fossil-bearing breccia is placed below the Brunhes-Matuyama boundary, constrained by paleomagnetic analyses between 0.99 and 0.77 Ma. The large mammal remains were probably carried into the cave by the giant hyena *Pachycrocuta brevirostris*. Here, we present new information and discuss the feeding behavior of *Pachycrocuta brevirostris* at Cueva Victoria, with special emphasis on the consumption of seal. Indeed, the occurrence at Cueva Victoria of a seal (represented by a maxillary bone and a partial mandible with teeth) suggests that the giant hyena, similarly to the populations of the modern brown hyena *Parahyaena brunnea* in Namibia (Wiesel, 2006), could feed on living or dead pinnipeds, and could vary from scavenging to active hunting depending on the circumstances. The study of the ecology of the giant hyena at Cueva Victoria might represent one of the latest occurrences of the species in Europe before its extinction at the end of the Early Pleistocene (Iannucci et al., 2021).

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Evaluating parasitic Holocene dynamics in *Chamelea gallina* in fossil and modern Northern Adriatic shoreface settings

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Parasites are crucial for maintaining a healthy ecosystem; it is important to understand how anthropogenic activities affect parasite-host interactions. The Gymnophallidae and Lepocreadiidae (hereafter trematodes) induce traces on the interior of their bivalve hosts' shells, which can provide a fossil record of these organisms.

To analyze trematode dynamics, we evaluate parasite prevalence, intensity, and extirpation on 240 *Chamelea gallina* infested valves from 5 Middle-Late Holocene sub-fossil and 11 dead assemblages from the shoreface settings of the Adriatic Basin. Trematode prevalence is the proportion of valves with at least one trematode-induced pit, while trematode intensity is the number of pits per valve. Extirpation is based on grouping pits in size classes, with each pit's size calculated as the geometric mean of the primary and secondary axes. We use the densitymclust function from the mclust package in R to construct Gaussian finite mixture models of pit size groups separately for Holocene and Modern samples.

Our analysis indicates no decrease in trematode taxa infesting *C. gallina* over the investigated period. However, the prevalence of trematode infestation significantly decreased over time, along with the average number of pits, median size, and parasite pit intensity. These changes suggest a severe decline or collapse of the trematode-*C. gallina* interaction in the Adriatic Sea during a time of increasing human influence on this land-locked basin.

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Life after leviathans: taphonomy and deadfall ecology of marine reptiles from the pelagic Rosso Ammonitico Veronese (Middle-Upper Jurassic, northeastern Italy)

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In modern oceans, sunken carcasses of large pelagic vertebrates (deadfalls) play an essential role in flux of nutrients in deep oligotrophic settings, with the development of specialized, though ephemeral, ecological successions around the remains (e.g., whale-falls). Modern cetaceans have long been considered the best analogue for Mesozoic marine reptiles, with anatomical and histological similarities leading to shared biostratinomic patterns. Most taphonomic studies on Mesozoic deadfalls have been limited to shallow-water settings, often neglecting deeper waters. Here, we present results of a detailed, large-scale taphonomic survey of ichthyosaurs, pliosaurs and metriorhynchoids from the pelagic Middle-Upper Jurassic Rosso Ammonitico Veronese (RAV) of northeastern Italy. Our taphonomic revision of the RAV tetrapod record highlights a common poor state of preservation of the bones, often associated with abundant macrofossils, consistent with a prolonged exposure of carcasses on a well-oxygenated seafloor. For the first time, we confirm the role of nautiloids as active mobile scavengers by means of tens of beak elements (rhyncholites) found closely associated with, or even piercing, the bones. Hexanchiform shark teeth are also found associated with the carcasses, supporting a distinctive deep-water mobile scavenging community. Echinoids, sponges and other bioeroders are identified as representative of the enrichment-opportunist stage, and a high concentration of belemnites is believed to be indicative of mass-spawning deaths in the surroundings of the carcasses. Abundant crinoids are recognized as part of the reef stage by colonization of the eroded bones, in some cases being found growing inside the spongiosa itself. While some of our data deviate from previous Mesozoic reptile-falls from shallow-waters, they are consistent with findings at Recent whale-falls in bathyal zones, and overall represent a precious window into the complex ecology of Jurassic open seas.

The vertebrate fauna from the Konservat-Lagerstätte of Camp dels Ninots (Late Pliocene, Iberian Peninsula)

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Nestled within the town of Caldes de Malavella (North-Eastern Spain), the lacustrine site of Camp dels Ninots (CN) formed in a maar-diatreme volcano and stands out as one of the most important Konservat-Lagerstätte of the European Neogene. Anoxic conditions at the bottom of the CN paleolake resulted in the preservation of a rich vertebrate assemblage dated back to the Piacenzian stage of the Late Pliocene (MN15 mammal unit, ca. 3 Ma).

Two decades of excavations have produced a diverse collection of plants and vertebrates, including fishes, amphibians, reptiles, birds and mammals, mostly preserved in anatomical connection. Here we present an updated comprehensive vertebrate faunal list for CN, highlighting recent discoveries and published works.

The CN large mammal assemblage is comprised of three species, namely the bovid cf. *Alephis tigneresi*, the rhinoceros *Stephanorhinus* cf. *jeanvireti* and the tapir *Tapirus arvernensis*. Though not a diverse assemblage, these large mammals are represented by multiple specimens including complete and articulated skeletons, which is unique in the European Pliocene fossil record. Small mammals are represented by the rodent *Apodemus atavus* and a new genus and species of mole (Talpidae). Ectotherm diversity is high, including the turtles *Mauremys leprosa* and *Chelydropsis* cf. *pontica*; two species of newts, an undetermined Pleurodelinae and *Lissotriton* aff. *helveticus*; the green frog *Pelophylax* sp. and the freshwater fishes *Luciobarbus* sp. and *Squalius* sp. During the most recent years of excavations interesting new remains were unearthed, among them a large stork-like bird, two anguid lizards (*Pseudopus*) and a natricine, which are all still pending of formal description.

Habitat availability and environmental covariates drive Mesozoic neoselachian diversification: a multi-variate approach

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Neoselachians (sharks, rays, skates, and their closest relatives) belong to the highly successful group of chondrichthyans (cartilaginous fishes). The fossil record of neoselachians dates back to the earliest Permian. The Mesozoic was a key period leading to the ecological and evolutionary success of modern lineages. During this period, a series of diversification and extinction episodes shaped the current diversity of neoselachians, suggesting that extinctions were an influential factor in their present diversity. However, this narrative may be the result of a focus on extinction, as many previous studies have mainly provided a qualitative discussion of the possible drivers of diversification for this group, with few presenting assertions based on quantitative data, and those that do use quantitative data tend to use simple correlations without exploring the possible effect of the combination of multiple drivers. Aiming to provide a deeper understanding of the factors that may play a significant role in driving and maintaining neoselachian diversity, our study focuses on the intervals between extinction events. Based on an extensive fossil record database, our results suggest that a combination of available shallow marine habitat, atmospheric CO_2 concentration, and sea surface temperature were the main drivers of Mesozoic neoselachian diversity. These results have important implications for understanding the long- term evolution and adaptability of neoselachians to changing environments and may help to identify neoselachian clades that are particularly vulnerable to extinction due to their specific environmental requirements in the face of the current climate crisis and hypothesized mass extinction. This will be crucial for prioritizing conservation efforts for threatened taxa that, together with other neoselachians, are an essential part of their respective ecosystems.

New data on bovids from the early Middle Pleistocene site of Contrada Monticelli (Apulia, southern Italy)

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The paleontological site of Contrada Monticelli (CM; Apulia, southern Italy) has been revealing a rich record of large mammals, dated to the early stages of the Middle Pleistocene (ca. 0.6 Ma). Here, we present the previously undescribed remains of a large bovid, which consist of seven craniodental and four postcranial remains. In the context of the climatic and environmental changes produced by the Early-Middle Pleistocene Transition (EMPT), CM represents a pivotal locality for understanding the evolution of Southern European faunal assemblages after this crucial interval. The morphological and biometric analyses carried out on the sample and the comparison with large Bovinae (*Leptobos*, *Bison* and *Bos*) from the Early-Middle Pleistocene of Europe, suggest the attribution of the studied remains to *Bison* with strong affinities with the large-sized species *Bison schoetensacki*. Despite that, the scantiness of the sample and the lack of diagnostic cranial remains (e.g., horncores, occipital and frontal regions) recommend caution, thus we refer the remains from CM to *Bison* cf. *schoetensacki*. If confirmed, this report would represent the southernmost evidence of the species in Italy, validating the hypothesis that *B. schoetensacki* was a common element of the Mediterranean ungulate guild at the beginning of the Middle Pleistocene. Furthermore, the presence of this large but slender bison in CM provides further hints for the paleoenvironmental reconstruction of this interesting Middle Pleistocene site. In fact, in addition to *B.* cf. *schoetensacki*, other herbivores have been recognized in the CM site, such as *Palaeoloxodon antiquus*, *Stephanorhinus hundsheimensis*, *Dama* cf. *roberti*, and equids. An herbivore fauna with such flexible feeding habits seems to be coherent with the presence of a relatively heterogeneous habitat, characterized by open areas suitable for grazing alternating with areas with greater woody-forest cover.

Palaeoecology of Pleistocene dwarf elephants: dietary behaviours of *Palaeoloxodon falconeri* and *Palaeoloxodon mnaidriensis* from Sicily

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The fossil records of the Mediterranean islands testify several cases of island dwarfism within the proboscideans. The extinct large-sized straight-tusked elephant, *Palaeoloxodon antiquus*, underwent this process at least twice during the Pleistocene, thus resulting in the evolution of *Palaeoloxodon falconeri* (early Middle Pleistocene) and *Palaeoloxodon mnaidriensis* (late Middle Pleistocene/Late Pleistocene).

This unique case of two insular taxa evolving from the same ancestral species, which spread into the Siculo-Maltese archipelago during two distinct and consecutive colonisation events, represents an opportunity to investigate evolutionary patterns and processes of proboscideans to insular environments during the Pleistocene.

Here, we investigated the dietary adaptations of *P. falconeri* and *P. mnaidriensis* from Sicily using dental microwear patterns to test hypothesis on their niche occupation. We hypothesise that, at least *P. falconeri*, displayed a browse-rich high-quality diet due to the complete lack of competition. Surprisingly, dental microwear of both *P. falconeri* and *P. mnaidriensis* points to a grass-rich diet, which can be explained as an adaptation to arid insular conditions with extremely low resource availability composed mostly by though, abrasive vegetation. Also, the vegetation composition and seasonality may have played an important role in diet. However, a grass rich diet is a common strategy adopted by herbivorous taxa on islands to exploit all available limited food resources.

In the case of *P. mnaidriensis,* which shares the environment with other medium- or large-sized herbivores (e.g., red deer, aurochs), these results can also be explained as an adaptation to maximise the use of more diverse vegetation to sustain its body mass while avoiding competition.

Sharks do not spare anyone: a taphonomic cold case from the Pliocene of Orciano Pisano (PI, Italy), and its palaeoecological implications

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Evidence of trophic interactions (predation and scavenging) between large sharks and cetaceans is relatively widespread in the fossil record, mostly in the form of tooth marks on bones, and secondarily with teeth or tooth fragments embedded in or associated to skeletal remains. Here, we provide an updated description of an early juvenile mysticete partial forelimb, featuring the humerus and radius. This historical specimen (Ugolini, 1907) is currently held at the Museo di Storia Naturale dell'Università di Pisa (Calci, PI) where it is exhibited in the Pliocene room of the 'Gallery of Geological Eras'. Both the humerus and radius bear tooth marks identified as belonging to *Linichnus* cf. *bromleyi*, which had never been reported before from this specimen. Whether these traces are due to active predation or to scavenging cannot be ascertained given the fragmentary nature of the studied remains.

During the Pliocene, the Mediterranean Basin was inhabited by a diverse elasmobranch fauna, including a good deal of mammalophagous forms (e.g., *Galeocerdo cuvier* and some *Carcharhinus* species, as well as the extinct *Cosmopolitodus* and *Parotodus*) that no longer inhabit the Mediterranean Sea. Newborn and early juvenile mysticetes were also likely more common than today in the Pliocene Mediterranean Sea, which may have contained balaenid and balaenopterid calving grounds, thus providing the Mediterranean mammalophogous sharks with vulnerable, energetically valuable potential prey (Collareta et al., 2023).

In this perspective, our reappraisal of the neonate mysticete forelimb from Orciano Pisano exemplifies a kind of trophic interaction that was likely common and ecologically relevant in the Mediterranean Sea during the Pliocene.

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Brachiopod sclerochemistry and climate change: a case study from the Wuchiapingian of Iran

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The Lopingian (Late Permian) time interval is represented by several brachiopod-bearing sedimentary successions across Iran. As brachiopods are considered one of the best tools for investigating past conditions (e.g. Brand et al., 2011), a sclerochemical analysis has been performed on brachiopod shells from the Julfa and Abadeh sections (Ghaderi et al., 2014; Viaretti et al., 2022) to unravel the still debated Wuchiapingian (early Lopingian) climate change. All the analysed shells belong to the species *Araxilevis intermedius* (Abich, 1878), coming from correlatable beds in the two sections. Shells were sampled for sclerochemistry ($\delta^{18}O$ and $\delta^{13}C$), with calcite powder collected at a high resolution along the axis of maximum growth, obtaining a seasonal record. Comparing our results to modern seasonal variations at similar palaeolatitudes and environmental settings, a higher temperature seasonality is recorded at the base of both sections; seasonality then decreases upward, returning to the expected variation. Since stronger seasonal variations can be associated with cooler climates, our data suggest the occurrence of a cooling phase at the start of the Lopingian, adding a new piece of evidence to the collection of different archives and proxies supporting a cooling phase linked to the emplacement and weathering of the Emeishan LIP in South China. Our study highlights the robustness of the brachiopod archive for studying past climate and improves the constraints on the debated duration of the cooling phase, which should have lasted slightly more than one million years. Interestingly, the analysis of other proxies (shell size, microstructural elements and biodiversity indices) indicates that brachiopods were quite resilient to the observed climatic change.

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Tecnica fotomicrografica innovativa per riprese di microfossili

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Viene presentata una nuova tecnica di acquisizione fotografica digitale, che permette la ripresa di microfossili senza utilizzo di stereomicroscopio o SEM. La tecnica è stata sviluppata negli ultimi mesi basandosi sulla tecnica di macrofotografia di insetti che hanno dimensioni simili a quelle dei microfossili da fotografare. La tecnica da me sviluppata prevede l'uso di: una fotocamera reflex (nel mio caso di una Nikon D7100) montata su cavalletto, un obiettivo Mitakon 20 mm f/2 4.5X super macro, una slitta micrometrica e un sistema di luci artificiali per ricreare i tempi di scatto corretti per ridurre gli ISO al minimo e quindi calare il rumore già all'atto dello scatto. Si procede tramite una tecnica di focus-stacking, cioè si acquisiscono tra 30 e 80 immagini di ogni esemplare, secondo le sue caratteristiche morfologiche, variando minimamente la messa a fuoco. Le immagini sono poi processate con un programma di photo-merging che consente di avere tutto il soggetto perfettamente a fuoco. I colori originali, così come i dettagli, sono conservati e messi in evidenza. Rispetto a riprese fotografiche analoghe tramite stereomicroscopio, questa tecnica ha il vantaggio di consentire l'acquisizione di immagini variando i parametri direttamente sulla macchina fotografica, senza il vincolo delle caratteristiche del microscopio.
La tecnica è stata sperimentata fotografando microfossili appartenenti a vari gruppi tassonomici, provenienti dal Paleozoico delle Alpi Carniche. Più precisamente conodonti di età diversa compresa tra il Silurano e il Carbonifero, e una ricca e diversificata associazione del Siluriano inferiore, comprendente: trilobiti, crinoidi, bivalvi, brachiopodi, gasteropodi, molluschi problematici (*Jinonicella*), foraminiferi, poriferi, ostracodi e altro.

