13th International Symposium on Fossil Cnidaria and Porifera

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ABSTRACT BOOK

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Mississippian reefs and mounds in Europe and North Africa

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After the latest Famennian (Strunian) reef association collapsed with the final disappearance of the Palaeozoic stromatoporid sponges in the End-Devonian extinction event, the Mississippian is characterised by its own reef history with particular reef associations. In general, the abundance of reefs and mounds during the Mississippian was lower compared to the Middle Palaeozoic peak, but there are spatially and temporally much more common than previously thought. Timing and duration of reef development and dimensions of the reefs varied considerably on a regional scale, but the reefs developed almost continuously throughout the entire Mississippian period. Reefs and mounds have been found in very different shallow and deeper-water facies and different organisms and communities contributed to their formation. Although microbial communities often played a crucial role in the formation of build-ups, the Mississippian mounds and reefs cannot be reduced to a post-disaster phase of mud-dominated build-ups after the late Devonian extinction events. The single reef and mound is directly bound to the local tectono-sedimentary history, but global governing factors as palaeoclimate and geodynamic evolution control the regional reef patterns.

Mississippian reefs and mounds are widely distributed in Europe from the Ivorian (upper Tournaisian) onward; their absence in the Hastarian (lower Tournaisian) is due to unsuitable facies conditions and the necessary reorganisation of the reef associations following the loss of the main Strunian bioconstructors. During Mississippian times, the deeper parts of ramp-dominated shelf systems are often occupied by mud-dominated build-ups. This is not restricted to the Waulsortian Facies of the Ivorian, but a more general phenomenon as evidenced by the late Viséan (Asbian and Brigantian) of the British Isles and Poland.

During Viséan times, very different bioconstructors formed reefs in various parts of rimmed-shelf systems. The Belgian Viséan gives a rare insight into reef formation in marginal marine settings, where microbial communities and microconchids constructed small reefs. On carbonate platforms along the passive margins of Laurussia and Gondwana, reef formation is often hampered by small-scaled glacio-eustatic sea-level oscillations, and reef dimensions stayed relatively low. This can be seen in the Molinacian and Livian (lower and middle Viséan) reefs in England and Belgium, when framework formation resulted from the interaction of microbial communities, bryozoans, tabulate corals and subordinated brachiopods. However, when accommodation space was available, reefs could attain thicknesses of several hundred meters. This becomes especially true along the edges of late Viséan shelf systems, where a reef association comprising microbes, sponges, corals, and bryozoans became abundant. In England these reefs are named Cracoan build-ups, but they are also abundant in Ireland, Belgium, Spain and in North Africa (Morocco and Algeria). The African records are the first reefs described in northwestern Gondwana since the early late Devonian (Frasnian). It is important to note that many late Viséan build-ups previously described as mounds or mud-mounds contain a well-defined framework, and thus represent true reefs. In southern Europe and in Morocco, these late Viséan reefs were cannibalized in the collapse of shelf systems during the Variscan Orogeny, and today are only documented in olistoliths in flysch basins.

Coral biostromes are another important reef type in the middle and late Viséan reefs of Europe. Compositions and dimensions can be very different, and their variations can be best described between the end-members “local, thin monospecific coral biostrome”, “regional, thick polyspecific coral biostrome complex” and “mixed coral-metazoan biostrome”. The best example of a biostrome complex is found in the 50 m thick pauciradiale beds in NW Ireland.

The youngest Mississippian reefs of Western and Central Europe are earliest Serpukhovian in age and found in southern France. Reef formation in the Serpukhovian is found in North Africa south of the mobile Variscan belt in the cratonal basins of the Sahara. The best examples are from the Béchar Basin, but compared to the Viséan, those reefs are less common, and smaller in sizes.

Numerical modelling of the Mississippian palaeoclimate gives useful information on relative seawater temperature and current patterns, which contribute to a better understanding not only of limiting factors for reef formation, but also on the taxonomical composition of reef builders and reef dwellers.

Scleractinian corals from the Lower Oligocene of the Eastern Alps, Austria: taxonomy, palaeoecology and palaeobiogeography

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In the Werlberg Member (Rupelian *pro parte)* of the Häring Formation (Eastern Alps), an assemblage of colonial corals of 11 species pertaining to 11 genera and 11 families was identified: *Stylocoenia carryensis* (Oligocene–Lower Miocene; Astrocoeniidae), *Acropora lavandulina* (Middle Eocene–Lower Miocene; Acroporidae), *Colpophyllia* sp. (Faviidae), *Dendropgyra intermedia* (Oligocene; Meandrinidae), *Caulastraea pseudoflabellum* (Middle Eocene–Oligocene; Merulinidae), *Symphyllia pseudomeandrites* (Lower Oligocene; Symphylliidae), *Pindosmilia? brunni* (Oligocene; Stylophylliidae), *Actinacis rollei* (Upper Eocene–Oligocene; Actinacididae), *Pavona profunda* (Oligocene; Agariciidae), *Agathiphyllia gregaria* (Upper Eocene–Oligocene; Agathiphylliidae), and *Faksephyllia faxoensis* (Paleocene–Oligocene; Caryophylliidae). This is the first Oligocene coral assemblage reported from the Eastern Alps. Taxonomically, it represents a considerably diverse fauna that is characterized by the presence of exclusively colonial forms belonging to three general categories of polyp integration, none of which is dominant: cerioid to plocoid forms (4 species); meandroid to thamnasterioid forms (4 species); and branching forms (3 species). With regard to polyp size, the Oligocene coral fauna of Austria is distinctly dominated by forms having medium to large-size corallites (4 to >10 mm in diameter), including both all of the meandroid-thamnasterioid and the branching groups, as well as the plocoid *Agathiphyllia gregaria* (73%). In contrast, only corals of the plocoid-cerioid group (with the exception of *Agathiphyllia gregaria*), are characterized by smaller polyps (around 2 mm in diameter) (27%). The Werlberg Member accumulated during marine transgression onto a truncated succession of older carbonate rocks. The corals grew as isolated colonies and in open carpets mainly in protected shoreface settings punctuated by high-energy events. Coral growth forms comprise massive to sublamellar forms, and branched (dendroid, ramose) forms. Ten taxa pertain to corals found elsewhere in (sub)tropical reefal and peri-reefal settings, but the caryophylliine 'shallow- to deep-water' coral *Faksephyllia* also is present. The presence of coral fragments that differ with respect to corallite integration and other skeletal features from the identified species suggests that the diversity of the original biocoenosis was higher.

