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7th International Meeting on Taphonomy and Fossilization Ferrara, September 10th-13th, 2014

ABSTRACT BOOK

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Volume 1 (2014)

7th International Meeting on Taphonomy and Fossilization 10th–13th September 2014, Ferrara, Italy

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DAVIDE BASSI AND RENATO POSENATO

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Taphos 2014 logo, project design by Hiroki Yamada (Tokyo)

TAPHOS 2014

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Thursday, September 11th	Registration, **scientific sessions** (talks and posters). Aula Magna, Dept. of Economics and Management, via Voltapaletto 11 (point 1, see Map) 18:15: visit to the Estense Castle (point 3, see Map)
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Saturday, September 13th	Post-meeting field trips: **(B) Tonezza del Cimone** (Vicenza, NE Italy). Departure 7:30, meeting point number 2 (see Map), close to the Estense Castle, Largo Castello. Return: *ca*. 19:00 **(C) Grotta di Fumane**, Museum of Prehistory and Palaeontology at S. Anna d'Alfaedo, Riparo Tagliente (Lessini Mountains, Verona, NE Italy). Departure 8:00, meeting point number 2 (see Map), close to the Estense Castle, Largo Castello. Return: *ca*. 18:00

bold: presenter

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MAP and LOCATIONS

1. Taphos 2014, venue; Dept. of Economics and Management, via Voltapaletto 11
2. Meeting point for the pre- and post-meeting field trips
3. Visit to the Estense Castle
4. Bale Buste, Trattoria/wine bar, via della Vittoria 44

ABSTRACTS

BENTHIC FORAMINIFERA AS INDICATORS FOR SUB-MARINE MASS FLOW EVENTS IN THE NORTHERN GULF OF EILAT/AQABA

Anat Ash[1], Revital Bookman[1], Ahuva Almogi-Labin[2] and Zvi Ben-Avraham[3]

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2. Geological Survey of Israel, Jerusalem, Israel
3. Department of Geophysics and Planetary Sciences, Tel Aviv University, Tel Aviv, Israel

The Northern Gulf of Eilat, part of the Red Sea-Dead Sea Transform, has high tectonic hazardous potential. This region is considered seismically active and most likely triggered sub-marine sediment collapse along the steep continental slope. We hypothesize past earthquakes left evidence as underwater mass flow sediment units (turbidites). These displaced sediments were identified using habitat-displaced foraminifera assemblages and analysis of their taphonomy. The specific aims of this study are: 1) to establish the reliability of symbiont bearing larger benthic foraminifera (LBF) as proxy for paleo-seismicity based on their known habitats and anomalous occurrence in displaced sediments; 2) to link the occurrence of displaced LBF and the timing of past earthquakes in the area; 3) to establish the connection between the LBFs taphonomic properties and the intensities and energy involved in their displacement.

This research is based on Holocene and modern sedimentary records extracted from the Gulf of Eilat floor (100-700m water depth). The following three cores were studied so far: 1) MG10P27 – 67cm long, taken from the lower part of the main canyon dissecting the northern slope at 532m water depth; 2) MG10P22 – 253cm long, take from the western slope at 316m water depth; 3) MG10P30 – 256cm long, taken down slope from the second core at 390m water depth. The homogeneous deep-sea fine sediments in the cores were disturbed by several units, a few cm thick, of coarser sediments suspected as displaced. Samples for radiocarbon dating were taken above and below the disturbed units. Dating result reveal two different accumulation patterns, as the first canyon core spans the last 2,500 years and the second core, taken from the western slope at 316m water depth, spans approximately 13,000 years.

Larger symbiont bearing benthic foraminiferal shells >150µm are hand-picked along the entire cores and more frequently above, within and below the disturbed units. The species that dominate the death assemblages in the first two cores are *Assilina ammonoides* and *Amphistegina* sp., mainly *A. papillosa,* when in the last core, *Elphidum jenseni* and *Elphidum cf E. limbatum* are most abundant. Shells size was measured (>1mm) as well as the degree of breakage (shell loss >50%) and the presence of yellowish color.

The microfaunal and taphonomic results were compared to the grain size (<2mm) analysis preformed on the cores (Kanari et al., 2012). The disturbed units are characterized by coarse grain size and show generally higher numerical abundance of LBF and poorer preservation compared to typical deep sea fine sediments micro-fauna. *Assilina ammonoides* and *Amphistegina papillosa* larger than 1mm appear in the disturbed sediments with the former ranging up to 5mm and comprising up to 70%, and the later up to 25% of the LBF assemblage. This, unlike their original habitat in the gulf that ranges between ~40 and ~120m, in accordance with their symbionts' light requirements. The disturbed units also contain up to 65% of severely broken shells, with more than 50% of the shell missing (figure 1). The large shell size and degree of breakage indicates that high energy is involved in the displacement. Furthermore, the disturbed units contain up to 40% of yellow-colored LBF shells (figure 1), as opposed to null in non-disturbed units and unlike living specimens that are of whitish color. Yellowish color is known to be associated with increasing burial time/depth.

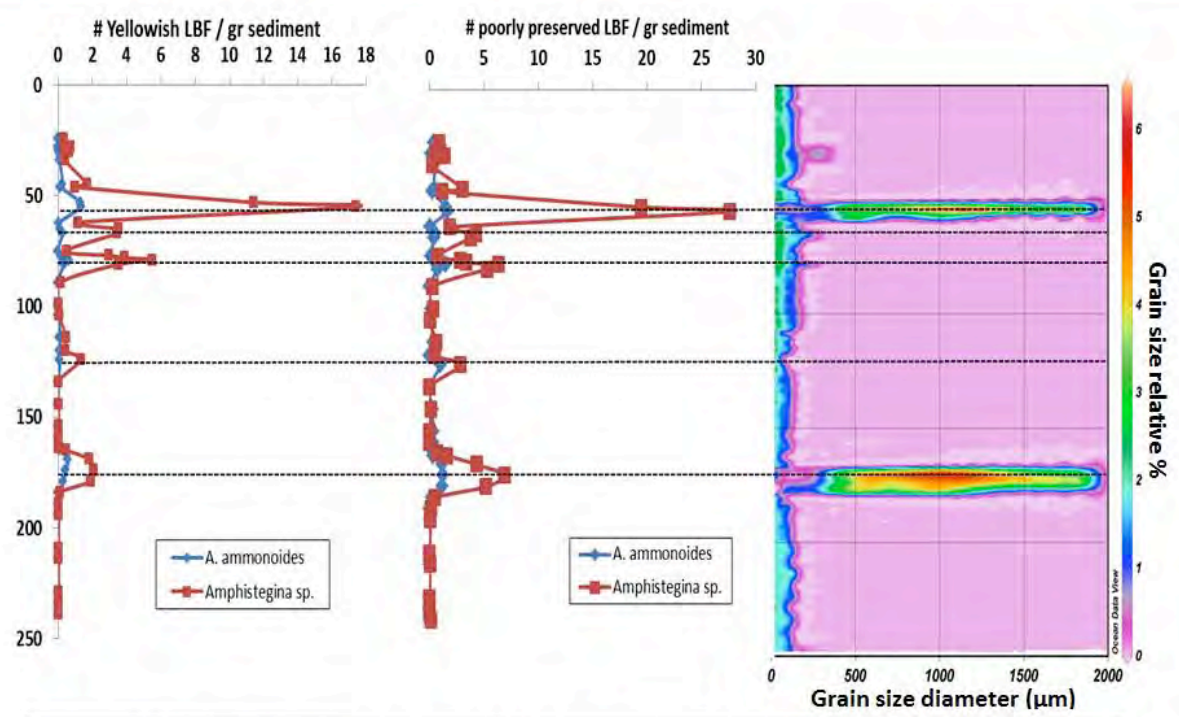

Fig. 1. MG10P22 number of yellowish LBF per gr sediment (left), number of poorly preserved LBF per gr sediment (center) and grain size results (right).

These results indicate the reliability of LBF as a paleo-seismicity proxy and suggest further lab work and data analysis that will shed light on turbidite dynamics, relative magnitudes and recurrence intervals of past mass-flow events and possible correlation with known earthquakes.

TAPHONOMY AND POST-DEPOSITIONAL MOVEMENTS OF A BRONZE AGE MASS GRAVE IN THE ARCHAEOLOGICAL SITE OF GROTTA DELLA MONACA (CALABRIA)

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Grotta della Monaca site is located in the Sant'Agata di Esaro place (Cosenza), in the north of Calabria region. This cave presents plentiful iron oxides and copper carbonates, which have been intensively extracted since very ancient times (about 6000 BP). The archaeological importance of this site is confirmed by the presence of an extended underground graveyard dated to the Middle Bronze Age (3500 BP). The skeletons have been inhumed in the most underground chambers of the cave, into niches and cracks of the walls. A mass grave (called "m5v") containing 24 individuals has been recently discovered in one of these niches. The skeletons have not been found in anatomic connection. They were in bad state of preservation for many taphonomic events: the passage of men during post-medieval times, the action of animals, the humidity of the cave that crumbled the human skeletal remains. During archaeological excavating it was not possible to identify any complete skeletons because they were dismembered and disorderly clamped. This work would present the state of preservation of human bones found in an underground archaeological context and the analysis of specific taphonomic traces: animal's traces of gnawing (furrows and scores), traces of animal's passage (trampling marks), wathering cracks (Fig. 1a-d). The anthropological analysis permitted to reconstruct each skeleton using the mass graves methods of reconstruction and provided information about taphonomic processes and movements involving the bones after tissues decomposition.

Concluding: (a) the sample of Grotta della Monaca was in bad state of preservation because of the repeated passage of men during different periods; (b) the action of animals in the cave and the humidity left evident taphonomic marks on the bones; (c) in m5v mass burial there were 24 individuals that have been inhumed in different times of the Middle Bronze Age. The ossicles of these skeletons slipped to the lower levels of archaeological deposit because the grave had not been filled with soil by Bronze Age people. The skeletons have been found superimposed and their position followed natural inclination of the burial place.

Fig. 1. a. Furrows. b, Scores. **c**. Trampling marks. d, Wathering cracks.

TOOTH WEAR IN CHIROPTERANS: THE CASE OF SALA DE LAS CHIMENEAS (MALTRAVIESO, CÁCERES, SPAIN)

Sandra Bañuls-Cardona, Juan Manuel López-García and Antoni Canals

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Maltravieso Cave is located in the city of Cáceres (Extremadura, Spain). Into this cave is found Sala de las Chimeneas, our studied area. The recovered records from the level A of the Sala de las Chimeneas consist mainly of lithic tools, faunal and ornamentals remains. The radiocarbon dates (14C AMS) have provided an absolute chronology of between 19500 to 18700 cal. BP and 19700 to 18750 cal. BP.

Coming from the level A of Sala de las Chimeneas have been identified 37 chiropterans remains: 7 pertaining to *Myotis myotis – blythii* and 27 to *Myotis bechsteinii*.

In this study we use the tooth wear methodology, that establish four categories of wear: (0) without wear, (1) slight wear, (2) cusps and crests worn, and (3) cusps and crests very worn (Fig.1).

The wear tooth study, allow us to observe that our remains contains only adult individuals, and that all of these display the three late wear levels identified in the individuals classified as *Myotis bechsteinii* and in those classified as *Myotis myotis-blythii*. This dental deformation may be caused for two types of wear, abrasion or attrition. The molars that we have classified as level 3 wear, could be due to attrition chiefly due to tooth-tooth contact, with the scratches caused by hard particles between the tooth surfaces. While the rest of levels of wear could be classified as intensity teeth abrasion, related to age or a hypocalcemia process.

Accordingly our results, the bats accumulation in the cave are not produced by a predator or predators as the rest of the small mammals association. The analysed wear tooth in bats dentition shows that this accumulation is produced by natural death, probably, during the hibernation in which the most adult individuals died.

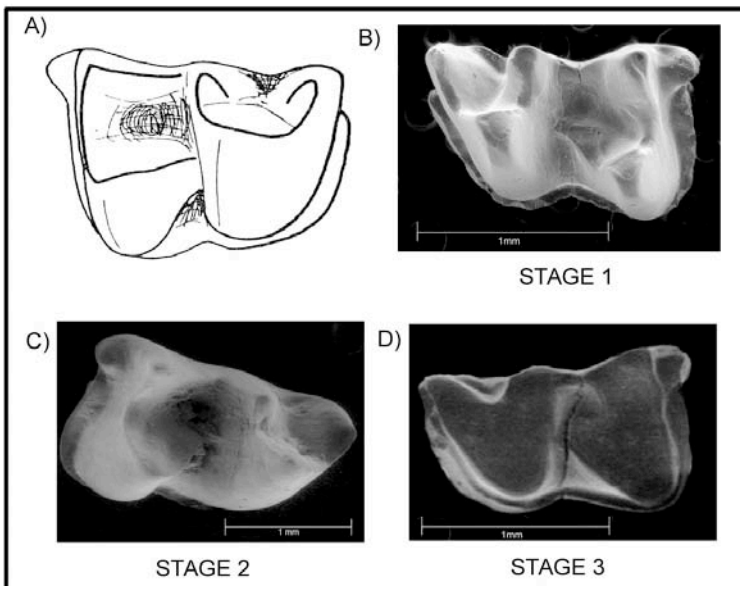

Fig. 1. Diagram of the different degrees of dental wear in the m1 of chiropterans from La Sala de las Chimeneas. A. Original morphology right m1 of Myotis. B. Left m1 of *Myotis bechsteinii*. C. Right m1 of *Myotis myotis-blythii*. D. Left m1 of *Myotis bechsteinii*. Scale 1mm.

ICHNOCOENOSIS IN PRESENT-DAY MACROID, ALGAL NODULE AND RHODOLITH BEDS (SW JAPAN, E AUSTRALIA, S SPAIN): PALAEOECOLOGICAL IMPLICATIONS

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Skeletal parts of organisms can be invaded by a range of biota before they become part of the fossil record. Skeletal hard substrates may host a range of organisms (e.g., serpulid worms, bryozoan colonies, crinoids, adherent foraminifera, algae, fungi, etc.). Here, we analyse ichnocoenosis in present-day macroid, algal nodule and rhodolith beds.

An ichnofacies is largely based on the trace fossil association in a particular lithofacies and related to a bathymetric gradient. Ichnodiversity and ichnodisparity distinguish the *EGTM* (*Entobia*, *Gastrochaenolites*, *Trypanites*, *Maeandropolydora*) ichnofacies and the *TM* (*Trypanites*, *Maeandropolydora*) ichnofacies, both characterised by boring traces. The ichnofacies are assessed in terms of (1) the nature of the substrate and its preservation, and (2) the fossil traces made by boring organisms during the host's life and eventually just after its death. The studied beds, from shallow (*ca*. 2.5 m) to deep (*ca*. 117 m) marine settings, are located in: southwestern Japan (Central Ryukyu Islands), eastern Australia (Fraser Island) and Southern Spain (Cabo de Gata).

The two ichnofacies have in common the process of fabrication, ethology of producers, macroid/algal nodule/rhodolith shape, and acervulinid and coralline growth rates. In contrast, they differ in macroid/algal nodule/rhodolith size, coralline thallial thickness, and nature of sediment substrate.

We suggest that macroid/algal nodule/rhodolith size and growth pattern are likely the key factors governing the preferential settlement and growth of calcareous epilithobionts/endoliths. The distinguished ichnofabric designs (tiering patterns) show that bioerosion is highest where the substrate surface (i.e., macroid/algal nodule/rhodolith) suitable for colonization of epilithobionts/endoliths consists of even foraminiferal/algal growth forms. Fruticose coralline growth forms hamper colonization by boring organisms.

The *EGTM* ichnofacies shows a higher ichnodiversity and ichnodisparity than the *TM* ichnofacies suggesting a more diversified benthic assemblage of bioeroding organisms in those macroid/algal nodule/rhodolith beds. In the *TM* ichnofacies bioerosion and carbonate accretion are slow and epibenthic/endolithic communities take years to mature.

TAPHONOMICAL ANALYSIS ON FAUNAL REMAINS FROM GROTTA REALI (ISERNIA, SOUTHERN ITALY)

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The site of Grotta Reali (Rocchetta al Volturno, Isernia) is located in the high-hilly area of the Abruzzo-Molise Apennines, a few kilometers from the Volturno springs. The cave, today partially modified by old quarry works, is part of a system of karst phenomena affecting a platform of calcareous tufa outcropping in the area, arranged in the form of plans and cliffs, that document an ancient lake-cascade system. The archaeological deposit, discovered in 2001, has been object of systematic investigation until 2007 directed by the formerly Department of Biology and Evolution of the University of Ferrara in collaboration with the Soprintendenza archeologica del Molise.

The stratigraphic sequence has a thickness of about two meters and consists of 7 main depositional units, with a sub-horizontal stratification.

Within the sequence two main anthropic levels (US 5 and US 2β), alternating with sterile levels made up of silt and fitoclastic sands deposited by the waters that overflowed from the threshold of the waterfall, have been recognized.

The archaeological levels - defined by abundant lithic fragments, faunal remains and hearths - fall into two distinct moments of occupation attributed to an interstadial phase of MIS 3, dated between 45 and 34 Ky BP uncalibrated C14.

The faunal assemblage is composed of 16,265 fragments, 97% of which are unidentifiable. The high fragmentation degree of the assemblage is related to the action of many taphonomic agents that have modified the bone surfaces throughout the stratigraphic sequence. The taphonomical analysis was carried out using a stereomicroscope Leica S6D (6-40 x) with integrated camera EC3.

Weathering cracks, exfoliation and concretions are the main edaphic modifications that altered the bone surfaces. Some bone fragments present smoothed fracture edges that may be attributed to the water percolation restart after the anthropic frequentation. To this phenomenon the presence of calcareous concretions related to the travertine formation can be associated too.

Carnivores marks are particularly abundant in the upper part of the stratigraphic sequence (SSUU 1, 2 abc). Furrows, scores and pits have been often identified on diaphyseal portions and less on the epiphysis. In these layers digested bone fragments are particularly frequent, indicating the occupation of the cave by carnivores, after the departure of Neandertals groups.

Anthropic activities were mostly detected on unidentified diaphyseal fragments, that bear insistent repeated cutmarks produced by the recovery of the meat, the detachment of muscle mass and skin. The lack of disarticulation traces is probably due to the absence of epiphyseal portions in the sample.

DEEP-SEA CORAL GRAVEYARDS FROM ORPHAN KNOLL AND FLEMISH CAP, OFFSHORE EASTERN CANADA: TAPHONOMIC PROCESSES AND RATES IN A LOW SEDIMENTATION ENVIRONMENT

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Modern deep sea coral graveyards are time-averaged accumulations of subfossil corals are exposed at the sediment surface in the deep sea. Coral graveyards provide a rare opportunity to evaluate bioclast degradation in a deep-water low sedimentation rate environment, in which the exposure time of each coral can be determined by radiometric dating. The aim of this study is to characterize the degradation processes and rates of subfossil *Desmophyllum dianthus* solitary stony corals collected from two deep-sea graveyards at Orphan Knoll and Flemish cap, off the coast of Newfoundland. We used radiocarbon and Uranium-series method to date 145 samples; subfossil coral sample ages ranged from Late Holocene (< 1000 y) to MIS 7 (181 ky), and were dominantly from interglacial intervals. Encrustation and breakage were more important on samples between one thousand and two thousand years old. Macro-boring was very important for samples older than 5 000 years old. Loss of skeletal detail, mainly driven by microboring, was most important for the older samples. Macro-bioerosion and loss of detail were both positively correlated with sample age. We observed a saturation of each taphonomic parameters' value. Breakage and encrustation reached the saturation value sooner than macro-boring and loss of details. Macro-boring and loss of detail remove the record of encrustation and breakage, making these parameters appear to decline in intensity in very old samples. The saturation of taphonomic signal was explained by the prolonged residence time of the specimens at the water sediment interface. Although the taphonomic processes observed were similar to those seen in shallow water carbonate environments, the processes occurred at rates several orders of magnitude slower than in shallow water. The apparent absence of repetitive burial and exhumation events in these deep water environments allow more continuous taphonomic alteration and a stronger relationship between taphonomic degradation and sample age than observed in many shallow water environments.

CONSTRUCTIONAL EFFECTS ON FOSSIL PRESERVATION. THE CASE OF "MACCHERONE" CORALLINE ALGAE

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Variations in microarchitecture imply differential susceptibility to taphonomic processes of dissimilar parts within a single skeleton. Coralline algae with protuberances in their thalli are common and instructive examples of constructional effects on fossil preservation. The body (thallus) of non-geniculate coralline algae is a coherent mass of branching cell filaments. All vegetative cells, except the epithallial ones at the tip of each filament are enclosed by a High-Mg calcite wall. Filament growth, and subsequent lateral expansion and increase in thickness of thallus, is achieved by repeated division of the cell immediately underneath the epithallial one. Many extant and extinct species of coralline algae possess protuberances in their thalli. Protuberances occur both on the dorsal surface of algae that grow attached to a rigid substrate and in unattached specimens living on loose sediment. In either case, protuberances develop due to a higher growth rate of filaments in their center. In each growth step, the cells formed below the epithallial cells at the protuberance apex are longer than coeval cells at the protuberance sides. The length of the newly added cells decreases radially outwards from the protuberance tip. Consequently, central cells in protuberances are generally longer than lateral ones. Calcite walls of central, longer cells are thinner and less dense than those of lateral cells and more susceptible to dissolution during fossilization. As a result, dead and fossil coralline algae with protuberance centers partially or totally dissolved are relatively common. In these cases, protuberances occur as structures with an empty or vuggy central part and well-preserved sides. This "maccherone"-like preservation of coralline algae is particularly common in Cenozoic maerl deposits, mainly formed by accumulations of unattached branching coralline thalli.

NEW EVIDENCE OF INTERACTION BETWEEN NEANDERTAL AND CAVE BEAR DURING MIDDLE PALAEOLITHIC IN NORTH ITALY (BORGOSESIA, VC)

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The Ciota Ciara cave is located in the karst of Monte Fenera (Borgosesia - VC) and is the only Middle Palaeolithic site in Piedmont where the presence of *Homo neanderthalensis* has been attested. In 2009, systematic excavations at the Ciota Ciara cave were reintroduced once again by the University of Ferrara in collaboration with the *Soprintendenza per i Beni Archeologici del Piemonte e del Museo di Antichità Egizie*. The archaeological interventions have been carried out systematically and with a multidisciplinary approach. After a restoration of the previous excavations, the new researches shown 4 stratigraphic units: 13, 103,14 and 15. The small mammal association from Ciota Ciara cave (S.U. 13, 103 and 14) gives some information about the environment that surrounded the site and made it possible to establish the chronology of the site in a temperate-humid period of MIS 5 (80-70 ka). The whole of the faunal remains studied until now demonstrated a strong predominance of *Ursus spelaeus* in all the units while an increase of skeletal component of herbivorous is attested in the stratigraphic sequence going from S.U. 13 to S.U. 14. The environment was characterized by deciduous woodland and, probably at the base of the mountain, by glades. The intersection between different habitats, the presence of lithic raw materials and water sources were the main factors that certainly favored the human occupation during the Upper Pleistocene.

The lithic assemblage is composed by flakes, retouched tools, cores and *debris*. The exploitation of the raw materials was achieved through the direct percussion technique with varied methods: S.S.D.A., discoid and Levallois. Many lithologies are represented in different proportion: quartz is the prevalent used raw material, followed by spongolite, sandstone, mylonite and opal. The archaeological record is constituted by many typologies of quartz: macrocrystalline pegmatitic quartz, microcrystalline pegmatitic quartz and hyaline quartz. The reduction sequences on quartz are complete although no refitting was found as a result of the characteristics of this raw material. The reduction sequence is not complete for most part of the other raw materials. The *débitage* products are small or middle size (1-4 cm) and have different morphologies.

A preliminary taphonomic study has been performed on a portion of the palaeontological remains from the SU 14 (1144 bones). To test the efficiency of the tools made by local quartz during the slaughtering activity, was performed an experimental butchery on a carcass of wild boar. During the experimentation, tools made by local quartz and instruments made by allochthonous flint have been employed. The analysis of this experimental collection allowed us to distinguish with certainty the cut-marks made by quartz tools from those made by flint tools. The same kind of quartz cut-marks have been found on the archaeological faunal remains from the Ciota Ciara cave.

The presence of cut-marks on *Ursus spelaeus*, made by lithic instruments, has been attested. The position of the cut marks on the bones can be related to fur removal and butchery. The osteological remains where were encountered evidence of cut-marks on *Ursus spelaeus* are portions of the appendicular and axial skeleton and specifically on: atlas, thoracic vertebra, ribs, humerus, radius, tibia and scapholunar.

The data coming from the Ciota Ciara and from other European sites like Scladina Cave (Belgium) help us to clarify the interactions between *Homo neanderthalensis* and *Ursus spelaeus*. According to these evidences the traditional and widespread hypothesis of seasonal alternation in the use of the cave, with no interaction between man and bear, must be revised.