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POSTERS
Abstracts

Reassessment of the "Sea-God" shark *Phorcynis catulina* from the Upper Jurassic of Europe

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The Jurassic shark, *Phorcynis catulina* Thiollière, 1852, was originally described based on a single holomorphic skeleton from the Kimmeridgian of Cerin (eastern France; see Villalobos-Segura et al., 2023). Over time, skeletons with morphological traits similar to those of *P. catulina* have been assigned to dubious taxa leading to eminent confusion in the taxonomy of Jurassic sharks (see Villalobos-Segura et al., 2023). Here, the species-specific features of *P. catulina* are re-described based on multiple holomorphic specimens from the Upper Jurassic of France and Germany. The present revision allowed the systematic re-evaluation of *P. catulina* within a phylogenetic context for the first time, also providing a more stable taxonomy. The resulting strict consensus tree (parsimony) clearly shows the close relationships between *P. catulina* and orectolobiform sharks. *P. catulina* and modern orectolobiforms show a similar overall morphology, with a broad head and a short snout, large and rounded pectoral and pelvic fins, two spineless dorsal fins placed posteriorly on the body, pelvic fins without apical angle, a small and rounded anal fin, and teeth with a broad labial apron. This study is crucial for shedding light on the evolutionary pathways of orectolobiform sharks, laying a solid foundation for future phylogenetic studies on Jurassic sharks and better understanding the biodiversity of sharks in deep time.

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Outreach in paleontology: latest results from the synergy between historical fossil collections and new field data — the examples of Dego (Liguria) and Carrosio (Piedmont) in the Tertiary Piedmont Basin (TPB)

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Paleontological outreach is an important goal in modern geological sciences because it helps people understand how our research can be applied to different aspects. In the villages of Dego (Liguria) and Carrosio (Piedmont), geology and paleontology outreach have recently assumed a major role thanks to the presence of two geosites: the greatly preserved fossil coral reef of Dego (Briguglio et al., 2021) and the GSSP of Carrosio that points to the Chattian-Aquitanian passage (Steininger et al., 1997). The Dego coral reef belongs to the Molare Formation of the Tertiary Piedmont Basin (TPB) and gives the opportunity to understand the ancient marine history of the territory through a dedicated path and website. The Lemme-Carrosio GSSP geosite belongs to the Rocchetta-Monesiglio Formation of the TPB, and it is a global landmark for the beginning of the Neogene. This geosite has a dedicated path where different signs explain the geological history of the territory and the importance of the GSSP. The intensity and quality of the activities proposed derive from the synergy between historical fossil collections and recent research. Abundant material collected almost 200 years ago is now preserved at the University of Genova, and part of it has been made available to the public to understand the paleoenvironmental evolution of the territory and to give everyone the possibility to see these finds otherwise forgotten.

From 2023 to 2024, Dego and Carrosio authorities organized events, interviews, and hikes focused on the divulgation of these geosites and showed increased interest in the prehistory of the territory from inhabitants and an increase in tourism, according to the municipal authorities. Led by this interest, the Municipality of Carrosio decided to allocate funds for the construction of a divulgation center focused on the geopaleontology of the territory and beyond.

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The enigmatic African wolf (*Canis lupaster*): insights from morphological and molecular analyses

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Canis lupaster, commonly known as the African wolf or the African golden wolf (ex. *Canis anthus*), is a medium-sized canid with wolf-like characteristics that occurs at present in central and northern Africa. Historically, some scholars considered it as a subspecies of the Eurasian *Canis aureus* due to phenotypic similarities. However, recent phylogenetic studies based on both mitochondrial and nuclear DNA have demonstrated that the African wolf is more closely related to *Canis lupus* than to *C. aureus*, thus supporting the validity of *C. lupaster* as a distinct species.

During paleontological excavations conducted by the Tanzanian Human Origins Research (THOR) team at Geolocality 83 in Olduvai Gorge between 2018 and 2022, a new vertebrate assemblage was discovered. This assemblage includes some exceptionally preserved mammalian fossils, among which three nearly complete canid skeletons stand out, showing striking morphological similarities to extant *C. lupaster*. Radiocarbon dating on ostrich eggshells supports an age of approximately 38 to 33 cal^{14}C ka for the paleontological assemblage, indicating that it is one of the few of Late Pleistocene age at Olduvai as well as in the whole of Eastern Africa.

The discovery of these complete skeletons from Olduvai represents the first unequivocal report of fossil African wolf from the continent, although some historical reports of *C. aureus* might have been misinterpreted and could rather represent *C. lupaster*. In this study, we present a morphological and morphometrical characterization of *C. lupaster* and its comparison with other African dogs. In addition to ongoing molecular (ancient DNA) analysis, this project aims to further refine our knowledge on the anatomy, variation, systematics, and phylogenetic relationships of this species.

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Analysis of growth patterns in Permian brachiopods: a case study from the Qarari Unit, Oman

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Permian brachiopods from the Qarari Unit, Oman are well known for their abundance and optimal preservation, representing a palaeobiodiversity hotspot at the transition from the Cisuralian (Early Permian) to the Guadalupian (Middle Permian) (Viaretti et al., 2022).
Among this very rich fauna, particularly interesting for modelling growth patterns is the seminfaunal brachiopod *Calliprotonia* sp., characterised by a concave-convex shape and distinctive ornamentation of regularly arranged growth bands bearing spines and densely spaced growth lines.
A detailed analysis of the length of the growth bands, the spacing of the growth lines and the distribution and size of the spines on several specimens of this taxon has shown some interesting features which may be interpreted in terms of growth rates and the environmental factors that control this pattern.
Growth bands increase their length anteriorly up to mid-length and then it is stable, so their formation is not directly controlled by growth rates which should decrease with age. The spacing and number of growth lines are similar in the posterior and anterior bands but may be variable inside each band; the spines are larger in the middle part of each band.
The growth bands do not appear to be related to brachiopod growth rates, but instead, along with the spines, they probably had the main function of stabilising the seminfaunal shells in the soft muddy substrate. The space and number of growth lines are not compatible with daily shell increase, but may suggest a pattern of fortnightly growth linked to neap tides.

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Mapping paleontological heritage: a step forward from Tuscany

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In recent years, the necessity to protect and preserve Italian geopaleontological heritage has become more and more urgent. From the valorization of their scientific importance to the possible vulnerability, paleontological sites and their fossils deserve more attention and suitable management. Taking in mind the complex nature of paleontological remains (in a feeble balance in between their nature of being part either of cultural and natural heritage), the Società Paleontologica Italiana (SPI) has started to promote direct actions on the matter (AAVV, 2019): a preliminary census and mapping of fossil localities in different Italian regions based on the selection made by the "Responsabili Regionali" of the SPI. This led to the encounter between SPI and Istituto Centrale per l'Archeologia (ICA) and the use of the already established Geoportale Nazionale per l'Archeologia (GNA). This online resource represents a dynamic archaeological map of the national territory, implementable over time, freely accessible and easy to be consulted. Their benefits include the opportunity of displaying geodata on the map, together with all their accessory info. With this initial collaboration, paleontological sites finally become part of an official catalogue established and maintained by Ministry officials. At present around a hundred paleontological sites are represented into GNA. Following an established line of research on geo-paleontological heritage (Faggi et al., 2023), the Earth Science Department of the University of Florence, together with the Geology and Paleontology Museum of Florence, have recently signed an agreement with ICA. Results of this collaboration include the accommodation of georeferenced data on paleontological sites from Tuscany within GNA. About two hundred sites were included in the online repository using a QGIS template suitable for this purpose. The data were processed in compliance with uniform guidelines defined by ICA.

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Results of the excavation campaign 2021-2022 at the Cave A of Veja

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Veja cave is situated in the Educational Nature Reserve area of the Parco Naturale Regionale della Lessinia. The largest cave within this karstic system is Cave A, investigated in the past century on its shelter portion and relatively dated to the Middle-Late Palaeolithic. In 2021-2022, the Ca' Foscari University of Venice initiated new investigations in the innermost portion of the cave.
The team investigated an area of two square meters, preparing the area for successive campaigns. We identified five stratigraphic units. Unit 1 yielded most of the fossil remains and is the result of reworked sediments from the underneath layers. Layers 2-5 are in their primary deposition and the result of both human past activities and accumulation of guano. Unit 3 consists of runoff deposit of allochthonous sediments of aeolian origin and unit 4 is partially solidified within a carbonate crust and contains weathered faunal remains. Twelve radiocarbon datings across the sequence yielded ages between 44.090-3.876 cal BP for the accumulation of this trench.
The fauna is represented by *Ursus spelaeus*, a few bones of *Canis lupus*, and *Meles meles*. The species *Myotis myotis*, *Myotis blythii* and *Miniopterus schreibersii* are present, and *Rhinolophus mehelyi* is reported for the first time at Veja. Charcoal is represented by thousands of fragments recovered from unit 1, 2 and unit 5. The anthracological record is represented by *Quercus* deciduous type,

followed by the genera *Pinus nigra* type, *Fraxinus* and *Fagus*, suggesting wetter and richer soils compared to the modern environment around Veja.

The preliminary results from the Cave A of Veja testify a consistent presence of human groups inside the cave at least since 13.000 y BP. Moreover, the presence of large carnivores, including wolves, is confirmed at about 180 meters from the cave entrance. The biotic assemblage of unit 2 adds a fundamental tile of the transitional environment of Veja right after the Bølling–Allerød interstadial.

Ediacaran trace fossils from the Naturtejo UNESCO Global Geopark (Central Portugal): between the Avalon explosion and the Agronomic Revolution

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The Ediacaran strata of Iberia were deposited between 599 and 545 Ma in back-arc basins of the Cadomian magmatic arc system (Pereira, 2015). As such, these deposits represent the ideal ground to investigate the radiation of complex multicellular animal life, an event known as the Avalon Explosion (Shen, 2008). However, there is no published evidence of Metazoa from the Proterozoic of Portugal. Here, we report previously undescribed metazoan trace fossils from the Beiras Group (Ediacaran) of the Naturtejo UNESCO Global Geopark (Central Portugal). The trace fossils are simple horizontal unbranched burrows that range from 1 to 3 mm in width. The burrows are unlined, while the burrow fill frequently differs in texture from the host rock. These aspects suggest that the Ediacaran burrows from the Naturtejo UNESCO Global Geopark were produced by a deposit-feeding infaunal marine animal. As such, they represent an early (Ediacaran) onset of the Agronomic Revolution, a sudden diversification of burrowing behaviors that took place during the early Cambrian (Seilacher & Pflüger, 1994; Mángano & Buatois, 2017).

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Marine mammals, sharks, and burrowing crustaceans: ichnofossils reveal the palaeoenvironment of a Miocene vertebrate ecosystem (Burdigalian; Carcavelos, Portugal)

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The Lisbon Region is known for its rich record of vertebrate body fossils, including remains of Elasmobranchii, Sirenia and Cetacea from the Miocene. Specifically, the Burdigalian deposits of the Carcavelos Beach (Cascais) preserve some of the westernmost fossil remains of marine mammals of Europe (Estevens, 2000), as well as locally abundant shark teeth (Esteves & da Silva, 2014). Here, we report a previously undescribed ichnosite from Carcavelos, which can help to better define the physico-chemical characteristics of the vertebrate ecosystem. The *Thalassinoides* ichnoassociation of Carcavelos is dominated by abundant branched burrows (*Thalassinoides*) passively filled by coarse bioclastic calcarenites (bioturbation intensity 60%). It is interpreted to represent the work of decapod crustaceans that colonized a high-hydrodynamics shoreface setting. This ichnoassociation frequently transitions with the *Psilonichnus* ichnoassociation, which is interpreted to represent the activity of brachyurans at the backshore/foreshore transition (bioturbation intensity 20-40%). The Rhizoliths ichnoassociation displays mm-thick, bundled to mainly horizontal root traces (bioturbation intensity 50-70%) preserved within a coarse sandstone unit. In light of its sedimentological and ichnological characteristics, the Rhizoliths ichnoassociation represents the work of vegetation reworking a coastal setting with brackish-water waterbodies. The U-burrows ichnoassociation includes U-shaped burrows with thick lining (bioturbation intensity 70%). The thick lining is interpreted as an adaptation to cope with shifting substrates. Based on neoichnological comparison, this ichnoassociation likely reflects the work of upogebiid crustaceans or brachyurans. The presence of bioerosional structures (*Gastrochaenolites* ichnoassociation) indicates the local presence of firmgrounds and/or hardgrounds colonized by bivalves.

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Disturbance ecology in a Permian volcanic caldera (Gocciadoro, N-Italy; Athesian Volcanic Complex)

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Disturbance events such as volcanic eruptions can alter ecosystems by modifying the physical environment and resource availability. However, there is a notable lack of paleontological research addressing disturbance ecology in volcanic regions. The Athesian Volcanic Complex in Northern Italy (Bolzano and Trento provinces) offers a unique opportunity to fill this gap by examining how terrestrial ecosystems respond to disturbances in volcanic settings (Baucon et al., 2024). Here, we introduce the Gocciadoro ichnosite, representing a Cisuralian (early Permian) alluvial fan shaped by discrete disturbance events, specifically hyperconcentrated debris flows within the Castelliere Formation. Ichnological analysis reveals two distinct ichnofabric classes at the Gocciadoro site: the *Planolites* ichnofabric (bioturbation intensity >90%) and the Massive Ichnofabric (no discernible trace fossils). These typically appear in depositional couplets, with *Planolites* dominating fine-grained intervals overlying coarse-grained intervals predominantly devoid of distinct trace fossils (Massive IF). We propose a three-stage model to describe ecosystem responses to these disturbance events: 1) Pre-disturbance stage corresponding to an unvegetated alluvial fan setting with no burrows; the high frequency of disturbance events and the stressful conditions precluded the development of a K-selected community; 2) Disturbance stage where the deposition disrupted biological communities, if any, but provided a new nutrient-rich surface; 3) post-disturbance stage where an opportunistic community of r-selected deposit-feeders colonized the newly deposited substrate.