The assemblage consists of stress-resistant coral genera widespread in the Eocene to Miocene of central and southern Europe, Central America, and Caribbean islands. On the species level, closest correspondence is with faunas of southern Europe, especially with the ones of northern Italy (Lessini shelf). With respect to phylogenetic ancestry, the fauna consists of a mix of Mesozoic hold-over taxa with genera that appeared during the Paleogene. Comparison with Oligocene coral assemblages outside of the Alps suggests that, in the west-central Tethys, the northern limit of hermatypical coral growth became constricted from roughly 38°N palaeolatitude during the Rupelian to about 30°N latitude in the Chattian. Only during the Middle Miocene (Badenian stage) climatic optimum, oligotypic assemblages of stress-resistant corals grew again, and for the last time, in the area of the present Eastern Alps.

Early ontogeny and blastogeny of the Famennian heterocoral *Oligophylloides* from Morocco

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Perfectly preserved specimens of the heterocoral *Oligophylloides maroccanus* Weyer, 2017 from Jebel Bou Ifaherioun (SE Morocco) have been investigated to trace the earliest stages of ontogeny in protocorallites and blastogeny in branching corallites of the colonies.

The initial proximal parts of protocorallites display circular or elliptical attachment bases (talon), gradually thinning toward the distal cone. Serial tranversal and longitudinal sections of the basal part exhibit atypical ontogenetic development during the initial stages of growth: 1) in the most proximal part, the central lumen, circular in shape, is empty – i.e., without a septal apparatus and tabulae; 2) the insertion of septa started on the first tabula at least 0.5 mm above the basal disk, which was circular in shape; and 3) the protoheterotheca was developed centrifugally at the basal part, often forming an initial vesicular structure around the axial lumen. The dimensions of the lumen in the most proximal part of the skeleton are 0.4-0.5 mm, indicating that heterocoral larvae were relatively small attaining this diameter at their base, when they started to produce the skeleton. Similar developmental patterns and dimensions were also observed in massive proximal parts of paracolonies of *Oligophylloides,* where new larvae settled on their basal parts. The early ontogeny of studied protocorallites does not resemble any examples known in other Palaeozoic coral groups. Hence, there seems to be no basis for a systematic taxonomic relationship between Heterocorallia and Rugosa.

Blastogenetic studies of branching corallites in *Oligophylloides* indicate that offsetting was common and proceeded in most cases in a single plane by dichotomous division. However, offsets were mostly created on the heterotheca (at various thickness). Continuous growth of heterotheca on the ‘parent’ and ‘daughter’ corallites may suggest that they were most plausibly produced by common tissue. The initial direction of the offsets’ growth was set at an 80-90° angle from the heterotheca. The first offsets could be produced relatively early in the protocorallite ontogenic sequence. Although corallites after offsetting mostly grew separately, they could temporarily reunite, which corroborates the view that the heterotheca was covered by soft tissue.

Early to Middle Devonian coral-dominated cryptic ecosystems from carbonate mounds of Hamar Laghdad (Anti-Atlas, Morocco)

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Unique and exceptionally well-preserved fossil, coral-dominated, cryptic communities have been discovered in submarine cavities of the Lower and Middle Devonian (Emsian to Givetian) mud mounds in the Hamar Laghdad area (Anti-Atlas, Morocco). The cryptic corals encrusted the roofs of the cavities and grew predominantly oriented upside down. These unique coelobiotic communities were dominated by various taxa of solitary rugose corals, which very often displayed a "calice-in-calice" growth pattern. Apart from the rugosans, the cavities were inhabited by other sessile invertebrates, predominantly: massive and branching tabulate corals, cladochonids, crinoids and lithistid sponges. Many of the 'hanging' skeletons were encrusted by microbial structures. The high density of organisms overgrowing each other points to intensive competition for space in all studied Devonian submarine crypts. The late Emsian to latest Givetian cavities were colonised by various sets of coelobiotic corals mostly originating from the surrounding deep-water marine environments. It is suggested that the local species pool was a decisive factor in determining the ecological succession and taxonomic structure of cryptic coral communities. The changes in taxonomic composition and diversity, over time and space, were primarily related to variations in local physical environment. Consequently, the coral communities in crypts affected by venting of high-temperature fluids or hydrocarbon seepage were of low diversity and included endemic elements and characteristically small specimens. While unique in several palaeoecological and taxonomical aspects, the Devonian cryptic assemblages of Hamar Laghdad display similarities to the few known analogues of cryptic biocoenoses inhabited by corals described from modern and subfossil marine environments, pointing to similar constraints shaping the ecology of coral-dominated coelobiotic communities throughout the Phanerozoic.

The reef coral fauna of the upper Oligocene Castro Limestone (Salento peninsula, S Italy)

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The Oligocene is well known as the apex of Cenozoic reef growth, with extensive coral reefs recorded in particular in the Caribbean and Mediterranean regions. The reefs have provided rich and famous coral collections since the 19th century.

The upper Oligocene Castro Limestone, outcropping along the eastern coastline of the Salento Peninsula for about 17 km, is one of the best preserved coral reefs in the Mediterranean paleo-biogeographic province and has been interpreted as a fringing reef complex with facies extending from the back reef to the fore-reef slope and including a distally steepened ramp. Studies, so far, have focussed basically on facies analysis and reconstruction of the depositional model, with only preliminary data about its luxurious coral fauna.

Herein we characterize in detail the composition and distribution of the coral fauna in the Castro Limestone combining results from taxonomic identification of coral collections at the genus and species level and from quantitative data obtained directly in the field. Quantitative methods include: counts of coral colonies in growth position on subvertical measured surfaces, line-intercept transects, quadrats placed on a subvertical outcrop surface, and measurements of coral colony size.

The coral collection, deposited at the Department of Chemical and Geological Sciences of the University of Modena and Reggio Emilia, is represented by 212 specimens and consists of 25 genera and 41 species, confirming the high taxonomic richness that is usually recognized in upper Oligocene reefs. Most genera comprise 1 to 2 species, except *Goniopora*, *Montastraea* and *Stylophora* which have 3 to 4 species. The stratigraphic distribution of the identified species shows that about 41% were already present during the Eocene, 29% are strictly Oligocene, and only 5% range from the Eocene to the Miocene. Their paleobiogeographic distribution is strictly Mediterranean, with a few occurrences in Iran, Pakistan and Tanzania, thus highlighting some Indo-Pacific affinity.

Quantitative data from field surveys show that the coral assemblages of various reef facies differ both in their composition and in their proportions (relative abundance of genera). Coral cover, expressed as the % of corals preserved in growth position vs the % of inter-coral sediment (from linear measurements), shows very clear variation across the reef profile from 4-20% in the back reef up to 63% of the reef front facies, followed by a decrease toward the reef slope corresponding with a decrease of colony size.