ESTONIRHYNCHIA ESTONICA: TAPHONOMY, DEFORMATION PATTERNS, PALEOECOLOGY, GEOCHEMISTRY, FUNCTIONAL MORPHOLOGY AND EVOLUTIONARY TRACTS INSIDE SUPERFAMILY UNCINULOIDEA (BRACHIOPODA)

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We examined more than 700 specimens of *Estonirhynchia estonica* coming from 24 localities from Silurian (from Adavere to Paadla stage, Llandovery *p.p.* to Ludlow *p.p.*) of Estonia, plus other uncinuloids (mostly also from Silurian Baltoscandian paleobasin). The study favored the identification of several morphotypes (distinguishable on the base of outline shape, ribs number width and length, umbo and foramen morphology) proofing a high phenotypic plasticity in *E.estonica*. The same is deducible from literature for its strict relatives *Plagiorhyncha* and *Spherirhynchia*, also found in the Silurian of the Baltoscandian paleobasin but in different temporal and facies setting.

A distinctive taphonomic aspect of *Estonirhynchia* is a widespread evident to strong plastic deformation mostly localized in the anterior area. Additionally, dependent on age and locality, we also recorded breakage, dislocation, shell dissolution and/or replacement, shell perforations associated to pyrite crystal growth. Encrusting epifauna (cornulitids, bryozoans, brachiopods, *Allonema sp.*) is rare and mostly localized in the anterior area, suggesting commensal relationship. Deformation pattern and distribution of epifauna, together with other anatomical features (in particular the commonly atrophied peduncle), suggests that: a) most of specimens was subject to an early diagenetic plastic deformation in life position in course of sediment compaction; b) *E.estonica* changed its life style during ontogenesis from benthic to semi-infaunal, as already suggested for its relative *Spherirhynchia*.

E.estonica flourishing during Early Sheinwoodian stable isotopic (C and O) positive excursion (Ireviken event) recorded in Paramaja outcrop, during in a sea level transgressive phase, proof as this specie was able to thrive in “peculiar” ecological environment.

Considering Silurian Baltoscandian basin sea level evolution and features of uncinuloids there found, we suggest that this group gradually moved to the shallow-water environments, i.e. from relatively deep sea *Plagiorhyncha* (flatter and smooth) to the shallower *Estonirhynchia* (spherical, more ribbed, partially smooth), and then to *Spherirhynchia* (spheroidal, fully ribbed, geniculation and spines) adapted to high-energy environments. The evolutionary trend will continue with the Devonian Uncinulidae which will develop also the squama-glotta structure to seal the sunken part of the shell.

High phenotypic plasticity (so as blooming during transgressive sea level and stable isotopic positive excursion) of *Plagiorhyncha-Estonirhynchia-Spherirhynchia* lineage resembles that one of *Apringia-Soaresirhynchia-Stolmorhynchia* (Early Jurassic) within Basiliolidae (Permian-recent). This suggest that fast evolution and morphological adaptation to new colonized environments (phenotypic plasticity) may represent one of the determinant factors which favored rhynchonellids survival until today.

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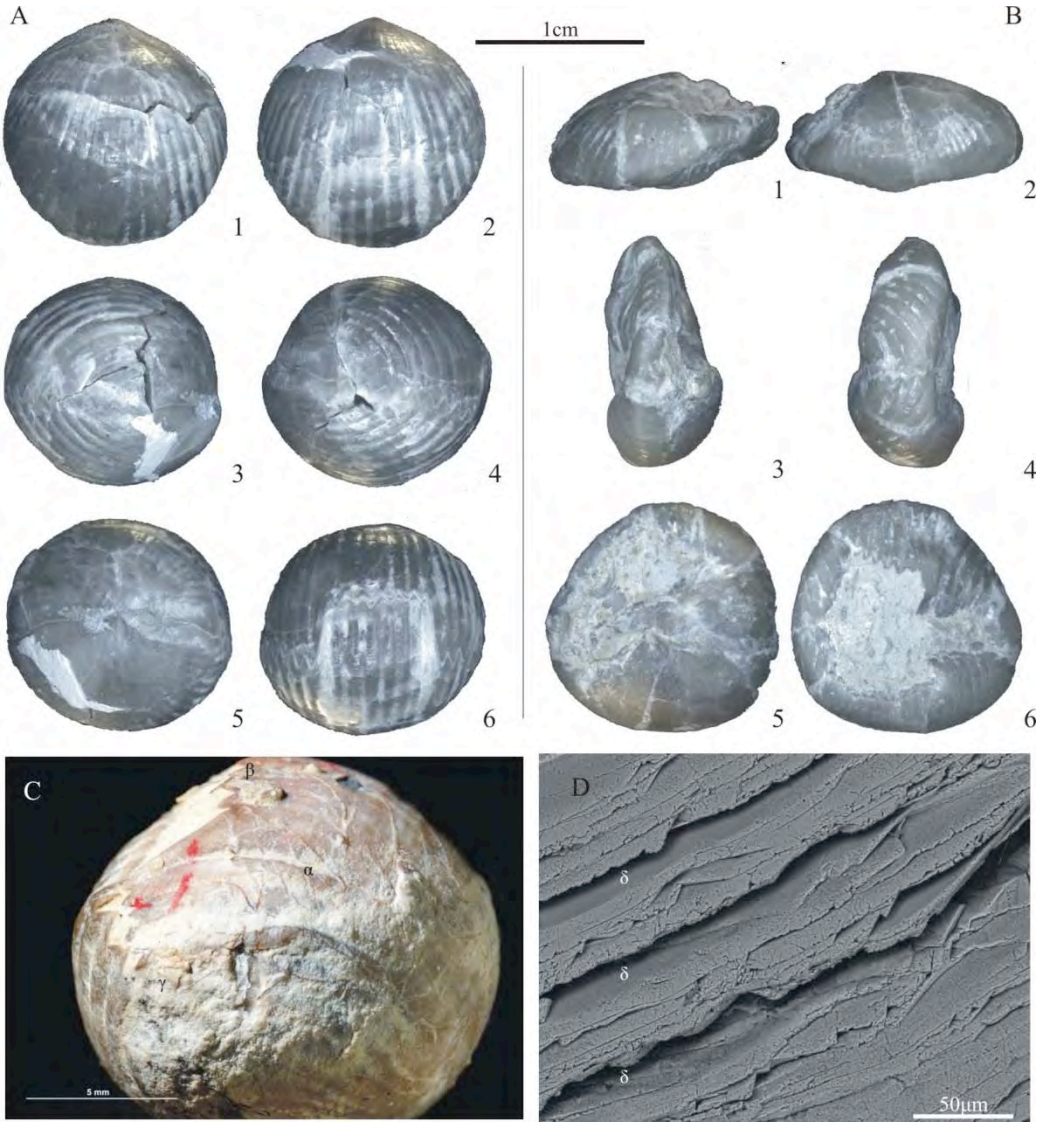

Fig. 1. *E. estonica* from Paramaja (Jaani stage, Paramaja mb.). A,B) showing different degree of deformation. Both specimens (A: sp. ELM008 ; B: sp. ELM004) respectively in brachial (1), pedicular (2), sx lateral (3), dx lateral (4), posterior (5) and anterior (6) view; C) Epifauna, sp. 700-222-4 (note that bryozoans (β), cornulitid (γ) and *Allonema sp.* (α) are on frontal/anterior area); D) secondary layer ultrastructure at SEM, sp. PRM.C.22 (note the detachments surfaces (δ)).

BRACHIOPOD GEOCHEMISTRY: NEW INFORMATION FOR THE PALEOZOIC OF ESTONIA

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In this study we report new data on $\delta^{13}C_{shell}$ and $\delta^{18}O_{shell}$ (calcitic brachiopods, trilobites, corals), coupled with correspondent analyses of rock matrix ($\delta^{13}C_{rock}$), from Ordovician and Silurian of Estonia. Due to low resolution, most of the second-order stable carbon isotopic excursions, except for the Ireviken Event, are not well reflected in the new $\delta^{13}C_{rock}$ and $\delta^{13}C_{brach.}$ data. More interesting are the results from $\delta^{18}O_{brach.}$ values. Most of the Ordovician values are generally higher than those reported in literature from other brachiopod data (especially from Laurentia and Southern China blocks). Silurian values (lower Sheinwoodian, upper Ludfordian, Pridoli) are similar to those reported for Gotland. Taking into account that $\delta^{18}O$ is susceptible to various other environmental changes, interpreting those values in terms of paleotemperatures may suggest the following: a) Katian high values support a cooling suggested by the Katian $\delta^{13}C_{rock}$ isotope excursions; b) Ordovician values point out a thermal latitudinal gradient when compared with those from Laurentia, which is in agreement with paleogeography and brachiopod paleobioprovinces; c) during Silurian the isotopic values tend to be similar to those from Laurentia, which is also compatible with northward drifting of Baltica paleocontinent. Additionally, direct comparisons from specimens from same beds show that $\delta^{13}C_{brach}$ is almost always heavier than $\delta^{13}C_{rock}$ (so as supported by literature). Tests with trilobites and corals show that $\delta^{13}C$ and $\delta^{18}O$ values are in a similar range to those obtained from brachiopods. Finally we will present additional data about sulphur isotopes ($\delta^{34}S_{brach}$). Fossil phosphatic shelled (lingulate) brachiopods, instead, show a variation in the apatite chemistry along shell lamination and their direct use for isotopic analyses should be handled with care. Infrared (ATR FT-IR) and energy dispersive spectroscopic (EDS) mapping of the cross sections of Furongian lingulate brachiopod *Ungula ingrica* shells show that the apatite in porous baculate laminae differs from the apatite in compact laminae mainly by its higher carbonate anion and fluorine contents. Less pronounced differences appear also in the relative contents of various cations (Ca, Na, Mg). Additional crystallographic investigation with electron backscatter diffraction (EBSD) and electron probe microanalysis (EPMA) on the cross sections of calcitic brachiopods is currently in progress to investigate further their preservation, and to assess the influence of crystallography on Mg^{2+} concentration and distribution in brachiopods calcite bio-minerals (with implications for Mg/Ca thermometry and for “vital effect”).

LATE CRETACEOS ICHTYOFAUNA IN NORTHEAST MEXICO: A MICROSTRUCTURAL ANALYSIS

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Marine fossil fish from Turonian age are well exposed in the area of Vallecillo, Nuevo León, within the Agua Nueva Formation in northeastern Mexico. Informally known as "the Vallecillo fish Member", this sequence of shale-interbedded marlstones is characterized by the presence of occasional goethite nodules and the absence of bioturbation and other trace fossils. Abundant fossil fish and a few other vertebrates, as well as some invertebrates such as pteriomorphian bivalves and ammonites, and microfossils of planktonic foraminifera are preserved *in situ* within laminated marlstones. Until now, the biota of Vallecillos consists of approximatelly 400 exemplars, most of them fishes, but also including ammonites, inoceramids and even some marine turtles. The fossil ichtyofauna documented in the few studies from this locality have reported a diverse fossil fish assemblage dominated by the presence of osteichthyan fish such as Pycnodontiformes, Pachycormiformes, Ichthyodectiformes, Dercetidae, Pachyrhizodontidae, and Tselfatiidae among others, with the occasional presence of some fossil chondrichthyans. These previos wok on this locality have suggested that Vallecillos represents the outer part of a shallow marine shelf under stagnant conditions as the most probable paleonvironmental setting, with anoxic-dysoxic conditions where massive fossilization was possible. In this work we report the occurrence of fossil specimens newly added to the existing inventory, and a detailed petrographic and geochemical analysis of the microstructure as key taphonomic elements important for paleontological interpretation. Among the most significant but preliminary results is the high iridium content found in some fossil fish from Vallecillos and its probable implications in the context of the K/T event.

QUANTITATIVE TAPHONOMY AND EXCEPTIONAL FOSSIL PRESERVATION STYLES OF THE UPPER KIMMERIDGIAN WATTENDORF PLATTENKALK LAGERSTÄTTE (SOUTHERN GERMANY)

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Plattenkalk lagerstätten represent unique windows into ancient palaeobiodiversity due to the exceptional preservation of their fossil biota. This preservation is dependent on special environmental conditions, which are oftentimes obscured by the lack of sedimentary structures and other palaeoenvironmental proxies. By utilisation of qualitative as well as quantitative taphonomic analyses, the palaeoenvironmental data hidden in these lagerstätten can be unlocked. The Wattendorf Plattenkalk, the oldest of the Solnhofen-type Plattenkalks of Southern Germany, allows qualitative and quantitative taphonomic investigations, because every bedding plane of the 20 cm thick Plattenkalk-unit has been equally thoroughly searched for fossils over a time span of eleven years. The data was obtained from fossil neopterygian fishes because of their abundance and multi-jointed internal skeletons and scale envelopes, which make carcasses prone to modification by environmental agents. For the quantitative taphonomic analysis, hierarchically arranged, comparable taphonomic features have been processed. These features were: bending of the spinal column, dissociation of articulated extremities from the trunk (completeness) and overall skeletal articulation. By clustering combinations of the different biostratinomic features per layer four distinct taphofacies (taphofacies A to D) could be established.

These taphofacies indicate four energy regimes represented in the depositional environment of the Wattendorf Plattenkalk. The transition from taphofacies A to taphofacies D marks a development from only slight environmental disturbance to conditions of higher disturbance affecting the fish carcasses.

With regard to qualitative taphonomy, the Wattendorf Plattenkalk has so far yielded three distinct modes of soft tissue preservation. In some fish fossils, connective tissues preserved as francolite can be observed. Besides this phosphatic permineralization, there is also evidence of soft tissue preservation via pyritization. The third type of soft tissue preservation is impregnation of internal voids in bones left by osteocytes and blood vessels by amorphic pyrite precursor minerals.

A combination of these findings, together with geochemical proxies, allows the reconstruction of a restricted depositional environment that exhibited stable environmental conditions with widespread anoxia in a subtropical palaeoclimate at the beginning of Plattenkalk deposition. Towards the end of deposition, palaeoenvironmental conditions started to fluctuate. Strong perturbations in fossil fish preservation were induced by bottom-water currents and mixing of the water column, initiated by strong storms which also induced oxygenated waters to the bottom of the otherwise inhospitable basin, allowing for a unique kind of soft-tissue preservation.

TAPHONOMY AND MUSEUM

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Natural Science Museums are emblematic institutions in scientific investigation. These were developed during XIX century, along with the exploration of the world. In that century, material culture and fossils from New World were relocated in different European museums. South American native fauna was one of the most required fossils objects because of the unique forms these animals had had. Nowadays, they can be found in museums from Spain, Italy, Switzerland, Germany and even Denmark. This material was extracted mostly from Pampean and Patagonian region, in Argentina during 19th century and the first decades from 20th century. The excavation procedure used in those days distance from what it was established latter. No registrations of the stratigraphy, context or associations were done.

It is considered that this material has original information that can be extracted with new methodologies and incorporate into modern studies. In the investigation developed by the author, anthropic marks are search in order to understand the colonization or modification of native niches in first American peopling. Thus, a taphonomical analytical procedure is necessary in order to interpret the different agents that affected these bones.

With the intention of systematize the data that can be extracted from these collections, museums (and the related excavation activities) have to be seen as a post burial disturbance factor in two ways. First of all, materials housed in museums are generally a selection of skeletal parts and specimens required in those times. In this way, they are a biased sample that lost their nearest information context. But they inform at a regional level, since most of the collections have the locality provenance (Fig. 1, part 1). Taphonomy can be useful in order to detect natural agencies that acted at a large scale resolution. In this way, general ecological past conditions of the fossil samples formation can be reconstructed. This focus is comparable with distributional archaeology that gives importance to surface material. In these cases associations and contexts are also lost, and what it is found reflexes the activity of natural forces that acted at the surroundings.

On the other side, museums are post burial agents since manipulation or restoration of the bones can add anthropic marks. In this sense, an historical view is necessary in order to analyze the skeletal elements. Through this way, the succession of the agents that affected the surface can be establish (Figure 1, part 2). Taphonomy helps to detect when natural and anthropic agents affected the bones: before burial, after burial or during excavations or when the material was store in the museum. Only when anthropic marks are detected before the development of natural agents, it can be interpret that hunting or scavenging activities were developed. If not they can be the result of manipulation and restoration activities or even the reuse of the material in the past.

In this way, taphonomy contributes to diminish the post depositional bias of samples from museums and to interpret the information they contain. This is a novel axis of investigation that is being developed in order to incorporate nineteenth collection into new studies.

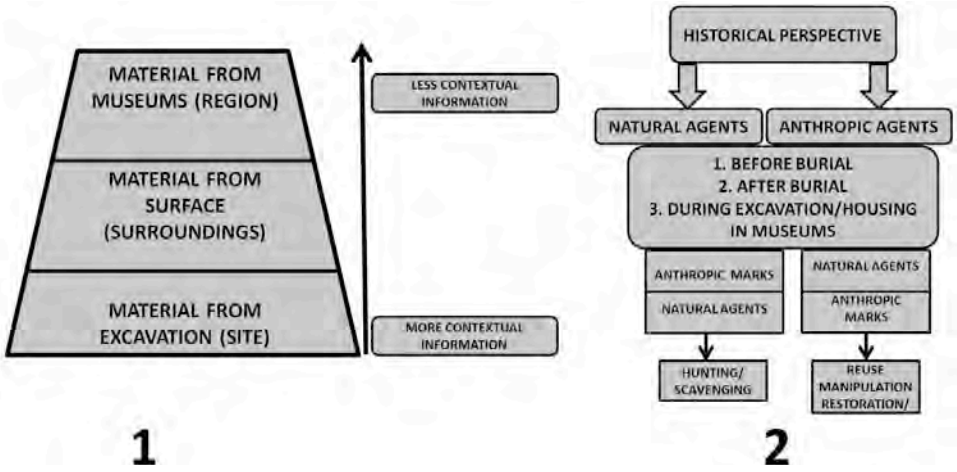

Fig. 1. Museums as post burial agent. (1) Consideration of the context within museums samples. (2) Historical perspective in order to detect cut marks related with hunting or scavenging activities

TAPHONOMY OF A CAMPANIAN VERTEBRATE-BEARING LOCALITY IN SOUTHEASTERN FRANCE

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The Velaux-la Bastide Neuve fossil-bearing site, located in southeastern France (Bouches-du-Rhône) has yielded a diversified vertebrate assemblage. Since 1992 and the discovery of the fossils, three major field campaigns yielded dozens of vertebrate remains (dinosaur, turtle, crocodile, hybodont shark and pterosaur) in the same area. Biostratigraphical studies on dinosaur eggs and charophytes roughly suggest a late Campanian age for this locality. A new taxon of dinosaur, *Atsinganosaurus velauciensis*, was described from this site. Our objective is to combine several sedimentological and paleontological methods, in order to reconstruct the paleoenvironment of this site and the taphonomy of the fossils.

We observed three main vertebrate bonebeds; bones are particularly abundant in the coarsest facies, while few remains were found in the finest'. Most of fossils were found disarticulated and dispersed, except a partially articulated titanosaur skeleton. Predation marks are rare, indicating a low incidence of scavenging in the locality. The transport was rather short, as proved by sharp bone edges. Observation of bone surface suggests that carcasses were not exposed subaerially for a long time and were quickly buried. The vertebrate assemblage of Velaux represents a mixture of animals that originated from different habitats.

Lithological and taphonomic studies, associated with microfacies and palynofacies analyses, indicate a fluvial paleoenvironment, not particularly powerful, with large floodplain and meandering rivers for Velaux-la Bastide Neuve. The fluvial system transported and accumulated vertebrate remains, together with reworked Aptian sediments.

EVALUATING THE IMPACT OF *CLADOCORA CAESPITOSA* ASSOCIATION IN THE TAPHONOMIC CONDITION OF FORAMINIFERAL ASSEMBLAGE FROM THE VELIKO JEZERO SEDIMENTS (MLJET IS., ADRIATIC SEA)

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The taphonomic conditions of foraminiferal tests from shallow-water environments are the result of multiple taphonomic processes caused by the age of the sediments, sedimentary processes, depositional environment and burial history. The most important taphonomic processes affecting the composition of shallow, benthic foraminiferal assemblages are transport and destruction of tests. To evaluate these effects, we analyzed surface sediment samples collected at the *Cladocora caespitosa* bank in Veliko jezero, Island of Mljet, Adriatic Sea. The *C. caespitosa* bank ranges from depths of 6–18 m and covers an area of 650 m^2, forming one of the largest banks of *C. caespitosa* found in the Mediterranean Sea. Veliko jezero is a karstic depression filled with saline water, connected to the open sea through a shallow, narrow channel, characterized by microtidal amplitudes and restricted anthropogenic influence, while meteorological effects (surge, caused by wind and barometric pressure) are rare. Hand samples were collected by scuba diving at different water depths. In 2012 samples were recovered from 5 sites (7, 11, 12, 14 and 16 m of water depth; 42^0 46 0'N, 17^0 22 8'E), while in 2005, samples were taken only at 16 m water depth. Grain size analysis of the sediments (Folk, 1959) showed that the structure of the samples at 7, 11 and 12 m consist of sand while samples at 14 and 16 m are classified as slightly gravelly sand. The total foraminiferal assemblages (including both living and dead) were assessed, following standard procedure for foraminiferal analysis. The studied foraminiferal assemblages are low to moderately diverse. Shannon-Wiener index values obtained in this study are consistent with those typical of marginal marine environments (Murray, 2006). All samples from 2012 are characterized by dominance of three genera: *Peneroplis (P. pertosus*, *P. planatus* making up from 51 to 64% of the total assemblage)*, Elphidium (E. crispum* varying from 18 to 30% of the total assemblage) and *Quinqueloculina* (reaching a maximum proportion of 12%). The dominant taphonomic characteristics of the assemblages include high fragmentation, high abundance of coloured tests (reworked) and low corrosion. According to taphonomic modifications, all types are classified into six groups: pristine tests, tests with the youngest whorl exfoliated, broken tests (a great portion of test is missing, but genus is still possible to define), tests with minor physical damages on the last chamber wall, abraded and coloured tests (yellowish or blackish). The *Elphidium crispum* population has a great proportion of pristine tests in all studied samples except from samples collected at 12 m. Broken tests are most common at the shallowest depth and coloured tests were very rare. By contrast, the tests of representatives of *Peneroplis* are coloured, either yellowish or blackish. The blackish tests dominate at shallower samples (57% of the population at sample from 7 m water depth), while yellowish tests are more common at greater depths (reaching up to 43% of the population in samples from 12 m of water depth). A low proportion of tests are well preserved. Broken and coloured tests of *Quinqueloculina* sp. show uniform distribution at all studied samples. The assemblage collected in 2005 at 16 m depth, apart for having lower species richness and diversity indices, shows a better preserved foraminiferal assemblage. In this well preserved assemblage, only broken *Elphidium* tests have been recorded. Our analysis shows a complex relationship between taphonomic modification of tests and water depth. Well preserved *Elphidium* tests representing about 80% of the population are found in the deepest sample (gravely sands) and in samples from 12 m water depth abraded tests prevail (61%). Strong domination of

peneroplids seems to be related to *Cladocora* rubbly substrate, reflecting biological preferences of species. Robust tests of *P. pertusus* are abundant in deeper settings down to 16 m depth, and flat forms of *P. planatus* prefer shallow water settings. Clinging to small filamentous macroalgae, in almost vertical position with the aperture face turned toward algal filaments, these “purple gardeners” are successfully hiding from strong wave breakers as well as dwelling in geographically confined areas where bank construction offers somewhat protected areas. The studied assemblages are para-autochthonous, and taphonomic modifications observed are transport of tests from life position due to storms and tidal currents. Comparison with the previous study, conducted in 2005, revealed that along with expansion of the bank, the overall foraminiferal diversity increased, arenaceous (*Textularia* sp., *Ammodicus* sp.) and planktonic species (making up to 25% of the total assemblage) disappeared, and peneroplids flourished and dominated the assemblage.

TAPHONOMY OF BADENIAN OYSTERS FROM THE CARPATHIAN FOREDEEP IN CZECH REPUBLIC: PRELIMINARY RESULTS

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The oyster samples coming from Carpathian Foredeep in Moravia, Czech Republic (CF) were studied in museum collections (Vlastivědné Muzeum of Olomouc and Muzeum Prostějovska of Prostějov). The most representative localities are Luleč, Slatinky, Laškov, Hluchov and Myslejovice. More than 20 oyster species occur within the museum samples, but mostly with an obsolete or incorrect nomenclature, therefore the revision of the material was necessary in the first phase of this work.

The revised oysters are mostly represented by: *Crassostrea gryphoides*, *Hyotissa hyotis*, *Neopycnodonte navicularis*, *Ostrea crassicostata*, *Ostrea lamellosa*, *Ostrea* cf. *fimbriata*, *Ostrea* spp..

Crassostrea gryphoides dominates the assemblage as taxon most abundant; for the Neogene outcrops, very abundant oyster accumulations with large shells of *Crassostrea gryphoides* are mentioned in the literature (Harzhauser et al., 2003; Hoşgör, 2008; Gramigna et al., 2008). After Jimenez et al. (1991), in the past, *Crassostrea* banks developed basinward of coral reefs, very different from actual style of life, in shallow-intertidal to shallow sea water with lowered salinity.

The oyster shells keep a good state of preservation, favored by the resistance to diagenetic processes, in particular way in the larger size oysters. The alterations are more evident along the margins of the valves and along the areas affected by bioerosional traces. The presence of ichnogenera is brought out especially by *Entobia*, *Caulostrepsis*, *Meandropolydora*, *Gastrochaenolites* (boring ichnotaxa) and by barnacles, sponges, bryozoans, worms, gastropods and bivalves (encrusting organisms). These organisms have affected the oysters, highlighting structures and furrows along the entire extension of their shells with reticular, channel shaped and punctuate structures. *Entobia* is the most widespread (~45%) in all the samples compared to the other ichnogenera, which probably took turns in different life cycles of the oysters (pre- and post-mortem); this activity could indicate several reworking episodes, related to burial and exhumation.