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Understanding phytoplankton response to marine alkalinization

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Understanding the adaptation of marine phytoplankton to varying physico-chemical oceanic conditions is paramount to understand both fossil and contemporary assemblages under different environmental scenarios. Ocean Alkalinity Enhancement (OAE), among the most promising marine Carbon Dioxide Removal technologies, seeks to augment the ocean's CO_2 uptake capacity via the dispersal on the ocean surface of an alkaline substance, such as calcium hydroxide (slaked lime). The investigation of coccolithophores, the primary ocean Ca-carbonate producers, offers valuable insight into fluctuation in present and past oceanic conditions, and may provide significant insights concerning OAE potential impacts. However, despite their significance for elucidating phytoplankton response to changing oceanic conditions, experiments on coccolithophores have rarely been conducted using mesocosms. In this perspective, a series of experiments in mesocosms were conducted to examine the response of coccolithophore assemblages to OAE. Two mesocosm experiments were conducted at the CIM-ECIMAT (Marine Research Centre of the University of Vigo, CIM UVIGO) and CretaCosmos (Hellenic Centre for Marine Research, Crete) facilities, examining the response of the eutrophic Ria de Vigo upwelling system (eastern Atlantic) and the eastern Mediterranean ultraoligotrophic setting, respectively, with varying concentration of Ca-hydroxide slurry.

The composition of the coccolithophore assemblage at the two sites was assessed with optical microscopy analysis of filtered seawater, revealing a more abundant and diverse assemblage in Crete compared to Vigo. The preliminary analysis of the assemblage response indicates a relative consistency across the two settings, with coccolithophore demonstrating primarily neutral reactions to lime-induced alkalinisation and showing greater sensitivity to their permanence within the mesocosms. If validated, this finding suggests that large-scale implementation of OAE treatments in the open ocean may not exert a significant impact on marine calcifying phytoplankton. Furthermore, this analysis could establish a baseline for understanding potential adaptation of coccolithophores to past alkalinity changes.

Some updates on the ongoing preparation of a right whale (Mysticeti: Balaenidae) skeleton from the Pliocene of Casenuove (Empoli, Florence Province) at the PaleoLab-UniPi

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In the summer of 1995, an incomplete and largely disarticulated cetacean skeleton was collected in a clay quarry near Casenuove (Empoli, FI). The finding consists of various cranial bones, the right mandible, two ribs and other postcranial fragments belonging to a baleen-bearing whale (Cetacea: Mysticeti) (Bianucci, 1996). Based on various osteological features (e.g., a rounded anterior outline of the supraoccipital, a ventrolaterally projecting zygomatic process of the squamosal, and a greatly reduced coronoid process of the mandible), this specimen was provisionally determined as belonging to the mysticete family Balaenidae, somewhat reminiscent of the genus *Eubalaena* (Bianucci, 1996). Nowadays, the Casenuove skeleton is part of the palaeontological collection of the Museo di Storia Naturale dell'Università di Pisa (MSNUP) with catalogue number MSNUP I-16839 (Bianucci & Sorbini, 2014). In November 2023, the preparation of this huge skeleton has finally started within the palaeontological laboratories (PaleoLab) of the University of Pisa. At present, this ongoing effort has led to liberating the right premaxilla and one rib of MSNUP I-16839 from the entombing sediment. Characters of both these newly prepared bones confirm the assignment of the Casenuove whale to the balaenids. Hopefully, the preparation of the remaining skeletal elements will soon allow for an exhaustive description of this fossil whale as well as for its eventual musealization at the MSNUP, some thirty years after its discovery.

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Environmental changes in the Barents Sea over the past four centuries: benthic foraminifera evidence

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The Barents Sea is a key area of the northern hemisphere oceanic circulation through its sensitive shallow water polar ecosystem to the recent expansion of the warmer Atlantic Water (AW) into the region, i.e., Atlantification (Årthun et al. 2012). In this regard, we reconstruct the last centuries paleoenviromental changes from the core HH1141, located at 74.015°N 21.071°E at 285 m water depth, based on benthic foraminiferal assemblages. The age-depth model is based on excess ^{210}Pb extrapolated down-core assuming stable sediment accumulation rates (SAR) below the 20th century. The results allow us to identify three main oceanographic intervals. From ca. 1579 to 1834 yr AD, the dominance of *Elphidium clavatum*, *Cassidulina reniforme*, *Islandiella helenae*, *Islandiella norcrossi*, *Stainforthia feylingi*, *Stainforthia loeblechi* indicate cold conditions. The second period, from ca. 1834-1920 AD, for the presence of *Adercotryma glomeratum*, *Buccella frigida*, *Melonis barleanus*, results as a "transition interval" with increase of Atlantic water masses inflow. As far as the third interval from ca. 1920 to 2018 AD, the foraminiferal assemblages composed by *A. glomeratum*, *B. frigida*, *Epistominella nipponica*, *Globobulimina auriculata*, *M. barleanus*, *Nonionellina labradorica*, *Reophax* sp., *Trifarina angulosa*, document warm water masses presence related to the expand incursion of Atlantic Ocean. Geochemical and biomarkers analyses are in progress in order to provide further details on the paleoceanographic history in the Barents Sea. Understanding the "Atlantification" process is crucial to forecast the environmental changes in this region susceptible to heat transport through the Atlantic gateways affecting climate and ecosystems.

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Middle Pleistocene microbial-induced Ca-carbonate deposition in a lacustrine environment (Mercure paleolake - Southern Italy)

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The varved carbonates of the Mercure Basin are representative of a paleolake basinal setting, where the normal pelagic sedimentation was interrupted by occasional sedimentary flows triggered by the intrinsic lake dynamics (river floods, storms, etc.). The presence of in-place charophytes green algae oogonia testifies to a limited lake depth that favored the necessary light filtration for this biota. In this environmental setting, micrite is the dominant component and occurs with microbial aphanitic and clotted fabrics. At the nanoscale, both micrites are characterized by a tight aggregation of nano-spheres forming irregular to globular major-size clots, spherical and semi-cylindrical aggregates with a common internal hollow structure, typical of microbial-induced bio-mineralization processes. Moreover, the hollow structures of the nanospheres aggregates could be linked with green algae and bacteria cells whose blooms may cause whiting phenomena.

Inception and development of Mediterranean algal reefs

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The CORSUB project – To the CORe of the SUBstrate - is a pioneering project aimed at unraveling the mysterious morphologies discovered between 80 and 130 meters water depth off the Punta Licosa Promontory in the Tyrrhenian Sea (Campania Region, Italy). These enigmatic structures, identified during a 2003 survey, exhibit sub-circular shapes unpublished in existing literature. Although they contain living crustose coralline algae, their true biogenic origin and the reasons behind their unique forms remain elusive.

The project aims to explore the possibility that these occurrences are linked to deep bioconstructions, potentially Coralligenous, influenced by the underwater topography of the Quaternary period. Coralligenous reefs, characterized by monumental build-ups predominantly composed of crustose coralline algae, represent a crucial component of the marine seascape, harboring diverse biodiversity and serving as a significant natural heritage. However, despite their importance, they remain poorly understood and underexplored at these water depths.

The CORSUB project intends to conduct oceanographic campaigns to map the habitat comprehensively, by a combination of remote sensing and techniques of direct data collection. This study aims to reconstruct the inception and development of potential deep Coralligenous reefs over at least Holocene epoch by integrating geophysical, stratigraphical, sedimentological, and paleontological approaches. Moreover, the project represents a concerted effort to unlock the secrets of these enigmatic marine formations, bridging gaps in our understanding of deep-sea ecosystems and contributing to the preservation of this invaluable natural heritage for present and future generations.

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Carbonate–silica interplay: unraveling microbial synergy and fossil preservation in alkaline lacustrine stromatolites

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Stromatolites are ideal microbe–sediment synergy ecosystems with a fossil record ranging from the Precambrian to the present. We aim to investigate the preservational processes of microorganisms in stromatolites from Lake Ashenge, Ethiopia; Lake Abbe, Djibouti; and the Carri Laufquen Lakes, Argentina. These sites exhibit conditions of extremely high alkalinity (pH ~8.8, 9.9, and 7.2 to 9.9, respectively), and modern examples of stromatolites are found on the shores of the lakes as well as on the basaltic bedrock. The internal laminations of the stromatolites are composed of extracellular polymeric substances (EPS), cyanobacterial sheaths and isolated filaments, interpreted using optical microscopy and scanning electron microscopy (SEM). X-ray diffractometry demonstrated a general Mg-calcite paragenesis, however, the preservation of carbonaceous materials, including filamentous structures and biomolecular components identified by Raman spectroscopy, is intrinsically associated with silicate mineral phase. In samples from the three study areas, molds of filamentous structures are preserved empty; partially filled with EPS; or totally filled with microscopic silicate mineral. The primary difference in the preservation of these filamentous microorganisms lies in the composition of the associated clay minerals, as African samples contain an Mg-silicate phase, whereas Argentinian samples contain an Al-rich silicate phase. The input of silica into these systems is likely related to weathering of the volcanic bedrock and the dissolution of diatoms, which appear to contribute to the preservation of filamentous cyanobacteria by increasing the supply of silica. Fragmented and partially dissolved diatoms valves have been observed in SEM micrographs. In summary, recent stromatolites demonstrate efficiency in preserving microfossils in extreme alkaline environments, thus providing an excellent laboratory for studying taphonomic processes involving carbonate–silica associations in deep time.

A comparison between living and dead mollusc assemblages from the northern Tyrrhenian Sea (Livorno, Italy)

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Studies that compare the dead shelly macrofauna ("dead assemblage", DA) with the living counterpart ("living assemblage", LA) are gaining ever greater importance to evaluate ecological shifts in marine ecosystems. The disagreement in species composition between LAs and DAs can be indicative of a recent anthropogenic change.

The samples included in this study were collected off the Calambrone Beach, north of Livorno (South Ligurian Sea, Italy), specifically at four stations distributed along the pipeline connecting the floating regasification unit to the coast. Two stations, respectively at 4 and 5 meters depth, belong to the SFBC (Sabbie Fini Ben Calibrate, i.e. well-sorted fine-grained sands) biocenosis. The other two, at 57 and 90 meters depth, belong to the VTC (Fanghi Terrigeni Costieri, i.e. coastal terrigenous mud) biocenosis. At each station, we compared the diversity and the taxonomic and ecological composition of LAs and DAs, focusing the attention on the mollusc assemblages (bivalves, gastropods and scaphopods).

As expected, due to time-averaging, species richness is higher in DAs compared to LAs. This difference is more pronounced in the offshore stations. In the onshore DAs, the dominance of *Bittium latreillii* (an herbivorous gastropod usually associated with *Posidonia oceanica* meadows), and its absence in the LAs, are clues of the loss of this endemic seagrass and its habitat along this stretch of coast. In the offshore stations, the higher proportion in the LAs of infaunal chemosymbiotic bivalves, like *Axinulus alleni* and *Thyasira biplicata*, suggests a progressive organic enrichment of the environment. The data collected in our study highlight a wide alteration of the communities' structure observed in all the investigated stations. Major changes were identified in the onshore stations, more prone to human impact due to the progressive expansion of maritime activities (e.g., the Scolmatore channel, the Livorno harbour), touristic infrastructures and fishing.

Mississippian mud mounds of Derbyshire (UK): facies architecture and biotic evolution

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Mud mounds, part of the reef spectrum, are carbonate deposits predominantly consisting of carbonate mud with minimal skeletal framework. They are widespread in the Mississippian record (Bridges et al., 1995), and crucial to understand marine ecosystems of this time interval; yet extant analogues are lacking, posing challenges in elucidating their growth patterns, depositional environments, and paleoecology.

The study of the upper Visean (Mississippian) brachiopod-rich mud mounds of the Derbyshire Carbonate Platform in the UK offers insights into factors influencing mud mound growth and brachiopod colonisation. This has been achieved through investigations of mud mound lithofacies architecture and petrography, brachiopod fauna distribution and composition across different depositional settings in the platform.

Comparative analysis across multiple mud mounds sheds light on the variability of lithofacies architecture and brachiopod fauna. The geometry, dimensions, and architecture of the mud mounds are controlled by the available accommodation and depositional setting. Brachiopods are found to be diverse (seven orders) and widespread throughout mud mound lithofacies, challenging prior notions of their distribution in scoured erosional 'pockets' (Gutteridge, 1990). Their diversity is supported by the variability of substrates in the mounds (muddy soft to hard cemented substrates), whereas the dimensions and relative abundance of the brachiopod taxa are controlled by the availability of food resources.

This comprehensive investigation enhances the understanding of Mississippian mud mounds and their associated brachiopod fauna, paving the way for further research in paleoecology and carbonate sedimentology in late Palaeozoic reefs.

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Approccio micropaleontologico integrato nella ricostruzione dell'evoluzione paleoambientale quaternaria dell'area di Livorno

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Sono presentati i risultati preliminari ottenuti dall'indagine stratigrafica e micropaleontologica integrata di sei sondaggi a carotaggio continuo e di due sezioni, ubicati in una zona compresa fra il Cantiere Orlando e il Porto Mediceo di Livorno. Questo studio ha lo scopo di ampliare le conoscenze delle unità di sottosuolo dell'area livornese. Basandosi sul presupposto che l'analisi comparata delle associazioni di diversi gruppi di microfossili costituisce uno strumento importante e utile nella caratterizzazione paleoambientale dei depositi quaternari, anche in chiave paleoclimatica, è stata eseguita un'indagine micropaleontologica integrata sugli ostracodi, foraminiferi, nannoplancton calcareo e micromolluschi rinvenuti. Nel complesso lo studio delle sezioni e dei vari livelli relativi ai sondaggi ha previsto osservazioni litologiche, sedimentologiche, macro e micropaleontologiche, che hanno consentito, correlando i vari dati, di riconoscere una successione costituita da 6 unità stratigrafiche informali di sottosuolo. L'unità inferiore (Unità 1) è attribuibile alle biozone a nannoplancton calcareo MNN19b-19d di Rio et al. (1990) del Santerniano-Emiliano (Calabriano, Pleistocene inferiore). La soprastante unità (Unità 2) è attribuibile alla biozona MNN19e del Siciliano (Calabriano). Al di sopra le unità dalla 3 alla 5 sono riferite a formazioni affioranti, del Pleistocene superiore (Boschian et al., 2006): Panchina *Auct.* (Unità 3), Conglomerati di Rio Maggiore (Unità 4), e Sabbie di Donoratico (Unità 5). L'unità sommitale (Unità 6) è costituita da sedimenti dell'Olocene. I risultati di questa ricerca hanno fornito nuovi dati, utili per definire dettagliatamente le geometrie del sottosuolo e l'evoluzione paleoambientale quaternaria di questo peculiare settore dell'area Mediterranea, confermando anche quanto riportato sull'argomento dalla letteratura più recente (Catanzariti & Da Prato, 2020).