These results obtained from the study of the coral fauna complete the overall picture of the Castro Limestone, showing one of the best examples of the explosion of reef corals during the Oligocene. The Castro Limestone should be thus considered as a potential geosite in order to protect and promote its geological and paleontological significance.

Revisiting reef models in the Oligocene of Northern Italy (Venetian Southern Alps)

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Well-developed coral reefs were globally scarce during most of the Paleogene but increased in abundance, size, and biotic diversity during the Oligocene, perhaps related to an increasing Mg/Ca ratio in ocean water. The Lessini Shelf (Venetian southern Alps, N Italy) records this trend in an exemplary fashion.

Exceptional for the time, the presence of a Rupelian (early Oligocene) reef system is witnessed in the area of Castelgomberto by a large lagoon with abundant coral colonizations. Its presence has been interpreted as related to a seaward bioconstructed margin, possibly located in the present-day Colli Berici, that acted as a protection from strong waves and currents during sea-level low-stands.

This barrier-reef lagoon model has been repeatedly challenged, proposing instead of a reef-rimmed platform, a ramp depositional system. The lack on an evident, *in situ* coral framework and the dominance of coralline red algae in the Colli Berici, are the main arguments against the barrier-reef hypothesis.

Here we provide new data supporting the barrier-reef hypothesis. (1) An *in situ* coral reef has been located at the Eremo di San Cassiano (Colli Berici), where massive corals (mostly *Antiguastraea*) are nearly 50% in growth position, with the rest tilted but rarely fragmented. Although strong karstification prevents a quantification of coral cover, coral colonies appear to form a three dimensional framework, with intra reef sediments represented by calcarenites with abundant (but not dominant) red algae. (2) The lagoonal facies near Castelgomberto displays very different features, with dominant coral taxa represented by branching corals (ramose *Actinacis* and phaceloid *Caulastrea*) and occurrence of a marly sediment. When present, lagoon patch reefs differ from the barrier colonizations by their lenticular shape and limited thickness. (3) While the San Cassiano reef margin displays a massive appearance, the lagoon facies is characterized by a sharp planar bedding and an evident cyclicity. This latter feature is due to the superimposition of high-energy, coarse biocalcirudites, sometimes rich in coral fragments and lower-energy deposits, characterized by *in situ* coral colonies and thin marly levels that can be associated to phases during which the coral barrier acted as a protection from the open sea.

A carbonate platform rimmed by one the earliest Cenozoic barrier reefs of the world is thus the best interpretation of the data at hand.

Exceptional development of dissepimental coenosteum in a new Eocene scleractinian coral

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In colonial corals, the polyps are interconnected with a common tissue called coenosarc. Polyps and coenosarc secrete distinct skeletal structures: corallites and coenosteum, respectively. Ratio of corallite to coenosteum development may vary resulting in two extreme architectural patterns of coral colonies: corallite-dominated (e.g., cerioid) and coenosteum-dominated (e.g., aphroid) colonies. A large suite of examples of these patterns can be identified in the fossil record, including Paleozoic rugosan corals.

Herein we describe a new early Eocene colonial scleractinian coral that forms exceptional coenosteum-dominated colonies. The colonies were found in Ypresian limestones of Monte Postale (Lessini Mountains, Veneto, NE Italy), very close to the Pesciara di Bolca Fossil-Lagerstätte, where coralgal buildups have been recently recognized and described. The corallum is massive and consists of corallites of variable size (typically few millimetres in lesser calicular diameter) dispersed and protruding from a very extensive and dense dissepimental coenosteum. The coenosteum forms ca. 60-80% of the corallum volume and is made of vesicular convex dissepiments. Among the fossil scleractinian corals, similar extend of dissepimental coenosteum development is shown only by some Mesozoic amphiastreids.

Experimental studies show that dissepiments are rapid growing skeletal elements, hence formation of light, dissepiment-dominated coralla could be an efficient strategy to compete for space and/or maximize light and food interception.

Coral calcification during the geological past –was it different?

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The present increase in atmospheric carbon dioxide (pCO_2) due to the burning of fuels is unprecedented in earth history. As a result, ongoing ocean acidification increasingly endangers marine calcareous biota such as reef corals. For testing predictions on the carbonate saturation state of the surface ocean in reef settings over geological time, we present the first comprehensive set of reef-coral sclerochronological records and calcification data from specimens being between 23 and 1 million years old. The sclerochronological data document environmental variability at annual and inter-annual time-scale compatible with the Recent. The calcification patterns of the fossil corals differ from corals in present-day reef settings (warm and oligotrophic), but are indistinguishable from those in oceanic low carbonate supersaturation (CS) environments. This finding may indicate to low seawater CS during the geological past. By now it is not clear, however, whether low CS was an effect of globally high pCO_2, or local environmental stressors (low temperature, turbid water, upwelling, etc.). We also find that investing calcification resources preferentially in skeletal extension rather than skeletal density is a conservative evolutionary trait of the scleractinian reef corals. It reflects an adaption to colonizing space on a reef in low CS environments of the past and likely was an essential pre-adaption to compete with rapid, deglacial sea-level rises.

Eocene meandroid corals from Friuli, Italy, and the evolution of the scleractinian family Faviidae

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Integrated morphological and molecular analyses have found that modern Caribbean and Indo-Pacific meandroid corals, traditionally assigned to the family Faviidae, are evolutionarily distinct and belong to two separate families [Faviidae (=Mussidae) in the Caribbean, Merulinidae in the Indo-Pacific]. We are using morphological phylogenetic analyses (maximum parsimony) including extinct and extant species to reconstruct the divergence and evolutionary history of these two groups. Our previous work indicates that only two of eleven meandroid species in the Mediterranean Oligocene belong to the Faviidae (subfamily Faviinae), whereas nine belong to the Merulinidae. Mediterranean meandroid corals were therefore interpreted as having stronger affinities with the Indo-Pacific than with the Caribbean during the Oligocene.

In the present study, we continue this research by going back to the Eocene when the Mediterranean was a major center of diversity. We focus on 11 meandroid species from the lower Eocene of Friuli (NE Italy), which we determined in collections at Museo Friulano di Storia Naturale, Udine, and at Museo di Storia Naturale, Geologia e Paleontologia, Firenze. Six of the 11 species have distributions that extend into the Oligocene, and five are limited to the Eocene. Two species are new. We perform two phylogenetic analyses on these taxa: the first comparing them with species in the Mediterranean Oligocene (11 taxa), and the second comparing them with species in the Caribbean Eocene (14 taxa). The datasets for both analyses also contain a set of modern, genetically-characterized corals from the families Faviidae (15 species), Merulinidae (31 species), and Lobophylliidae (14 species). The same 50 morphological characters (24 macromorphology, 11 micromorphology, 15 microstructure) are used in both analyses.