ENGRAVINGS OR NATURAL MARKS? THE CASE OF THE PEBBLES FROM THE EPIGRAVETTIAN LAYERS OF GROTTA DEL MEZZOGIORNO (POSITANO, CAMPANIA, SOUTH-WESTERN ITALY)

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Grotta del Mezzogiorno is a coastal Palaeolithic site, located in the Costiera Amalfitana (Positano, Campania, South-Western Italy.

The cave is situated at the base of Lattari Mountains (at 80 m asl), directly overlooking the sea. This is an area characterized by carbonate promontories rising more than 1400 m, which steeply descend into the Tyrrhenian sea and form vertical cliffs and narrow valleys.

The archaeological excavations of the site were carried out between 1966 and 1968 by the University of Pisa on a surface area of approximately 25 m^2, under the scientific supervision of A.M. Radmilli. The sedimentary sequence (about 2,5 m thick) was subdivided in 23 levels, not always corresponding to stratigraphic layers, that testify a long-term human occupation that spans from the Final Pleistocene to the Early Holocene.

The prehistoric sequence can be divided in two archaeological units belonging to the Epigravettian: the uppermost (from level 4 to 9) and the lowermost (from level 11 to 23) that are separated by a volcanic layer (level 10).

The presence of this volcanic layer (0,30 m thick) is extended on the whole surface of excavation and allows to assign an excellent stratigraphic reliability to the analysed evidences coming from the levels of the lower unit. Available radiometric data were obtained in the 1970s and seems to be quite contradictory, ranging from 7540±135 BP (level 4, 14-C cal BP 8344±132) to 10780±405 BP (level 14, 14-C cal BP 12524±531) and 9535±170 BP (level 12, 14-C cal BP 10894±241). Datings related to the oldest part of the archaeological sequence are not available. (*Datings were calibrated using CalPal Online).

The lithic industry, coming from archaeological levels of Grotta del Mezzogiorno, belongs to the Final Epigravettian. Faunal remains consist of ibex, the most represented taxon in all layers, followed by deers and wild boar; subsistence activities include also marine and terrestrial molluscs exploitation.

A taphonomical analysis has been carried out, using stereomicroscope and SEM, on 7 pebbles, coming from the levels of the lowermost unit, that bear a sequence of quadrangular low relief (a sort of grid) only on one side of the stone (usually the flat one). These pebbles are made of light grey and grey-brownish limestone, with smoothed surfaces. The small quadrangular relieves are repetitive and in some cases they seems to disappears by smoothing actions. The surfaces of these pebbles have been compared to other archaeological pebbles that do not present this modifications but others produced by well-known taphonomical agents and these marks do not belongs to any natural phenomena. In our opinion this motif could be attributed to anthropic activity, even if the purpose is still not clear. Further analyses with an experimental approach will clarify the origin of these marks.

TETHYAN PLANKTIC FORAMINIFERA RESPONSE TO THE EARLY EOCENE HYPERTHERMALS ETM2, H2 AND I1: REAL ASSEMBLAGES MODIFICATION OR TAPHONOMIC EFFECT? (TERCHE SECTION, NORTHESTERN ITALY)

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Superimposed on the long-term early Paleogene warming trend, peaking in the Early Eocene Climatic Optimum (EECO), several transient episodes of extreme warming, the so-called hyperthermals, have been globally detected in the last years. The most intense and pronounced hyperthermals recorded are: 1) the well known Paleocene-Eocene Thermal Maximum (PETM) or Eocene Thermal Maximum 1 (ETM1) (~55.5 Ma); 2) the Eocene Thermal Maximum 2 (ETM2) or "Eocene Level of Mysterious Origin" (ELMO) or H1 (~53.7 Ma); 3) the Eocene Thermal Maximum 3 (ETM3) or X-Event (~52.5 Ma). These events are associated to massive injection of ^{13}C-depleted carbon to the ocean-atmospheric system, which resulted in: a) more or less prominent negative carbonate isotope excursion (CIE); b) deep-sea carbonate dissolution due to the rise of the CCD/lysocline; c) acceleration of the hydrological cycle and consequent enhanced weathering; d) transient and/or evolutionary modifications of both marine and continental biota. It has been estimated that the magnitude of the CIE and the increase in temperature during the ETM2 were about the half of the magnitude recorded during the PETM, the most extreme of these events.

To the present, perturbations produced by post-PETM hyperthermals are rather well documented in terms of geochemical variations, whereas their influence on the biota is still largely unexplored. On other hand, the correct comprehension of the effects of these climatic perturbations on the calcareous plankton can be problematic in deep water settings due to the possible dissolution that might affect selectively the planktic foraminifera due to the lysocline rise associated to these events. Therefore, it is important to adopt specific analysis methods in order to recognize whether the changes observed in the assemblages reflect real response of the biota to these climatic perturbations or whether they are affected by the above mentioned taphonomic problems. A widely adopted method to evaluate the degree of dissolution of calcitic tests is counting the number of planktic foraminiferal fragments or partially dissolved tests vs entire tests on ~300 elements (expressed in percentages) and indicated as fragmentation index (F-index). Fragmented foraminifera include specimens showing notable deterioration, missing chambers and substantial breakage.

Here we present a detailed quantitative analysis of planktic foraminiferal assemblages across the post-PETM hyperthermals ETM2, H2 and I1 in the Terche section, located in the Valbelluna Venetian Prealps (northeastern Italy). The Valbelluna area contains several continuous deep-water successions only weakly affected by the Alpine tectonic deformation, and it is therefore particularly suitable to study the lower Paleogene interval. This area has been indeed previously investigated for the study of other early Paleogene climatic perturbations such as the PETM in the Forada section, the X-Event in the Farra section, and the Middle Eocene Climatic Optimum (MECO) in the Alano section.

The well exposed and expanded latest Paleocene-lower Eocene Terche section contains three marly-clayey units (MUs) corresponding to intervals of negative carbon isotope excursions (CIEs). Calcareous plankton biostratigraphy allow us to refer them to the hyperthermals ETM2, H2 and I1. The recorded δ^{13}C excursions are in-line with values from literature for H2 and I1 whereas the ETM2 negative shift results considerably lower and it is most probably affected by diagenetic or laboratory bias.

Quantitative analysis of planktic foraminiferal genera (>63 μm fraction) shows marked changes closely related to the CIEs and MUs, consisting basically in pronounced increase of the warm-indices acarininids (up to 68% for ETM2) and a parallel marked decline in subbotinid abundance. The MUs are also associated with an increase of the eutrophic radiolarians. Considering negligible the taphonomic effects, these data point to abrupt and transient episodes of environmental perturbation that resulted in improved eutrophication of the sea-surface waters coupled with the intense warmth. The increased surface-water eutrophication during hyperthermals was forced by strengthening of the hydrological cycle and increased weathering, as a consequence to expanded greenhouse effect that improved nutrient availability in the surface waters. These conditions favored the acarininids, likely able to temporarily colonize warmer deeper and nutrient-richer waters previously occupied by subbotinids. The Terche record evidences similarities with the PETM and X-event (ETM3) responses recorded in the nearby Forada and Farra sections respectively, though with changes of smaller magnitude. It must be noted however that studies on PETM planktic foraminifera from oceanic sites designates subbotinids as the most dissolution-susceptible genus with respect to *Morozovella* and *Acarinina*, previously believed to be the most dissolution-prone forms. Therefore, Eocene assemblages affected by extensive dissolution could be expected to be impoverished in the most dissolution-susceptible subbotinids. These results have been partly disproved by other analyses that document for the MECO (Alano section) a dominance of subbotinids within intervals affected by very high F-index values and heavy carbonate dissolution. The dissolution-susceptibility of planktic foraminifera appears therefore to have changed in different time-intervals being species-related and not exclusively associated to the different genera. On the other hand, one major difference characterizes the Terche record with respect to the other Valbelluna successions that is the degree of shells dissolution and consequently the deterioration of the carbonate preservation. In fact, our data show very low F-index values in correspondence to the MUs (maximum ~30%) in comparison with those observed in other sections of the Belluno Basin across the PETM (up to ~100%) and at the less intense X-event (up to ~90%). This indicates that the planktic foraminiferal record of the Terche section is not significantly biased by taphonomic effects and reflects genuine modifications of the assemblages, at least with reference to carbonate dissolution. The marked decrease of carbonate content within MUs can be thus largely attributed to dilution, produced by enhanced terrigenous sediments, rather than dissolution. Moreover, the coarse fraction values (CF), which generally give indications on planktic foraminiferal productivity in pelagic sediments, not significantly affected by dissolution, record only slightly decreases across the MUs. We interpret also these changes as mainly related to dilution rather than to a decrease in planktic foraminiferal productivity. Thus, the strong decline in subbotinids abundance across the MUs was probably balanced by the marked increase of the muricate warm-indices and total planktic foraminiferal productivity could have remained approximately unchanged.

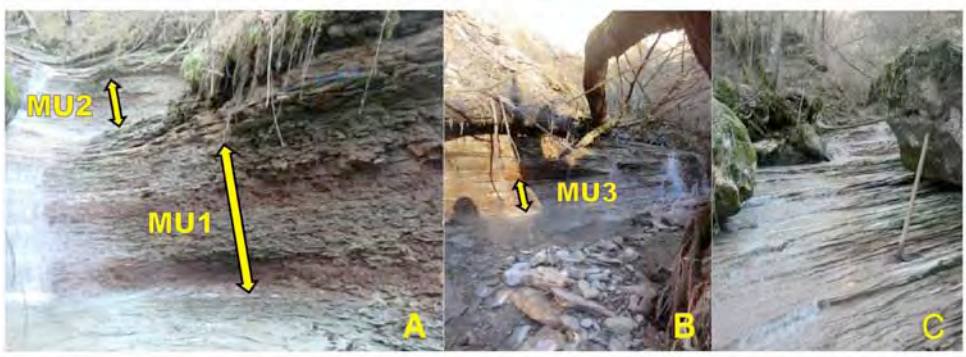

Fig.1. Overviews of the Terche section (Venetian Pre-Alps, northeastern Italy): A) Marly units MU1 and MU2, which correspond respectively to the hyperthermal events ETM2 and H2; B) Marly unit MU3, which corresponds to the hyperthermal event I1; C) Markedly cyclical Ypresian Scaglia Rossa below the Marly Units.

SPHAEROGYPSINA GLOBULUS SENSU LATO (REUSS, 1848) RECENT AND FOSSIL IN MICRO XCT_400 XRADIA-ZEISS TOMOGRAPHY AND FILMS

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The aim of this study is to provide some basic information to tackle the systematics and the shell morphology of the globular foraminifer called *Sphareogypsina* Galloway, 1933. We focus on the species *S. globulus* (Reuss, 1848), which, first described as a Bryozoan, seems to be common in all Palaeogene tropical shallow water carbonates. In fact, it has been recorded in Caribbean, Mediterranean, and Red Sea to Indo-Pacific sediments from the Palaeocene to the recent. Although some morphological variations have been reported (e.g., the proloculus size seems to be larger in the late Eocene than in the Recent) and few genera have been established, all rounded gypsinids are commonly called *S. globulus sensu lato* in every bioprovince and from the Palaeogene onward only due to the lack of detailed morphological characterization of the internal structures of the juvenile apparatus and its ontogenetic development. The main factor that hampers a detailed morphological description is the spherical morphology of the specimen which does not show any equatorial (or axial) plane where the whole embryo can be properly exposed and studied.

The MicroCT- method offers an accurate interpretation of internal structures, dimensions of structural elements and volumetric rendering as well as the analysis of ontogenetic development of foraminiferal tests without test destruction.

To accomplish these tasks, we have scanned almost 30 specimens of well preserved globular shpaerogypsinids using two main equipments (Micro XCT_400 Xradia – ZEISS from the Slovenian National Building and Civil Engineering Institute, and the MicroCT- Skyscan1173 from the Institute of Palaeontology, University of Vienna) and we have observed their embryonic apparatus. So far, the material we have studied encompasses specimens from the Cuisian (France), Priabonian (France and Tanzania), Chattian (France), Burdigalian (India), Badenian (Austria) and Recent (Adriatic Sea, Bay of Aqaba, Florida, Okinawa).

On all specimens we have observed the characteristic “chessboard surface” which seems to be a variable parameter to be kept into consideration for taxonomic differentiation. Shape and size of initial chambers and the building mechanisms of the subsequent chambers have been observed on a three dimensional basis seeming that a number of connections are open between the proloculus and all the surrounding chambers. The size (in term of volume) between proloculus (P) and deuteroloculus (D) points, at least in recent specimens, to an isolepidine embryonic apparatus where both chambers possess similar size (Recent specimen from Florida: P: $4.9 \cdot 10^{-5}$ mm^3; D: $4.1 \cdot 10^{-5}$ mm^3), while in specimens from the uppermost Eocene it seems to be slightly nephrolepidine (specimen from Tanzania: P: $9.9 \cdot 10^{-5}$ mm^3; D: $2.7 \cdot 10^{-5}$ mm^3).

In many other specimens the proloculus is so small (diameter < 20 microns) that is hard to be recognized and it might point to microspheric generations.

These first observed differences lead to the conclusion that a profound revision of the genus *Sphaerogypsina* is due and necessary (as suggested by Hottinger et al., 1993), and the results must be compared with data from the literature to check if evolutionary trends are visible and/ or if palaeo-bioprovinces works as a boundary among taxa or if the genus was and is a cosmopolitan inhabitant of all shallow water deposits.

VERTEBRATE TAPHONOMY, IS IT THE STUDY OF BIAS?

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When doing a taphonomic study of a fossil site, especially fossil vertebrate sites, several questions may be addressed. The main objective is to study the events occurred from present recovery of the fossils to the past ecosystem when animals and plants were alive. Vertebrate taphonomy has four main objectives of interest:

a. Modes of preservation, patterns or laws of fossilization, situations that favour or destroy fossils from the molecular level to the general structural aspect, both before burial and after burial, as well as fossil recovering, preparation and storage

b. Time averaging and Detection of Reworking i.e. is time and spatial mixtures of fossils from different associations.

c. Description of the Site Formation, historical description of all processes occurred to the fossil associations. In this respect, some agents, such as predation or human activity have had certain priority of study, because through taphonomic studies their behaviours and ecological meaning, way of living, sometimes even their social strategies can be interpreted.

d. Interpretation of the past ecosystems, once the information from previous objectives is known (modes of preservation from production to fossilization and absence/presence of mixtures), we may then reconstitute the past ecosystems (palaeocology).

Frequently other disciplines and many peers consider that taphonomy is the study of bias. However, the subject and objective of taphonomy is to reconstitute the past to the maximum detail, to decipher and interpret the information coded and recorded on the fossil surfaces, their geochemical composition and histological structure. Taphonomy detect biases affecting biological preservation and biocenosis (distortion of the original ecological community), but once these biases are known, ' *Taphonomy produces a method for controlling the reconstructions on an evolutionary basis, and so aids these reconstructions to acquire the preciseness of which they are greatly in want*' (Efremov, 1940, page 93: last sentence).

THE EVOLUTION OF TAPHOS 1990-2014

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The first meeting of Taphos was held in Madrid, 1990 due to an initiative lead by Sixto Fernández-López and several researchers based at the University Complutense of Madrid and the Museo Nacional de Ciencias Naturales. Almost simultaneously, the book 'Owls, Caves and Fossils' by P. Andrews appeared setting the methodology for analyzing vertebrate microfaunal taphonomy.

The original aim of the first Taphos meeting was to bring together scientists with a wide multidisciplinary background to go through the meanings that taphonomy acquired since its definition by Efremov in 1940. The type of studies that involve taphonomy is attractive to several sister disciplines of geology, paleontology, archaeology and biology. However, the wide range of specialization, varying research objectives and diverse nomenclature of taphonomists made it difficult to understand each other well. This great objective of the first meeting could not be achieved because the many participants did not have enough time available to discuss these fundamental aspects.

In the following years, more disciplines joined investigations referred to as taphonomy. Therefore, forensic scholars started to meet and publish congress volumes named 'Forensic Taphonomy'. This was a slightly different application of taphonomy, given that the studied subject is modern and no fossil-diagenesis, where there is transition from the biosphere to the lithosphere, is involved. The relatively ambiguous etymology of the discipline (*Taphos*=burial and *nomos*=laws) caused the emergence of the 'Bone Diagenesis' meetings since 1988 as a separate subject from taphonomy. Recently, a new type of initiative, ' Site Formation' workshop, showed the initial problem was not yet solved. Some lack of agreement among different specialists still persists, such as considering anthropogenic artifacts and buildings to be the subject of taphonomic studies. Whether this assignment is correct or not, the subject has recently been debated among taphonomists in two papers published in Journal of Taphonomy in 2010 and 2011.

Evidently, taphonomy is a rich, diverse and certainly useful field of investigation for many different study subjects and objectives by diverse specialists. The evolution of this discipline has surpassed the original viewpoints that lead to the creation of the discipline less than 75 years ago.

The debate is open.

THE BAT FOSSIL REMAINS FROM THE TE9C LEVEL OF SIMA DEL ELEFANTE (ATAPUERCA, SPAIN): A DETAILED TAPHONOMIC ANALYSIS

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Due to the particular ethology of bats their fossil assemblages are not necessarily originated by the same processes as those of other small mammals, so we consider that their separate study might be of interests for a global understanding of the palaeontological site. Here we performed a taphonomic analysis of the chiropteran remains from the fossiliferous level TE9c (Sima del Elefante Lower Red Unit, TELRU, Early Pleistocene). The main point of this work is characterizing the assemblage in terms of taxonomic composition, anatomical elements sorting, taphonomic alteration and teeth wear pattern related to age, from which we may discuss the origin and conditions of the accumulation by contrasting this taphonomic data-set with the sedimentological and geomorphological context of the site.

The Sierra de Atapuerca (Burgos, Spain) is well known due to its very complete, exhaustively studied quaternary stratigraphic and paleontological record. The Sima del Elefante site is an old output point for groundwater flow. When TELRU was deposited, the opening of the pit had been abandoned and was suspended on the mountain slope becoming a cave entrance which connected the intermediate level of Cueva Mayor—a vadose karst-conduit by then—with the outside. The TELRU levels are formed by detritic sediments coming from the immediate vicinity which display marked inclination of the strata. TE9c is an alternation of detritic levels with subangular clasts and bands of plastic clays without clasts. A jaw of hominine has been found in there dated ca. 1.22 Ma, and also some Mode 1 lithic tools.

We study all the available samples excavated at the whole TE9c level from 2003 to 2008. The analyzed fossil material consists of disarticulated cranial and postcranial bat remains collected by the water-screening of the rock matrix. A total of 136 remains were picked up corresponding to a minimum number of 15 individuals (MNI). All they were determined to species level distinguishing three taxa; in order of abundance they are: *Myotis* gr. *myotis/blythii* (73 %, Fig. 1 A,B,C,D,E), *Miniopterus schreibersii* (27 %, Fig. 1 F,G) and *Rhinolophus ferrumequinum* (only one specimen recovered, Fig. 1 H). They all inhabit the Iberian Peninsula nowadays. Neither horizontally nor vertically differential distribution patterns of the bat remains have been observed within the TE9c level.

The most abundant elements in the sample in terms of absolute values (minimum number of elements, MNE) are isolated teeth, but humeri and mandibles dominates if their relative abundance (R_i = MNE x 100 / MNI x E_i) is considered, where E_i is the number of a concrete anatomic element per individual. The lack of isolated incisors and premolars 2 and 3 in the sample is remarkable, maybe due to a taphonomic bias or to a sampling error as these pieces are very small. The proportion of postcranial and cranial bone in the bat assemblage (Humeri + Femur)/(Mandibles + Maxillae) is 0.7 indicating some process of differential lost of postcranial bone, probably transport. This value varies from one taxa to the other if we consider them separately, which could mean that each group were affected by different processes, although the little amount of specimens of *M. schreibersii* might have bias de analysis. The majority of the elements in the sample appear broken; neither long bones nor skulls were recovered without fracturing, but 6 mandibles were picked up completed. The taphonomic alterations affecting the remains are: carbonate concretions (32 % of the specimens), manganese oxide patina (54 %), dissolution/corrosion (40 %), flaking (3 %) and enamel showing mosaic-pattern (73 % of the dental remains). The entire mandibles affected by carbonate concretions show exceptional preservation of teeth, with all the pieces

attached to the bone; in some samples a whole individual of bat may be even identified including cranial and postcranial elements. The existence of soft tissue attached to bone in the accumulation moment could favour the early formation of these concretions. The presence of oxide of manganese has been related by some authors to bacterial activity in humid, anaerobic and rather basic environments, or to alternation of oxidation-reduction cycles; this patina never occurs under the carbonate concretions in any of the studied specimens. The dissolution affecting the specimens does not extent to the enamel and there is no evidence of digestion-origin for this alteration; it could be a consequence of diagenesis as the sediment has been affected by groundwater flow after its deposition. The teeth wear indicates that the age sorting of dead individuals in the *Myotis* group is yearlings and old individuals in similar proportion, while there is only yearlings in *M. schreibersii* and the mandible of *R. ferrumequinum* is an adult individual.

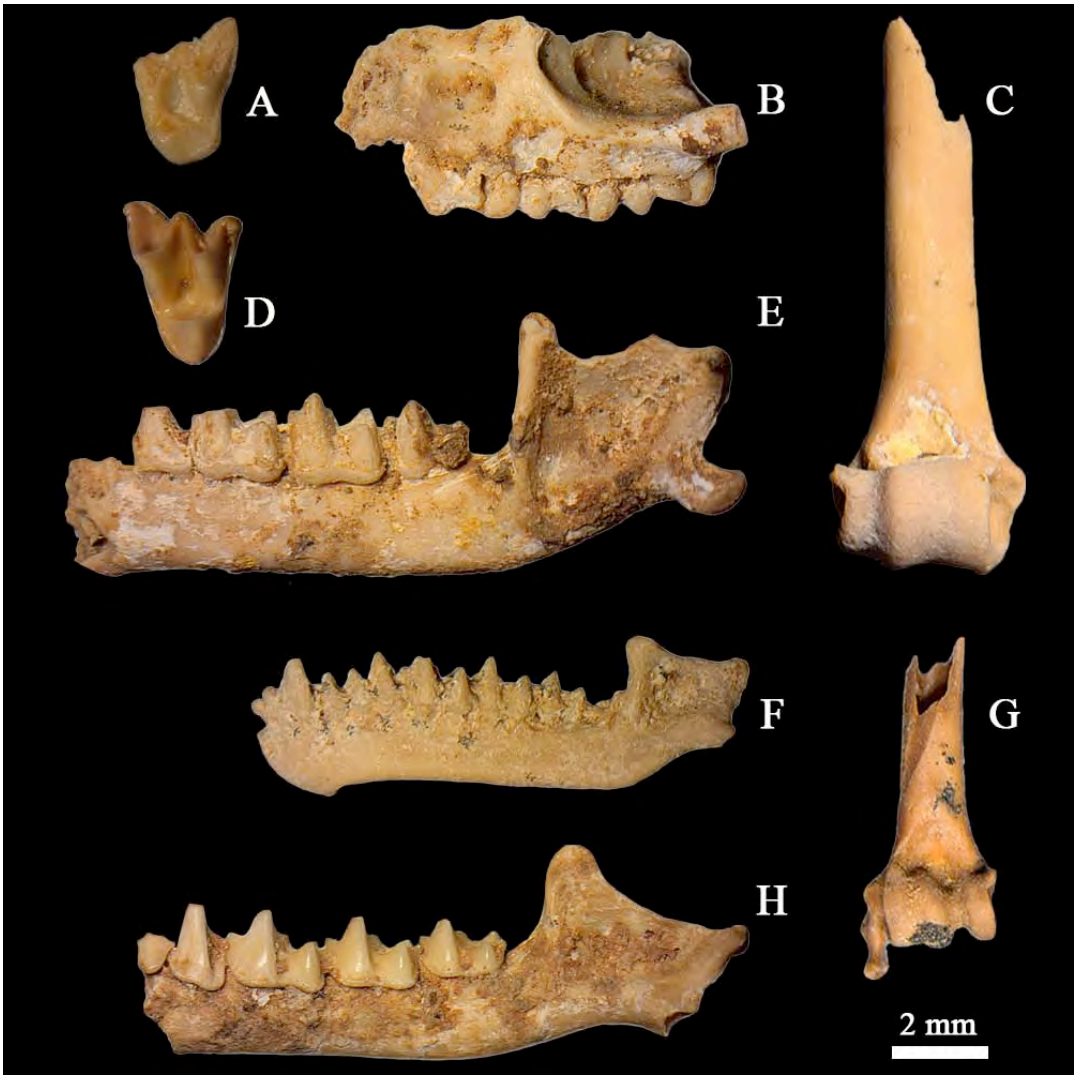

Fig. 1. *Myotis* gr. *myotis/blythii*: (A) left upper molar 1 of an old individual; (B) fragment of left maxilla; (C) distal epiphysis of right humerus; (D) right upper molar 2 of a yearling; (E) left mandible. *Miniopterus schreibersii*: (F) left mandible; (G) distal epyphisis of left humerus. *Rhinolophus ferrumequinum*: (H) left mandible.