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Shell microstructure and mineralogy of the mollusc species *Anadara uropigimelana* (Bory de Saint-Vincent, 1827), *Tivela stefaninii* (Nardini, 1933) and *Oliva bulbosa* (Röding, 1798)

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Mollusc shells are composite structures built of crystals of calcium carbonate (calcite, aragonite, or both) and biopolymers, arranged in a great variety of microstructures. Shell formation is affected by environmental and physiological factors and differences in shell microstructures are believed to be of phylogenetic and adaptive biomechanical significance. Here, we performed a detailed characterisation and illustration, through SEM and XRD analyses, of the shell microstructure and mineralogy of specimens belonging to the bivalves *Anadara uropigimelana* (Bory de Saint-Vincent, 1827) and *Tivela stefaninii* (Nardini, 1933), and to the gastropod *Oliva bulbosa* (Röding, 1798), collected in the Upper Holocene (Meghalayan) HAS1 settlement and in a shell midden in the Khor Rori Archaeological Park (Dhofar, Oman). Specimens of *Anadara uropigimelana* show an aragonitic shell with an outer crossed lamellar layer, an inner complex crossed lamellar layer and an irregular simple prismatic pallial myostracum; furthermore, periodic bands of dendritic nondenticular composite prisms occur in the outer part of the outer layer, reflecting seasonal changes in water temperatures. Specimens of *Tivela stefaninii* show an aragonitic shell with an outer composite prismatic layer, a middle crossed lamellar layer and an inner complex crossed lamellar layer, whereas specimens of *Oliva bulbosa* have an aragonitic shell characterised by an irregular alternation of crossed lamellar layers. With this investigation, we aim to provide novel data on the shell fabric of these poorly known mollusc species, increasing the availability of valuable characters for phylogenetic, evolutionary, palaeoenvironmental and crystallographic studies.

Are the ROV-based sampling tools exhaustive for geobiological characterization of recent marine bioconstructions?

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Coralligenous build-ups, vermetid reefs, deep-sea cold-water corals, sabellariid build-ups and serpulid/bryozoan biostalactites from submarine caves are the main biogenic "reefs" in the temperate Mediterranean Sea. They form in a wide range of marine settings, from shallow to deep water and from open to confined sectors and constitute important archives of recent environmental and climate changes. Among these, the coralligenous bioconstructions represent an important "*hot spot*" of biodiversity characterized by a low accretion rate and a high sensitivity to natural and anthropic impacts, including the ongoing climate change.

In the frame of the project "CRESCIBLUREEF", in accordance with the principles outlined in the European Blue Growth Strategy, an innovative ROV-based technology for minimally invasive sampling of marine bioconstructions has been developed and tested. This underwater coring device is operated through a specially designed control interface (that includes information such as core rotation speed, drilling depth, and tool magazine positioning) and comprises three main modules: (i) a core drilling head, (ii) an anchoring system, and (iii) a mechanism for retrieving sample cores.

In this context, coralligenous core samples, collected from Marzamemi (Sicily, Italy), were characterized from a geobiological perspective, and compared with data obtained from coralligenous build-ups sampled in the same area by scuba-divers.

This approach will enable to verify if core-samples obtained with ROV-based technique can be considered representative of the "*tale quale*" bioconstruction. In the case of ascertained representativeness, sampling of marine bioconstructions using the new tool would be possible, allowing minimal invasiveness and avoiding damages to these delicate ecosystems.

Plio-Pleistocene barnacles and barnacle-rich facies for high-resolution palaeonvironmental reconstructions

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We investigate the use of sessile barnacles as a robust palaeoenvironmental proxy. Their ubiquitous presence in nearshore environments, coupled with the composition of their shells consisting of diagenetically stable low-Mg calcite, makes them particularly promising for such analyses. Moreover, their rapid growth rate allows the recording of short-term variations.

We present analyses conducted on specimens collected from various Pliocene and Pleistocene Italian barnacle-rich deposits. Employing a new approach integrating sedimentology, taphonomy, stable isotope geochemistry, and detailed comparisons with modern counterparts, we demonstrate the efficacy of barnacles in palaeoenvironmental reconstructions. Our findings reveal a barnacle diversity peaking in shallow, nearshore waters and diminishing offshore. This spatial gradient offers valuable insights into water depth and proximity to the coastline. Taphonomic observations highlight distinct preservation patterns, with well-preserved specimens predominantly found in protected areas, contrasting with less pristine specimens in high-energy environments. Notably, the presence or absence of opercular plates serves as a useful indicator of the prevailing hydrodynamic conditions. Regarding C and O isotope analyses, due to the porous and coarse-grained nature of the deposits in which barnacle remains are usually found, the shells are often exposed to meteoric water percolation during diagenesis. On the other hand, specimens sourced from fine-grained substrates exhibit minimal alteration and isotopic ratios consistent with their modern counterparts. Intra-shell variations observed in these fossils reflect patterns similar to those observed in modern barnacles and indicative of short-term environmental fluctuations, such as seasonal cycles.

Our study underscores the enduring utility of barnacles in detailed palaeoenvironmental reconstructions based on skeletal assemblages and their suitability as proxies for palaeoseasonality.

Advancing Understanding of Larger Foraminifera Biogeography in the Late Cretaceous Western and Central Tethys Shores

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Larger foraminifera are unicellular marine organisms with a complex mineralized shell. Their morphological and ecological traits include large size, adult dimorphism, symbiosis with unicellular algae, and adaptation to K-strategy requirements. In modern oceans, they inhabit tropical to warm-temperate, oligotrophic to mesotrophic marine bottoms and are typically found up to the lower limit of the photic zone, but absent or unable to survive in waters of high trophism or low average temperatures.

During the Late Cretaceous, the positioning of continental masses, coupled with high sea level and warm climate, facilitated the significant development of shallow carbonate environments. While these areas hosted few corals, larger foraminifera diversified and extended their presence, ranging approximately from 40° North to 40° South.

The Late Cretaceous Pyrenean Gulf (Atlantic domain), and the carbonate platforms of the Western Tethys (peri Mediterranean domain) were considered as sharply separated larger foraminiferal bioprovinces (Caus et al., 2009), each distinguished by a distinctive association. Data from new Turonian-Campanian successions provide novel insights. Species of *Orbitokathina* (Consorti et al., 2024) and *Calcarinella* demonstrate a broader dispersal beyond the traditional Pyrenean Gulf, reaching into the Central Tethys (Arabian domain), highlighting previously undocumented oceanographic connections. While the Pyrenean still retains its status as an area characterized by endemism for taxa such as Meandropsinidae and Fabulariidae, among others, there are also endemic taxa, including rotaliids, conical agglutinated, and larger porcelaneous species, within contemporaneous platforms of the Western Tethys. Faunal exchange among the Western and Central Tethys is evidenced by the common occurrence of species of *Reticulinella* and Rhapydioninidae, whereas species of *Nezzazatinella* and *Dicyclina* look being cosmopolitan.

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High-resolution quantitative biostratigraphy of planktonic foraminifera across the Aquitanian/Burdigalian boundary at low latitudes

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Very few high-resolution quantitative records of planktonic foraminifera are available for the Aquitanian to Burdigalian interval, especially at low latitudes. In addition, the Burdigalian GSSP has not yet been defined and the bioevent that best approximates the boundary is still debated. Provisionally, Base *Helicosphaera ampliaperta* (calcareous nannofossil), calibrated at 20.43 Ma (Ceara Rise), is chosen to recognize the base of the Burdigalian Stage (Raffi et al., 2020). Here, the results of a high-resolution quantitative study of the planktonic foraminiferal assemblages, performed at Site 926 (ODP Leg 154, Ceara Rise, Equatorial Atlantic Ocean), are presented for the time interval from 21.4 to 17.5 Ma. Following the composite section of Site 926, astronomically tuned by Shackleton et al. (1999) and Palike et al. (2006), 142 samples were selected with a time resolution of ~30 kyr. This study provides quantitative distribution patterns of the low-latitude biostratigraphic marker species and the refinement of the stratigraphic position and age calibration of bioevents, such as Top *Paragloborotalia pseudokugleri*, Top common *Paragloborotalia kugleri*, Top *P. kugleri*, Top *Tenuitella munda*, Base *Globigerinoides altiaperturus,* and Base *Globigerinatella* sp. *Catapsydrax dissimilis* and randomly coiled *Paragloborotalia siakensis* occur in the entire studied interval. The obtained results improve the biostratigraphic resolution across the Aquitanian/Burdigalian boundary.

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Disseminating palaeontology at mineral and fossil exhibitions

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Different lines of evidence document the effects of anthropogenic actions on present-day climate change. The concept of change is intrinsic in the nature of the Earth, but the awareness to live on a restless planet is strong in geologists, who continuously face major and often dramatic changes recorded in the recent and distant past. Being used to deal with time at every scale, geologists and palaeontologists, can have an important role in sharing the concept of Earth dynamics with citizenry. The project "S4E: Science for the Earth: geology awareness in a changing world" is planned to facilitate and promote two-way exchanges between geoscientists and society in order to increase the awareness of the complexity of the natural processes that rule our planet. One first step to reach this goal has been to set up a stand at the Bologna Mineral Show and Euromineralexpo in Milan, where geoscientists of Milan and Rome Universities have promoted a "public understanding of science". Concerning palaeontological aspects, we have focused the attention to the main environmental stressors affecting our planet and its biodiversity in the geological past, today and in the future. We have planned different activities and have given the possibility to the public to touch and observe real fossils and casts from different time intervals and stratigraphic contexts, and belonging to different taxa, from macroinvertebrates, such as brachiopods, trilobites, bivalves, crinoids or corals, to vertebrate, as mammals and reptiles, to microorganisms, like foraminifera or conodonts, observable only with a microscope. This has enabled us to stress the importance and the fundamental role of fossils not only in dating rocks, but also in reconstructing past ecosystems and climates, as well as in the comprehension of the evolution of life on Earth; concepts which may be ordinary for geoscientists but that are not for the non-specialist public.

When Paleontological and Atmospheric Sciences combine: new methods for the evaluation of emissions due to the taphonomy of organic-rich sediments

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Climate change is now a well-known issue, expected to affect local and global policies for decades to come. Despite the enormous effort of several scientific communities and the consequent achievements going in the direction of more efficient sustainability, several aspects of climate change and the natural balance of climate altering agents in the atmosphere – now largely perturbed by anthropic activities – are still puzzling scientists. For instance, there is enough evidence to prove that sinks and emission rates of methane linked to natural origins are not well understood (Nisbet et al., 2019). One of the key solutions that could at least partially overcome these gaps in our knowledge of natural emission rates is an interdisciplinary approach between Paleontology and Atmospheric Sciences aimed specifically at evaluating emissions from organic-rich sediments. Experiments going in this direction are currently being performed as a joint endeavor between University of Calabria and CNR-ISAC: Picarro CRDS (Cavity Ring-Down Spectrometry) analyzers are used to detect emissions from sedimentary rocks under three different conditions, each accounting for a plausible scenario. In fact, the experiment is covering standard conditions, with no perturbations whatsoever, as well as thermal and chemical stresses, accounting for global warming and increases in acidic rain rates, respectively. The main advantage of this developing methodology is the high-resolution of these instruments, which are normally used for continuous atmospheric measurements (e.g., Cristofanelli et al., 2017). Preliminary analyses are focusing on lagoonal clays from Cessaniti (Vibo Valentia, Calabria), a fossiliferous site of remarkable importance. Later on, the experiments will focus on a wider range of samples, accounting for different geological ages, taphonomic history, and environmental parameters. The final step, requiring extra instruments, will also account for carbon isotope fractionation.

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Teaching at the Museum: the experience of students in implementation of coral exhibitions

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The role of university museums of sciences for enhancing students' formation and especially scientific education at different stages of learning is indisputable.
At the Museum of Paleontology of the Department of Biological, Geological and Environmental Sciences of the University of Catania, a teaching strategy adopted to facilitate learning of the content of the Paleontology course is to admit students to carry out part of their preparation in the museum. Focusing on invertebrate taxonomy, in addition to reviewing and strengthening knowledge through direct observation of specimens in the exhibitions, additional to those present in the didactic collection, students are encouraged to participate in guided discussions in front of the exhibition displays and in practical activities. Active collaboration from the students is also encouraged in suggesting possible implementations to the collections on display by updating the explanatory labels to facilitate communication towards young visitors.
In this context, during the academic year 2023-2024, a group of students deepened the study of a topic of their interest, i.e., the formation of subfossil red coral found on the Sciacca banks (Sicily Channel) in an active volcanic context. After reading some papers (e.g., Di Geronimo et al., 1993; Lodolo et al., 2017), they contributed to implement the exhibition with new drawings of coral specimens within their palaeoenvironment. Remarkably, the interaction between students was very constructive from a didactic point of view.

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Palaeontological and archaeological heritage of the Italian show caves: an overview

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Show caves are underground environments open to the public for tourist purposes. They are managed by a government or commercial organisation. There are at least 94 tourist caves in Italy, a very small fraction of the total number of documented caves. A part of these, only 64, are classified as show caves (Sanna et al., 2023). The implementation of interdisciplinary studies, including different environmental and cultural heritage components, can facilitate the sustainable management of tourism in show caves. Therefore, research has been carried out to characterise these environments from the perspective of the cultural heritage of Italian show caves. Here we present a detailed analysis of the archaeological and palaeontological evidence of these tourist caves. For each of them, a literature search was carried out and data on the presence of palaeontological and archaeological remains and the cultural values expressed by them, among others, were collected in a database (Thun Hohenstein et al., 2024, in press). By describing the diversity of the cultural heritage of Italian show caves, it was possible to improve the knowledge of tourist caves, to identify their attractiveness through the archaeopaleontological record, and to identify possible critical issues in the sustainability of show cave tourism management.

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Benthic foraminifera and mollusks from La Maddalena Harbour (Sardinia, Italy): A proxy for recent environmental changes

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Benthic foraminifera and mollusks are useful tools for palaeoenvironmental reconstructions due to their ubiquitous presence across marine habitats and their sensitivity to environmental changes induced by natural and anthropogenic events. Their community structures offer valuable insights into habitat characteristics, with certain species acting as bio-indicators of specific environmental conditions. This study delves into the micro- (benthic foraminifera) and macropaleontological (mollusks) analysis of a sediment core drilled from the shallow seabed (maximum depth ~15 m) in the Ex-military arsenal of the La Maddalena harbour located on the southern coast of La Maddalena island (Sardinia, Italy). In this site, a naval arsenal worked for nearly one century with heavy impact on the coastal zone.

By examining changes in species composition, abundance and diversity, the research aims to elucidate the environmental history and ecological trajectory of the marine ecosystem in the area. Through the identification of over 90 species of foraminifera and 101 mollusk species, the study reveals a decline in diversity indices with depth, accompanied by shifts in foraminiferal assemblages indicative of different coastal settings. The most frequent foraminiferal species were *Elphidium crispum*, *Ammonia tepida*, *Planorbulina mediterranensis* and *Spiroloculina ornata*. These results, supported by statistical analyses, allowed identification of distinct assemblages corresponding to varying marine environments. Similarly, mollusk analysis underscores changes in habitat preferences, reflecting a transition from infralittoral vegetated bottoms to more complex substrates, possibly linked to colonization of the area during the last centuries and harbour renovation activities. Collectively, the integration of mollusk and foraminifera data provides a comprehensive understanding of past environmental dynamics, offering valuable insights into the evolution of marine ecosystems in the La Maddalena harbour.