The results for the first analysis are similar to previous work on the Mediterranean Oligocene, with only two Eocene species (*Colpophyllia flexuosa*, *Variabilifavia confertissima*) belonging to the family Faviidae (subfamily Faviinae) and the other nine Eocene species belonging to the family Merulinidae. The results for the second analysis show similarities between Mediterranean and Caribbean Eocene meandroid corals, especially in the genus *Colpophyllia* and a clade containing species previously assigned to the genus "*Leptoria*". One important difference between the two faunas is the genus *Hydnophyllia*, which occurred in the Mediterranean but not in the Caribbean. In conclusion, the family Merulinidae was diverse and cosmopolitan during the Eocene, extending around the globe in the tropics. The Faviidae were less diverse and less widespread than the Merulinidae, but they were more widespread during the Eocene than they were later on. During the Oligo-Miocene, the Faviidae became restricted to the Caribbean and diversified, as the Atlantic widened and the Caribbean became more isolated.

Variations in growth and skeletal characteristics of a temperate non-zooxanthellate colonial coral naturally living at CO_2 vents

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Ocean acidification may impact ecosystems reliant on calcifying organisms, potentially reducing the socioeconomic benefits these habitats provide. This study investigates the response of growth and skeletal properties of the non-zooxanthellate stony coral *Astroides calycularis* living in naturally acidified seawater at a Mediterranean CO_2 vent (Ischia, Italy). Unexpectedly, contrasting patterns of calcification were found at polyp and colony levels. Polyp linear extension rate, bulk skeletal density and net calcification rate increased with acidification (i.e., skeletal porosity decreased). At the colony level, a decrease of net calcification rate was observed in acidified conditions, with colonies that extended less, were smaller, and were composed by fewer polyps, thus partitioning the available energy among less polyps. As a result, the single polyps had a higher amount of resources available for calcification than in control conditions, and all their growth parameters had higher values. This unforeseen pattern of response to acidification was observed in this study for the first time, and contrasts with what previously observed in the Mediterranean solitary coral *Balanophyllia europaea*, whose polyps invest the calcification resources in linear extension rate to reach the size at sexual maturity at the expenses of skeletal resistance (i.e. bulk skeletal density). In the colonial *A. calycularis* asexual reproduction is possible and corals may invest more on skeletal resistance without the urge to reach sexual maturity.

Microstructure and crystallography in the genus *Morenaphyllum*

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The microstructure of the genus *Morenaphyllum* has been studied in ultrathin sections by means of petrographic microscopy and computer integrated polarization microscopy (CIP). Although the studied specimens are partially recrystallized by diagenesis (e.g., degrading neomorphism coupled with random crystallographic orientations), the biogenic microstructure can be still observed in well-preserved areas. *Morenaphyllum* shows thick walls mainly composed of lamellae piled in bundles, lamellar dissepiments, tabulae and stereoplasmatic thickenings and septa composed of small fibres, which change their orientation from the periphery to the axial zones of the coral. A gradual transition between the different microstructural domains (i.e., lamellae and fibers) has been observed. This feature is characteristic of Paleozoic corals when the biogenic properties are preserved. The crystallographic orientation between the microstructures is coherent and kept along domains (e.g. lamellae, fibers) and structural elements (e.g., septa, axial tabellae and wall).

In spite of the presence of some peculiarities, characteristic of intrageneric variations, this microstructure fit well with that described in other Axophyllinae. Moreover, the microstructural features suggest that the studied skeletons are composed of hierarchical structures, similarly to other Paleozoic corals.

Furthermore, some crystallographical properties of *Morenaphyllium* skeletons suggest a common evolutionary pathway between Cambrian coralomorphs and Rugosa, which should be studied as a prospective challenge to understand the evolutionary biomineralization processes within the phylum Cnidaria.

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Uncommon reef coral association from the Eifelian (Mid. Devonian) of S Belgium: a palaeobiogeographic puzzle

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The Lower Middle Devonian of Belgium – long known as 'Couvinian' – displays a large range of buildups type from stromatoporoid biostromes and coral beds to wide bioherms with microbial core and stromatoporoid-coral framework. Such a bioherm occurs in the Wancennes locality, E of Couvin. Despite poor outcrop conditions (discontinuous sections, spot outcrops and blocs emerging in furrows of ploughed fields), the Wancennes Formation was recently described as a complex reefal structure starting on crinoidal rudstone stabilised by lamellar stromatoporoids and evolving upwards into a tabulate corals-stromatoporoid framestone rich in solitary and colonial rugose corals. The reef core displays fine-grained facies with abundant cement-filled cavities containing abundant brachiopods. The reef-crest is dominated by bulbous stromatoporoids and *Heliolites* accumulation within crinoidal rudstone.

The rugose coral diversity evolves upwards in parallel with the diversification of facies – and thus diversification of niches. A first assemblage is dominated by fasciculate to subcerioid '*Batterbyia varia*'*, *Spongophyllum* sp., *Lyrielasma* sp., *Sociophyllum* spp., *Stringophyllum* spp. and various *Mesophyllum* and *Cystiphylloides* species. Massive colonies of *Alveolites* spp. and *Heliolites porosus* are also abundant in the stromatoporoid facies. Colonies of *Australophyllum* sp. occur sporadically. In the fine-grained facies, solitary cystimorphic corals dominate with *Acanthophyllum* spp., *Dohmophyllum* spp., *Thamnophyllum* spp., '*Battersbyia**' sp., chaetetids and thamnoporid tabulates. The upper rudstone facies suggests hydronynamic settings yields the most diverse assemblage with *Spongophyllum sedgwicki*, '*Battersbyia varia**' (both fasciculate and cerioid colonies), colonial and gregarious *Mesophyllum* spp., numerous large solitary rugose, yet undescribed species of *Xystriphyllum*, *Cyathophyllum*, *Neomphyma, Lyrielasma* and *Taimyrophyllum*.

The top of the reef is affected by a subaerial erosion surface interpreted as a major sequence boundary overlaid by the siliciclastic deposits of the Jemelle Formation (Chavées Member). The later yields a poorly diverse fauna of solitary rugose corals (cystimorphic, *Acanthophyllum*) and rare *Thamnophyllum* sp.

The facies assemblage of the Wancennes reef exemplifies perfectly what is expected to find in a Middle Devonian bioherm. Its limited lateral extension (c. 300 m high, 3 km-long) is most probably due to syn-sedimentary block-faulting due to the tectonic structuration of the basin at this time. The faunal assemblage is comparable to other Eifelian reefs in similar context in Germany and Russia. However, most surprising is the joined occurrence of coral taxa characteristic of other palaeobiogeographic provinces. Among them, *Australophyllum* and *Taimyrophyllum* that are described from N Canada, E Australia and central Asia but noticed in W Europe for the first time. *Lyrielasma* and *Neomphyma* have been described sporadically in the Eifelian of Belgium and Germany but are more typical of Australian and Canadian assemblages. Hence, the palaeobiogeography signal is important as it seems now that very most Middle Devonian genera are cosmopolitan, with less and less exceptions. Dispersal of corals have also consequences for palaeogeography, palaeoclimatology and sea level fluctuations.