TAPHONOMIC FEEDBACK IN A THICK *TEREBRATULA* SHELL BED FROM THE PLIOCENE OF SOUTHEASTERN SPAIN

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Brachiopods were a dominant benthic clade in the Paleozoic, but in contrast to bivalves, were severely impacted by and never fully recovered from the Permo-Triassic mass extinction. However, Post-Paleozoic brachiopods may become the dominant marine benthic taxa in particular environments, forming dense paucispecific brachiopod-dominated bioherms. For instance, the extant *Laqueus californianus* from the coasts of California, and *Gryphus vitreus* in the Mediterranean, can be mentioned, both forming notable brachiopod-dominated biocoenoses typical for the outer shelf to slope settings.

The current note aims to describe a striking example of shallow-water brachiopod-dominated concentrations formed by *Terebratula calabra* within a mixed siliciclastic-temperate carbonate succession of late Early Pliocene age in southeastern Spain. This unique record of brachiopod concentrations may help us to understand the factors that led to the particular success of large-sized brachiopods like *Terebratula* in Cenozoic environments typically dominated by bivalves.

The brachiopod concentrations described in this note are located in the Cañada Brusca area, near the town of Águilas (Murcia, Spain). The Águilas Basin constitutes one out of the five small basins that comprise the inner sector of the so-called Águilas Arc, a tectonic indentation megastructure laterally bound by prominent strike-slip faults. The onset of Pliocene marine sedimentation in this basin took place during the MPl 1 foraminiferal biozone with proximal alluvio-deltaic sedimentary systems that represent the early stage of an abrupt transgression. In this sector, the stratigraphic architecture of the Pliocene sedimentation consists of sigmoidal lithosomes displaying an offlap prograding geometry. Each of these lithosomes, overall attributable to a highstand stage, is characterized by a coarsening and shallowing upward trend. Occurrence of the planktic foraminifer *Globorotalia puncticulata* in the studied section, combined with the absence of *G. margaritae*, allows the attribution of these sediments to the MPl 4a biozone of the Mediterranean Pliocene.

In a gradual transition with the underlying fine-grained sandy levels cropping out at the base of the studied section, a 1.5 meters thick shell bed occurs. The matrix of this shell bed is composed of bioturbated fine-grained sands that bear a significant content in poorly sorted bioclasts, mostly derived from shells of *Terebratula*. This shell bed records a diverse fauna, including brachiopods (*Terebratula*, *Ancistrocrania*, *Megerlia*, *Megathiris*, *Aphelesia*, very rare *Terebratulina*), scallops (*Aequipecten*, *Pecten*, rare *Flabellipecten* and *Amusium*), oysters (*Ostrea*, *Spondylus*, *Anomia*, *Pododesmus*), rare gastropods (*Stenorhytis*, *Epitonium*), echinoids (*Arbacina*, *Cidaris*, *Echinocyamus*, *Spatangus*, *Clypeaster* fragments), bryozoans, mammal bones, etc. Distribution of shell remains along the shell bed denotes a laterally varying degree of density and sorting of bioclasts. Most conspicuous shell accumulations display a wide range of biofabrics, from loosely dispersed to densely-packed, as well as examples of concave-up vertical stacking and nesting of shells. Most of the larger fragments of ventral and dorsal valves of *Terebratula* consist only of the posterior part of the shell. These *Terebratula* fragments are generally affected by 1) corrasion (rounded fractured margins, hinge teeth and rims of foramen, rounded to completely missing symphytium, etc.), 2) bioerosion (with a decreasing order of relative abundance of *Entobia*, *Gnathichnus*, *Podichnus obliquus*, *Maeandropolydora*, *Caulostrepsis*, *Oichnus*, *Renichnus*/*Centrichnus*) and 3) encrustation (mostly by bryozoans and *Ancistrocrania*, many specimens of which are cemented to the inner wall of the fragments, proving their prolonged exposure on the sea-floor). In addition to the above mentioned encrusting taxa, it is worth to point out that the upper valves of the small and delicate anomiid bivalve *Pododesmus* are abundant, very well preserved, and a relatively high proportion of these shells are affected by *Oichnus* traces. The excellent preservation of *Pododesmus* specimens contrasts with that of most fragments of *Terebratula*. Co-occurrence of highly altered fragments and pristine, articulated shells of

Terebratula, demonstrates that specimens of the brachiopod *Terebratula* recorded in this shell bed underwent different taphonomic pathways, suggesting that different generations of *Terebratula* were able to thrive in this habitat over a period of time long enough to produce the range of taphonomic signatures described above. Taphofacies point to a case of within-habitat time-averaged fossil assemblage, namely: 1) sediment starvation (inferred from a relatively dense bioturbation and taphofacies of largely abraded, bioeroded, encrusted, and fragmented shells accumulated in clusters). 2) fossils with distinctly different taphonomic signatures corresponding to the biostratinomic phase (but not to the diagenetic one). 3) lithologically homogeneous matrix. 4) a functional agreement between fauna and matrix. The recruitment of fixossesile organisms such as *Pododesmus*, *Ancistrocrania* and the remarkable abundance of *Podichnus obliquus* (which suggests that conspecific specimens attached to dead and alive shells of *Terebratula*) and other bioerosive traces, point out an upward change in the type of substrate at the basal part of the section. A shift from a soft/firmground to a shelly-ground was propitious for the colonization by a remarkable diversity of epilithic animals. This case of taphonomic feedback related to a brachiopod bioherm may be associated with a mixture of autigenic and allogenic modes. Allogenic mode is referred herein to the effects of reworking and winnowing induced by storm currents. Influence of possible storm activity is inferred from the occurrence of unaltered, hollow shells of *Terebratula* pointing to a rapid burial, the stacked biofabrics of disarticulated shells, and the infilling of pod-like pits by shell fragments.

TAPHONOMY OF THE MINUTE IRREGULAR ECHINOID *ECHINOCYAMUS PUSILLUS* FROM THE MEDITERRANEAN SEA (ISOLA DEL GIGLIO)

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Echinoid skeletons often rapidly disarticulate after death depending on the strength of interplate connections as well as the environment in which they live. After death, complete tests can easily be destroyed. Sea urchins of the minute clypeasteroid genus *Echinocyamus*, however, feature an internal support system that stabilizes the test after death. Thus, this echinoid, which occurs in a wide variety of habitats, is often found preserved as complete tests in large numbers. Since *Echinocyamus* has a good preservation potential in both Recent and fossil sediments, this echinoid is predestined for comparative analyses with respect to ecological parameters, sediment types and between time slices.

In the presented research, recent *Echinocyamus pusillus* (in all 192 individuals) from the Mediterranean Sea are analysed for 7 taphonomic features of different morphological characters: (1) test abrasion, (2) ambitus abrasion, (3) peristome abrasion, (4) periproct abrasion, (5) encrustation and, if available, (6) drillhole outline and (7) drillhole abrasion. Each taphonomic feature is categorized into 5 grades ranging from very well preserved (Grade 1) to highly affected (Grade 5). These results are compared with respect to different localities, depths and size classes as well as to comparable data on *Echinocyamus crispus* from tropical settings of the Red Sea. The amount of drilled and undrilled tests along the taphonomic gradient are also compared in order to investigate the influence of this specific type of test damage due to drilling predation on shell preservation. The results show that most individuals can be categorized into taphonomic grades 1 and 2 with only few individuals showing higher levels of damage. This result is discussed with respect to depositional environment and possible surface residence times of the echinoids.

WHY MEDUSAE ARE THE ULTIMATE TAPHONOMIC PROXY

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Among animals, cnidarian medusae (or "jellyfish") have extremely low preservation potential. This is largely because they have almost no biomineralized or chitinous tissues, and usually decay rapidly or are scavenged after death or burial. Thus, when medusae occur in ancient deposits they signal anomalous environments or distinct moments in Earth history.

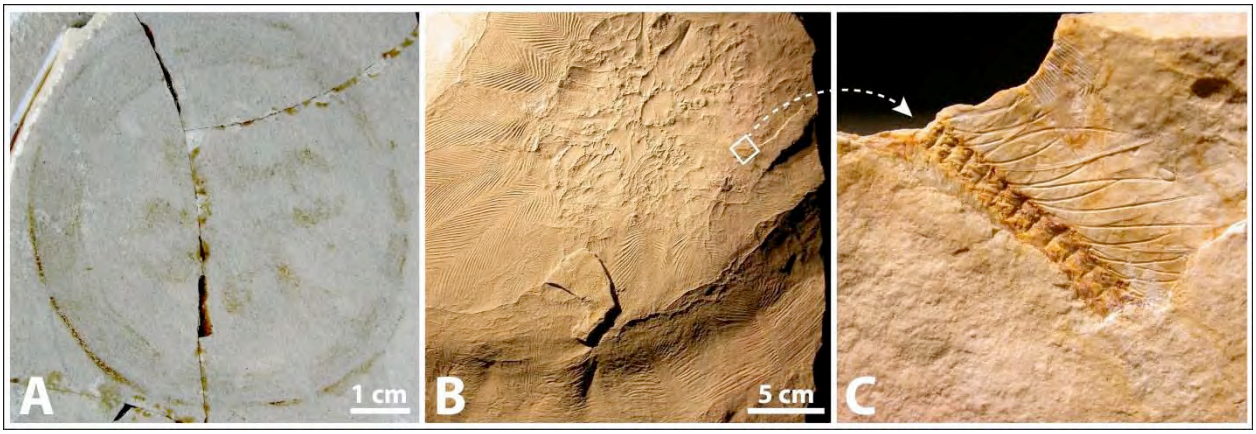
Unlike some short-lived or extinct groups of soft-bodied organisms (such as Ediacaran 'vendobionts'), cnidarian medusae have been around for at least ~550 Ma, and are hypothesized to have been abundant in global oceans through much of the Phanerozoic. Yet even within the hundreds of known Konservat-Lagerstätten that span Proterozoic and Phanerozoic time, Cnidaria and their medusae are the least common major metazoan phylum represented. Thus despite their deep evolutionary roots and frequent taphonomic opportunities for soft-tissue preservation, they are only known from about a dozen fossil deposits.

So what does the presence or absence of cnidarian medusae in such deposits tell us about moments or places in deep time? And how does their taphonomic sensitivity inform our understanding of past processes?

Although medusae (including hydrozoan, scyphozoan, and cubozoan jellies) thrive in many aquatic environments, they are typically only preserved in three types of depositional settings: 1) Medusae are most abundant in strata deposited in sand- and mud-flats dominated by tides or low-energy wave regimes. In such environments they are precise shoreline indicators because they become deposited at the strandline where flotsam accumulates; their presence in such settings is also an indicator that robust microbial films or mats were present. 2) Medusae are also preserved in mudstones deposited in lagoonal or estuarine embayments in which soupy sediments predominate. In such settings, fossilized medusae are indicative of fluctuating salinity or salinity stratification, rapid burial in fine dysaerobic/anaerobic mud, and/or the presence of dysaerobic/anaerobic bottom waters that both inhibited tissue decomposition and fostered early early diagenetic mineralization. 3) More rarely fossil medusae occur in shales representing dysaerobic/anaerobic deeper water settings. In such settings they signal rapid burial often associated with bacterial fermentation and mineralization.

Over Phanerozoic time, the taphonomic windows that permitted preservation of medusae have become increasingly small, or have shut entirely. For example, strandline deposits of medusae, in which hundreds of thousands of specimens occur in a given deposit, are restricted to the early Paleozoic – before metazoans began disrupting or consuming the microbial mats that fostered soft-tissue preservation in sand- and mud-flats, and before burrowing metazoans began consuming buried medusan carcasses. Whereas molecular data indicates that medusozoan cnidarians evolved in the latest Proterozoic, early Paleozoic medusa-bearing deposits enhance this knowledge by letting us know that jellyfish were not just present, but were abundant. Like Burgess Shale-type preservation, preservation of medusae in deeper marine settings disappears by the end-Paleozoic, possibly owing to increasing colonization of dysaerobic and anaerobic basin bottoms by bioturbating organisms. The only remaining environments in which medusae are preserved in the Mesozoic and Cenozoic are lagoonal- or embayment-like settings, in which metazoan activity and microbial degradation is retarded by fluctuating salinity or oxygenation, where fine sediment settling predominates to facilitate burial and sinking of carcasses, and where microbially mediated authigenic or early diagenetic mineralization is fostered.

This brings us to the present – which is often a key to the past. If this is true, where are medusae being preserved on earth today?



(A) Eocene cnidarian medusa from Monte Bolca, Italy, illustrating gonads and coronal rings (*specimen:* Museo Civico di Storia Naturale). (B) Jurassic semeastome medusa from Solnhofen, Germany, illustrating coronal rings, muscle structure, tentacle bases, and (C) at least one fish in its stomach (*specimen*: Bayerische Staatssammlung für Paläontologie und Geologie).

HISTORICAL ECOLOGY OF THE NORTHERN ADRIATIC SEA: SAMPLING METHODS AND FIRST RESULTS

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Our study on the historical ecology of the northern Adriatic Sea has yielded 54 sediment cores at seven sampling stations in Croatia, Italy, and Slovenia. One set of smaller cores are being analysed for radiometric Pb-sediment-dating, grain size, TOC, TAC and heavy metals. The other set of larger cores delivered shelly remains of endo- or epibenthic hard part producers (e.g. molluscs, crustaceans, echinoderms) to enable the reconstruction of death assemblages in core layers from top to bottom. We recorded down-core changes of such assemblages, demonstrating ecological shifts over the last several centuries. We attribute these to human impacts. Based on the sedimentation rates here, a 1.5 m-long core can cover up to about 2000 years of ecological history. The specially modified coring method met the following requirements: a) deliver 1.5-m-long cores from different sediment settings (mud to sand, reflecting a wide range of benthic habitats in the northern Adriatic); b) quick and easy deployment to ensure that multiple cores can be taken at the individual sampling stations within a short time; c) be affordable and allow handling by the researchers themselves, potentially using a small vessel in order to further contain the operating costs.

Two types of UWITEC™ piston corers were used to meet these requirements. A model with 90 mm of diameter (samples for sediment analysis) and another one with 160 mm, specifically designed to obtain the large amount of material needed for shell analysis, successfully delivered a total of 54 cores. The device consists of a stabilizing tripod and the interchangeable coring cylinders. It is equipped with a so-called hammer action that enables at least the smaller cylinder to penetrate even harder sediments. A closing mechanism retains the sediment in the cylinder upon extraction; it works either automatically through hydraulic pressure once the final core-length is reached, or can be triggered manually at any time from the surface using a connected hose and water pump. The whole coring device weighs less than 300 kg and can be transported in a van. It can easily be assembled, disassembled and operated by two to three persons after a brief training. The newly designed, very simple and effective extrusion device allows the cores to be sliced in an upright position directly on board after extraction. This device is suitable for any smaller coring operations on lakes, streams, or at sea.

PALAEOECOLOGICAL ANALYSIS OF A HIGHLY DIVERSE LATE TRIASSIC MARINE BIOTA FROM THE CASSIAN FORMATION (NORTH ITALY, DOLOMITES)

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A bulk sample of marine invertebrates from the Late Triassic Cassian Formation (North Italy) yields one of the most diverse Early Mesozoic fossil assemblages ever reported. About 170 species could be identified. The assemblage is strongly dominated by molluscs, especially by gastropods. The sample also yields echinoderm ossicles (echinoids, crinoids, holothurians, ophiuroids), articulate brachiopods and representatives of some other groups. Remains of calcareous sponges and corals are scarce. Rarefaction analysis suggests that diversity of the bulk sample and a surface collection (35 species) from the same locality is in the same magnitude. However, species richness, taxonomic composition and rank abundance differ strongly according to sampling method. Most of the fossils are smaller than 1 cm reflecting small adult sizes as well as size sorting during transport. Microbial encrustation, fragmentation and the presence of ooids and coated grains indicate that the fossil assemblage was transported from a carbonate platform into the adjacent basin where it was embedded within basin clays. The especially high diversity can be recognized because of low-grade lithification of the clayey sediments, which facilitates disaggregation and discovering of small fossils. Sample standardization exhibits that the studied Late Triassic collection is much more diverse than known Early Triassic marine faunas. However, diversity is comparable to assemblages of Anisian age, suggesting that recovery from the end-Permian mass extinction was quite advanced in the Middle Triassic and alpha-diversity remained high until the Late Triassic. According to current models, Early and Middle Triassic marine faunal assemblages match the niche overlap phase of recovery during which diversity is built up by increasing alpha-diversity, while beta-diversity rises slowly. Afterwards, increasing competition leads to contraction of the habitat width of species, which makes beta-diversity to the principal drive of overall diversity increase. Diversity of various Late Triassic marine assemblages from the Cassian Formation meets the predictions for the transition from the niche overlap to the habitat contraction phase.

METHODOLOGICAL AND TAPHONOMIC CONSTRAINTS OF MOLLUSCAN BIODIVERSITY ASSESSMENTS IN MODERN AND PLEISTOCENE CORAL REEFS OF THE NORTHERN RED SEA

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Biodiversity and taphonomy of Pleistocene and Recent coral-reef associated molluscs are studied in the Northern Red Sea, to make a contribution to a better palaeoecological understanding of molluscs in subtidal coral reef zones. This study is divided into two major questions:

First, we study how methodological constraints affect the assessment of biodiversity. Specifically, the effect of different mesh sizes on biodiversity measurements is going to be evaluated. Therefore, various sediment samples from the Northern Red Sea were sieved with different mesh sizes, for which ecological analyses of shelled molluscs are performed for species abundance and richness, community composition, frequency of drilling predation, sediment depth, and habitat. Results from samples collected near Aqaba (Jordan) show that molluscan species richness is higher in a *Millepora*-fringing reef compared to a patch reef. Most species were found in the mesh size fraction 2 mm – 2 cm when compared to the fraction 1 mm – 2 mm. However, molluscs larger than 2cm were very scarce.

Second, by comparing Pleistocene and Recent data sets with each other the degree of taphonomic loss in Pleistocene coral reefs is studied. When preservation biases are estimated, Pleistocene reefs can serve as a baseline to assess anthropogenic effects on biodiversity and ecology of Recent reefs. Taphonomic loss in Pleistocene coral reefs from the Northern Red Sea (El Quseir, Egypt) will be analysed to evaluate which molluscan taxa and shell sizes are suitable for a comparison between Recent and Pleistocene reefs. Species abundance and richness, taxonomic composition, trophic structures, and body size will be evaluated and compared to data from a Recent coral reef near El Quseir. Preliminary results show that small size classes of molluscs are preferentially lost in Pleistocene reefs.

TAPHONOMY AND SEDIMENTARY DYNAMICS OF MODERN AND FOSSIL RHODOLITH BEDS FROM NORTH ATLANTIC ISLANDS

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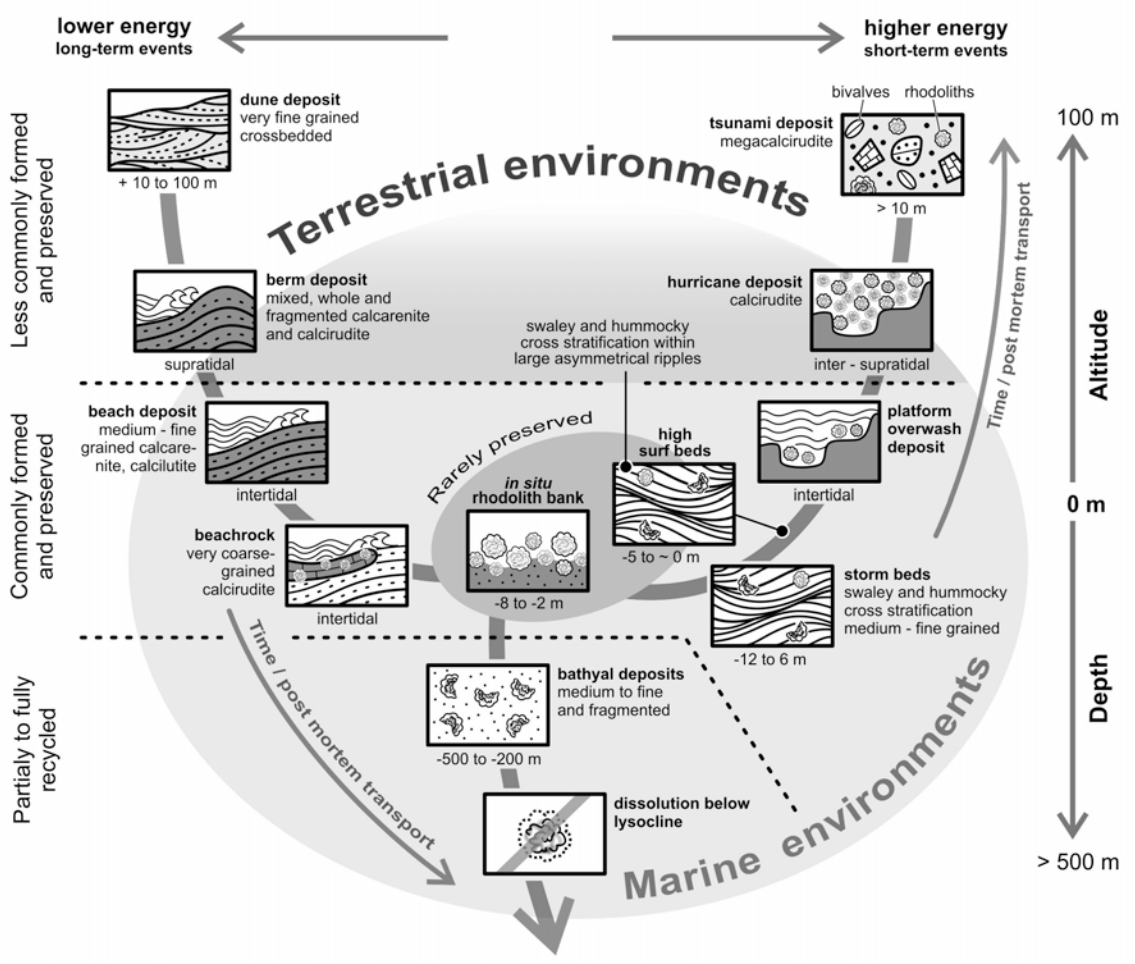
Living rhodoliths in the Macaronesian realm (North Atlantic Ocean) are distributed around islands with extensive rocky shores and narrow shelves that rapidly drop off at the shelf break normally between the 100-m to 130-m isobaths. Wind and wave erosion is intense on north and northeast-facing shores due to the prevailing northeasterly trade winds. Southern shores offer more sheltered, leeward settings. Rhodolith beds tend to thrive on eastern shores with strong long-shore currents and southeastern shores that benefit from wave refraction. Rhodoliths are not entirely absent off northern shores, but may fail to reach maximum size before being washed ashore to make berms and beaches. Islands considered in this survey include Santiago, Maio, São Nicolau, and Sal from the Cape Verde Islands, Fuerteventura in the Canary Islands, and Porto Santo in the Madeira Islands. In direct comparison with living counterparts, the objective is to show that rhodoliths from these islands enter the fossil record as taphofacies defined by the degree of breakage and corrosion also characterized by sedimentological criteria regarding the amount of matrix and degree of packing among bioclasts. Fossil rhodolith deposits in Macaronesia seldom reflect settings under natural growth conditions. Rather, they were subject to transportation and post-mortem disintegration resulting in the accumulation of materials captured by subtidal storm deposits, tidal pools and platform over-wash deposits, as well as beachrock, beach, berm, hurricane, tsunami, and coastal dune deposits. Some of this material is transferred offshore, but exposed strata indicate shoreward migration of taphofacies under a range of different energy regimes (shown below).

Rhodolith beds provide a habitat for many species of marine invertebrates, including epifaunal and infaunal elements directly associated with whole rhodoliths. Some encrusting and boring activities occurred while the host rhodolith was still alive, but others after the host was transported onto rocky shores far from the optimum life habitat.



Taphofacies inferred from sedimentary dynamics in carbonate deposits dominated by rhodoliths and degraded rhodolith materials in the Macaronesian realm.

EARLY JURASSIC *LITHOTIS*-FACIES BIVALVES IN REEF-TYPE BUILDUP IN MOROCCAN HIGH ATLAS (JEBEL AZOURKI, ASSEMSOUK) – A CASE STUDY

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Recovery of marine reef fauna after Triassic/Jurassic mass extinction event was mainly marked by *Lithiotis*-type bivalves buildups occurrences. Their world-wide distribution indicates both very rapid occupation of specific ecological niches (mainly shallow-marine/lagoon-type carbonate sedimentation) and palaeogeographic/geody-namic regimes during break-up of Pangea in Pliensbachian-Early Toarcian times. The most characteristic bivalves which belong to the so-called *Lithiotis*-facies are: *Lithiotis*, *Cochlearites*, *Lithioperna*, *Mytiloperna* and *Opisoma*. In numerous causes the Pliensbachian-Early Toarcian sections represent carbonate and carbonate-clastic shallow-water environments, and these bivalves occur in huge amount, very often in life position, and constructed "reef/biostrome" buildups. One of the spectacular place where such bioconstruction we can studied is Assemsouk section in Jebel Azourki range in the Moroccan High Atlas Mountains. Perfectly crop out section of the Pliensbachian carbonate-clastic deposits (with transition to Toarcian?) is represented by record of regression manifested by continuous transition from shallow-water full marine limestones with corals trough calcareous-marly deposits (most probably lagoon-type) with numerous bivalves mentioned above, up to nearshore clastic-carbonate deposits, often with good recorded cross-bedding structures and with abundant remains of plants which most probably represent lagoonal-paralic environments (Fig. 1). In the middle part of the section „*Lithiotis* buildup" occur with huge (up to 0.5 m long) shells of *Cochlearites* and/or *Lithiotis*, which in topmost part of the buildup are in life position and are represented by monospecific autochthonous association. The margins of this buildup are biodetritic limestones of tallus-type which are characteristic for fossil reef structures and originated as erosion and resedimentation of carbonate material from positive relief of this biostructure. The most probably it occupied place between more or less isolated lagoon and full marine realm and has been barrier "reef" of this Early Jurassic palaeoenvironment. Such interpretation very well corresponds to several other localities of the *Lithiotis*-type bivalves-bearing deposits which are known in Eurasian region (e.g. Spain, Italy, Slovenia, Croatia, Greece, Turkey, Oman, Iran) where similar bivalve buildups represented most probably the same palaeoenvironmental regimes.