Ricostruzione Virtuale e Valorizzazione del Geosito "Ciampate del Diavolo"

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«Ciampate del Diavolo» è un sito paleontologico di immenso valore che ospita alcune tra le piste fossili più antiche del mondo, lasciate dal passaggio di individui del genere *Homo* che hanno camminato su uno strato di cenere pastosa sulle pendici del vulcano campano Roccamonfina (Mietto et al., 2003). Gli eventi esplosivi che hanno caratterizzato la storia eruttiva di questo vulcano hanno generato una serie di sedimenti piroclastici di composizione potassica. In particolare, una di queste superfici si è litificata grazie al processo di zeolitizzazione, attraverso una serie di eventi chimici susseguitisi in una sequenza estremamente rara, conservando la testimonianza delle impronte fino ad oggi. Questo luogo rappresenta un ottimo candidato per essere ricostruito digitalmente in un'ottica di valorizzazione tramite le tecnologie digitali, in particolar modo con l'utilizzo della Realtà Virtuale (Hutson & Hutson, 2023). L'acquisizione digitale grazie alla fotogrammetria (Saborit et al., 2019) ha permesso di generare un modello che è stato inserito in uno spazio virtuale, rendendo così l'accesso al sito e alle informazioni su di esso molto più semplice e allo stesso tempo coinvolgente. Questa esperienza digitale, se applicata ad un contesto museale, migliora in una chiave moderna l'esperienza di visita; inoltre è semplificata al massimo la possibilità per gli utenti di accedervi, garantendo anche a persone con disabilità la possibilità di conoscere un sito così importante e per loro altrimenti inaccessibile.

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Two alternative ages for the Montebamboli *Oreopithecus* (Late Miocene, Tuscany)

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19th century scientists concerned with the interpretation of well and outcrop data collected during mining activities in southern Tuscany (Italy) agreed on the isochrony of the Montebamboli, Casteani, Ribolla and Montemassi Late Miocene black lignite and fetid limestone. The associated faunal and floral remains from the four localities, including the primate *Oreopithecus bambolii* Gervais, 1872, first described from a fossil collected at Montebamboli, were similarly interpreted as coeval. A second wave of scientists reconsidered the Montebamboli fossils during the 1950s, expanded the research to the Baccinello area, further south, and interpreted the Late Miocene record of Tuscany to signal instances of phyletic transitions among insular species. On the basis of palaeontological data, without discussing the correlations emerged during mining activities, the Montebamboli fauna was interpreted as a fauna younger than the fauna associated with the Casteani and Baccinello black lignite. The new point of view justified a palaeobiogeographic scenario characterised by multiple dispersal events from the continental mainland to an insular Tuscan bioprovince, and from there to Sardinia, where an analogous Late Miocene *Oreopithecus*-associated insular fauna has been meanwhile studied. Based on old and new field data, the isochronic interpretation of the Montebamboli and Casteani black lignite is here resumed and an alternative palaeobiogeographic scenario is proposed, in the attempt to minimize inconsistencies that stem from the more recent school of thought. The alternative scenario points to a single phase of Tusco-Sardinian insularism bracketed between two intervals of faunal interchange when Tuscany and Sardinia came in contact with the continental mainland. Insularism took place within a single large island, or a single larger archipelago comprising southern Tuscany, Corsica and Sardinia, existing before and shortly after the opening of the Tyrrhenian Sea during the Tortonian.

Integrated stratigraphy in the Pliocene of Legoli (Valdera Basin, Tuscany, Italy)

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Freshly-cut outcrops associated with the waste disposal plant at Peccioli, in Val d'Era (Tuscany), allowed the integrated stratigraphic study of a 100 m-thick succession of Pliocene marine sediments through paleoecological, paleomagnetic and plankton biostratigraphic analyses. The succession is dominated by mudstones that conformably rest on a sandstone indicative of a shoreface paleoenvironment and are interrupted in their middle part by a sharply-based lenticular sandstone. Biogenic shell beds associated to the mudstones, abundant in the lower and upper part of the succession, represent outer shelf benthic communities. They indicate a rapid deepening-up at the passage from the basal sandstone to the lowest part of the mudstone interval. Sedimentological shell beds in the mid-sandstones, characterized by a shoreface fauna, suggest that this unit represents a delta-front paleoenvironment, as also indicated by sedimentary structures typical of hyperpycnal flows.

According to paleomagnetic data, the lower 70 m of the succession were deposited under inverse magnetic polarity, while the upper 30 m under normal magnetic polarity.

Biostratigraphic analyses allowed to recognize the lower part of the calcareous nannofossil Zone MNN16a (Rio et al., 1990) and the transition between the planktonic foraminifera Zones MPL4a and MPL4b (Lirer et al., 2019). The overall results suggest that the Legoli succession represents the uppermost part of the Zanclean and the lowermost part of the Piacenzian stages and includes the Gilbert-Gauss magnetic reversal.

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The Carboniferous plant fossil collection from the MuSTe (University of Bari "Aldo Moro")

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The collection of Carboniferous plant fossils housed in the "Museo di Scienze della Terra" (MuSTe) of the University of Bari "Aldo Moro" comprises 30 rock slabs with leaf and stem fragments preserved mainly on fine-grained, dark sediments. The information from the museum's catalog or on the fossil labels is often incomplete. The fossils come from various locations, mostly Central and Western Europe, with just two samples coming from North America (Pennsylvania) and one specimen from the Atlas Mountains in Morocco. In this study, based on morphological and morphometric analyses, several *taxa* have been recognized at genus and species level, although some specimens are poorly preserved and lack key diagnostic features. The specimens belong to lycophytes (*Lepidodendron, Sigillaria*), sphenophytes (*Calamites, Asterophyllites equisetiformis*), ferns (*Pecopteris polymorpha, Psaronius*), seed ferns (*Alethopteris, Mariopteris nervosa, Linopteris, Callipteris*) and conifers (*Walchia*). The study indicates that the Carboniferous plant fossils of the MuSTe mainly represent the most common *taxa* of the Euroamerican Carboniferous swamp communities (Chaloner & Lacey, 1973), thus enhancing the paleontological value of the samples and its hosting in the museum.

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Upper Miocene molluscs of the Ponsano Sandstone (northern Apennines, Italy): revision of the collection at the Museo di Storia Naturale, Università di Pisa

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The revision of fossil specimens mainly collected in the sixties of the last century and today hosted at the Museo di Storia Naturale of the University of Pisa, allowed to update the taxonomy of early Tortonian bivalves and to recognise some gastropods of the Ponsano Sandstone, cropping out in southern Tuscany, in the Pisa and Siena provinces (Italy). The stratigraphy of the original collecting sites was reconstructed and quantitative data were obtained by counting museum specimens and by interpreting semiquantitative data from the literature. The paleoecology of three distinct assemblages was based on the relative abundance of bivalves and the transgressive-regressive trend of the succession in the type area, previously known from sedimentary and micropaleontological data, was confirmed for the first time based on the macrofauna. The revision and reappraisal of the sixty-year-old museum collection allowed us to outline the bathymetric gradient. As expected, bivalve assemblages of the Ponsano Sandstone share a higher proportion of extinct species with respect to analogous younger shell beds of the Mediterranean area. However, the structure of the paleocommunities and the recurring presence of species dominating younger assemblages suggest that the Early Tortonian bathymetric gradient did not differ from the modern.

Exploring macrofaunal remains in Antarctic micropaleontological records

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Paleoenvironmental reconstructions are an essential tool to understand the evolution of past climatic conditions. These studies often rely on microfossil analyses to discern different environmental characteristics. Conversely, the stratigraphical distribution of macrofaunal-related microfossils (150 µm – 1 mm) has been extensively overlooked, especially for the Holocene and within remote areas such as the polar regions. Here, we examine a Late Holocene (3.6 kyrs) high-resolution marine sediment core located in a fjord on the northwestern part of the Ross Sea. Our findings demonstrate that the use of macrofaunal remains, in the present case of echinoderms, can yield detailed and complex information about recent past environmental conditions. Two distinct echinoderm groups were identified: ophiuroids (*Ophionotus victoriae*) and irregular echinoids. Despite the challenges to estimating population size due to the abundance of ossicles, we apply a statistical approach to the presence/absence of data to estimate the probability of occurrence of these organisms. By comparing the results with other proxies derived from the same record and nearby cores, we were able to successfully employ echinoderms as a novel proxy for polar environment reconstruction. The presence of *O. victoriae* can be associated with interannually stable sea-ice cycles with yearly organic matter deposition, while simultaneously indicating periods of a mature benthic community. Irregular echinoid forms have been associated with the presence of organic matter on the seafloor. By comparing different proxies, we could distinguish a specific climatic phase (the Ophiuroid Optimum), revealing additional insight into the environmental evolution of the area, unattainable with standard proxies. In conclusion, this study provides compelling evidence that the inclusion of macrofaunal-related proxies in paleoenvironmental reconstructions is crucial for capturing complex environmental dynamics.

Paleoceanographic changes suggested by planktic and benthic foraminifera in the Western Svalbard Slope (Bellsund Drift) during the last century

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The aim of this research is to analyze climatic fluctuations in the Western Svalbard Slope over the past century. We analyzed a high-resolution sedimentary record and its foraminiferal content as indicators of surface and deep-water characteristics. The studied area serves as a crucial gateway where warm Atlantic waters enter the Arctic Ocean via the West Spitsbergen Current, marking the northern extremity of the Global Thermohaline Circulation. We use species like *Neogloboquadrina pachyderma* and *Turborotalita quinqueloba* as proxies for cold Arctic and temperate Atlantic waters, respectively, and benthic species like *Cibicidoides wuellerstorfi*, *Epistominella exigua*, and *Oridorsalis tener* as proxies for bottom water currents and paleoproductivity. By integrating foraminiferal analysis results with satellite observations of sea-ice extent and long-term temperature records from the West Spitsbergen Current, our study supports the hypothesis of a progressively rising heat influx into the Arctic Ocean due to an increasing Atlantic water inflow, leading to a decline in sea ice coverage during the last century.

The Castello di Vallandona section revisited: new stratigraphic and micropaleontological data

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The Castello di Vallandona section (Asti, Piedmont), described as the stratotype of the "Astian" (Ferrero, 1971), belongs to the shallow water Asti Sandstone Fm. (ASF), which represents the transition between the deep marine Argille Azzurre Fm. (AAF) of early Zanclean age and the continental Villafranchian Fm. of late Zanclean to Calabrian age (Ghielmi et al. 2019). An upper *Isogonomon* and a lower *Glycimeris* key levels characterize the ASF. Their fossil assemblages are representative of the infralittoral zone and of a shallowing upward trend. During a recent survey, a decimetric-thick bioturbated interval was identified just below the *Glycimeris* level. The *Isognomon* level is reworked in the Andona Valley, whereas at East, in the Valle Botto area it is in-situ, possibly suggesting an articulated sea floor topography controlling the energy of the depositional environment. These observations and new foraminifer analyses allowed a review of the stratigraphic architecture and paleoenvironmental setting of this important and historical paleontological site.

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Skeletal development of large felids: from newborn to adulthood

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The lack of comparative specimens and metadata in museum collections reduces their applicability in new studies, and in particular for paleozoological analyses.
We examined 117 modern skeletons of Felidae at the National Museums Scotland (Edinburgh) and the Burke Museum (Seattle) to arrange them in the correct ontogenetic sequence. We focused on dental and skeletal development from birth to full adulthood in four species of large carnivorans: lion, tiger, snow leopard, and leopard. The project aimed at comparing growth patterns within the genus *Panthera*, and to establish an improved reference for absolute age estimation using skeletal specimens.
Dental eruption and cranial and postcranial ossification resulted strongly time-biased, with teeth reaching adult stage before bones. Deciduous dentition and the neurocranial portion of the skull provide the most information at the early stage of development, whereas long bone ossification becomes informative after deciduous teeth are completely functional. Asynchrony spans several years in the largest species and skeletal ossification become less fixed and influenced more by exogenous factors over time.
By aligning major ontogenetic milestones with an absolute timeline tied to species-specific morphological, social, and behavioral characteristics, we enhanced the accuracy of age estimation across the four species from skeletons.
We applied the method to some fossil materials of lions and leopards considered as case studies, emphasizing the importance of museum collections for interpreting paleontological assemblages.

Pseudosuchians: an enormous but little-appreciated diversity

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While classically regarded as "living fossils", modern crocodylians constitute but a fraction of the past diversity of the clade Pseudosuchia (Zittel 1887-1890), which originated in the Triassic and gave rise to a plethora of different forms, including not only semiaquatic taxa, but also terrestrial, sometimes bizarre-looking predators and herbivores, dinosaur- and mammal-mimics, and pelagic cetacean-like predators, many of which couldn't be further away from the common idea of "crocodile". A synthetic review of the major pseudosuchian clades is given, with the intent of conveying a general idea of the incredible anatomical and ecological diversity of the group.

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Biometric analysis of *Ursus spelaeus* remains from Liguria

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This study aims to provide new data on cave bear (*Ursus spelaeus*) long bone growth patterns using specimens preserved at the Genova Natural History Museum "Giacomo Doria". The first step of the study was assessing the state of the samples, categorizing and measuring the maximum length of each bone and, if possible, also epiphyseal length. After gathering data from 520 individual bones (76 femorae, 94 ulnae, 146 humeri, 66 radii, 114 tibiae, and 24 scapulae), multiple histograms were made, showing the frequency of maximum length and epiphyseal length in every type of bone, with the intent of trying to detect eventual multiple grouping within each data set to reveal possible sexual dimorphism or specimens belonging to younglings versus adults. Most of the population is made up of adult bears, where sexual dimorphism can sometimes be observed, mostly in femorae, ulnae, and radii. Data reveals that these types of bones in the adult size range, often form two distinct cusps, possibly representing males and females who are generally known to be larger and smaller, respectively. The few smaller bones likely belong to individuals a little over one year old, who also usually form a cusp in the histograms, albeit a smaller one. By correlating the data collected, it was then possible to estimate the average bone length of the different age groups (one-year-olds and adults).
Beside this analysis, we attempted to find correlation between the length of the bones and the age of the animal. Using the collected data and literature data (Fossea et al., 2014), an approximated growth pattern was made for every type of bone using the Gompertz growth model, which proved accurate enough to be used in further studies.

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Estimating the impact of erosion on a dinosaur footprint-bearing surface: the case of the Lerici Triassic ichnosite

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Archosaur footprint sites from the Late Triassic are excellent sources of data to provide insights into the dinosaur origin, early evolution, and subsequent rise. Under different circumstances, numerous trace-bearing outcrops situated within areas characterized by high hydrodynamic energy may find themselves prone to rapid weathering and erosion phenomena. Here we evaluate the impact of erosion on the Upper Triassic ichnosite of Lerici (La Spezia, Italy), which is the type locality of *Evazoum siriguii* (Nicosia & Loi, 2003), associated with a small but diverse ichnoassemblage that includes other dinosaur and non-dinosaur ichnotaxa. Comparative analyses (following Zimmer et al., 2018) were carried out using digital three-dimensional models of the present-day main surface (digitized in 2024) and the original fibreglass cast in the Town Museum of Lerici (made in or before 2003); the 3D models were obtained using photogrammetric and structured light scanning procedures. Most tracks, if not all, appear to have suffered a moderate to severe weather, and some footprints of the in situ surface are now lost. Critical measures are required to mitigate the erosive pressures on this important, yet progressively vanishing, track-bearing surface. During the analyses, it was also observed that the original cast shows a concave deformation in its central part, possibly due to its own weight and incorrect positioning. This case study stands as an example of how integrating the in situ digitization of footprint-bearing surfaces and the production of solid copies thereof can prove useful for evaluating erosion rates as well as for quantifying the quality of previous models. Also in these peculiar aspects, 3D digitisation proves to be an irreplaceable tool for modern and future palaeontologists.