*the name *'Battersbyia varia'* is provisionally used to designate the fasciculate to (sub)-cerioid colonies that were also described as *Fasciculum varium*, *Beugniesastraea varia* and *Xystripyllum implicatum* by various researchers. This taxon is currently under revision, based on type material, topotypes and numerous colonies from S Belgium.

Exploration of morphospace in the Viséan rugose coral *Siphonodendron martini*

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Siphonodendron martini is one of the most common colonial rugose corals through the Viséan of Western Europe, North Africa and Turkey. The species evolved from *S. ondulosum* in the early Viséan through progenesis and a reduction of size. During the rest of the Viséan (i.e. during c. 10 My), *S. martini* is characterised by a very stable morphology. However, some trends in size and thickening, possibly in link with the environment were long suspected. The aim of this study is to explore statistically the morphospace of this abundant and very regular species is order to detect morphometric variations either in time or in space or through environmental settings.

The Belgian Viséan succession is probably one of the best documented in terms of depositional settings and stratigraphy and the large collection of *S. martini* available acts as a good sample for the analysis. For comparison, time-equivalent specimens from Morocco, UK and Turkey were also included in the dataset. Eight morphometric characters were measured in at least ten individual per colony: external diameter, tabularium diameter, number of septa, length of minor septa, length of major septa, length and width of columella and number of dissepiment rows. Additionally, the presence/absence of thickening of septa, dissepiments and wall were noted. After normalisation of the raw data, PCA analysis was run with R.

It appears that most of the variation is carried by the diameter and number of septa in all samples, which confirms the value of such diagnostic character. However, the development of the columella and dissepimentarium is strongly related to environment, seemingly to hydrodynamic conditions, as often suspected.

Cluster analysis tends to show no clear locality of age-related clustering, suggesting that variation is similar both in time and space.

Principal component analysis shows that colonies coming from different localities of the same age (at least the same biozone) are significantly more different than colonies of different age. In other words, more variability is explained by local conditions than as variation through time (phenetic). It confirms that *S. martini* has a relatively stable morphology throughout its stratigraphical extension, with some exceptions, notably within the oldest colonies of the lower Viséan.

Comparison with other species of *Siphonodendron* indicates that the variation is similar and therefore that the variability signal is probably a supra-specific character. Further investigation of homeomorphic corals (such as the Australian *Cionodendron* spp.) could possibly demonstrate that the taxonomy, besides environment, explains the way variability is expressed in corals.

Holocene distribution of azooxanthellate scleractinian corals off San'in district, Japan Sea

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The species compositions and distributions of azooxanthellate scleractinian corals have rarely been reported, especially in the Holocene Japan Sea. In this presentation, we show their species compositions and distributions, established by the analysis of bottom sediments collected off the San'in district, which is located in the southern part of the Japan Sea. The latitude of the San'in district is similar to that of Tokyo and Busan. The Oki Islands lie off the coast of the San'in district. We examined samples from 286 sites (water depths of 27–1570 m), collected by a survey cruise (GH86-2) conducted by The Geological Survey of Japan (AIST).

Scleractinian corals were found at 74 sites (water depths of 27–175 m, bottom-water temperatures of 6.0–22.0 °C). Thirty species belonging to 23 genera and 10 families were identified among the total 4385 individuals. *Deltocyathoides orientalis* belonging to the family Turbinoliidae was the commonest coral, occurring at 63 sites at depths of 27–175 m, and the total number of *D. orientalis* individuals was 2455. The species diversity is high around the Oki Islands and the adjacent western continental shelf. Corals are most abundant on fine-grained sandy sediment. Almost half the individuals sampled, many of which were *D. orientalis,* were found in fine-grained sand sediment. No corals were present on clay bottoms, whereas their occurrence was highest on outcrops, where the number of individuals and the number of species of both free-living or attached corals were greatest.

Most of the coral species found in this study originally inhabited regions south of the collection sites (GH86-2). These recognized species have previously been recorded at water depths of 0–1048 m and water temperatures of 5.8–24.3 °C. Off the San'in district, most corals live at a depth of ~100 m, although they occur at depths up to ~150 m. The Tsushima Current occurs at a depth of ~200 m deep off the San'in district, and is underlain by the Japan Sea Proper Water, which has a temperature of < 2 °C. The bottom-water temperature is ~15 °C at a depth of ~100 m, 6 °C at a depth of ~150 m, and < 2 °C at a depth of > 200 m. Corals were distributed in areas in which the bottom-water temperature is > 6 °C throughout the year. This is consistent with the previous finding that none of the species found off the San'in district occur at temperatures below 5.8 °C in other regions. Therefore, the bottom-water temperature might be the main factor limiting the distribution of corals off the San'in district. The water temperature is highly variable in the region and often decreases to < 6 °C because the main thermocline occurs at a depth of 150 m, which might explain the fewer individuals found at a depth of ca. 150 m.

Scleractinian corals off the San'in district are considered to have a southern origin, and were brought into the Japan Sea by the Tsushima Current. They occur only in shallow, warm areas throughout the year. This study demonstrates that water temperature has greatly influenced the expansion and contraction of the range of azooxanthellate scleractinian corals.

Epibionts immured in heterocoral *Oligophylloides maroccanus* (Weyer 2017) – a case study from the Famennian (Late Devonian) of Morocco

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Well-preserved proximal parts of colonies (?paracolonies) of the upper Famennian heterocoral *Oligophylloides maroccanus* Weyer, 2017 collected at Jebel Bou Ifarherioun, Anti-Atlas, Morocco provide a unique morphological record of synvivo interactions with other sessile epibionts. Detailed analysis of the sectioned specimens (serial polished slabs and thin sections) allowed us to trace mutual interactions during growth of the host (*Oligophylloides*) and the infesting epibionts. The proximal parts of the *Oligophylloides* colonies were encrusted by various colonial and solitary epibionts, i.e., the colonial tabulates *Zemmourella* sp. and *Aulopora* sp.; solitary rugose corals ?*Czarnockia* sp. and ?*Gorizdronia* sp., other juvenile, undeterminable solitary rugosans, crinoids, as well as microbial structures. All studied associations show that the encrusters infested the proximal parts of the Oligophylloides skeletons in places devoid of soft tissue. Following the settlement, growth of the epibionts was relatively rapid and not disturbed by the host. After death, however, the epibiont skeletons were again fouled by the heterotheca of *Oligophylloides*, which finally immured the encrusters. The studied associations show that: 1) the epibionts must have settled on the exposed parts of the calcitic heterotheca of the living host (*Oligophylloides*); 2) the host had no ability to prevent infestation or overgrow the epibionts as long as they were alive (possibly due to their aggressive activity, e.g., sweeping tentacles); 3) soft tissue of *Oligophylloides* could retract and expand again once the encrusters died; 4) the process of bioimmuration of the encrusters took place shortly after their death, which is marked by thin layers of microbial encrustations developing on the epibiont skeletons prior to their overgrowth by the host skeleton.