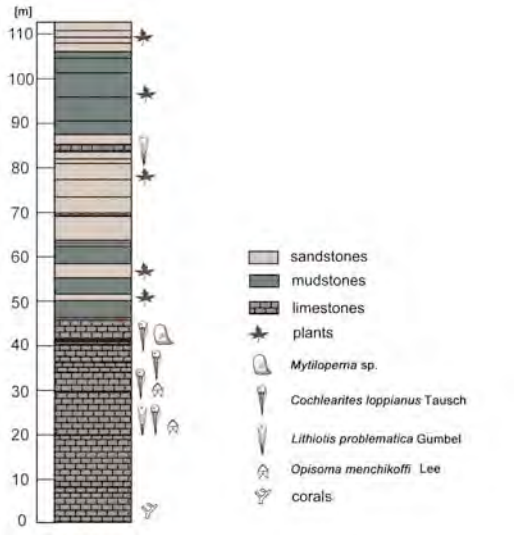

Fig. 1. Assemsouk section (Jebel Azourki, High Atlas, Morocco) record of regressive type of carbonate-clastic sedimentation with *Lithiotis*-facies bivalves.

EXCEPTIONAL PRESERVATION IN MARBLES OF THE NEVADO-FILÁBRIDES COMPLEX (BETIC CORDILLERA, SE SPAIN)

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Preservation of macrofossils in medium to high-degree metamorphic rocks is not very common. Outstandingly, however, crinoid ossicles have been found even in eclogites and migmatitic gneisses. Processes involved during the metamorphism, such as recrystallization, increase in pressure and temperature, fluid circulation and tectonic deformation, most likely destroy skeletal remains already fossilized in the original sedimentary rocks. Further to fossil destruction, taphonomic signatures (either traits produced in the taphonomic active zone or during early fossildiagenesis) are also obliterated during metamorphism.

Near Águilas (Murcia, SE Spain), massive marble beds and calc-schist belonging to the Nevado-Filábrides Complex of the Inner Zones of the Betic Cordillera crop out extensively. These metamorphic rocks, although they have suffered intense Alpine metamorphism and deformation, contain a great abundance of fossils. Crinoids are the most abundant components of the assemblages, by far. Other identifiable organisms are rugose corals, brachiopods, cephalopods (ammonoids and orthoceratids), sections of putative trilobites, and what may be gastropods and benthic foraminifers. In addition, contorted laminar structures similar to algal thalli occur. Nonetheless, recrystallization has obliterated the inner structure and it is impossible to accurately identify them. Finally, possible cyanobacterial, *Girvanella*-like structures are also present. The exceptional preservation of some of these fossils, especially crinoids and corals, allows us inferring bioestratinomic processes even after metamorphism transformed the original sedimentary rocks.

The study area is located in the easternmost sector of the Betic Cordillera, from near Ramonete (Lorca, Murcia) to Sierra del Aguillón, close to Pilar de Jaravía (Pulpí, Almería). We have studied three sections located in a NE-SW cartographic belt following the so-called Águilas tectonic arc. In all these sections, three members can be differentiated: 1) a lower member made up of siliciclastic deposits; 2) a middle member consisting of carbonates and siliciclastics; and 3) an upper member constituted mostly by siliciclastics with a high content of graphite. The fossils occur in massive marble beds and calc-schist tabular beds of the middle member, the former containing more diverse and abundant fossil assemblages than the latter.

One of the most outstanding taphonomic attributes linked to biostratinomic processes is the preservation of articulated crinoids in the calc-schist beds. Portions of crinoid columns, several decimetres in length, occur articulated. Uncommonly, sections of articulated arms are also present. Very exceptionally, one articulated calyx has been also found. Further, large structures, 100-150 mm in larger dimension, with an external rough bell shape are visible. They can be interpreted as collapsed calyxes of crinoids. However, extreme deformation precludes any confident identification. All these articulated fossils occur in the base of the calc-schist beds, which show irregular bottoms. Crinoid disarticulation in present-day shallow and deep settings takes place very rapidly, in a few days to weeks. Therefore, articulation of crinoid elements would be guaranteed under sudden entombment with no further reworking. Since intact or articulated preservation of the highly susceptible crinoids is very rare, the fossil material of the calc-schist beds can be identified as fossil lagerstätten.

Crinoids also dominate the fossil assemblages of the massive marbles, but in this case they occur as isolated columnals and brachials. Additionally, rugose corals, brachiopods, ammonoids

and orthoceratids are also important components. Regarding the corals, they are massive nodular in shape and partially preserve the inner structures of the colonies. Longitudinal septa, as well as other inner anatomical traits, can be seen in several coral specimens. In some of them, the external wall of the colony, the epitheca, has been also preserved. Disarticulation of crinoids and preservation of the external walls of the corals, which are prone to abrasion and decay quickly after death, indicate that shells remained exposed on the sea floor, but under low hydrodynamic conditions precluding intense abrasion.

During late diagenesis, fossils were affected by recrystallization and deformation. The former altered the original inner structures of the skeletal remains, making it difficult to identify some of the organisms. Epithaxial growth of calcite also affected crinoid ossicles. Finally, dynamic recrystallization destroyed fossils smaller than the final size of the crystals. The most outstanding taphonimic alterations due to deformation are: 1) stretching, sometimes very strong, or thinning of the skeletal remains when fossils are parallel or perpendicular to maximum deformation, respectively; 2) collapse of void structures, such ammonoids or crinoid calyxes; 3) portions of articulated crinoid columns oriented parallel to the strongest deformation vectors are mostly disarticulated following the stretching lineation (stretching disarticulation); and, finally, 4) portions of articulated crinoid columns oriented oblique to stretching lineation, that has slightly displaced ossicles along the inter-columnar sutures occurring as domino pieces.

THE RECORD OF HUMAN ACTIVITY IMPRESSED ON THE BONE SURFACES OF A LATE PLEISTOCENE ZOOARCHAEOLOGICAL ASSEMBLAGE IN NORTH ITALY. RESULTS FROM FIRST INVESTIGATIONS.

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Recent investigations carried out at a late Pleistocene cave named Cuoléto de Nadale and located in the North of Italy, has produced bone and lithic material enough for advancing a first reconstruction of the main taphonomic processes. The site is a small rockshelter oppupied during the Middle Palaeolithic, at a height of 50 m.a.s.l. The shelter was first reported by some excursionists in 2007 who found several macromammals bones and lithic industry in the superficial level (US 1 rim). This reworked level was disturbed both by anthropic and animal activities (badgers), and it was removed during the preliminary research in 2013. Authors carried out the first excavation campaign in May 2014 and detected a single anthropic layer (US 7).

Taxonomic determination and zooarchaeology analysis has been carried out on the faunal remains of the level US 1 rim, while the material that came from the anthropic level is still under study. The faunal remains suggest the presence of an open and scarcely forested environment: bovids and large-size cervids would have required plains and grasslands, in a general cold-temperate climatic context. The presence of elk, red deer and roe deer is linked to the proximity to wetlands with water sources and likely undergrowth limited areas.

The taphonomic analysis revealed an excellent conservation of the osteological material: the remains are large and their surface shows clearly the human traces, not being heavily worn by natural agents. The most frequent natural alterations are due to the presence of the manganese, the growth of the roots and the formation of concretions on the surface. The cracking patterns of the weathering and other natural alterations (such as corrosion pits, fluitation and exfoliation) are present in a low percentage. Few remains seem to had been affected by the carnivores' or roditors' gnawing.

The study revealed butchering traces on nearly half of the total number of remains: cut marks, scraping marks, percussion notches and spiral fractures, typical of fresh bone, were observed on bones coming from almost every anatomical district. Numerous shaft fragments (107; 7,15%) were used as retouchers in the final phases of the lithic *chaîne opératoire* and therefore present retouch-induced stigmata. The retouch-induced stigmata have been found mostly on long and thick bones. One of the most remarkable remain featuring these traces is a jaw of *Megaloceros*, which still presents some teeth and was used as a retoucher in two different areas.

Additional excavation and analyses, both on the lithic industry and on the faunal remains, will cast new light on the site and clarify its relationship with the territory, the organization of the site itself, the activities, the hunting areas and the chronology of the occupation.

WHEN WILD CATS FEED ON RABBITS: AN EXPERIMENTAL TAPHONOMY STUDY

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Studies of the feeding ecology of the European wildcat (*Felis silvestris*) show that leporids, mostly European rabbit (*Oryctolagus cuniculus*), dominate their diet (70-75% of the total consumed biomass) in regions where they are present. The remains of wildcats have been found at Pleistocene and Holocene archaeological sites, raising the possibility that they were active leporid bones accumulating agents in caves and shelters that they shared with other terrestrial carnivores, raptors and humans. Taphonomic studies on rabbit remains consumed by this terrestrial carnivore do not exist and their role in bone accumulations at archaeological sites is not understood. With the aim of plugging this gap in knowledge an experimental study was carried out with a wildcat female kept in captivity. She was fed with nine complete rabbit carcasses and non-ingested remains and scats were recovered for analysis. Anatomical representation, breakage, digestion and tooth marks patterns were analysed.

Our results for non-ingested remains show: i) a high representation of all skeletal elements except those from the forelimbs and axial skeleton; ii) a high proportion of whole bones; iii) a substantial number of tooth marked bones. Skeletal remains in scats were scarce and they were characterized by a heavy degree of breakage and digestion corrosion.

Comparisons of these results with those obtained for other predators, reveal that the taphonomic signature of wildcats differs from most other agents of accumulation.

NUMMULITE-DITRUPA FACIES IN THE EOCENE SHALLOW-WATER CARBONATES, TATRA MTS (POLAND) – PALAEOECOLOGICAL IMPLICATIONS AND TAPHONOMY

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The shallow-water carbonates of the so called "Nummulitic Eocene" of the Tatra Mts, Poland, is a transgressive sequence which starts with conglomerates composed of bedrock Mesozoic clasts. The conglomerates are covered by lower Bartonian detrital dolomites (extraclastic packstones) with rare large benthic foraminifera mainly *Nummulites* sp. In the upper part of this succession *Nummulite-Ditrupa* and *Nummulitic* bank facies occur. These deposits are followed by the upper Bartonian *Discocyclin*a-bearing facies comprising *Nummulite-Discocyclina* bioclastic packstone and *Discocyclina* rudstone, which are finally overlain by the Priabonian glauconitic marls with planktonic foraminifera. The uppermost part of the section is characterized by distinct facies variation and is represented by organodetritic limestones, flora-bearing limestones and upper conglomerates. These deposits are of the Priabonian age. The carbonates are succeeded by thick complex of the Oligocene turbiditic deposits.

The studied *Nummulite-Ditrupa* wackestone (up to 2.0 m thick) is composed predominantly of sand-size dolomite grains, quartz, calcareous tubes of serpulid polychaete *Ditrupa* sp., numerous robust and spherical tests of *Nummulites perforatus* and bivalve shells. The tests of foraminifera bear evidence of fragmentation, abrasion as well as borings. They display current imbrication or linear accumulation. Some tests are encrusted by *Miniacina* or *Haddoni*a type foraminifera, and show geopetal infillings. Occasionally, nummulitid test's poles are truncated or the outer surface of the youngest whorl is exfoliated.

The *Nummulite-Ditrupa* facies constitutes a transition between littoral detritic dolomites and *Nummulitic* bank facies composed exclusively of *Nummulites perforatus.* The proposed transitional facies contains relatively well-preserved *Nummulites* with taphonomically modificated tests (taphonomic category1 *sensu* Beavington Penney, 2004) suggesting seawards transport over a short distance by the action of storm-driven currents and sediment gravity flows.

Abundant *Ditrupa* in well-sorted fine- and medium-grained sands support their dependence upon substrates and most probably energy regime. The abundance of *Ditrupa* tubes (suspensions – feeders) points to an increasing input of organic flux to the bottom sea.

4D-VIRTOPSY AND THE TAPHONOMY OF A MOLE FROM THE UPPER OLIGOCENE OF ENSPEL (GERMANY)

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Taphonomic experiments and *μ*-CT-analyses of extant *Talpa europaea* provide a closer look into the decay process of small mammals under limnic conditions. The carcasses floated on the water surface when first placed in water. After a few hours they sank down or remained floating. Soft tissues began to decompose and putrefaction gas was produced at the same time. Consequently, the carcasses bloated and the before sunken specimens refloated to the water surface. The body cavities, filled with putrefaction gas, were 3D reconstructed and volumes were measured (**Fig.**). Experiments under different temperature conditions showed, that the higher the temperature, the faster the gas formation and decomposition occurred. With ongoing decomposition, the skeleton was successively disarticulated, beginning with the phalanges and the mandibles, after most of the gas had emerged from the carcass. Parts of the floating specimens were scattered. These observations were used for a taphonomic interpretation of the partial skeleton of a Late Oligocene mole (*Geotrypus antiquus*) from the fossillagerstätte Enspel in Germany. The positions of anterior extremities, and the presence of distal hand elements and left femur in addition to both mandibles articulated with occluding teeth indicate that a completely articulated specimen sank to the bottom of the lake, without an extended period of floating. After full decomposition of soft tissues, some bones were shifted, by a waterdraft from the right side, before the skeleton was finally embedded.

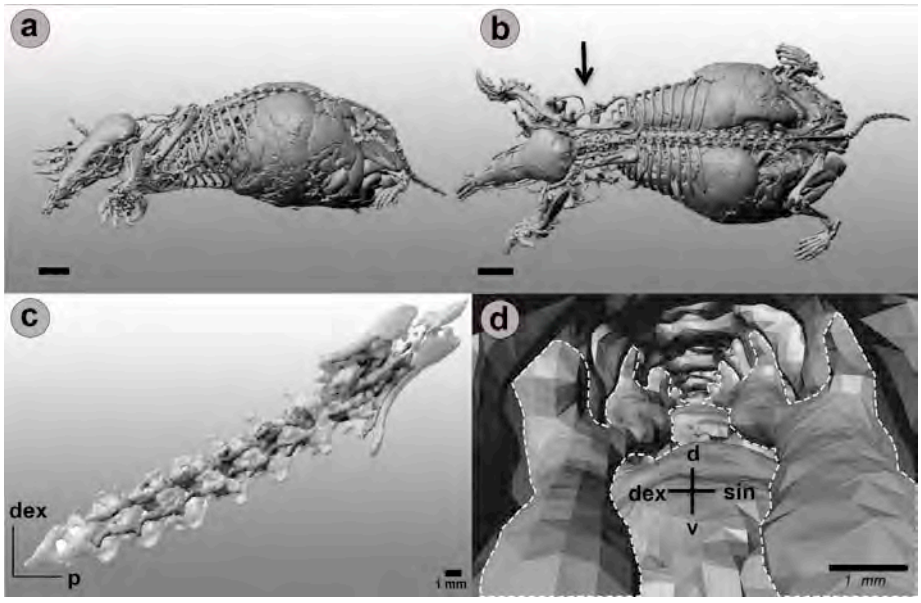

Fig: 3D-models of *Talpa europaea* T_1 (StIPB M7678) on day 5; **a** sinistral view of the skeleton containing gas accumulation; **b** dorsal view of the skeleton containing gas accumulation; gas inside the neck veins; **c** *ventral view*; gas inside the veins of the vertebra column and the pelvis; **d** *inferior* view; inside look of the thoracic vertebrae with gas filled veins (dashed line); ***d*** dorsal; ***dex*** dextal; ***sin*** sinistral; ***p*** posterior; ***v*** ventral *Scale bar* 10 mm if not declared (Mähler et al. under review)

ECHINOID TAPHONOMY AND TAPHOFACIES ALONG A SHELF GRADIENT DURING THE MIOCENE OF SARDINIA

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Sardinia is well known for a rich echinoids fauna from various Miocene sediments from different depositional environments. Although the echinoids are often found in together in large numbers as mass occurrences, these assemblages differ significantly with respect to diversity, sedimentological features as well taphonomic details. The detailed analysis of these features has allowed these echinoid shell beds to be differentiated as far as the depositional environment and specific mode of formation is concerned along a shelf gradient from shallow to deeper water settings.

The various mass accumulations have been differentiated in details with respect to taxonomic make up, size frequency distributions, density of occurrence, accompanying fauna and sedimentology. Analyzed taphonomic details include completeness of shells, type of fragmentation, plate disarticulation encrustation and bioerosion. Biostratinomic details include density of occurrence, inclination of tests, relationship of convex up and down specimens, preferred orientation and so on.

Shallow water echinoid successions are dominated by mass accumulations of clypeasteroids, which by means of interlocking plate connections and internal supports have high preservation potentials in higher energy environments. The accumulations are dominated by only a few genera including *Clypeaster*, *Parascutella* and *Amphiope*. These mass occurrences originate predominately in siliciclastic environments and range from 25 to 220 cm in thickness. Randomly dispersed to densely packed, highly imbricated echinoids are present. Although all echinoids show spine disarticulation, they differ with respect to intraplate disarticulation, surface abrasion, encrustation and non-lethal predation. Post-depositional features such as grain indentation and radial cracking are also present. Although these mass occurrences are interpreted to all originate from the shallow water, shoreface environment, they show strong differences in their genesis ranging from proximal storm deposits to multiple reworked, in situ accumulations.

Deeper water echinoid accumulations are characterized by echinoids with less robust skeletons including regular echinoids as well as thin shelled spatangoids. Three different monotypic assemblages were again compared with respect to preservational fabric and taphonomic signatures. Regular echinoid spines and rare tests represent a composite tempestite. A phymosomatid (regular echinoid) assemblage is interpreted to have been rapidly buried by obrution, and finally, a spatangoid assemblage consisting of the echinoid *Brissopsis* is seen to represent a mixed accumulation of transported and par-autochthonous skeletons. The origination of these assemblages can, in part, be ascribed to gregarious behavior, but also to sedimentological events in different settings along a storm-dominated siliciclastic shelf environment.

DISCRIMINATION BETWEEN PERI-MORTEM AND POST-MORTEM TRAUMAS ON HUMAN SKELETAL REMAINS: THE CASE OF PREDAPPIO (FORLÌ-CESENA, ITALY)

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Distinguishing between *peri-mortem* and *post-mortem* traumas is one of the main aspects of taphonomy applied to human skeletal remains. The formers occur just before or near the moment of death and are usually linked to its dynamics, while the latters are created after deposition by taphonomic agents and help reconstructing the burial environment. Post-depositional alterations due to weathering, soil, biological agents, excavation etc. can, on the other hand, mimic evidence of accidental or inflicted traumas, generating confusion in the reconstruction of past populations' behavior. This work reports the results of the analysis conducted on some emblematic lesions, generating confusion, detected in a skeletal sample coming from Predappio (Forlì-Cesena, Italy). The site was discovered in year 2005 and a first brief survey was made in year 2010; initially, its characteristic and location made hypothesizing it was linked to the Second World War. The retrieved human skeletal remains were thus analysed with special care for skeletal lesions that might be referred to intentional violence, such as cut-marks, chopping marks, crush fractures, bullet marks etc., that were effectively detected on the sample. The application of methods developed in taphonomic and forensic sciences and the use of applied techniques such as microscopy has helped in distinguishing between lesions occurred on fresh bone (*peri-mortem*) and those occurred on dry bone (*post-mortem*), and in identifying the agents or the eventual instruments and actions that generated them. After the analysis, few of the detected lesions were effectively confirmed as *peri-mortem* traumas, while the majority of them were ascribed to taphonomic effects. For example, some hypothesized sharp force injuries on the left *os coxae* of an adult female individual were finally diagnosed as *post- mortem* damages created by the weight of sediments and trampling (Fig.1). These results were then confirmed in year 2011, when more accurate archaeological surveys at the site (University of Ferrara, Dr. Federica Fontana) allowed to ascribe it to a secondary burial context belonging to medieval-modern period, already explored by illegal diggers. The presence of *peri-mortem* traumas in the sample can therefore be linked to accidents or eventually to some occasional episode of interpersonal violence, instead of some massacre linked to the Second World War. In conclusion, this study has underlined the benefits of the use of an interdisciplinary approach and application of taphonomic techniques to osteo-archaeology for discriminating between *peri-mortem* and *post-mortem* lesions, thus giving an important contribution to the reconstruction of the site's history and past populations' behavior.

Fig.1. Left *os coxae* of a female individual with taphonomic lesions miming sharp force injuries.

PINCTADA MARGARITIFERA PROCESSING IN NEOLITHIC OMAN: RH-5, RA'S AL-HAMRA CASE OF STUDY (IV MILLENNIUM BC)

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RH-5 is an a-ceramic Neolithic site, located in the Qurum cape, 13 km NW from the Capital City Area of Muscat, Sultanate of Oman (coordinates: 23° 37' 32'' N, 58° 28' 41'' E). Its stratigraphy spans from the end of the V millennium BC to the second part of the IV millennium BC, on a time lapse of over 700 years. It consists of a settlement and a funeral area, that corresponds to the middle phases of the settlement. During the excavations, carried out by a German-Italian team during the 80s and a French-Italian team during the 2000s, seven phases were recognised in the 1.5 m thick stratigraphy. The most recent is called "recent phase" and corresponds to layers 0, 1 and 1b. Layers 2 separates the "recent" from the "middle phase", represented by layer 3, 3b ,3c and 3d. Then, level 4 divides the "middle phase" from the "ancient one". The "ancient phase" is represented by layers 5, 5a and 5b (end of the V millennium-beginning of the IV millennium BC).

The material culture of the site is sea-oriented: a lot of finds are related to fisheries, such as net sinkers (mainly made of stone, or pebbles) and fish-hooks (both in shell and bone). Among the ornamental artefacts, the presence of schist and steatite earrings and soft stone pendants have to be highlighted. As mentioned before, this is an a-ceramic site but some fragments of a ceramic vessel were recovered at the top of the stratigraphy: the Iranian style of this ware suggests an ancient origin of the Arabian Gulf trade. Lithic tools include hammers and anvils, Hamrian bulin, limestone files, retouched flakes and blades; the most common raw material is jasper. Shells are one of the most common raw material. Among shell artefacts most of them are made by Pterioidea family specimens. This study aims to clarify the choice and use of this shell fragments.

The sample comes from the 2009-2010 field excavations: it belongs to the settlement area, specifically to Sector B2, dated at the beginning of the IV millennium BC. In the analyzed sample, at least two taxa were identified: *Pinctada margaritifera* and *Isognomon* sp. The purpose of this study is double: firstly to confirm the attribution of the fragments to the different phases of the *chaîne opératoire*, secondly to contribute to the interpretation of the SSUU.

All the fragments were counted (NR: 345), measured, classified by anatomical part, entered into a database (Microsoft Access®), observed by stereomicroscope (Leica SD6 with integrated digital camera EC3) and photographed. The majority of fragments was recovered in SU 3002 ; even the tomb contexts have quite abundant material. SU 3000, 3003 and 3004 gave an average percentage of fragments, while in the remaining layers only few fragments were brought to light. For which is concerning the For which the taphonomic analysis is concerning, four parameters were examined: the state of preservation, the presence of biological attack, the shape and the colour. With regard to the state of preservation, we attempted to identify if the fragment still bore traces of the outer coating layer, the inner layer, or both; then, we described it as intact (good condition), peeled, altered by processing (worked) or fire (burning). The biological attack consists of a series of holes, variably s deep, on the surface of the shell: only the 11% of the fragments are affected, almost concentrated in layer 3004. The detection of the shape is rather complex: although many fragments have polygonal sides, the shape is often ascribed to the category irregular (88,99%), because does not fall within the parameters of geometric shapes. To check the colour of the fragments, we referred to the Natural Color System (NCS) Index, second edition. The most common colour is identified by the code S 0502 Y (nacre; 62,61%); white and pink shades are quite common. A few fragment are described by the code S 0505-Y20R (yellow). Shades of grey are present on only four fragments, one of which bears traces of combustion; the other burnt elements are white (S 0500-N).

In order to achieve a better understanding of the *chaîne opératoire* traces on the fragments, we undertook an archaeological experimentation with the collaboration of Mr Alfio Tomaselli. We worked on three specimen of *Pinctada margaritifera* recently collected in Ra's al-Khaima lagoon,

Sultanate of Oman. All the steps of the experimentation were documented by photos and videos ; each step was described in a suitable form, filled at the time of the experimentation. The material was collected and bagged separately, in order to allow the observation of each piece and the comparison with the archaeological material. The experimental materials have undergone a similar classification to that one carried out on the archaeological sample. The fragments were analyzed according to the phases of the *chaîne opératoire* to which they belong, measured and described according to their shape. The taphonomic analysis of this material concerns the edges, the morphology of the fractures, the presence of concretions and the surfaces.