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Are continental and marine stalactites so different? The geobiological point of view

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Biomineralization is a natural process where biological activity influences the formation of minerals and the production of geological structures. Recently, the formation of biologically driven structures in confined, both continental and marine settings, has drawn attention. Peculiar macroscopic similarities can be observed between speleothems and simple stalactites that form in continental karst caves, and biostalactites from submarine caves. Knowledge of geobiological processes involved in the formation of these carbonate concretions is still fragmentary and, to date, no studies have been carried out on their comparison.

Whether the formation of continental cave speleothems is biogenic, abiogenic or a combination of both is a matter of debate. A few laboratory experiments demonstrated that bacteria isolated from continental cave environments are able to form crystals from organic calcium salts. The precipitation of carbonate biominerals by bacterial communities associated to cave concretions supports the hypothesis that similar processes may occur in nature. Despite processes that lead to mineralization being still not fully understood, the absence of skeletal organisms suggests that speleothems' morphologies are mainly controlled by physical processes, notably the gravity and characteristics of the fluid flux.

By contrast, the biogenic origin of biostalactites has been recently demonstrated through their detailed geobiological characterization, coupling optical and scanning electron microscopy with biogeochemical analyses (Guido et al., 2022). Two types of building engineers were detected: sessile skeletonized organisms and microbialites. These contribute to the formation of two boundstone frameworks: 1) a purely skeletal-supported boundstone, build mainly by large Serpulidae tubes; 2) a microbialite/skeletal boundstone, in which the framework is reinforced by the precipitation of autochthonous micrite induced by the metabolic activity of microbial communities. Even if the so-called biostalactites show distinctive growth from ceiling and walls of submarine caves, differently from the stalactites formed in continental caves, they are influenced by the vital effect of the organisms and the final growth morphology is not controlled by physical processes.

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New material of *Tetraclaenodon* (Phenacodontidae, Mammalia), from the San Juan Basin of New Mexico, sheds light on its evolution and phylogenetic position

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Following the K-Pg mass extinction, 66 Ma, some of the first placental pioneers where the 'condylarth' phenacodontids, postulated to be related to modern perissodactyls (Radinsky, 1966). *Tetraclaenodon*, the basal-most phenacodontid from the Torrejonian (~64.77 Ma to ~62.36 Ma) NALMA of North America, is fundamental for the definition of the group and thus its position in the placental mammal family tree.

Here, we describe new craniodental and postcranial material that is tentatively assigned to two morphospecies based on size, stratigraphy and subtle morphological differences. The two morphs are the smaller *T. pliciferus*, present in the lower levels of the Torrejonian (Tj1-Tj3), and the larger *T. puercensis*, present in the upper levels (Tj4-Tj6). The body size in *Tetraclaenodon* increases ~50%, implying either speciation or an anagenetic lineage.

An ingroup phylogeny of phenacodontids, alongside early Paleocene and Eocene placentals and modern mammals, provides preliminary results confirming the basal position of *Tetraclaenodon* within the Phenacodontidae and their stem position to perissodactyls.

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CT-based description of a partial cranium of *Stephanorhinus hundsheimensis* from the early Middle Pleistocene site of Contrada Monticelli (Apulia, Italy)

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The early Middle Pleistocene site of Contrada Monticelli (CM) was discovered in 1978 near Castellana Grotte (Apulia, southern Italy). During the construction of a residential building, the excavation activities exposed some poorly preserved fossils of large mammals currently hosted at the Museo di Scienze della Terra of Bari University. The remains of *Dama* cf. *roberti*, *Palaeoloxodon antiquus*, *Canis mosbachensis*, lagomorph and rhinoceros, suggest a biochronological attribution of CM to the Isernia Faunal Unit (Galerian Mammal Age, ca. 600 ka).

Skeletal remains of rhinoceroses are relatively abundant and represented by cranial and postcranial bones studied since the 1980s. The sample was initially assigned to *Rhinoceros mercki* (= *Stephanorhinus kirchbergensis*) by Luperto Sinni & Colucci (1985) and then to *S. hundsheimensis* by Mazza & Varola (1999). The latter taxonomic attribution was recently supported by Stefanelli et al. (2024) based on postcranial bone analysis. Fossils of *S. hundsheimensis* have been recovered throughout Europe in deposits ranging from the late Early Pleistocene to the Late Pleistocene (MIS 5), as suggested by the data from Cova del Rinoceront site (Catalunya, Spain) and by ongoing studies in Apulia (i.e., Grotta Romanelli lower complex).

Here, we present a preliminary CT-based description of the paranasal sinuses and neurovascular system of a partial cranium (MSTB - CM 30814) referable to *S. hundsheimensis*. The endocranial anatomy of fossil and extant rhinoceroses still remains largely unknown and represents a potential source of useful information to enhance our knowledge on the paleobiology and systematics of these remarkable representatives of the Quaternary megafauna.

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Ammonite biostratigraphy, sedimentology and paleoenvironmental considerations of Toarcian key outcrops of the Umbria-Marche (Northern Apennines, N Italy) and Longobucco (Sila Greca, S Italy) Basins

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In this contribution we present seven stratigraphic sections spanning from the upper Pliensbachian to the lower Aalenian within the Umbria-Marche and Longobucco basins, focusing on the biostratigraphy and sedimentology of the Toarcian stage. The standard Tethyan and Mediterranean ammonite biozonations were used for the correlation of the analyzed domains characterized by fully comparable faunal assemblages. In the Umbria Marche Domain, the Emaciatum Zone of the upper Pliensbachian is represented essentially by the pelagic limestone of the Corniola, and occasionally by the marly/clayey facies of the Marne di Monte Serrone. On the other hand, a shallow-water carbonate facies characterizes the Emaciatum Zone at Caloveto. The passage from the Emaciatum to the Polymorphum Zone is abrupt and marked by a hardground between the Corniola and the Rosso Ammonitico, and transitional between the Corniola and the Marne di Monte Serrone. At Caloveto, a hiatus marks the Pliensbachian-Toarcian transition, spanning at least to the Polymorphum Zone; the Serpentinum Zone, documented in the literature, was not identified in this study. Above the Polymorphum Zone, the T-OAE is commonly marked by a black shale horizon; when this black shale is absent, the T-OAE can still be distinguished for the significant faunal turnover occurring in the Serpentinum Zone. The Bifrons Zone is characterized by a typically nodular marly limestones, with an upward increase in $CaCO_3$ content. Notably, the Marne di Monte Serrone are often heteropic with the Rosso Ammonitico in the lower Toarcian. At the Toarcian/Aalenian boundary sedimentation becomes increasingly calcareous, coinciding with the first occurrence of chert.

Varanus remains from the Early Pliocene of Langebaanweg (South Africa)

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The Early Pliocene fossil assemblage from Langebaanweg (South Africa) is characterized by a very rich vertebrate record including several lizards referable to at least, as already listed by Hendey in 1981, chameleons, geckos, and monitor lizards. We describe here a small sample of *Varanus* skeletal elements coming from the Varswater formation and hosted in the collection of Iziko Museums of South Africa (Cape Town). The sample includes the following elements (in some cases only partially preserved): 4 maxillae, 3 dentaries, several tooth bearing bones, 2 premaxillae, 1 surangular, 1 pair of fused nasals, 1 septomaxilla, 4 pterygoids, 1 coronoid, 1 supraorbital, 2 postorbitofrontals, 1 prefrontal, 1 parietal, 1 vomer, 1 prootic, 2 ilia, and 26 vertebrae. The general morphology of the skeletal elements and, more in particular, the number of tooth positions presented by the best-preserved tooth bearing bones, combined with the tooth morphology, allows us to exclude the presence of, among the extant African monitor lizards, *Varanus exanthematicus*, *Varanus griseus*, and *Varanus niloticus*. We preliminarily refer all the material to *Varanus albigularis* (as *Varanus* aff. *albigularis*). The presence of an extinct taxon related to the latter cannot be excluded and a detailed morphological analysis is currently carried out in the frame of the master thesis of the first author. In particular, the grooves of the teeth (of at least two different individuals) appear not to be congruent with the morphology shown by *Varanus albigularis*, but a larger sample of this extant species is needed in order to evaluate the variability of this trait. Worth mentioning is that monitor lizards are currently extirpated from south western South Africa and that *V. albigularis* is the species with the closest range to Langebaanweg.

Climatic impact on terrestrial and marine realms of the eastern Mediterranean at the Plio-Pleistocene transition The PPT PRIN Project

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The Earth's climate showed a certain instability and, over the past million years, cyclically changed, suddenly passing from cold to warm phases. Nowadays, the climate is changing faster than in the recent past, posing potential threats on different ecosystems and biota, and impacting the landscape evolution. The need to develop exhaustive knowledge about the time and mode of climatic transformation strongly motivates studies aimed at detecting how different climatic events impact Earth surface dynamics. The Mediterranean is a very sensitive ecosystem that emphasizes the effects of climate change. Few marine records of the Plio-Pleistocene transition (PPT) were studied in the central and western Mediterranean, and the PPT time interval from the eastern Mediterranean has been less studied, even if two strategic records are present from ODP Leg 160: Site 967 (south of Cyprus) and Site 964 (Pisano Plateau). Both holes recover a succession from present-day sediments to Pliocene deposits dated up to ~2.8 Ma. The holes cross several sapropel layers whose origins were closely related to climate. Solid datasets are available for these records, including chronological and geochemical data, however, high-resolution quantitative analyses of the foraminifera assemblages and pollen records have never been carried out on these successions.

The PPT PRIN Project aims to integrate existing data with new high resolution micropaleontological and palynological data for an in-deep understanding of the modification of marine biota to the climate changes that occurred in the eastern Mediterranean during PPT. In addition, comparing new marine data with new continental data from the Valimi Fm (Gulf of Corinth, Greece) will provide a unique, expanded, and almost continuous record around the time interval of the PPT. This correlation between the marine and continental realms is essential to gain a holistic understanding of the impacts of climate change in the Mediterranean Basin.

Exploring the reef coral-neritic carbonates of southern Pakistan during the Late Oligocene Warming Event

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The Oligocene-Miocene boundary marks a critical juncture characterized by remarkable alterations in the global climate. The transition from the relatively warm conditions of the late Oligocene to the onset of the Mi-1 glaciation, heralds changes in the composition of neritic carbonates and in the distribution patterns of zooxanthellate reef corals. In fact, while numerous Oligocene neritic carbonate successions worldwide feature abundant reef corals, our preliminary investigations, on a limited dataset primarily sourced from Europe, Iran, the Indo-Pacific, and the Caribbean, indicate a temporary decrease in their significance as carbonate producers after the Oligocene, reaching a minimum around the middle Miocene.

Herein, we aim to elucidate the dynamics of the upper Oligocene coral-bearing units of the Southern Khirthar fold and thrust belt (S Pakistan), focusing on the understudied Jhill Limestone Unit (Gaj Formation). Through the analysis of four selected sections, the skeletal assemblages reveal a dominance of coralline algae, large benthic foraminifera (including *Miogypsinoides*, *Miogypsina*, *Spiroclypeus*, *Nephrolepidina*, and *Archaias*, alongside *Operculina*, *Sorites*, and sporadic *Eulepidina*), and reef corals (e.g., *Hydnophora*, *Acropora*, *Porites*). Reef corals are represented by colonies that form small patches in three out of four investigated sections, locally dominating the assemblages. Large benthic foraminifera suggest deposition during the Late Oligocene, potentially Shallow Benthic Zone 23, indicative of the Late Oligocene Warming Event, thus challenging previous assertions indicating a Burdigalian age for the Gaj Formation in the study area. These refined stratigraphic constraints facilitate comparative analyses of these coral-bearing shallow-water carbonates with analogous units from European and Indo-Pacific regions, providing a bridge between the two bio-provinces and a better understanding of the response of reef coral carbonates to past warming events.

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Revaluation of the taxonomy and systematic position of the Eocene syngnathoid fishes (Teleostei: Syngnathiformes) from the Bolca Lagerstätte, Italy

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The suborder Syngnathoidei is a diverse group of bony fishes including about 350 living species known as trumpetfishes, cornetfishes, ghost pipefishes, pipefishes, shrimpfishes and seahorses, having worldwide distribution and mostly inhabiting shallow tropical to temperate waters where they live associated with rocky substrates, coral reefs and seagrass beds. Syngnathoids are considered as one of the most highly specialized group of teleost fishes being characterized, e.g., by head and trunk encased in bony plates and tail covered by bony rings, posttemporal co-ossified with cranium, interopercle widely separated from the reduced subopercle, and small and toothless mouth at end of tube-shaped snout (Nelson et al., 2016). The fossil record of Syngnathoidei dates back to the Late Cretaceous and includes representatives from all families. Most of fossil syngnathoids are represented by complete and articulated specimens coming from the Eocene fossiliferous strata of the Bolca Lagerstätte (NE Italy), whose sediments deposited about 50 million years ago in a shallow water coral reef context of the western Tethys Sea. Syngnathoids are one of the most diverse groups of the Bolca ichthyofauna, being represented by about nine families and 20 species (Carnevale et al., 2014). Unfortunately, the large part of the fauna needs revision, since these specimens were poorly described and have not been looked at in the last 44 years. The goal of this research is to review the taxonomy and systematic position of the syngnathoids taxa of the Bolca ichthyofauna housed in several Italian and European museums in order to definitively asses their diversity, to re-evaluate their anatomy, to interpret their paleontological significance and improving, at the same time, our understanding of the early Cenozoic evolutionary history of this group of fishes, and our knowledge about the paleobiodiversity of this world-famous Eocene fish assemblage.

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Talking heads: disentangling the shape changes of hippopotamus during its ontogenetic development

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Hippopotamus amphibius and *Choeropsis liberiensis* are the only extant representatives of the family Hippopotamidae. *Hippopotamus amphibius* is particularly interesting due to its unique semi-aquatic lifestyle, which serves as land-water linkage, with a significant impact on both terrestrial and aquatic African ecosystems. This work aims at detecting the intraspecific variability in the hippopotamus skull shape and size during ontogeny, using 3D geometric morphometrics methods coupled with statistical analyses. The major morphological changes through ontogeny in the cranial elements of the extant hippopotamus might be related to the onset of weaning, with the consequent interruption of suckling. A minor shift is also detectable from the sub-adult age to the adult one. The analyses herein performed also demonstrate that *H. amphibius* is affected by allometric constraints. Furthermore, some fossil specimens included in our analysis show that landmarks are also a powerful tool for taxonomic attribution. Our results represent a starting point for future research that should also include more *C. liberiensis* specimens and fossil representatives of the family Hippopotamidae, together with specific physiological and life history data, to better understand evolutionary patterns and adaptive traits within this group of endangered large mammals.