The Pennsylvanian rugose corals of Egypt

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In Egypt, marine and marginal marine Carboniferous sedimentary successions were recorded mainly from the subsurface. Outcrops are discontinuous, and limited to both sides of the Gulf of Suez. Rugose and tabulate corals from the eastern side of the Gulf (Sinai) are only known from the middle to early late Viséan Um Bogma Formation. From its western side, Pennsylvanian corals have been recorded from late Moscovian levels of the upper Rod El Hamal Formation at Wadi Araba, and from the late Moscovian to ?Ghzelian lower member of the overlying Aheimer Formation at the Northern Galala These Pennsylvanian faunas are of special importance, as they represent the youngest Carboniferous corals from the platforms that stretch along the southern Palaeotethys, respectively along the northern Gondwana margin across North Africa. Time equivalent marine deposits from the Levant and Arabia are missing. Therefore, faunas from comparable palaeobiogeographic setting are expected as distant as in the peri-Gondwana terranes from Turkey and Iran.

The late Moscovian coral fauna from the Rod El Hamal Formation has been derived from a some meters thick interval of interbedded marl and silty to sandy bioclastic limestone, embedded in calcareous sandstones. The strongly fossiliferous limestones are tempestites that besides the corals concentrated brachiopods, bryozoans, crinoid and echinoid ossicles, molluscan moulds, and some trilobites. The moderately abundant, low diverse coral fauna consists of large, dissepimented, solitary Rugosa belonging to the Bothrophyllidae and Geyerophyllidae; colonial taxa are missing. Besides three undeterminable bothrophyllids, we recently introduced the endemic *Bothrophyllum suezensis*, *Bothrophyllum cylindricum*, and *Amygdalophylloides omarai*. The corals were attached to the soft substrate by talons and rootlets, growing either as mud-stickers or secondary recliners. Growth interruptions are frequent. Characters of the coral fauna and carbonate facies indicate a littoral to inner neritic environment, probably within an embayment of the Southern Palaeotethys.

The late Moscovian to ?Ghzelian lower member of the overlying Aheimer Formation is composed of calcareous silty shale intercalated with thin, ferruginous, silty dolostone and calcareous siltstone beds. In its lower part, brachiopods, fenestrate bryozoans, crinoid ossicles and stem fragments, and small foraminifers occur besides a low diverse rugose coral association. It consists of small, solitary, non-dissepimented species of the *Cyathaxonia* fauna, altogether nine genera from two families. Additional taxa mentioned in earlier descriptions need revision and are not considered herein. Most corals suffered from destructive physical alterations of their skeletons such as crushing and flattening; all calices are laterally compressed. In some specimens, the interior skeletal elements of the corals are partly to completely dissolved or septa are completely broken. Recrystallization, dolomitization, ferrugination and late silicification of open pore spaces inside the corals are common diagenetic features. Laccophyllidae are represented by *Syringaxon* cf. *beruinensis*. All other taxa are attributed to the Hapsiphyllidae: One species of *Actinophrentis* and another one from *Monophyllum* are new. *Lytvolasma* cf. *canadense*, *Lytvolasma* sp. 1, *Zaphrentites* cf. *parallela* , and *Zaphrentites* sp. are new to the Aheimer Formaton, whereas *Lytvolasma* sp. 2 and *Rotiphyllum exile* were recorded before.

The corals of the Aheimer Formation do not show evidences of attachment during mature stages, but well preserved specimens might exhibit somewhat well-developed attachment scars in their apical parts. Rejuvenation, encrustation, and bioerosion are not common. In addition to the embedding in the silty shales, this indicates that the corals lived on a soft bottom without much reworking. Cyathaxonid corals are generally adapted to unfavourable conditions. In the case of the Aheimer Formation, these are turbid waters. A sheltered shallow marine habitat is envisaged, grading into intertidal(?) conditions in the uppermost part of the lower Aheimer Formation, as seen by the appearance of vertical *Skolithos*-type burrows.

Palaeobiogeographic similarities on generic level with the Cantabrian Mountains (N Spain), the Donetz and Moscow basins indicate unequivocal attribution of the Rod El Hamal corals to the Palaeotethys realm. For the Aheimer corals, certain similarities with North America have been claimed before, but these are doubtful due to the suturing of NW Africa and eastern N America in the early Bashkirian and problems in the taxonomic assignment of the simple structured (homeomorph?) North American and Eurasian cyathaxonid corals.

Mississippian (early Carboniferous, Viséan) tabulate corals from the Sinai (Egypt)

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Marine Viséan sedimentary deposits from the west-central Sinai (Egypt) represent the isolated relicts of the extended Mississippian platforms and basins framing northern Gondwana. These strata are of special importance, as sucessions of equivalent age and palaeogeographical setting are restricted to distant regions, i.e. to the Saharan basins stretching from Libya across Algeria to Morocco. Further comparable successions have to be sought in the peri-Gondwana terranes preserved in Turkey and Iran. Therefore, the Viséan microfauna and macrofauna from the Sinai attracted considerable attention. Still, the knowledge on tabulate corals is scarce. Herein, we report results of renewed sampling of the middle to early late Viséan Um Bogma Formation, done in the context of current work on the Carboniferous coral fauna from Egypt

The Um Bogma Formation consists of a lower and upper dolomitic member, and a middle member made up from an alternation of thin-bedded marly dolostones, dolomitic limestones, soft siltstones, and shale interbeds. Only this middle member (El-Qor Member) yielded rich microbiota and a diversified macrofauna. Logging and collecting of the El-Qor in four sections from the west central Sinai (Gebel El-Lahian, Wadi Khaboba, Wadi Nukhul, Wadi Shallal) yielded abundant brachiopods, bryozoans, bivalves, rugose corals, rare trilobites, and indeterminable echinoderm ossicles, as well as sparse tabulate corals. Syringoporids, *Michelinia*, a single specimen of '*Palaeacis*', and *Aulopora* encrusting brachiopod shells occur.