The microscope analysis allowed to recognise the only one fragment with processing traces in the archaeological assemblage; moreover the comparison between archaeological and experimental material permits the attribution to a clear step of the *chaîne opératoire*.

It's difficult to recognise archaeological fragments referred to the first stage of the *chaîne opératoire,* because they completely lack the *periostracum*. The edges, produced in the first two phases of percussion, cannot be directly correlated to the archaeological material, but the material of the third stage, with the particular notches and peaks detected, recalls some of the characteristics observed in the archaeological material. It's also remarkable the similarity between the percentage of the two classes of the materials in the dimensional analysis. The polishing (step 4) can be noted only on pieces in an advanced stage of processing, which are not present in our sample. The fifth phase, the drilling of the preform, is represented by only one fragment of the archaeological sample. It is a broken fragment, about 2 cm long, with a hole of 1,3 cm in diameter, quite comparable with the perforated preform made experimentally. Perhaps the breakage is attributable to the next stage, the opening or ovalization of the hole. We cannot affirm that all this fragments belong to the *Pinctada margaritifera* fish-hook processing, because the early stages of the *chaîne opératoire* overlap with those of the production of shell-rings, and we cannot distinguish between the two, especially in our sample. In substance, it seems clear that, because of the thickness and the hardness of the raw material, the fragments belong to, although in the form of waste, the processing of *Pinctada margaritifera* shell. Furthermore the small number of fragments, although it is impossible to estimate the MNI (Minimum Number of Individuals), indicates a limited use of the resource, excluding a predominantly food value of the species. To underline the importance as raw material, we stress that the species should be collected by immersion, even in shallow waters (3-20 meters). Moreover the species is well-known as pearl oyster.

This study also attempts to clarify the SSUU interpretation. In almost every case the original interpretation was supported and proved by our conclusions. We also noticed that the funeral contest (GRAVE 421 and GRAVE 422) are similar, in shell composition, to the other layers, therefore we could affirm that these fragments belong to the filling material of the graves.

Our future aim is to better analyze the shell processing in order to clarify the characteristic traces of each step of the *chaîne opératoire* on this material.

A TAPHONOMIC ANALYSIS OF BURNED HUMAN REMAINS FROM THE ETRUSCAN SITE OF SPINA (VI-III CENTURY. B.C.)

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Etruscans were one of the great pre-Roman civilizations in Italy. The Etruscan site of Spina is located in Etruria Padana, in the Po Valley (north-eastern Italy). During the period from the end of 6th to the 3rd century B.C., the great commercial port of Spina was a lagoon city dispersed over several small island surrounded by channels and protected by strong embankments. The necropolis was located on the sand dunes outside the city and two different types of burial have been reported: inhumation and cremation. The burned human remains examined come from 67 cremation graves. Taphonomy is an essential tool for the interpretation of these burned skeletal remains, particularly for the recognition of the changes involving the bone, and for the reconstruction of the original position of the body during the combustion process. Exposure to fire and the combustion temperature acting on the bone caused color changes, fractures, cracks, deformations and contractions. The human remains of Spina showed the typical crack patterns and fissures indicative of fresh cremation on bone with organic matter. The presence of different combustion degrees can be established by looking at the color giving information on cremation process. Methods by Holck (1986), Shipman (1984), Franchet (1970) were used for the recognition of the color of the bone fragments and its association with the combustion temperature. Despite some methodological differences, all the cited authors found a similar basic pattern of dark reds and browns at low firing temperatures (300°C), giving way to a charred black appearance and then progressively lightening again with increasing temperature, so that ultimately the fragments are white (800-1000°C). The areas of the skeleton that appear lighter were subject to higher temperatures and were in direct contact with the fire, while the bones who had darker coloration were those in which the heat came indirectly. In all cremations from Spina the prevailing colors of the bone material were light gray, white, dark gray and shades of blue related to 2 and 3 degree of the chromatic scale by Holck, corresponding to temperatures between 400 °C and 800 °C (Fig. 1). All skeletal materials from different graves are homogenous, displaying the same burning degree. Therefore, it can be assumed that the combustion has taken place in a similar way for all subjects.

Fig. 1. Pattern of color in burned human remains from site of Spina

DINOSAUR TAPHONOMY IN THE LOURINHÃ FORMATION (LATE JURASSIC, PORTUGAL)

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The Upper Jurassic Lourinhã Formation is known by the richness in vertebrate specimens, mostly dinosaurs, mainly in the middle section of the formation, i.e. within or close to the Porto Novo and Praia Azul Members. The bone preservation in the upper part of the formation (Assenta and Santa Rita Mbs.) are rarer, maybe due to geochemical conditions (i.e., pH) unfavorable to bone fossilization. These conditions may resulted of the paleoenvironment: less confined channel in more distal delta position, which induced more fluid circulation.

Skeletons. In the Lourinhã Formation, dinosaur skeletons have been found, mostly incomplete. Articulation mainly occurs in fine sandstones that correspond to confined river channels in a meandric deltaic river system, while grey mudstones usually preserve microfossils (such as crocodylomorph and mammaliamorph teeth or albanerpetontid bones) but seldom macro-skeletal remains. Full articulation is rare but occasional association is more common, while complete disarticulation and preservation of isolated bone parts is frequent. Incomplete, but associated to articulated skeletons have been found for the holotypes of the tetanuran theropods *Lourinhanosaurus antunesi* and *Allosaurus europeus*, the diplodocid *Dinheirosaurus lourinhanensis*, the camptosaurid *Draconyx loureiroi*, and the nodosaurid *Dracopelta zbyszewskii.* High association (but not fully articulation) was present in the holotypes of the brachiosaurid *Lusotitan atalaiensis*, the basal neosauropod *Lourinhasaurus alenquerensis*, the turiasaur *Zby atlanticus*, and the Dacentrurinae *Miragaia longicollum*. Many other type specimens are based upon isolated bones.

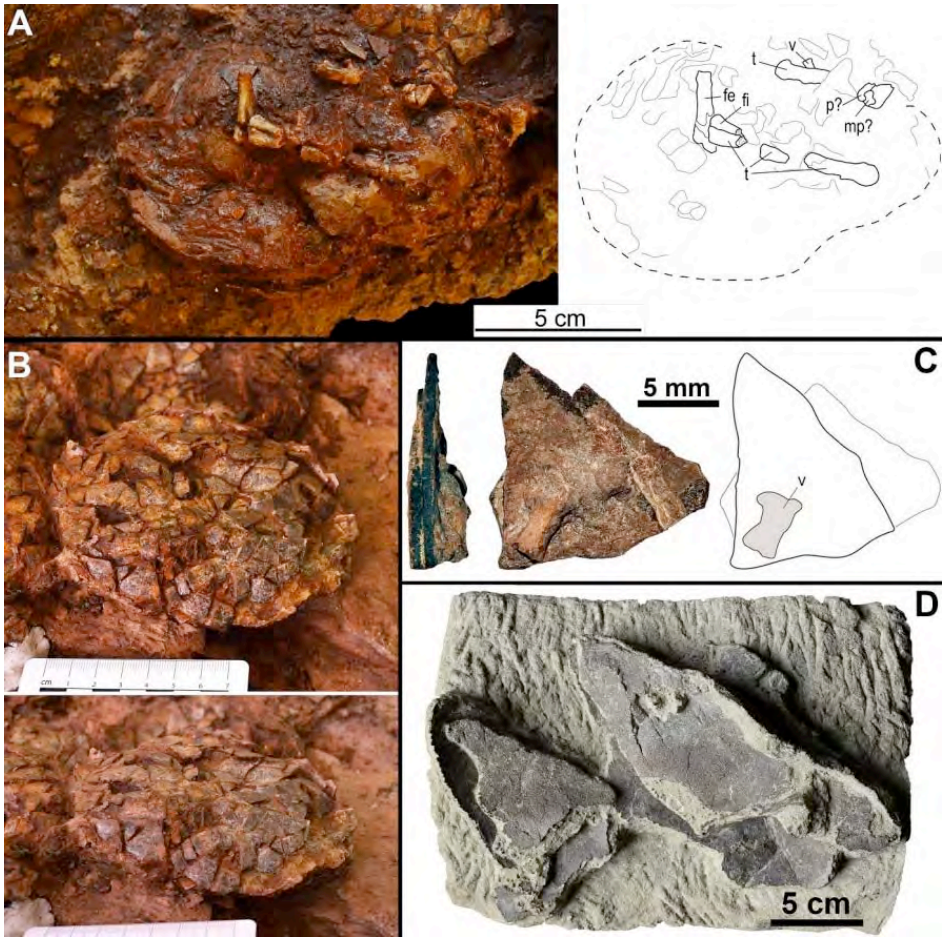
Z. atlanticus ML 368 comprised a hindlimb, chevron and complete tooth with root: due to the presence of the crown, we can assume it was disaggregated *post-mortem* out of the skull (though unpreserved), thus it was not a shed tooth. In *L. antunesi*, where bones were found broken with sandstone infills, and in *Z. atlanticus*, where the radius presents a concavity made by the pressure contact with a manual phalanx. These cases show a strong lithostatic pressure during the diagenesis, but while the bones still preserved a certain degree of elasticity. Signs of sclerobiont activity are rare.

Gastroliths. In the Late Jurassic of Portugal, sauropod specimens are often associated with gastroliths (i.e. *Dinheirosaurus*, *Zby*, and indet. sauropods), and a well visible case in the theropod *Lourinhanosaurus antunesi* ML370 holotype, with 32 gastroliths within the ribcage and, among them, four ungual phalanges of an ornithopod.

Tracks and footprints. Dinosaur true tracks (concave epireliefs) are usually common in carbonate platforms of shallow marine facies. But in Lourinhã Formation, rocks are mainly a succession of intercalated sandstone and mudstone, with only rare limestone transgressive levels. In this situation, track preservation occurs when tracks were produced at the interface of the two lithologies, or near it. The vast majority (> 80%) of footprints in the Lourinhã Formation are sandstone natural casts infills, i.e. sand filling of the original true tracks produced in the mud surface. In some specimens, skin and claw impressions and striation marks are preserved.

Eggs and nests. Different localities provided nests and eggs with embryos of the theropodian species *Lourinhanosaurus antunesi* and *Torvosaurus gurneyi*, always preserved in mud or siltstones. In the Paimogo nesting ground, the eggs were rearranged by a flood event. The thick mudstones, stratigraphically above and below the nesting horizons, indicate a long persistence of periodic flooding, alternating with pedogenesis in a semi-arid and subtropical climate with dry and moist conditions.

Due to different levels of the eggshell solidity and porosity, the thinner and less porous eggshells of *L. antunesi* are brittle. The eggshells break as the eggs deforms vertically (down to 20%) by lithostatic pressure during the early stages of the diagenesis, with the egg being filled by mudstone. In contrast, the eggshells of *T. gurney* deformed plastically without breaking (until a certain limit) probably due to their higher porosity. In both cases, eggs are vertically compressed but they still partly preserve the original outline.



(A) ML565: photograph (left) and interpretative drawing (right) of a Paimogo egg with *Lourinhanosaurus antunesi* embryonic bone; fe = femur; fi = fibula; mp = metapodium; p = pelvis; t = tibia; v = vertebra. (B) ML565: photograph of a *L. antunesi* egg in orthogonal (upper) and oblique (lower) view. (C) ML565-046: lateral view (left), internal view (center), and interpretative drawing (right) of two eggshell fragments with a vertebra of *L. antunesi* on the eggshell internal surface; v = vertebra. (D) ML1842: photograph of the egg from Porto das Barcas attributed to the megalosaurid *Torvosaurus gurney*.

RECONSTRUCTING THE COLOURS OF FOSSIL VERTEBRATE SKIN: IMPLICATIONS OF NON-INTEGUMENTARY MELANOSOMES

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Melanin is a biologically widespread tyrosine-based polymer with important physiological functions. It is a key component of visual signals in animals via its incorporation into integumentary patterning and, in vertebrates, occurs in skin and its derivatives as discrete micron-sized membrane-bound organelles, melanosomes. Preserved melanosomes and chemical evidence of melanin have been used to infer the original plumage colours of fossil birds, feathered dinosaurs and isolated feathers, and to infer the evolution of visual signaling strategies through time. In a recent analysis of soft tissues in fossil marine reptiles, diagnostic chemical evidence of melanin associated with microstructures previously interpreted as bacteria was used to interpret original integumentary coloration. In extant vertebrates, however, melanosomes also occur in internal tissues, and hence melanosomes preserved in fossils may not derive solely from the integument. Here, by analyzing the internal tissues of extant and fossil frogs using scanning electron microscopy, transmission electron microscopy, histology, and fluorescence microscopy, coupled with statistical analysis of digital images, we show that non-integumentary melanosomes are extremely abundant. In fossils, non-integumentary melanosomes are usually localised to the torso but can also occur in the limbs, presumably due to dispersal during decay. Melanosomes from the body outlines of fossils cannot, therefore, reliably inform on integumentary coloration. Crucially, statistical analysis of melanosomes in SEM images shows that non-integumentary and integumentary melanosomes differ in geometry in both fossil and modern frogs and, in fossils, occur as discrete layers. It is therefore possible to differentiate integumentary from non-integumentary melanosomes in fossils by analysing melanosome geometry, distribution and layering. Such an approach is essential to any attempt to reconstruct the original colours of vertebrate skin.

TAPHONOMICAL AGENTS AND FAUNAL EXPLOITATION DURING THE MOUSTERIAN: THE CASE OF BONE REFITS IN LEVEL 37 OF RIPARO TAGLIENTE, VERONA

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In recent decades, many research questions focused on occupational patterns in the Middle Palaeolithic. Many discussions on that topic, addressed the temporal resolution of assemblage's accumulation and the character of palimpsests that can be observed at archaeological sites. In this case bone refits are a good example to analyze questions related to temporal resolution of human occupations. For more than a century archaeologists have been refitting or conjoining fragments of lithic, ceramic artifacts and bones.

This work presents the results achieved by the archaeozoological analyses, carried out on the faunal remains coming from the mousterian level 37 of Riparo Tagliente. The site, discovered in 1958 by F. Tagliente, lies on the left side of the Valpantena valley, in the Venetian Prealps, at 250 metres above sea-level. The chronology, that spans from about 60,000 BP to 30,000 BP., for all the sequence of the mousterian levels from 52 to 31, corresponds to a glacial cycle. The taphonomical analysis proceeded by selecting all the bone fragments, whose surfaces are generally well preserved. This fact allowed a detailed analysis of modifications, caused by anthropic activities. Several diaphyses fragments with marginal notches testify the interest in marrow extraction that produce an high degree of fragmentation. Multiple cut-marks, that are often oblique and related to defleshing with a lithic tools, are present on the surface of numerous diaphyseal fragments, as well as traces showing the utilization of the bones in order to retouch lithic tools. In other cases, alteration by digestion, transport, weathering, soil corrosion, trampling, exfoliation and/or erosion, burning and diagenesis have affected the surface in a more or less invasive way. All of these processes are known to leave characteristic patterns of alteration and fragmentation on bone surfaces. Moreover, this work is also correlated by faunal refits with the aim to improve the knowledge of the site formation processes. This approach is correlated with neighborhood analysis and spatial distribution. In this way we can reconstruct some of the natural and cultural processes involved in this record, in order to explore the anthropogenic use of the site, the differences between occupational patterns, subsistence activities, domestic areas and level of group's sophistication and duration of the site occupation. This fact shows the importance of this approach, with the intent that the diversity of occupational patterns and ways of life of the human communities of the European Middle Palaeolithic could be better described.

HUNTING IN PREHISTORY: HOW TO RECOGNIZE IT? RESULTS FROM IDENTIFYING EXPERIMENTAL IMPACT MARKS ON MEDIUM SIZE UNGULATE CAUSED BY LATE EPIGRAVETTIAN PROJECTILES

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The ability to kill prey at a distance gave to our ancestors an advantage over their ecological rivals like carnivores. For this reason, the introduction of projectile technology is nowadays recognized as one of the greatest innovation in human behavioral evolution.

Although there is a growing body of research focused on zooarchaeological projectile impact marks in European, Levantine and African assemblages, the criteria for their recognizing are currently strongly debated. The scarcity of archaeological evidence and the methodological inadequacy of several experimental protocols, in fact, did not allow the development of a standardized practice in impact marks identification. Besides, the great variability of extrinsic and intrinsic techno-functional parameters influencing impact marks, enhances the difficulty in establishing common interpretative keys of trauma morphologies and features.

If an integrated macro- and microscopical approach is required, it is also crucial considering all the features present on a bone and interpreting them on the basis of strong experimental references. This work aims to provide new clues to this methodological debate, focusing on bones injuries caused by Late Epigravettian lithic projectile implements (Fig. 1). The main goals of the experimental program were to explore the performance of these types of projectiles in penetrating medium-size ungulates, to prove their functional suitability within the bow-arrow delivery system and to create a reliable reference of impact damages essential for the interpretation of Late archaeological assemblages. Through identifications in macroscopic and microscopic 2d and 3d analysis results we show the practical application of this data in identifying Paleolithic arrow wound injuries.

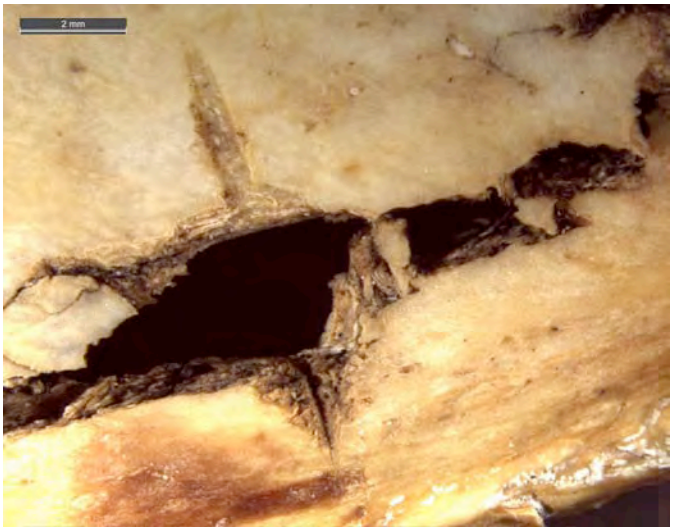

Fig. 1. Experimental puncture/fracture on shoulder blade.

STABLE ASSOCIATION IN A DYNAMIC CLADE: LIFE HABIT OF *MIOERYCINA LETOCHAI*, A COMMENSAL BIVALVE FROM THE MIDDLE MIOCENE OF THE CENTRAL PARATETHYS

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The superfamily Galeommatoidea represents one of the most species-rich groups of bivalves characterized by an unparalleled diversity of life habits. Apart from free-ling forms, its modern representatives encompass ecto- and endosymbionts, and burrow associates of various benthic invertebrates, including sponges, cnidarians, sipunculans, annelids, brachiopods, molluscs, crustacean and echinoderms. Recent molecular studies have documented remarkably dynamic evolution of their lifestyle with multiple instances of host specialization and switching occurring repeatedly in different galeommatoidean clades. As many host organisms have very poor preservation potential, interpretation of the life habit of extinct species of Galeommatoidea is a challenging task. Nevertheless, such data are necessary to constrain the temporal scales on which the evolution of commensal relationships takes place. They may also provide important information about the presence of certain hosts in ancient communities. Here we integrate evidence based on new fossil findings, shell morphology and actualistic data on living relatives, in order to reconstruct the life habit of *Mioerycina letochai* (Hörnes), a peculiar bivalve from the Badenian (Middle Miocene) of the Central Paratethys.

Mioerycina letochai is a rare and minute (up to ~4 mm) montacutid bivalve. Its shell is characterized by a distinct shape with a concave ventral margin and slightly twisted commisural plane. The sole living representative of the genus, *M. phascolionis* (Dautzenberg & Fischer), occurs along the Atlantic and Mediterranean coasts of Europe and is an obligate commensal species living inside empty gastropod shells occupied by the sipunculan worm *Phascolion strombi* (Montagu). The bivalves, often several individuals clumped together, occur in a secondary burrow within a mucous-cemented plug of sediment created by the worm. Just as *M. letochai,* the recent species exhibits an increase in shell asymmetry during ontogeny related to a constrained growth in a limited space of the shelter.

Two articulated specimens of *M. letochai* were found in situ inside the shell of *Nassarius volhynicus* (Andrzejowski) collected from fine sands of the Late Badenian age (Serravallian, Middle Miocene) at Vanzhuliv, western Ukraine. The bivalves were embedded in a loose sediment partly infilling the shell behind the aperture plugged by more strongly cemented sand. The gastropod shell has a chalky, eroded surface, which contrasts with pristine preservation of most of the associated fauna, and may point to a prolonged residence on the sea bottom. Subsequent survey of literature and museum records has shown that *M. letochai* is rare species, typically represented by a single specimen or just a few valves per locality, in spite of its wide geographic distribution throughout the Paratethys Sea. Such pattern of occurrence can be explained by a cryptic life habit. An exceptionally rich collection, encompassing several tens of *Mioerycina* shells, was obtained from the Korytnica clays (Lower Badenian, southern Poland) through an extensive washing of the sediment infillings of large gastropods shells, mostly of *Clavatula* spp. (pers. comm. G. Jakubowski, Museum of the Earth, Warsaw).

Although no direct evidence for the presence of sipunculid worms could be detected in the studied material, the above observations strongly support the interpretation of the life habit of *Mioerycina letochai* as similar to that of its modern relative *M. phascolionis.* Commensal relationship of minute montacutid bivalves with shell-dwelling sipunculans, which most likely developed as an anti-predatory adaptation, has therefore existed at least since the early Middle Miocene. In the context of a dynamic evolution of galeommatoid lifestyles, the *Mioerycina* linage may serve as an example of a clade with a long history of stable biotic association.

EXPERIMENTAL AND THEORETICAL HYDRODYNAMIC BEHAVIOUR OF *NUMMULITES* TESTS IN NUMMULITE BANKS

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The long-lasting debate regarding the accumulation of the biosedimentary bodies known as 'nummulite banks' views two opposite interpretations: an autochthonous one, as in the original definition of the banks, and an allochthonous one, where transport and selection of the nummulite tests play a fundamental role. The latter interpretation is currently followed by several researchers, who pointed out the different transportability of nummulite tests as the reason for the relative enrichment in larger B forms with respect to the smaller A forms of the same species.

To test the assumptions of the transport hypothesis, 58 well-preserved tests of fossil *Nummulites* from two banks were put in a settling tube to determine experimentally their settling velocities. These tests come from Pederiva di Grancona (A-forms of *N. lyelli* and *N. striatus*; Middle Eocene) and San Germano dei Berici (A and B-forms of *N. fabianii*; Late Eocene, both in the Berici Mts. (Veneto, northern Italy).

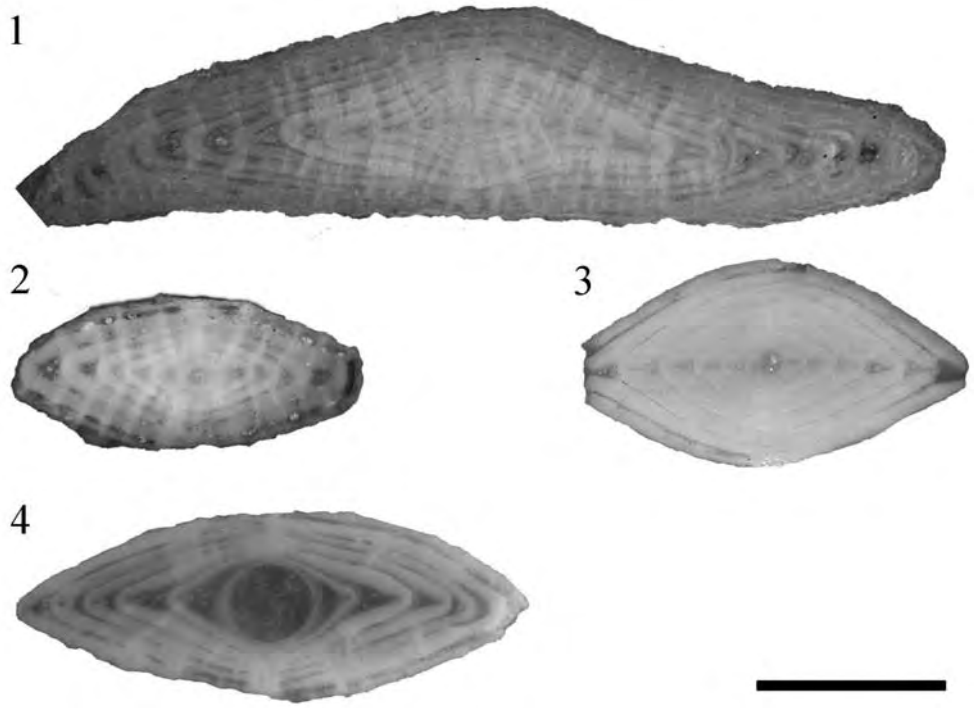
The obtained settling velocities were then corrected for the presence of calcite infilling the original empty spaces of the tests, to evaluate the hydrodynamic properties of the tests of the specimens when alive or right after death.

The theoretical behavior of the tests was then calculated by using the real density, obtained by weight/volume ratio, and the density calculated according to the half-tori method, which estimates the cavities filled with water or with calcite.