Rare evidence of trophic interaction between a shark and a bird in the fossil record (Pliocene, Italy)

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Evidence of trophic interactions between sharks and other vertebrates (mostly cetaceans and marine reptiles) is occasionally preserved in the fossil record, first and foremost in the form of tooth marks on bones. Here, we report on another such case from mid-Pliocene open-marine deposits exposed at Lucciolabella (Siena-Radicofani Basin; Tuscany, central Italy). The specimen investigated herein is an incomplete humerus, lacking the proximal and distal epiphyses. The external surface of the proximal part of the shaft, perpendicular to the linea for the m. latissimi dorsi, bears more than a dozen incisions consistent with tooth marks. Some of these marks are finely serrated, evoking a carcharhinid or squaliform tracemaker with crenulated or finely serrated tooth cutting edges. Whether the bites were inflicted as a consequence of active predation or scavenging cannot be ascertained due to the fragmentary nature of the specimen. To date, the fossil record has disclosed very few specimens that may reveal ancient cases of trophic interaction between sharks and birds, hence the relevance of our new record, however fragmentary it may be. As a token of the rarity of such records, the revision of the fossil seabird collections of the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos (Lima, Peru) revealed no bones with unambiguous tooth marks. Nowadays, birds comprise a somewhat appreciable portion of the diet of some extant macrophagous sharks, especially species in the ground shark order Carcharhiniformes (e.g., the tiger shark, *Galeocerdo cuvier*).

Changes in calcareous nannofossils across the Coniacian-Santonian (Late Cretaceous) of Site IODP U1513

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The Coniacian-Santonian interval represents a turning point in the Late Cretaceous marked by a gradual climatic deterioration to cooler conditions and a significant renovation of the planktonic community at global scale. The marine plankton is one of the main components of the deep-sea sediments and represents an important record of how the marine biota react to the changes in surface water conditions.

To determine the biostratigraphic and paleoceanographic changes of calcareous nannofossil associations during the Coniacian-Santonian, a sequence of IODP Site U1513 (33°47.6084′S, 112°29.1338′E) was investigated. The IODP Site U1513 was drilled on the western margin of the Mantelle Basin (southwestern Australia) during Expedition 369 providing an almost continuous Cenomanian-middle Santonian stratigraphic interval.

Quantitative analyses were carried out on 102 samples prepared with the settling technique. The observed nannofossil assemblages are abundant and generally well preserved allowing both the quantification of nannofossil abundance patterns and a revision of the biostratigraphy for this site. According to our results, the position of the following bioevents was revised: the lowest occurrence (LO) of *Marthasterites furcatus*, LO *Micula staurophora* and highest occurrence (HO) of *Zeugrhabdotus kerguelenensis*.

The quantitative data provided the evidence of one acme in *M. furcatus* in the CC13 Zone (early Coniacian) reaching up to 38.2% of the assemblage. Also, *M. staurophora* shows distinct phases of enrichment between the CC14 and CC16 Zones (middle Coniacian - middle Santonian). The occurrence of distinctive peaks in *M. furcatus* and *M. staurophora* during the Coniacian-Santonian, was previously observed in ODP/DSDP sites in the Equatorial and South Atlantic during the Oceanic Anoxic Event 3 (OAE3). This research was funded through MUR for ECORD-IODP Italia.

The fossil collections of the Dipartimento di Scienze della Terra 'Ardito Desio' move their steps into the virtual world of palaeontology

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The palaeontological collections of the Department of Earth Sciences 'Ardito Desio', University of Milan, are the result of years of field research carried on by national and international palaeontologists and geologists who have worked and collaborated within the University. The collections also include the historical heritage of fossils collected by the pioneers in the field of palaeontology during the early 20th century. It currently includes more than 12000 catalogue numbers, corresponding to several thousands of specimens of fossil invertebrates and vertebrates, ranging in age from the Palaeozoic to the Quaternary.

Through the use of virtual palaeontology methodologies, which have been already implemented in several national and international museums, we present a novel way to guarantee access, preservation and enhancement of the palaeontological heritage stored within the collections of the University of Milan. The employment of portable 3D scanners to acquire surface data, together with clinical and high-resolution CT- scanners will allow to realise a digital database where all specimen information, such as taxonomy, provenance and age, along with high-resolution 3D digital copies can be stored and easily shared for research and comparison purposes. In addition, the use of these methodologies will allow the development of new approaches to the study of fossil vertebrates and macroinvertebrates, including in-depth non-destructive fossil investigations of specimens still embedded within the matrix, or the detailed study of highly mineralised tissues that can be useful to reconstruct the palaeobiological and palaeoecological traits of extinct organisms, along with a detailed examination of frail and poorly-preserved fossil specimens.

Terrapin aches and pains: parasite borings and other bone modifications in an Italian Pliocene population of *Mauremys* (Testudinoidea: Geoemydidae)

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Despite the common and widespread occurrence of turtle shell remains in many fossil vertebrate assemblages worldwide, only few palaeontological studies exist detailing the palaeoecological significance of turtle bone modification features, though this is beginning to change. Here, we report on fossil traces occurring on carapacial and plastral remains of the small terrapin genus *Mauremys* from the Pliocene of 'Cava La Serra' (Merella et al., 2023), in the Valdelsa Basin (San Miniato, PI; Italy). The trace fossil assemblage includes the ichnogenera *Karethraichnus* (nonpenetrative, hemispherical boreholes), *Gunnellichnus* (wide depressions, many times wider than deep) and *Thatchtelithichnus* (nonpenetrative, ring-shaped boreholes; see also Collareta et al., 2020), all of which are found on the turtle shell exterior. As often observed, some of the *Karethraichnus* boreholes clearly occur along the epidermal sulci that mark the border between adjacent keratinous scutes. Based on the relevant literature, the studied ichnofossils are interpreted as due to the parasitic action of leeches/spirorchid liver flukes (*Karethraichnus* and *Thatchtelithichnus*) as well as to algal/bacterial (sub)cutaneous infections (*Gunnellichnus*). A similar suite of traces occurs on shell bones of the extant red-eared terrapin, *Trachemys scripta elegans* (Zonneveld & Bartels, 2022, 2023).

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An unusual nummulite infilling in a nautiloid inner mould from the Priabonian (upper Eocene) of Valsugana (Trentino, northern Italy)

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The inner mould of a nautiloid shell was recently found by G.R. in Valsugana (Trentino, northern Italy). The mould does not preserve any part of the original shell, and the traces of the septa are faint, whereas the overall shape is preserved, with a measured maximum diameter of ca. 16 cm. In the umbilical area, two ostreid valves are firmly attached on both sides of the shell.
However, the most unusual and peculiar feature of this specimen is given by the infilling sediment, which is apparently totally made by nummulite tests. The surface of these tests is characteristically reticulated, and in some places natural equatorial sections allow to determine that most of them belong to the species *Nummulites fabianii* (A forms). Therefore, the age of this fossil is Priabonian (upper Eocene).
To our knowledge, the stunning abundance of A forms of *N. fabianii* in such a context has never been reported. The study is underway, and we are considering different interpretations, ranging from a simple mechanical infilling by nummulitic gravel to a possible trophic interaction.

A new species of Lovebird (Aves, Psittaculidae, *Agapornis*) from the Plio-Pleistocene of the Cradle of Humankind (Gauteng, South Africa)

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Lovebirds (Psittaculidae, genus *Agapornis*) are a group of nine small-sized parrots endemic to sub-Saharan Africa and Madagascar. All nine species are strictly arboreal and live in woodlands or wooden savannahs where they breed in cavities in trees and feed on grass seeds or fruits collected primarily on the ground and, to a lesser degree, on trees. The fossil record of Lovebirds consists of two extinct species, *Agapornis atlanticus* from the Pliocene of Morocco and *A. attenboroughi* from the Pliocene of South Africa, plus few records of *Agapornis* sp. from the Pliocene and Pleistocene of Eastern and Southern Africa. A recent analysis of the bird remains from the Plio-Pleistocene of Kromdraai, Cooper's Cave, and Swartkrans (Cradle of Humankind, South Africa) allowed us to detect a new, as-yet undescribed species. The new species is represented by all the major wing bones (humerus, ulna, and carpometacarpus) and by the tarsometatarsus, together with a fragmentary mandible, coracoid, and a distal tibiotarsus. The size of the bones indicates a small species of *Agapornis* with an elongated tarsometatarsus, proportionately the longest of all living and fossil species of Lovebirds. This lengthening of the legs might be related to feeding adaptation of the extinct species, as the longer legs may have favored this ground feeder in the high and dense grassland characteristic of the Cradle of Humankind between the Plio-Pleistocene boundary and the Early Pleistocene.

Rediscovery of the beaked whale rostrum of '*Dioplodon longirostris*' from Pliocene of Piedmont described by Portis (1897)

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The beaked whales (Ziphiidae) represent the second most speciose extant family of cetaceans (24 species) despite being scarcely known for their elusive behavior and pelagic habitat (MacLeod 2018). Their fossil record is significant although many finds are represented by isolated rostra of cranium with limited diagnostic value. The fossil preservation of these rostra is favored by their original compactness and robustness, as many beaked whales have a peculiar pachyostosis and osteosclerosis of the bones of this part of the cranium. One of these fossil rostra was reported by Portis (1897) from the Briccone locality, near Isola d'Asti (Asti, Piedmont, Northern Italy). Portis (1897) described, but did not figure, this fossil, referring it to *Dioplodon longirostris* (Cuvier, 1822). The genus *Dioplodon* was later considered by Abel (1905) to be a more recent synonym of *Mesoplodon* and therefore Bianucci (1997) reported the Briccone rostrum belonging to *Mesoplodon longirostris*. The precise stratigraphic horizon from which the specimen comes is unknown, but probably it was found from the Pliocene Sabbie d'Asti Formation, extensively exposed at Briccone locality (Bianucci, 1997). For over a century after its first description this rostrum was lost, having only recently been reported in the Museo Paleontologico Territoriale dell'Astigiano (Damarco, 2014). Here we redescribe and figure for the first time this rostrum comparing it with other both fossil and extant species of ziphiids featured by similar pachiosteosclerosis and belonging to the Hyperoodontinae subfamily. Our comparisons further support the poor diagnostic value of isolated rostra and therefore also question the validity of fossil species, such as *Mesoplodon longirostris*, only based on these fragmentary parts of the cranium.

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Cava Ex Fornace RDB e Valle Botto, comparazione per la valutazione della rilevanza dei geositi

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I geositi sono luoghi di importanza geo-paleontologica e la raccolta di dati inerenti ad essi può dare impulso a future indagini per la loro gestione e conservazione. Qui viene applicata a due siti piemontesi, Cava Ex Fornace RDB e Valle Botto (si veda Pavia et al. 2004), un'innovativa procedura per la valutazione analitica della rilevanza di siti fossiliferi e della loro potenziale vulnerabilità (Faggi et al. 2023). Il primo geosito è stato fortemente trasformato e non esiste più in quanto tale: in seguito ai numerosi ritrovamenti paleontologici è stata creata un'Area Ecologica. Il secondo, al contrario, è in un'area protetta gestita dall'Ente di gestione del Parco Paleontologico Astigiano, che con, interventi e strutture atte a geoconservare e valorizzare gli affioramenti fossiliferi, ha organizzato un percorso didattico di fruizione pubblica. Confrontando i siti si nota che, nonostante sia un geosito non più accessibile, grazie alla diversità dei ritrovamenti Cava RDB (con molti vertebrati, piante ed invertebrati con generi e specie differenti) mantenga un valore scientifico potenzialmente maggiore rispetto a Valle Botto (alta biodiversità di invertebrati). La vulnerabilità risulta nulla per entrambi i siti per motivi opposti: uno è andato perduto mentre l'altro è completamente protetto. Questa analisi verrà poi estesa a tutti i geositi piemontesi per avere una visione più estesa dello stato di salute del patrimonio paleontologico e validare ulteriormente questa procedura analitica come efficiente strumento per la tutela dei siti geopaleontologici.

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Flashing the body mass of *Carnotaurus sastrei* with 3D volumetric method

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This communication aims to give a precise and updated estimation of the body mass (BM) of *Carnotaurus sastrei*, a theropod dinosaur with peculiar body proportions, discussing and evaluating the differences and accuracy of classical regression methods and volumetric density approach. The study is conducted on a cast of the holotype housed at the Museum of Natural History of the University of Pisa and includes a novel 3D volumetric reconstruction based on the photogrammetric scan of the mounted skeleton, as well as the most updated data on this taxon existing. Accurate estimation of BM is crucial in understanding various physiological and ecological variables, including metabolic rate, body temperature, locomotor costs, growth, reproduction, population density, diet, habitat, behavioral adaptations, and ecological niche partitioning. The classical regression method, based on osteological measurements and formulas derived from extant taxa, often yields wide and misleading ranges of values, whereas the volumetric method, reconstructing the individual in 3D and applying literature-derived tissue density ranges, proves significantly more precise (e.g., Romano et al 2022; Van den Brandt et al., 2023). Our results reinforce existing literature by demonstrating the superiority of the 3D volumetric method, which yielded a BM estimate for *Carnotaurus sastrei* consistent with its known size. Additionally, they highlight the limitations of regression formulas, which can result in significant overestimations or underestimations. The volumetric method, in contrast, provides more precise estimates with narrower ranges of values, making it preferable when dealing with sufficiently complete skeletal remains.

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Weighing the hippo: *in-vivo* reconstruction and body mass estimate of *Hippopotamus antiquus* from Figline (Upper Valdarno, Tuscany)

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In this contribution we present an *in-vivo* reconstruction and a body mass (BM) estimate of *Hippopotamus antiquus* comparing and discussing the results calculated with classic regression formulas with the values obtained through a new 3D volumetric approach. *H. antiquus*, with a biochronological range in the Italian peninsula from around 2.2 to 0.4 Ma, was an extinct semiaquatic megaherbivore foraging mainly on aquatic vegetation. Taking into consideration its lifestyle, considered to be more aquatic than the extant *H. amphibius*, and its very large body size, a correct estimate of the BM is crucial to correctly interpret several biological aspects of this fossil tetrapod. The mounted specimen on display at the Museum of Geology and Paleontology of the University of Florence was used for both the classical regression method and for the new 3D volumetric approach. The estimates obtained with the regression methods provide very high ranges compared to the volumetric approach, with minimum estimates of 200 kg and maximum estimates of over 6 tons, completely incompatible with a tetrapod of this size. Similar contrasting results have been recently obtained in a broad range of fossil tetrapods (e.g., Romano & Manucci, 2019; Romano & Rubidge, 2019). The new volumetric estimate in *H. antiquus* provides an average BM of approximately 3170 tons, thus confirming a body weight approximately double compared to the average values in the extant species *H. amphibius*.