Syringoporoids are predominant; 78 specimens were collected, though most are not well preserved. Three growth types include large massive phaceloid, thin platy, and dendroid open branching colonies. Phaceloid and platy morphotypes are characterized by small, evenly spaced, thin-walled corallites. They are attributed to different ecomorphotpyes of *Syringopora intraspinosa* Omara, 1971, previously described from the Sinai. The corallites of the dendroid branching colonies are characterized by thick walls and narrow lumen. They are attributed to the genus *Multithecopora*.

Only five micheliniid coralla were collected, two of them from Wadi Shallal with well-preserved skeletons. They show the wrinkled concentric growth lines of the thin holotheca that wraps the whole colony. Like in *Syringopora intraspinosa*, differing growth forms indicate strong ecological control of colony development. In one specimen, the corallites rise fan-like, in the other, more elongate specimen tube-like. Besides other characters, the statistical comparison of the corallite diameters of juvenile (four-sided), early adult (five-sided) and adult (six- and more-sided) corallites of our material with published photographs prove the assignment to *Michelinia egertoni* (Milne-Edwards & Haime, 1852), a species already described from the Um Bogma Fm. According to French authors, the microstructure of the corallite walls is the primary trait to differentiate micheliniid genera. The approximately parallel lamellar microstructure of the walls confirms the attribution to *Michelinia*. However, in few places also a *Paramichelinia*-type arrangement of lamellae oblique to the median dark line was observed.

An earlier published michelinid taxon from the lower member of the Um Bogma, tentatively assigned to *Michelina macerimuris* Webb 1990, is missing in our collection.

In summary, the tabulate coral fauna from the Viséan of the Sinai is of low diversity. It consists of the hitherto endemic *Syringopora intraspinosa*, of *Michelinia egertoni*, which, besides the Sinai, is widespread in the British Isles, and of not yet determined species of *Multithecopora*, '*Palaeacis*', and *Aulopora*. Apart from lithofacies, low diversity and strong development of ecomorphotypes indicate shallow, at least episodically restricted near-shore environments.

The influence of climatic variability on the long-term growth history of cold-water corals and bryozoans in the Alboran Sea (Melilla Mound Field)

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This study evidences the influence of long-term climate variability on cold-water coral growth and mound development in the eastern Alboran Sea (Brittlestar Ridge I) over the last 300 ka. Based on a multiproxy approach (macrofaunal quantification, benthic foraminiferal assemblages, grain size analysis, sediment geochemistry and foraminifera isotope composition), regional environmental conditions are reconstructed. Cold-water corals thrive at the onset of and during interglacial periods. On the contrary, environmental conditions during glacial periods, particularly during the Last Glacial Maximum, appear to better suit the ecological requirements of bryozoans. Maximum coral abundance is reached during Marine Isotope Stage 5. The results suggest that eutrophic and oxygen depleted conditions prevailed during interglacial periods. The benthic environment was less eutrophic during glacial periods, whilst bottom flow velocity was reduced in comparison with interglacial periods. These conditions would have been favorable for bryozoan development. The last glacial is marked by rapid shifts in benthic and planktonic $\delta^{18}O$ isotopic records. Bryozoans are the most abundant during Marine Isotope Stage 2 and are associated with the brachiopods *Grypheus vitreus* and *Terebratulina retusa*, and the bivalve *Bathyarca pectunculoides.* The presence of *Grypheus vitreus* confirms that bottom current velocities were moderate during MIS 2. *Grypheus vitreus* lives currently between 160 and 250 m depth. The presence of this species can be used as an indicator of low-sea level stand at our study site. During interglacial periods, wet conditions above the African continent would lead to increased fluvial discharge, enhancing primary productivity and as such, nutrient input. A strong mixing between intermediate and surface waters would favor turbulence, increasing lateral food availability and channeling increased nutrient input towards intermediate water depths. This would further promote sustained coral growth. Conversely, during glacial periods, arid conditions above the continent combined to more stratified water masses would lead to the dwindling of coral communities at Brittlestar Ridge I. The lower organic matter availability and the reduced turbulence during glacial periods favored bryozoan development.

Paleozoic alcyonacean sclerites: deciphering the Octocorallia record

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In spite of the ubiquitous presence of Alcyonacea in Recent seas (more than 3000 species have been described), this group has a scarce and irregular fossil record (from Silurian to Recent, but only one undoubted finding in the Paleozoic). This fact could be constrained by the low preservation potential of their skeletons, mostly assembled by single skeletal parts (sclerites) formed by high magnesium calcite (a very soluble $CaCO_3$ polymorph); but also, and most probably, by the challenge of the identification of these remains isolated into the rock matrix. This last hypothesis has led to questioning if the alcyonacea sclerites are more common in the fossil record than was expected.

In this work, 56 geological samples bearing Syringoalcyon, a genus constituted by Alcyonacea represented by sclerites encrusting the outer walls and stolons of a syringoporoid coral (Tabulata) have been studied. 12 of them correspond to colonies of *Syringopora*, 5 to colonies of *Multithecopora*, 1 colony of *Neosyringopora* and 1 sample bearing *Tryplasma,* a solitary rugose coral. These samples come from 18 different localities of Canada, USA, Mexico, Morocco, Algeria, Spain, Iran, and China. They are mostly Carboniferous except for one Silurian (Llandovery - Ludlow) sample and other Devonian (Lochkovian) in age. A subsequent descriptive study, from 168 thin sections and ultra-thin sections, was carried out to determine the main morphological, paleobiological and paleogeographic features of the sclerites and the Alcyonacea itself and to establish a new genus for these sclerites, *Termieralcyon*.

The study has allowed recognizing four sclerites morphotypes based on their bidimensional size, microstructure, and morphology such as spindle, elongate spindle, club, and arrowhead. The relation with the substrate as well as the arrangement of sclerites has been assessed, observing that most of them are attached through biotic substrates for instance syringoporoid and rugosan coral skeletons (by insertion, cementation and stacking) and occasionally to abiotic substrates (e.g. sparite and micropeloidal patches), arranged or isolated into the matrix but closely to coral skeletons.

Data provided from this study enables to compare the morphotypes identified, their dimensions, the relationship with the substrate, and sorts of arrangement with those of Recent Alcyonacea, establishing a close relationship between them. In addition, current evolutionary studies by molecular phylogeny supposed an origin for the order Alcyonacea rooted in the Paleozoic era. The data provided by the 18 new localities in Paleozoic materials support this hypothesis (suggesting that the origin of Alcyonacea could be Lower Ordovician – pre–Silurian), showing a more continuous record for such groups.

Finally, the presence of sclerites in corals that inhabited shallow seas of Paleo Tethys during Silurian to Carboniferous underlines the need for a detailed review of these materials that helps to outline the paleogeographic and paleoecological distribution of this group and a better understanding of their paleobiology.