Setting aside the different theoretical approaches, the calculated settling velocities, corrected for simulating water-filled tests, have been compared. The results show that *N. lyelli* A and *N. striatus* A from the Pederiva bank, in spite of their different size and shape (Fig. 1), have low differences in hydrodynamic properties. At the same time, *N. fabianii* A and B show similar, even if size-dependant, settling velocities.

The results are coherent with a substantially autochthonous depositional scenario, where the smaller A forms of the dominant species are accumulating in equilibrium with the hydrodynamic energy characterizing the depth; the larger B forms can tolerate slightly higher energy, so their accumulation over the A forms could explain the slight relief associated with the nummulite banks.

Fig. 1. Axial sections of *Nummulites* specimens. 1) *N. fabianii* B – Priabonian, San Germano dei Berici. 13; 2) *N. fabianii* A – Priabonian, San Germano dei Berici; 3) *N. striatus* A – Bartonian, Pederiva di Grancona; 4) *N. lyelli* A – Bartonian, Pederiva di Grancona. Scale bar = 2 mm.



THE TAPHONOMY OF MOLECULAR FOSSILS IN MICROBIALLY FORMED ROCKS

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Because Bacteria and Archaea rarely leave behind body-fossil evidence of their presence in ancient environments, geochemical approaches are required to understand their impact on the evolution of element cycling. Some information on the chemical zonation in ancient sedimentary successions can be gained from body fossils, trace fossils, and the analysis of redox-sensitive elements, but such studies only allow to vaguely constrain former prokaryotic populations. With the aid of some stable isotope systems (e.g., C, S, N, Mo) biogeochemical processes can be reconstructed. But even with such analyses it is not possible to identify bacterial or archaeal taxa. Therefore, only molecular fossils – commonly also referred to as lipid biomarkers – provide the means to trace certain groups of prokaryotes into deep time, given the low preservation potential of genetic information. Biomarkers are organic molecules, which are either identical of sufficiently similar to biological precursor molecules, allowing for their assignment to a specific source, usually a phylogenetic group of organisms (e.g., cyanobacteria). The majority of molecular fossils is represented by compounds that derive from cell membranes. The use of lipid biomarkers in environmental studies is not restricted to ancient environments. When applied to modern sediments or soils, biomarker studies have the disadvantage that the diversity of a population is underestimated, but they have the advantage over other culture-independent techniques that the key players (i.e., the most common taxa) are reliably identified, as no amplification of signals is required. Certain, yet usually only minor biases, however, are also involved in the quantitative reconstruction of the composition of prokaryotic populations from biomarkers, as, for example, bacterial lipids tend to degrade faster than archaeal lipids.

A critical aspect that needs to be considered when molecular fossils are used to reconstruct paleoenvironments is their taphonomy. Why are some molecules preserved whereas other are degraded? Many aspects affect the preservation of lipids, but the two most significant are biodegradation and maturity. Different groups of compounds (e.g., alkanes) withstand higher temperatures and pressures than others (e.g., alcohols), but overall maturity will have a similar effect on all lipids within a rock unit. In cases where migration of compounds is minor, the most severe effect of biodegradation on the lipid inventory will have occurred during or shortly after deposition.

An obvious, yet only one among many other applications of biomarkers is the study of microbially formed rocks. Such rocks form by a range of processes. The most significant process is commonly in situ mineral formation, which can be grouped into two categories: (1) precipitation driven by a microbial metabolism and (2) precipitation induced by matrix-solute interaction. In photosynthesis-based microbial mats different groups of microorganisms tightly interact, including oxygenic and anoxygenic phototrophs on the one hand and heterotrophs on the other hand. Some microbial mats mineralize, resulting in the formation of stromatolitic rock. One would expect that biomarkers preserved in stromatolites archive the average population of the parent microbial mats. This, however, is usually not the case. I will provide a suite of examples to highlight that the biomarker inventory of microbial rocks is largely influenced by the respective mineralization mode. If mineralization is driven by one dominant metabolism performed by a species-poor microbial community, the biomarkers of this community tend to be preserved very well. In more complex ecosystems, lipid preservation will be a function of community composition and the driving forces for mineral formation. Biomarkers of cyanobacteria will only be well preserved in stromatolites if mineralization is indeed driven by oxygenic photosynthesis. If, however, mineralization is largely a function of degradation of organic compounds in deeper parts the mat, cyanobacterial biomarkers tend to be erased and biomarkers of heterotrophic bacteria will be preferentially preserved. Such taphonomic biases need to be considered when prokaryotic populations are reconstructed from

biomarkers preserved in authigenic, microbially formed rocks. Because microbial carbonates are increasingly used as archives of environmental change, it will be important in the future to better constrain their actual formation modes in order to derive reliable reconstructions of paleoenvironmental conditions from this excellent, yet possibly biased archive.

BURROWING ACTIVITY AS TAPHONOMIC AGENT AFFECTING BENTHIC FORAMINIFERAL ASSEMBLAGES (LATE MIOCENE DEPOSITS, CONIL, SW SPAIN)

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Burrowing activity can be an important taphonomic agent producing significant alterations of fossil remains. In this study, we assess how bioturbation can alter benthic foraminiferal assemblages formed under homogeneous environmental conditions. We have studied late Miocene deposits that crop out continuously along coastal cliffs in the El Roqueo and La Fontanilla beaches from Conil de la Frontera (Cádiz, SW Spain). The late Miocene deposits, nearly 700 m in thickness and dipping ~25º to the southeast, consists mostly of siliciclastic sediments with carbonates at the very top. The whole section can be divided into three parts characterized by gradual transitions among them. The lower part, nearly 300 m thick, is made up of an alternation of packages of massive silts and medium-grained sand with pervasive large trough cross-bedding. Tabular beds, up to 10 cm thick, of medium-grained sand also intercalate in the silts. The middle part, up to 150 m thick, consists of blue marls. The grain size increases upwards, thus passing to the upper part, characterized by silts and fine-grained sands that intercalate carbonate beds with trough cross-bedding. The section ends with calcarenites and calcirudites with ubiquitous large-scale trough cross-bedding. The lower and middle parts of the section are enriched in glauconitic grains. The sediments in the whole section are strongly bioturbated (ichnofabric index 4; up to 70% of bioturbation), dominating almost exclusively *Macaronichnus*.

In the lower part of the blue marls, an evident alternation of intensely bioturbated and non-bioturbated beds is observed. The benthic foraminiferal assemblages of these alternances have been studied in order to investigate the effect of the bioturbation in the preservation styles of the foraminiferal tests as well as the changes in the composition of benthic foraminiferal assemblages. Nine samples distributed in the bioturbated (ROQ-1, ROQ-4, ROQ-6, ROQ-8 and ROQ-9) and non-bioturbated marls (ROQ-2, ROQ-3, ROQ-5 and ROQ-7) have been collected. We quantified taphonomic features of benthic foraminifera using different categories (0 when the specific taphonomic trait is absent): fragmentation (0 to 4), abrasion (0 to 3), dissolution (0 to 3), borings (0 to 3), recrystallization (0 = absence; 1 = coatings on the foraminifer tests), fillings (absence, calcite or pyrite), and preservation of the foraminifera with their original test or as moulds (0 = original test; 1 = mould). The quantitative taphonomic analysis was based on the first 200 benthic foraminiferal tests picked up from the size fraction >125 μm. The different taphofacies were established using Q-mode cluster analysis. Other parameters, such as the planktonic/benthic ratio (P/B ratio = [P/P+B] x 100), number of benthic foraminiferal tests per gram of dry sediment (N/g), diversity measures (Shannon index, equitativity and dominance) and benthic foraminiferal assemblages, have been obtained from sub-samples containing at least 300 benthic foraminifera from the size fraction >125 μm. Q-mode principal component analysis (PCA) was performed in order to group dominant species into assemblages.

Q-mode benthic foraminiferal assemblages, mostly dominated by *Cibicidoides pachydermus* (PC 1) and *Cibicides refulgens* (PC 2), indicate that the studied marls were deposited in an oligotrophic, well-oxygenated outer platform (100-200 m depth). No significant variation in the assemblages of the bioturbated and non-bioturbated beds is observed, except for subtle differences. In the non-bioturbated beds, *Brizalina spathulata*, a shallow infaunal and mesotrophic species, is more abundant than in the bioturbated ones. Furthermore, these non-bioturbated beds are characterised by relatively high diversity, low dominance, high P/B ratio and low N/g. In the

bioturbated beds, *Globocassidulina subglobosa*, an oligotrophic inhabitant of well-oxygenated bottoms, is more abundant than in the non-bioturbated ones. In addition, these beds show relatively low diversity, high dominance, low P/B ratio and high N/g. Predominance of *Macaronichnus* trace fossils in the burrowed beds suggests aeration of the bottom and a surplus of food particles. Nevertheless, benthic foraminifera indicate an oligotrophic setting. Burrowing activity has favoured the oxidation of the organic matter. This also explains the low diversity and high dominance of this oligotrophic environment. In contrast, in the non-bioturbated beds, more food particles and organic matter are concentrated and available for benthic foraminifera. This accounts for the higher diversity and lower dominance than in the bioturbated beds. Regarding the lower P/B ratio in the bioturbated beds, the burrowing activity might have destroyed preferentially the less resistant planktonic shells. In these beds, the high N/g ratio would indicate low sedimentation rate, which is consistent with the profuse development of trace fossils. Therefore, bioturbation accounts for the subtle differences in benthic foraminiferal assemblages and other parameters.

Q-mode cluster analysis shows two well-differentiated groups of samples: cluster 1 encompasses samples in the non-bioturbated sediments, while cluster 2 includes samples of intensively bioturbated beds. Fragmentation and recrystallization, being both taphonomic signatures higher in the bioturbated beds than in the non-bioturbated ones, are the taphonomic attributes that characterize the two clusters. The rest of taphonomic attributes does not exhibit any characteristic pattern related to the alternating bioturbation. Burrowing accounts for these differences in taphonomic signatures. Intense bioturbation increases fragmentation of benthic foraminiferal tests and favours circulation of pore fluids fostering recrystallization during diagenesis.

In conclusion, this study demonstrates that subtle changes in benthic foraminiferal assemblages and preservation of foraminiferal tests can be controlled by the activity of burrowing organisms. Quantitative taphonomy is a powerful tool to discriminate these minimal differences in fossil remains deposited under the same paleoenvironmental conditions.

TAPHONOMY OF A *LITHIOTIS PROBLEMATICA* MOUND-CORE

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Lithiotis problematica is a Lower Jurassic aberrant bivalve characterized by a strongly inequivalve shell consisting of a long stick-like umbonal part and a short spoon-shaped body cavity. It was a gregarious semi-infaunal bivalve, which inhabited muddy substrates characterized by a relatively high sedimentation rate. The species thrived in tropical shallow marine environments, throughout the Tethys and Panthalassa carbonate platforms, where it had a relevant role as mound builder. The term *Lithiotis* has been often used in literature also to indicate other more frequent Lower Jurassic gregarious bivalves, such as *Lithioperna* and *Cochlearites*, but the identification in the field of these three genera is not easy and they are generally indicated with the generic term “lithiotids”. For these reasons the paleoecology of the *Lithiotis problematica* build-ups is scarcely known and detailed taphonomic analysis are not available in literature.

The *L. problematica* mound studied here is located in the Rotzo Formation (Calcari Grigi Group) in the Tonezza del Cimone – Folgaria area (NE Italy). The bivalves make up a low lens-shaped accumulation, about 4 m wide and 20 cm high. The shells occur in a hard cemented limestone and are infilled by sparry calcite or greenish micrite. Lithology and preservation preclude the study of isolated specimens from the matrix. The reconstruction of the shells was, therefore, obtained through serial sectioning of some limestone blocks, originating from bed TO 41. The limestone blocks were sectioned in parallel slabs about 10 mm thick, which were then polished. The slab surfaces were scanned by an optical scanner at 1200 dpi.

The most part of the *Lithiotis* shells are still articulated and characterized by an unusual short shells with a broad body chamber and a long umbonal notch. The biofabric of the biogenic concentration consists of almost parallel and inclined (60° in mean) shells with respect to the upper bedding surface. The orientation of commissure plane is related to the shell density. In densely packed aggregates the commissure are parallel, while they are randomly oriented in loosely packed aggregates.

At the base of the mound, dispersed horizontal disarticulated valves of *Lithiotis*, preserved as casts, probably represented the hard surfaces for larval cementation and the colonization stage of the mound. The lower part of the mound is composed by marly limestone. Here, the shells were affected by a rapid dissolution, which destroyed both the apical regions of individuals in life position and the valves laying horizontally. In the middle-upper part of the mound, the shells are mostly infilled by calcitic cement or greenish mudstone coming from the overlain bed.

The matrix of the mound ranges from mud-supported in the lower part, with sparsely distributed bioclasts, to grain- and bioclastic-supported in the upper part, where the bioclasts consist of abundant larger foraminifera (e.g., *Orbitopsella*), green algae, brachiopods (*Lychnothyris*) and gastropods. Rare sponges and solitary corals are also present.

The shell fabric and fossil assemblages suggest the transition from relatively quite and muddy bottom conditions, favourable to the settlement and growth of *Lithiotis*, to a very shallow marine (euhaline) environment near the normal wave base. The occurrence, at the top of the mound, of abundant filter-feeding and sessile benthic forms suggests a drop in sedimentation and, probably, the emersion of the mound. The changes in the sedimentary rates controlled the shell shape (short and large) and the mound demise. On the basis of the growth increments of *Lithiotis*, the duration of the mound is discussed.

TAPHONOMY AND EVOLUTION OF AN EXTRAORDINARILY EXPOSED UPPER PLIENSBACHIAN - LOWER TOARCIAN SUCCESSION OF "*LITHIOTIS*" BEDS AT MERCATO SAN SEVERINO (SALERNO, SOUTHERN APENNINES)

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Lower Jurassic Tethyan and Panthalassan shallow water successions are characterized by aberrant bivalves belonging to the *Lithiotis* Fauna (also named lithiotids). Their widespread occurrence, often in rock-forming abundance, represents a global event, mostly restricted to the Pliensbachian – early Toarcian. Despite their global distribution and abundance, their biogeographic and stratigraphic distribution, and their evolutionary history are obscure, mostly because the classification at lower taxonomical rank (generic or specific level) is frequently not available in the literature.

In the Apennine Carbonate platform of southern Italy, the Lower Jurassic succession is represented by the *Palaeodasycladus* Limestone, overlain by the Oolitic-oncolitic Limestone. The former lithostratigraphical unit yields, in the upper part, the *Orbitopsella* Limestone and the *Lithiotis* Member. The latter, about one hundred metres thick, is characterized by the abundant occurrence of the lithiotid bivalves, which disappear in the lower beds of the Oolitic-oncolitic Limestones, at the onset of the early Toarcian anoxic event.

The *Lithiotis* Member and the lower Oolitic-oncolitic Limestones are beautifully exposed in a quarry west of Mercato San Severino. Here, the *Lithiotis* Member consists mainly of meter-thick — lithiotid biostromes, alternating with coarse peloidal-intraclastic grainstones and rudstones with abundant remains of *Palaeodasycladus mediterraneus*. Sometimes, the limestone beds are overlain by thin and discontinuous green marls. In the quarry succession more than 40 bivalve concentrations are present, the most part of which are represented by autochthonous monospecific to paucispecific assemblages, frequently with individuals preserved in life position. The taxonomic composition, biofabric and geometry of the accumulations have been examined.

The bivalve assemblages are dominated, among the *Lithiotis* Fauna, by *Mytiloperna*, *Cochlearites* and *Lithioperna*. The occurrence of *Lithiotis* is not proved. Other bivalves are represented by megalodontids and *Opisoma*. The biogenic concentrations exhibit generally a tabular shape. Lens-shaped accumulations (bivalve mud-mounds) are rare and low, not thicker than one meter.

The high abundance of the calcareous green alga *Palaeodasycladus* and of autochthonous shells of *Mytiloperna*, a marker of upper subtidal conditions, the tabular shape of the shell accumulations and the facies succession suggest a very shallow marine environment, with recurrent and prolonged emersions phases. This environmental setting is also supported by the absence of marine biota indicative of open platform /deep lagoon environments (e.g., brachiopods) and of infaunal bivalves (e.g. *Pholadomya*, *Gresslya*) typical of muddy substrates below the normal wave base.

The frequent preservation of the sessile epi- semi-infaunal bivalves still in life position suggests high sedimentation rates favoured by the stick- and spoon-shaped shells of the *Lithiotis* Fauna, through the prolific production (fecal pellets) and efficient trapping of the carbonate sediments. The absence of thick bivalve-mounds, the occurrence of autochthonous biota of very shallow marine environment, the highly fossiliferous content in a relatively thin succession (about one hundred meters) suggest a carbonate platform with a low subsidence rate but with rapid sedimentation processes typical of the lithiotid habitat.

PYRITIZED SKELETONS OF RADIOLARIA AND SILICEOUS SPONGES FROM OXYGEN RESTRICTED DEPOSITS (LOWER TOARCIAN, JURASSIC)

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In Lower Toarcian marls and marly limestone deposits from the South Iberia Palaeomargin (Fuente Vidriera section, Betic Cordillera, Southern Spain), siliceous skeletons of radiolarian and spicules of hexactinellid sponges are preserved in pyrite.

In the Fuente Vidriera section, bed-by-bed sampling for micropalaeontological analysis was conducted in the 30-m-thick rhythmic succession of soft and hard marlstones (24 sampling levels). No special chemical treatment of the samples was required prior to the washing procedure, which involved a column of standard stainless steel sieves with mesh openings of 500, 200 and 100 μm. Foraminifera, ostracods, woody coal fragments, pyrite framboids and pyritized radiolarian and sponge spicules were hand-picked under a Olympus SZ60 stereoscopic microscope. This research focuses on pyritized microfossils. The pyritized microfossils and framboids were analysed using scanning electron microscopy (SEM) with back-scattered electron (BSE) imaging with SCI Quanta 400 scanning electron microscope at the Universidad de Granada (Spain) and a Merlin Carl Zeiss at the Universidad de Jaén (Spain).

Recorded radiolarians correspond to Spumellaria (Hagiastridae, Pantanellidae and Praeconocaryommidae) and Nassellaria (Hsuidae). The original siliceous skeletons (hydrated amorphous silica) were dissolved and totally replaced by pyrite. The radiolarians are sometimes very well preserved as independent remains or fused to pyrite framboids, sometimes distorted by pyrite framboid growth. Isolated fragments of pyritized radiolarians are recorded on framboid surfaces. Pyritized sponge spicules correspond to hexactines and monactines (criccostyles and tylostyles) always with the well preserved axial channel.

Pyritization of the remains and decay of the organic matter of these organisms by sulphate-reducing bacteria favoured the precipitation of automicrite, and the early pyritization at the same time that silica dissolved. Therefore, pyrite formation was associated to organic matter decay by sulphate reduction; the amorphous silica skeleton acts either as a nucleation substrate or induces pyrite precipitation during biogenic silica dissolution. Pyrite formation was associated with organic matter decay by means of sulphate reduction and precipitation of Fe-sulphides (metastable precursors of pyrite such mackinawite and greigite) via bacterial activity. The organic matter may also help stabilize colloids that are important for framboid precipitation. Pyritization occurred soon after the death of the organism, taking place in the upper sediment column just below the sediment-water interface, at the redox boundary where oxygen-bearing and hydrogen sulphide-bearing waters are in contact. The size of pyritized radiolaria (> 40 μm) and the mean size of pyrite framboids (6.3-7.1 μm) are compatible with pyritization within the sediment-water interface under dysoxic conditions. The presence of trace fossils and benthic foraminifera exclude anoxic and euxinic conditions during the Early Toarcian in this setting.

Taphonomic model of pyritization of radiolarians and siliceous sponges in these oxygen restricted deposits include:

A. Accumulation of remains in the sea-bottom and initial decaying of organic matter by sulphate reducing bacteria favouring the precipitation of automicrite.

B. Transformation from opaline to crystalline silica, sulphate reduction of organic matter, automicrite precipitation and nucleation of iron monosulphide microcrystals (mackinawite).

C. Dissolution of crystalline silica resulting in empty inner cast, conversion of sulfide microcrystals to greigite and aggregation in framboids.

D. Conversion of aggregate framboids to pyrite framboids, precipitation of pyrite in the inner cast of the dissolved silica, and potential subsequent overgrowth of pyrite framboids.

TAPHONOMY AND ICHNOLOGY: TOOLS FOR INTERPRETING A MAXIMUM FLOODING INTERVAL IN THE BERRIASIAN OF TLEMCEN DOMAIN (WESTERN TELLIAN ATLAS, ALGERIA)

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During the Middle-Late Berriasian, a long-term climatic and eustatic change occurred, documented in the literature. However, data from the northern Gondwana palaeomargin are scarce. This research analyses the Lamoricière Clay Formation at the Ouled Mimoun section, focusing on fossil assemblages and using taphonomic and ichnological aspects to interpret a transgressive-regressive cycle.

The section starts with mudstones and oolitic grainstones representing shallow-water environments in the top part of the Ouled Mimoun Marly Limestones Formation (Upper Tithonian p.p. to lowermost Berriasian). Three different stratigraphic intervals may be recognized in the Lamoricière Clay Formation:

A first stratigraphic interval constitutes the base of the Lamoricière Clay Formation, and it is characterised by high clay content, cross lamination, and the record of the ostracod *Asciocythere*, dasyclad green algae, and the sponge *Cladocoropsis*. These features indicate it was still deposited in shallow water.

The second stratigraphic interval is characterized by the record of fossil-rich calcareous beds at the beginning of the Upper Berriasian (Boissieri Zone) with ammonoids and calpionellids. This is congruent with an increase in water depth. The sedimentation rate in the Late Berriasian was reduced, as indicated by the increment of fossil remains and trace fossils. Ammonoid moulds show taphonomic features pointing to long-lasting exposure on the sea floor prior to burial with corrasion and encrustation by sessile organisms such as serpulids, thecideidinids, and bryozoans. During calm periods crustaceans and worms intensely burrowed the sea floor. The record of *Thalassinoides* and *Rhizocorallium* indicates bottom conditions ranging from soft to firm. The low sedimentation rate and sediment by-passing probably favoured early lithification. The increasing carbonate content as well as decreasing sedimentation rate is compatible with the maximum distance to emerged areas during maximum flooding. High-energy events, probably related to storms, favoured the exhumation and extreme corrasion of ammonite moulds and trace fossils. In the resulting substrate limonitic films developed and encrusting organisms proliferated (serpulids, bryozoans and thecideidinids), colonizing both the bottom surface (hardground) and exhumed moulds of ammonoids and *Thalassinoides*.

The last stratigraphic interval is constituted by the uppermost 0.7 meters of the section and represents the return to shallow conditions, with increasing sedimentation rate and terrigenous detrital content, along with the disappearance of hemipelagic forms (ammonoids); hence it is interpreted as having developed in the beginning of a regressive context.

BIOSTRATINOMIC MARKS ON RABBITS AND EPIPALAEOLITHIC HUNTER-GATHERER BEHAVIOUR. THE CASE OF COVA DE LA GUINEU (NORTHEAST IBERIA)

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The consumption of small prey by humans throughout prehistory has been a much-discussed topic among researchers. It seems clear that the exploitation of this resource grows with the implementation of climate changes occurring in Europe between the late Pleistocene and Holocene. In the Mediterranean basin, on the Iberian Peninsula, this is mainly evidenced by an increase in the number of leporid remains recovered from Epipaleolithic archaeological sites. These faunal accumulations require a taphonomical analysis in order to ascribe the samples to the activity of early Holocene hunter- gatherers or, on the contrary, to a number of predators (raptors and terrestrial carnivores) that occupied the same biome over the same period and feed on the same prey. Our work aims to elucidate, through taphonomic analysis, the human activity on rabbits *(Oryctolagus cuniculus)* in comparison to other predators in Cova de la Guineu site (Barcelona province, northeast of the Iberian Peninsula), and to explain different ways of handling and exploiting rabbit carcasses. Results show that leporid remains recovered from the Epipaleolithic level respond to anthropogenic contribution. At a macroscopic level, high proportions of thermo-altered bone can be perceived. On a microscopic level, cut marks caused by lithic tools, and teeth marks are appreciated.