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Diagnostica non invasiva e applicazioni avanzate per restauro conservazione, tutela e valorizzazione di materiali paleobiologici: il WP4 dello Spoke 5 (*Science and Technologies for Diagnostics of Cultural Heritage*) all'interno del progetto CHANGES (*Cultural Heritage Active Innovation for Sustainable Society*)

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Nell'ambito del progetto CHANGES (*Cultural Heritage Active Innovation for Sustainable Society*) del PNRR, WP4 (*Advanced diagnostic and scientific methods for organic materials*), è attiva un'unità di ricerca presso il Paleo[Fab]Lab del Dipartimento di Scienze della Terra dell'Università di Firenze.
Le attività di questa unità di ricerca sono focalizzate nello sviluppo di tecniche diagnostiche digitali non invasive applicate ai reperti paleobiologici, per facilitare lo studio il restauro e la valorizzazione dei resti fossili, a tutti gli effetti Beni Culturali oltre che patrimonio naturalistico. In particolare, l'utilizzo complementare ed integrato di tecniche diverse (microscopia digitale 3D, tomografia assiale computerizzata e microCT, scanner in luce strutturata a diverse risoluzioni) si rivela un approccio utile e potente, in quanto rende possibile l'analisi e lo studio di morfologie e strutture esterne ed interne in maniera non invasiva, e al contempo permette di ottenere modelli 3D altamente fedeli. Questi ultimi, grazie alla crescente diffusione delle tecnologie di visualizzazione, hanno un'ampia varietà di utilizzi che includono lo studio anatomico e paleoecologico, il restauro di reperti deformati (retrodeformazione) e nuove forme di divulgazione del sapere concernente i beni culturali.

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Nanoscale preservation of feathers in zeolites

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The Pleistocene griffon vulture (*Gyps fulvus*) reported from the pyroclastic succession of the Peperino Albano ignimbrite (Alban Hills, Roma) preserves soft tissues and part of the plumage in three dimensions. Previous studies report conflicting hypotheses regarding the type of volcaniclastic deposit hosting the specimen. Critically, the taphonomy of the plumage remain largely unknown. This specimen offers a unique opportunity to investigate the taphonomic controls for the preservation of vertebrate soft tissues in volcanoclastic settings. Scanning electron microscopy (SEM) reveals replication of melanosomes and the surrounding feather cortex with nanoscale fidelity in a Fe-rich aluminosilicate mineral. Here, we use nano-X-ray fluorescence (n-XRF) and μ-Raman and μ-FTIR (Fourier-transform infrared) spectroscopy to characterize the chemistry of the mineral phase. Analysis via n-XRF shows that feather tissues are enriched in Fe, Ca, Ti and Cr. Data from μ-Raman and μ-FTIR spectroscopy reveal that the feathers are replicated in nanocrystalline zeolite, possibly of the analcime group. Our results confirm the potential for nanocrystalline zeolites to preserve feathers and perhaps other soft tissues at the nanoscale in fossils hosted in Si-Al rich sediments. Our study indicates that the vulture carcass was buried by a low temperature, water-rich fine-grained volcaniclastic flow associated with the last eruptive phase of the Alban Hills volcanic complex.

Further remains of *Testudo graeca* from the Early Pleistocene of Dmanisi (Georgia)

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The Early Pleistocene site of Dmanisi (Georgia, Lesser Caucasus), dated to 1.8 Ma, is a relevant locality not only as it documents one of the earliest human evidences in Western Europe, but also because of its geographic placement at the end of a natural corridor that allowed faunal communication between Africa and Eurasia.

The amphibian and reptile remains from Dmanisi represent at least six taxa: a green toad (*Bufotes* gr. *B. viridis*), the Greek tortoise (*Testudo graeca*), a green lizard (*Lacerta* gr. *L. viridis*), a four-lined snake (*Elaphe* gr. *E. quatuorlineata*), an indeterminate colubrid and a water snake (*Natrix* sp.) (Blain et al., 2022). The presence of the Greek tortoise has been based on a partial shell and few shell and appendicular fragments (Blain et al., 2014). Here, we report two additional specimens (Dm.2/151.1.A4.46 and Dm.8/153.2.A4.16) consisting of an adult and a juvenile shell, respectively. Both specimens come from the A4 upper ash Stratum, which preserves the oldest lithic artifacts and faunas, and served as the host sediment for pipes and gullies that filled with Stratum B1, where the hominin remains were found. They confirm the unusual anterior position of the humero-pectoral sulcus: in extant European populations of this species, this sulcus is generally placed posterior to the entoplastron, whereas in the specimens from Dmanisi the sulcus overlaps the posterior suture of the entoplastron or even enters slightly the entoplastron. Due to the importance of this character for the taxonomy of *Testudo* and the very broad range of *T. graeca*, further analyses are required for understanding the distribution of this character in different populations.

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Evoluzione degli ultimi 2000 anni dell'Edisto Inlet, Mare di Ross: le diatomee come indicatori paleoambientali

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L'area di studio, il fiordo di Edisto, Mare di Ross Occidentale, è interessata da numerosi progetti PNRA (Programma Nazionale di Ricerca in Antartide), i quali hanno permesso di raccogliere numerose carote caratterizzate da una sequenza laminata di origine biogenica (Tesi et al., 2020). Questa spessa sequenza sedimentaria è caratterizzata da un tasso di sedimentazione che varia negli ultimi 2,6 ka dai 0,7 ai 0,2 cm/yr (Tesi et al., 2020), rendendola ideale per studi paleoecologici ad alta risoluzione. Nel mio lavoro di tesi, in particolare, mi sono dedicata allo studio dell'associazione fossile a diatomee della carota HLF17-01, prelevata nel febbraio del 2017 nell'ambito del progetto HOLOFERNE all'interno del fiordo, per poter comprendere l'evoluzione paleo-ambientale del Golfo di Edisto negli ultimi 2 ka. I campioni (circa 150) sono stati trattati con acqua ossigenata, per rimuovere la materia organica e con acido cloridrico per rimuovere la presenza di carbonati, una volta raggiunto un pH di circa 5-6 sono stati preparati i vetrini. I vetrini sono stati poi osservati al microscopio ottico utilizzando l'obbiettivo 63x e in ogni vetrino sono state contate 300 valve di diatomee. In questo poster presento i risultati preliminari e nonostante siano ancora in fase di elaborazione, i primi dati fanno propendere per un'interpretazione simile a quella di Tesi et al., 2020.

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Planktic foraminiferal loss of resilience at the Middle Eocene Climatic Optimum (MECO): Atlantic Ocean Sites 1051, 1263, 702

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The Middle Eocene Climatic Optimum (MECO), centred at ~40 Ma, is characterized by marine bulk and benthic carbonate $\delta^{18}O$ values steadily declining by ~1‰ in over ~400 kyr, usually interpreted as a 3–6 °C increase in global temperature followed by rapid return to pre-event conditions. This event is increasingly attracting the scientific attention as recording temperatures and pCO_2 that Earth will reach whether anthropogenic emissions will not stop (RCP8.5). In addition, the $\delta^{13}C$ signal across the MECO event such as the paleoceanographic repercussions show great geographic heterogeneity, making this event still enigmatic. Despite that, the biotic impact of the MECO is still poorly constrained. We selected here the Atlantic Ocean Drilling Program sites 1051, 1263 and 702 that cover different latitude settings and provide established stratigraphic and stable isotope constrains. Planktic foraminifera display pronounced assemblage modifications across the MECO mainly related to surface-water temperature increase that altered the pelagic food webs, inducing enhanced upper water-column remineralization of organic matter thus decreasing the amount of food reaching the deep ocean. The intense warming caused a southern migration of warm-index taxa at Site 702, as also recorded for the calcareous nannofossils. However, the warm-indIces '*Large Acarinina*' (>150 μm) and the genus *Morozovelloides* markedly and permanently decline at sites 1051 and 1263 from the MECO top, ~2 My before their evolutional disappearance occurred at the Bartonian-Priabonian boundary. The planktic foraminifera never recover their pre-MECO assemblages thus demonstrating to have only temporarily absorbed the MECO stressors through a certain degree of plasticity. These results point and highlight the potential consequences of the ongoing, much faster climate warming.

Canis spp. remains preserved at the Geological Museum Gemmellaro in Palermo: preliminary analyses

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Sicily possesses a rich paleontological heritage characterized by a multitude of Pleistocene continental vertebrates, which testify to the alternation of different faunal associations that occurred on the island over time. Many of the most relevant and interesting fossil findings recovered in this region are nowadays stored at the Geological Museum "G.G. Gemmellaro" of the University of Palermo. New attention has recently been given to its historical paleontological collection composed of remains attributed to *Canis sp., Canis cf. lupus*, and *Canis lupus* (Burgio et al. 2002). Based on previous studies, the Sicilian paleofauna can be divided into five different faunal complexes (FCs), attributed to a time interval between the Early Pleistocene and the Late Glacial. Fossil specimens of wolves have been reported in the following faunal complexes: "*Elephas mnaidriensis,* F.C.", "San Teodoro-Pianetti F.C.", "Castello F.C.", and ultimately in Holocene faunas (Bonfiglio et al. 2002). The present work is intended to serve as a basis for the beginning of paleontological, palaeobiological, and paleogenetic analyses aimed at clarifying the island's populating dynamics by this taxon. Data of the cataloguing of all osteological samples attributed to the wolf have been collected and a preliminary descriptive and morphometric study performed. The last will allow, where possible, to reconstruct the shoulder height of the specimens, and to determine their age. Subsequently, in order to understand at what point in the population evolutionary history the fossil associations under consideration are placed, genetic data produced by a previous study focusing on the Sicilian wolf *(Canis lupus cristaldii*) (Ciucani et al. 2023) will be used and compared with the new information that will be obtained from the study of ancient DNA extracted from these findings. The purpose of this investigation is to assess whether the occurrence of *C. lupus* in the different faunal complexes can be attributed to a prolonged stay of this animal in Sicily, or to repeated entries of lupine populations on the island throughout the Pleistocene.

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2D FEA reveals evolutionary history of ichthyosaurs feeding strategies

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Ichthyosauria is a group of marine reptiles with an evolutionary history that spans from the Triassic up to about 30 million years before the end-Cretaceous extinction. Ichthyosaurs were predators and shared lifestyle and ecosystems with other reptiles such as Pachypleurosauria, Thalattosauria and, later, Mosasauria. The study of the diet of ichthyosaurs has been longly debated and they are traditionally divided into "piscivorous", "generalists" and "macropredators". This study aims to test this ecological division and explore evolutionary trends in ichthyosaurs' feeding habits by analysing their mandibles' biomechanical profiles. In doing so, we acquired 3D data for eleven specimens, representative of Triassic and Jurassic taxa. Acquire models were subjected to 2D Finite Element Analyses using the software Abaqus. The analyses produced results clearly showing an evolutionary pattern consisting of four different alimentary adaptations. A first group includes the Triassic taxa, showing an adaptation towards a piscivorous diet. Jurassic taxa instead show the greatest diversity, with a peak right after the Triassic-Jurassic mass extinction. The FEA results confirm the trend already observed in the past (Foffa et al., 2018). Ichthyosauria survived the Tr-J extinction thanks to a strong and thick mandible, occupying the piscivorous-generalist niche. In the Toarcian, the diet shifts towards a more piscivorous one, favoring a sleek and more hydrodynamic mandible. A similar trend can be observed in the Late Jurassic taxa as well. This strategy successfully enabled ichthyosaurs to thrive during the Jurassic but also made them more vulnerable to changes in environmental conditions. This, combined with the evolution of Mosasauria and the subsequent competition for the generalist predator niche (Stubbs et al., 2016) most likely resulted in the decline of Ichthyosauria at the end of the Cretaceous.

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Rediscovery, digitalization and preliminary study of sea turtle remains from Pietra Leccese at MuSTe of Bari

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In the collections of the "Museo di Scienze della Terra" (MuSTe) of the University of Bari Aldo Moro, 14 rock slabs containing fossil remains of sea turtle, have been rediscovered. The slabs are referable to the Pietra Leccese Formation (Miocene) and come from Salento (Southern Italy), where this type of rock is extracted in the form of slabs and used as a construction material. The slabs contain well-preserved fragments of the carapace of Dermochelyidae (Chelonoidea), only partially prepared. The preliminary study of the dermal ossicles allowed us to identify the remains as belonging to *Psephophorus polygonus* (Chelonioidea: Dermochelyidae), a common fossil species in Europe and already reported from the Pietra Leccese Formation (Chesi et al., 2007). A high-detail digitalization was also carried out with a structured light scanner for archiving and research purposes. The rediscovery and digitalization of these finds will allow further studies and the enhancing of the Apulian paleontological heritage exhibitions at MuSTe.

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SANDRONE on the road: Virtual reconstruction techniques and functional morphological analysis

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It has been 150 years since the discovery of *Oreopithecus bambolii* Gervais, 1872, a Miocene primate that inhabited the Tusco-Sardinian archipelago around 8.3 to 6.7 million years ago. The most complete specimen of *O. bambolii*, known as "Sandrone" (IGF 11778), was found in a lignite mine in Baccinello (Grosseto, Italy). Despite its completeness and anatomical articulation, Sandrone suffers from fragmentation and deformation due to taphonomic processes. Thus, digital acquisition and virtual restoration are essential for comparative and morphological analyses, reducing the risk of damage to original specimens. Since the foundation of Virtual Palaeontology, landmark-based methods have been applied to digitally repair different kinds of damage in fossil records, including surface warping, estimation of missing parts and reconstruction based on multivariate analysis. Furthermore, the distortion due to the taphonomic process can be virtually removed by applying retrodeformation techniques, and, for high-damaged fossils, the mean shape of well-preserved target specimens can be used as a reference for restoration. Here, we introduce "SANDRONE" (Scientific investigation, virtual reconstruction AND musealization of OReOpithecus bambolii: locomotor and manipulative adaptations before humaN Evolution) a national project (PRIN) aiming to digitally restore the entire fossil postcranial skeleton applying cutting-edge techniques in virtual palaeontology to further clarify its locomotor and manipulative capabilities in the frame of its (paleo)environment. Beyond the scientific aspect, the project aims to enhance the fossil, renewing the museum exhibition in the Geological and Paleontological Museum of Florence with a hyper-realistic body reconstruction of Sandrone and several panels illustrating the paleoenvironmental features of Baccinello area during the Miocene. Additionally, the expertise gathered in this project will be utilised to organise training courses for students and researchers about virtual restoration.

Arthropleura: huge arthropod… huge model!

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Arthropleura is the largest terrestrial arthropod known to date in the fossil record. Remains and traces of this giant millipede dating back to the late Paleozoic (Carboniferous and Permian) have been found in North America and Eurasia, including Italy. Despite the numerous localities, fossils of *Arthropleura* are generally represented by isolated fragments of exoskeleton and rarely by large articulated body parts. However, fossils and traces belonging to this genus allow us to estimate dimensions of over 2.5 meters in length and approximately 50 kg in weight (Davies et al., 2021). The type species, *Arthropleura armata* Jordan, 1854 (in Jordan & von Meyer, 1854), has also recently been reported in the Moscovian fluvial-lacustrine deposits of the San Giorgio Formation (Iglesias, southern Sardinia) (Pillola & Zoboli, 2021). A large fragment of a paratergite represents the fossil from Iglesias, currently housed at the Museo dei Paleoambienti Sulcitani "E.A. Martel" of Carbonia (Sardinia). The impressive size of *Arthropleura* has encouraged several natural history museums to exhibit life-size reconstructions of this myriapod. We briefly illustrate the making of a life-size model of this huge and iconic invertebrate based on the currently available fossil record.

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