THE IDENTIFICATION OF BONE TOOLS IN LOWER PALEOLITHIC CONTEXTS: AN INTEGRATED APPROACH BETWEEN TAPHONOMY, EXPERIMENTAL ARCHAEOLOGY AND USE-WEAR ANALYSIS

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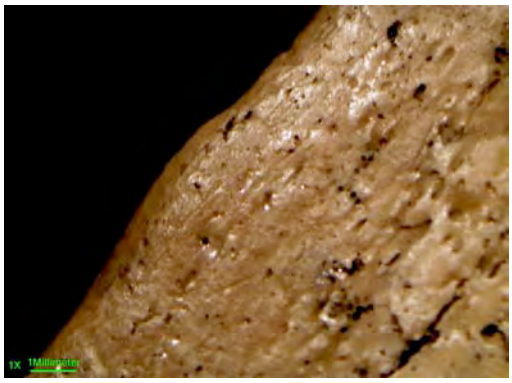
The aim of the research is to establish a method of analysis useful to identify possible bone tools coming from Lower Paleolithic osteological records. The main difficulty is represented by the fact that many agents could be responsible for similar morphologies of traces on the bone surface. For this reason, the analysis of the archaeological objects should be based on a multidisciplinary approach, intersecting data from three different fields: *Taphonomy*, *Experimental Archaeology*, *Use-wear Analysis*. This method was applied on faunal remains coming from two archaeological excavations, *Via Aurelia km 18,900* and *Collina Barbattini*, localized in the "Campagna Romana" and dated to the Middle Pleistocene (OIS 9). The fossils belong to the early Aurelian Faunal Complex that includes the faunal assemblages found in fluvial and fluvio-lacustrine deposits, ascribed to the Torre in Pietra FU. The examined materials presented a great incidence of limb bone fragments, especially shaft fragments, coming from large herbivores like *Palaeoloxodon antiquus* and *Bos primigenius*. The record provided quite an exhaustive sample of taphonomic alterations occurring in an archaeological context due to the carnivores' action (*pits*, *scores*, *furrowed areas* and *tooth notches*), the chemical action of root-etching and a low degree of weathering. The most present natural alteration was the sediment abrasion. All the fragments showed a light rounding of their surfaces due to the abrasive action of the gray sands and the silts that composed the marshy sediment where the bones laid. The human modifications related to butchering activities and marrow exploitation were present in form of *cut marks*, *chop marks* and *percussion marks*. The analysis of the fracture edges demonstrated that almost all these bones were broken while still fresh, with few uncertain exceptions whose fractures are probably linked to post-depositional events (dry state). During this first taphonomic observation of the fossil record, two objects were recognized as possible tools applying morphological and technological criteria. The first, ID15, a diaphyseal bone fragment of *Palaeoloxodon* limb bone, was characterized by a pointed distal end and technological modifications (knapping), while the second, ID14, a fragment of *Palaeoloxodon* limb bone (*tibia vel ulna*), although the absence of manufacturing, was instead selected for a natural long and straight edge ending in a point (*morpho-functional* criteria). On the base of the characteristics of the two pieces and taking into account the chronological frame under exam, an experimental collection using modern limb bones of adult and sub-adult individuals of *Bos taurus* was created. Fresh and dry fragments were used in different activities: digging soil, scraping hide, wood working, butchering. The further step regarded the use-wear analysis of the experimental objects conducted through a stereomicroscope and a metallographic microscope. All the information were described in forms and inserted into a database using FileMaker Pro Advanced program. The same recording system was utilized also for the analysis of the surface alterations due to the sediment abrasion. This aspect was experimentally tested thanks to the cooperation with the Engineering Laboratory of the University La Sapienza of Rome. The experiment was conducted 1) on fresh and dry bone fragments without any previous modification, to test the modification degree of bone surface in relation with a sandy sediment and 2) on fresh and dry fragments belonging to the experimental collection, to obtain a more realistic pattern where the use-wear and the natural traces were combined together and to test the preservation degree of the use-wear traces. The inferred active areas of the archaeological tools were finally interpreted considering both the information coming from the experimental sessions and those regarding other

taphonomic alterations inferred from bibliographical sources. ID15 showed flattened point with a rough *polish* and a cluster of semi-parallel thin *striae* probably generated by the repeated percussion of the tool against a hard material (wood). ID14 presented along the edge possible *edge removals* (unfortunately very rounded), a smooth *polish* associated with thin *striae* probably due to butchering activities. This study has not been completed and the investigation on the hypothetical artifacts is in progress. Although the research is still partial, the methodological approach gave more than satisfactory results, shading light on a productive way to integrate the three disciplines. The next step will be to extend the experimental sessions considering on one side other possible human activities and on the other side the action of other taphonomic agents in order to enlarge the reference collection of use-wear and natural traces.



Edge of studied sample ID14 photographed with stereomicroscope.

THE SIMA DE LOS HUESOS CRANIA. TAPHONOMIC ANALYSIS

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The Sima de los Huesos (SH) is one of the many archaeo-palaeontological sites in the Sierra de Atapuerca (Burgos, Spain). It is well-known for yielding an enormous collection of Middle Pleistocene (430 ka) hominin fossils – including a large sample of very complete skulls. The hominin fossils occur together with carnivore fossils (mainly *Ursus deningeri*) and an isolated Acheulian handaxe but without a single herbivore remain amid the many thousands of excavated fossils. The hominin fossils correspond to a minimum of 28 individuals.

How the human bodies arrived in this small chamber has been one of the most debated issues related to the formation of this site, and different hypotheses have been proposed until now. The present study concerning the taphonomy of the SH cranial sample aims to provide new data in order to evaluate the different interpretations proposed. Furthermore, the objective of the present work is to describe and to quantify the taphonomic aspects observed in the largest sample of hominin fossil cranial remains ever found in the paleontological record.

Here we analyze a collection of 17 skulls in different stages of completeness in terms of: fracture patterns, bone surface modifications and spatial distribution. For the taphonomic analysis, macro and micro techniques have been developed including three-dimensional CT images in order to distinguishing between *perimortem* and *postmortem* cranial trauma.

The SH hominin skulls show a fracture pattern characterized by a dominance of fractured edges with right angles and jagged surfaces. These properties are expected for post-depositional (*post-mortem*) fractures and are compatible with collective burial assemblages. Nevertheless, some crania do show concentric fractures, with bevelled edges associated with radial fractures. Furthermore, some of these fractures cross the unfused sutures. These features are typical of *peri-mortem* fractures.

The study of bone surface modification in the SH crania shows a very low presence of carnivore activity (1.10% of the NISP), a low incidence of trampling and rodent activities and different degrees of Manganese oxides staining. The study of the surface modifications also shows a complete absence of any traces of anthropic activity (for example cut-marks).

The cranial sample from SH is composed of hundreds of bone fragments fitted together. Due to the meticulous excavation method developed in SH, all bone fragments are documented in terms of spatial distribution within the site. The relationship between the locations of each fragment that conform each cranium allows us to understand the taphonomic history for each specimen. Different patterns in the spatial distribution of the cranial specimens are observed, indicating different taphonomic processes in the SH sample.

DOWN-CORE CHANGES IN MOLLUSCAN DEATH ASSEMBLAGES: AN IMPRINT OF THE YOUNGER ECOLOGICAL HISTORY IN THE NORTHERN ADRIATIC SEA

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Marine ecological studies investigating ecosystem responses to environmental changes are normally restricted to annual or decadal time scales. We use a historical ecology approach to study the ecological history of the northern Adriatic Sea over the last 500 to 2000 years. Our hypothesis is that this period experienced the major anthropogenic ecosystem impacts. The northern Adriatic Sea is among the most degraded marine ecosystems worldwide and is therefore a case study for ecosystem modification under human pressure. Moreover, historical data from marine surveys are available dating back to the 1930s.

We focus on down-core changes in death assemblages of benthic hard-part producers (molluscs, foraminifera, ostracods), whereby the degree of variation between different community compositions serves as a proxy for ecological shifts.

More than 50 cores of 1.5 m length and diameters of 90 and 160 mm were taken at seven sampling stations covering different sediment types, nutrient conditions and degrees of exposure to bottom trawling. The cores were analysed for species composition, abundance, taxonomic similarity, evidence for ecological interactions (i.e., frequencies of drilling predation) and taphonomic condition of shells. Our first results show clear down-core changes in the composition and abundance of bivalves and gastropods with time. In the Brijuni national park, a protected area in Croatia, the core revealed an increase of the bivalve *Striarca lactea* and a decrease of *Nuculana pella* with depth. Similar changes were observed in the other cores from Italy and Slovenia. The radiometric dating of the sediments revealed substantial differences in sedimentation rates and in the ratio between sediment depth and age. This information, together with carbon-calibrated amino acid- racemisation (AAR) of shells from selected species, will help to specify the timing of major ecological changes. Our approach is designed to deliver an image of “pristine” benthic communities that can serve as a reference for future conservation and management efforts in the northern Adriatic Sea.

STATE OF THE ART REVIEW BASED ON PALEO SEA-LEVEL RECONSTRUCTIONS INFERRED FROM VERMETID TUBES (GASTROPODA: MOLLUSCA) ALONG THE BRAZILIAN COAST

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Sea level rise is one of the most important, and most publicized, aspects of climate change. Prerequisites for reliable rise prediction are accurate assessment of past global and regional changes and complete understanding of the causes of these changes. One of the methods supported by geologically based reconstructions of relative sea-level is derived from biological sea level indicators. These are capable of reconstructing metre-scale relative sea level changes at multi-centennial to millennial time-scales. One of the most reliable inferences on the elevation of the Holocene highstand are given by the vermetids.

Vermetidae is a family of sessile gastropods that commonly live in the intertidal zone of hard substratum, particularly in the tropics. Whereas some species are solitary, others form monospecific clusters. Vermetids possesses several attributes that make them ideal for paleo sea-level reconstructions: they are extremely reliable tools for interpreting past sea-level and sea temperature, and consequently, of great importance for predicting future climatic trends; they are among the most used indicators, since their shells often resist time averaging and can be easily dated with 14C.

Up to date, two species of paleo sea-level indicators occurs along the Brazilian coast, from the state of Pernambuco to Santa Catarina: *Dendropoma irregulare* (d'Orbigny 1842) and *Petaloconchus varians* (d'Orbigny 1841); while Recent vermetids are commonly found distributed from the state of Amapá to Santa Catarina, including the oceanic islands. The total number of Recent vermetid taxa was recently increased to 16; however, only a few species are known from the Brazilian continental shelf: *D. irregulare*; *Thylacodes decussatus* (Gmelin 1791); *Petaloconchus erectus* (Dall 1888); *P. varians* and *Petaloconchus myrakeenae* Absalão & Rios 1987.

In this review, authors provide the state of knowledge on paleo sea-level reconstructions inferred from vermetid tubes in Brazilian coast, including the references which assess the use of vermetids as "*Biological Sea-Level Indicators*" – *"BioSLI"*. Also, provides an evaluation on the evidence on past climate changes along the Holocene in the coast of Brazil.

For instance, *D. irregulare* and *P. varians*, with their low intertidal distribution and narrow bathymetric ranges, have provided sea level estimates for the Brazilian coast spanning the Holocene period. For the most common hydrodynamic conditions along the Brazilian coast, a hypothesized precision of ±0.40 reaching ±1.00 m has been adopted by several authors studying the paleo sea-level oscillations in Brazil, recorded on *P. varians.*

Confusion regarding the complex taxonomy of the group and their true bathymetric ranges, however, is leading to concern over the widespread use of vermetids as reliable paleoclimatic indicators, reinforcing the need for further systematic work.

CORALLINE ALGAL FACIES AS AN INDICATORS OF RELATIVE SEA–LEVEL VARIATION IN BEACHROCKS FROM ARRAIAL DO CABO, BRAZIL

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The nature of the ocean–climate relationship can be investigated in a variety of ways and at a number of spatial and temporal scales. The methods are based on several marine paleoclimatic indicators, including sedimentary deposits (beachrocks), erosion (crevices), microfossils (diatoms and foraminifera) or ecological (platforms built by accretion from coralline red algae; CRA). The biotic composition of CRA reflects changes in environmental parameters such as water temperature and bathymetry which occurred during CRA growth. These variations in biotic composition as well as differences in CRA morphology can be used to assess the paleoecological settings.

During the Holocene there were many sea level variation along the Brazilian coast. Paleoclimatic indicators (beachrocks) with records of rising sea level up to 1.5 km from the present coast line were found between the cities of Buzios and Cabo Frio, State of Rio de Janeiro, Brazil. Beachrock is a consolidated coastal sedimentary formation resulting from a relatively rapid cementation of beach sediments through the precipitation of (mainly) carbonate cements typically consisting of High–Mg Calcite (HMC) or Aragonite (Ar), however its origin is still not fully understood. Facie analysis of beachrocks shallow–water carbonate succession in the outcrops from Cabo Frio Island (23° S, 42° W; Arraial do Cabo, RJ; Fig. 1) and the subsequent integration of paleoecological data have been used to produce a detailed paleoenvironmental model.

Geochronological results obtained from submerged beachrocks suggest that, between 11.940 and 11.240 cal yr BP, the relative sea–level was 4.5 m below the current. This time interval locally records the transition between the late Pleistocene and early Holocene on the coast of Rio de Janeiro State, southeastern Brazil. Analysis of Rhodophyta from species *Titanoderma pustulatum* (J.V. Lamouroux) Nägeli in the beachrock samples collected in the current mean sea level dated at 7910-7690 cal yr BP indicate a depositional environment in tropical waters with temperatures above 23°C, between the late Pleistocene and early Holocene. These paleo–temperatures are markedly different from the current records, in which the average is approximately 18ºC due to the coastal upwelling phenomenon. During this time interval, the process of beachrock lithification occurred in water conditions much warmer than the present ones.

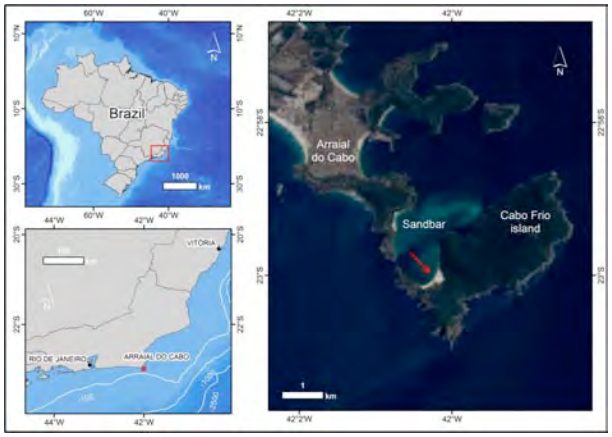

Fig. 1: Study site at Arraial do Cabo (red arrow).

LAST NEANDERTHAL EXPLOITATION STRATEGIES: THE TAPHONOMICAL APPROACH OF THE FAUNAL ASSEMBLAGES FROM RIPARO MEZZENA (VERONA, LESSINI MOUNTAIN, NORTHERN ITALY)

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The reanalyses of the large mammal assemblages from Riparo Mezzena, in Lessini Mountains (Verona, north-eastern Italy) is focused on the taphonomical analysis devoted to observe the role played by late Hn groups in the bone accumulation and the exploitation of animal resources.

The palaeontological revision of the large mammal assemblages has revealed a great uniformity among the composition of the faunal assemblage within the whole stratigraphic sequence: the cold environment taxa are rare but red deer and roe are dominant and supports for an attribution of the deposit to late MIS 3.

Riparo Mezzena, discovered in 1957 by Franco Mezzena, is a rockshelter located near Verona town (250 a.sl.); it opens on the Vajo Gallina, a little tributary valley of Valle d'Avesa, at about 75 m from the bottom of the valley, allowing the Neandertals to exploit different environments along the slopes and on the top of the crest and to hunt in the plain, reaching the Adige river which flows few Km downwards. Excavations were carried out by the Natural History Museum of Verona under the direction of F. Zorzi and A. Pasa and then by the University of Ferrara, highlighting three main lithological units (bottom to top layers III, II, I) within the stratigraphic sequence.

From layer I, several human remains were discovered: an incomplete mandible and 14 bone fragments, three of which belong to the post-cranial skeleton. The mandible has been morphologically determined and genetically typed *Homo neanderthalensis*. The lithic industry is referable to Mousterian assemblages (Longo et al., 2011).

For which the archaezoological study is concerned, the scarcity of the faunal assemblage and the consequent anatomical composition allow only a qualitative analysis and not a quantitative one. Therefore, it is not possible to reconstruct the exploitation of the carcasses by Neandertals. However all the identified taxa are represented only by cranial fragments and limbs bones.

An analysis of the bone surface has been carried out in order to identify the different taphonomical agents that altered the faunal assemblage. The specimens were affected by different post-depositional factors (weathering, oxides, concretion, exfoliation, root etching, floating and trampling) but anthropic modifications have been recognized too.

The taphonomical analysis, in particular, documents an intensive anthropic activity mostly in the third layer and it is particularly evident by the increase of cutmarks, notches, bone retouchers and burned remains. The anthropic modifications are more frequent on unidentified specimens, even of small dimensions, whose breakage was sometimes produced not only by old fracturing but also during the excavation. The intentional bone fracturing is well documented by the presence of many percussion notches and sometimes scraping marks have been identified on the bone surface, that can be related to the removal of the meat and/or the periosteum to ease the bone breakage.

The absence of any square reference prevent us from analysing the spatial distribution of the bone remains to identify the potential functional areas related to the treatment of the carcasses.

Carnivore specimens are few and gnawing marks are absent in all the layers; this can be explained by the intense anthropic occupation of the site that could have represented a strong deterrent for the activity of these animals. Finally no cutmarks on carnivore bones have been identified.

TAPHONOMY OF THE FAUNAL ASSEMBLAGES FROM GUADO SAN NICOLA (MONTERODUNI, ISERNIA, SOUTHERN ITALY): EDAPHIC MODIFICATIONS *VS* ANTHROPIC ACTIVITIES

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Guado San Nicola is an acheulian site, located on the distal part of an ancient terraced alluvial cone made by the Lorda creek, a tributary of the Volturno river. The stratigraphic sequence, more than two meters thick, was investigated by extensive excavations, carried out from 2008 to 2013, revealing three main anthropic layers (SS.UU. C, B*C and B). These Stratigraphic Units are characterized by the presence of numerous handaxes of different forms and variable size; the *débitage* component is characterized by the presence of a Levallois production. From a chronological point of view, despite the lithologic, morphographic and pedostratigraphic interpretation suggests a correlation to an Interstadial (MIS 6 to MIS 7), the considerations on the fauna (Late Galerian fauna) and radiometric datings (345-400.000 years) are in agreement with an attribution to MIS 11.

The faunal assemblages of Guado San Nicola, analysed in this palaeontological and archaeozoological study, comes from the SSUU C, B*C, B, and A*B. They are composed by *Ursus* sp., *Palaeoloxodon* sp., *Stephanorhinus kirchbergensis*, *Equus ferus* spp., *Cervus elaphus acoronatus*, *Dama* sp., Megacerini and *Bos primigenius*. On the basis of the number of remains the most frequent species are red-deer and horse. In SU C elephant is over-estimated because of teeth fragmentation. Aurochs is always documented within the SSUU, while Rhinoceros is scarce. Bear, fallow deer and megaceros are rare. Cervids antlers are over-represented. The faunal composition suggests the presence of several environments in the surrounding areas: wooden areas, even bushy, occupied by Cervids and open areas where elephants, aurochs and horses lived. Rhinoceros could graze in both environments. It is possible that for the presence of Rhinoceros of Merck and auroch and the lack of cold markers, this assemblage can be attributed to one or more temperate or hot-temperate moments. *Cervus elaphus acoronatus* belongs to the Galerian and the presence of *Equus ferus* spp. suggests that this assemblage could be referred to the most recent part of this mammal age, that is Fontana Ranuccio UF. Moreover, the presence of *Cervus elaphus acoronatus* excludes that the faunal assemblage could be later and places it in the recent part of MIS 11.

The taphonomical analysis was devoted to evaluate the degree of preservation of the osteological surfaces in order to establish the human intervention in the fauna assemblages accumulation. Several taphonomical factors modified the faunal remains: weathering, exfoliations, manganese and iron oxides, trampling, sediment abrasion, root-etching and in several cases smoothed edges produced by floating that have altered the bone surfaces. Nevertheless, on the few remains of horse and rhinoceros well-preserved cutmarks were identified, while intentional bone breakage features are well documented. Several notches were recognized at the base of shed antlers that could be referable to their intentional use as hammer. The archaeozoological analyses revealed that butchery activities were carried out on rhinoceros, horse and aurochs in order to processing carcasses by flesh removal and disarticulating bone with the aim of exploit the marrow.

THE FINAL MAGDALENIAN IN THE NW OF THE IBERIAN PENINSULA: A TAPHONOMIC AND ZOOARCHAEOLOGICAL APPROACH OF THE HOMINID SETTLEMENT DURING THE PLEISTOCENE-HOLOCENE TRANSITION. THE SITE OF VALDAVARA (BECERREÁ, LUGO)

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The study of the faunal remains from Valdavara is a first approach to the settlement of Pleistocene hominids in NW Iberian Peninsula through the zooarchaeology and taphonomy methodology. It is a cave site in which more than 1500 Pleistocene and Holocene preserved faunal remains were recovered. The cave is located in the NW of the Iberian Peninsula, at Becerreá (Lugo, Spain), 600 m above the sea level, in the Ancares mountains. It is a strategic place to cross the North of the Iberian Peninsula with the Cantabrian coast and South Iberian. Valdavara is on a limestone formation dated to lower- middle Cambrian, in the Manto de Mondoñedo rocks.

The archaeological site is divided into three areas of intervention: Valdavara 1 (levels 2 and 3, attached to the recent Prehistory and levels 4, 5 and 6, dated to the Upper Palaeolithic), Valdavara 2 (levels 2 and 3, recent prehistory, and levels C and D, from the Upper Palaeolithic) and Valdavara 1-2 (levels B, with Upper Palaeolitihic materials, C, Mesolithic and D, Upper Palaeolithic). NR, NISP, NME, NMI, MAU MAU% were calculated to evaluate the skeletal elements represented. Shannon Index was used to measure the biodiversity of the different levels. All bone surfaces were analyzed at macroscopic and microscopic level (OPTHEC 120) in order to observe fracture patterns, marks resulting from human activity (cutmarks, cremation and intentional anthropogenic fragmentation), traces caused by the action of carnivores and post-depositional modifications. The study of the anatomical parts present/absent indicates an alternation in the occupation of space, as well as some level of inter-dependence between hominid and carnivore access to carcasses.

The action of carnivores in the processes of formation/modification of faunal assemblages was analyzed by studying the frequency and distribution of tooth marks, the co-occurrence of anthropogenic and carnivores marks and calculating the ratio diaphyseal / epiphyseal presence in the faunal assemblage of Valdavara.

There have been massive and generalized pigmentation of the bones surface caused by the precipitation of manganese oxides. This post-depositional phenomenon is not associated with cracks, roundings or polished, and indicates stable climatics moisture conditions, probably relationed with stable water courses or low power puddles. Coloration by Manganese has not allowed the identification of combustion events.

The Magdalenian in the Iberian Peninsula is mainly located in three areas: Mediterranean, Cantabrian Coast, and Portugal. However, Valdavara is geographically at the crossroads between northern Portugal and the western part of the Cantabrian Coast. The fauna analyzed for this work represents a particular economic model, characterized by: 1) dominance of Caprinae (especially *Rupicapra Rupicapra*), followed by *Cervus elaphus* and *Oryctolagus cuniculus*; 2) diversified

Táboa 1: Size and taxa from the Valdavara archaeological site

Taphos 2014, Ferrara

Size	Taxa	Size	Taxa	Size	Taxa
Large	*Bos sp.*	**Small**	*Crocuta crocuta*	**Very Small**	*Felis sylvestris*
(300- 1000 Kg)	*Equus ferus*	(18- 100 Kg)	*Canis lupus*	(4- 18 Kg)	*Felis catus*
	Stephanorhinus hemitoechus		*Vulpes vulpes*		*Oryctolagus cuniculus*
	Ursus spelaeus		*Lynx pardina*	**Microfauna**	Phassianidae
Medium	*Cervus elaphus*		Carnivora indet.	(<4 Kg)	Passeriforme
(70- 300 Kg)	*Sus scrofa domesticus*		*Lutra lutra*		Ave indet.
			Meles meles		*Bufo bufo*
			Mustelidae indet.		Salmonidae
			Caprinii		
			Capra sp.		
			Rupicapra rupicapra		

econor -Holocene transition; 3) consur h, molluscs and few bird remain urces like Erinaceae and Leporid

The n economies in northern Portugal and with those of the Cantabrian coast, as well as certain aspects of Solutrean tradition that marked the culmination of a cultural evolution with economic characteristics began in the Solutrean and that reach the maximum level during the Magdalenian period (Yravedra, 2001; Baena et al., 2005; Bicho et al., 2006; Zilhao, 1993). Chamois specialization could be interpreted as an adaptation of the Valdavara hominins at a mountain area.

TAPHOFACIES AND COMPONENT ANALYSIS OF NUMMULITIC LIMESTONES FROM SONTHOFEN, ALLGÄU, SOUTHERN GERMANY

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Although there have been a number of studies concerning nummulitic limestone facies in, or adjacent to the southern Alps, similar facies north of the Alps have received comparatively little attention despite the fact that large foraminifera such as *Nummulites* and orthophragminids are important as index fossils and facies indicators of the Paleogene. The study area near Sonthofen in southern Germany was situated on the northern margin of the Tethys Ocean and represents one of the most northern distributions of larger foraminiferal assemblages during the Paleogene. The motivation for this study is to conduct a component and facies analysis of the "Nummulitenkalke" of Sonthofen, to describe their preservation and microtaphofacies, as well as compare the results to other well known localities.

The samples consists of thick carbonate succession dominated by various larger foraminifera and coralline red algae. There are 3 main facies types: 1) *Nummulites* dominated limestones with subordinated orthophragminids and encrusting *Acervulina*, 2) a coralline algal facies dominated by fragments of coralline algae and rhodoliths, and 3) a *Nummulites*-coralline algal facies with an admixture of both component types. Taphonomic features found in all facies are abrasion, fragmentation, bioerosion, encrustation and post-depositional pressure solution. The *Nummulites*-coralline algal facies also shows several phases of encrustation event. Quantitative analysis of both component distributions and taphonomic features as well as paleoecological interpretations are then used to reconstruct the depositional environments of the different facies types.

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