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Role of photosymbiosis in the Late Triassic expansion of shallow-water Scleractinia

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Since their appearance in the Anisian (ca. 240 Ma) scleractinian corals rapidly diversified and expanded across shallow marine environments, becoming the main builders of reefs. This ecological success corals owe to their symbiotic relationship with photosynthesizing dinoflagellate algae. Although mechanisms underlying this relationship have been broadly studied, fundamental questions regarding its origin and evolution remain open. The main obstacle in studies of symbiosis in the past is that coral skeletons do not preserve zooxanthellae. Conventionally, zooxanthellate corals are regarded as forming highly integrated colonies with small corallites, whereas the corals lacking zooxanthellae tend to have solitary forms or less integrated colonies with relatively large corallites. These features, however, are not exclusive for either ecological group, pointing to the need for more definitive indicators. Isotopic signatures of the skeletons i.e., carbonate $^{13}C/^{12}C$ and $^{18}O/^{16}O$, and intracrystalline skeletal organic matter (SOM) $^{15}N/^{14}N$ have been also used to distinguish symbiotic from asymbiotic corals. However, their application is restricted only to unaltered skeleton. This feature, although rare in the fossil record, was reported in coral skeletons as old as Triassic.

Recent development of two new methods gives opportunity for investigation of symbiosis in fossil scleractinians: microscale growth banding and "persulfate-denitrifier" high precision analysis of nitrogen isotopic composition of intracrystalline SOM. These methods were applied to a set of exceptionally preserved skeletons of Early Norian (ca. 212 Ma) scleractinian corals from Antalya (Turkey). Selected skeletons represented both, solitary or poorly integrated (phaceloid) and highly integrated (cerioid, meandroid and thamnasterioid) growth forms.

Microscale growth bands of Triassic corals were compared with those of living scleractinians. The examined fossil specimens, including forms traditionally considered as asymbiotic, exhibited a highly regular and continuous banding pattern typical for modern zooxanthellates, contrary to modern asymbiotic corals with irregular, often discontinuous bands. Nitrogen isotopic signatures of intracrystalline SOM in Triassic scleractinians fall below the range measured for modern asymbiotic corals, but overlaps data form modern zooxanthellates, indicating that each of examined Triassic corals harbored photosymbionts. If these Early Norian corals were symbiotic, their $\delta^{15}N$ suggests that local source values were similar to those of modern oligotrophic (sub)tropical North Atlantic. In fact, similarity between $\delta^{15}N$ from Triassic corals and modern Bermuda specimens suggests that they lived in similarly nutrient-poor waters. Further analyses show that Triassic specimens with pristine biogenic aragonite exhibit oxygen and carbon isotopic signatures compatible with those of modern symbiotic corals.

The presented combination of microstructural and geochemical indicators, provides a new, powerful toolkit for assessing symbiosis in well-preserved fossil corals. All criteria support our interpretation that Early Norian corals from Antalya lived in symbiosis with dinoflagellates, including small solitary and phaceloid forms, which based on morphology alone would be classified as asymbiotic. Since coral genera examined herein were widespread in the Late Triassic reefs of NW Tethys, we propose that symbiosis was the dominant if not the exclusive lifestyle in shallow-water corals from the Tethyan realm. These oligotrophic environments, provided strong impetus for establishing of symbiosis with photosynthesizing algae. Since the Triassic, the symbiotic relationship of corals and zooxanthellates facilitated the formation of the greatest oceanic bioconstructions - coral reefs.

Taphonomy, diagenesis and sedimentary environment of Eocene siliceous sponges from Chiampo, Lessini Mts, NE Italy

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The sponge fauna from a lower Lutetian tuffite horizon in the Chiampo Valley, Lessini Mountains, north-eastern Italy, consists of 32 species: 15 hexactinellid and 17 demosponges (15 lithistids and 2 hypercalcified). Such fauna shows affinities with sponges from the Eocene of Spain and the Cretaceous of Germany. The stratigraphical range of taxa as *Camerospongia*, *Toulminia*, *Ozotrachelus* and *Bolidium*, previously documented only till the Cretaceous, is now extended into the Eocene. The Recent hypercalcified demosponge genus *Astrosclera*, previously known only in the Triassic, is reported in the Cenozoic for the first time. Moreover, the Recent sphinctozoan genus *Vaceletia* is reported for the first time in the Eocene of the northern hemisphere.

The most common extant sponge taxa at Chiampo inhabit rather deep water today.

The presence of different modes of attachment in the investigated specimens suggests heterogeneous substrate conditions. Small, possibly young, sponges are present in the fauna, as well as sponge clusters. Field sampling revealed hexactinellids to be strongly dominant over lithistids, which suggest a deep-water setting greater than 200 m water depth.

In this study, we investigate the preservation and sedimentary context of this sponge fauna.

The present study has been based on museum collections, fieldwork stratigraphic logging and sampling, together with facies analysis. Thin sections were studied with petrographic microscopes, under transmitted optical and fluorescent light. For calcareous nannofossil analysis, raw sediments were processed to prepare standard smear slides. Environmental interpretation was aided by stable isotopic analysis of the carbonate of skeletal components and cements.

The embedding sediment is a sandy tuffite composed of rounded volcanic fragments, skeletal grains and calcitic cement. Associated fauna consists of smaller (benthic and planktic) and larger foraminifera (e.g., *Nummulites*, *Discocyclina*), decapods, ostracods, echinoids, crinoids, bryozoans, mollusks (gastropods, especially pteropods, bivalves and rare cephalopods), red algae and rare corals. The ichnofossil *Ophiomorpha nodosa* is also documented. The sponge fauna of Chiampo Valley consists of bodily preserved specimens with skeletons replaced with calcite. It was observed, in thin sections, that the space between spicules is often partially filled by clotted peloidal micrite. A veil of micrite and peloidal micrite always form coatings around spicules. Clotted peloidal micrite is systematically more abundant in lithistid sponges with respect to hexactinellids.

We infer that the sponges were preserved in situ and living when they were quickly buried by volcaniclastic sediments. This is proven by the absence of sediment in the sponge canals, the preservation of delicate encrusting bases, the mixed (shallow and deep marine) associate fauna, and the siliceous membrane preserved in some specimens. Partial calcification of decaying tissue, possibly by sulfate-reducing bacteria, produced the thin coatings of clotted peloidal micrite. During burial, the complete replacement of opaline skeletons by calcite sparite occurred.

Sponges *vs* microbialites: an example from the cryptic biogenic crusts of Aegean submarine caves (Eastern Mediterranean)

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Marine cave systems have been acknowledged as ideal natural laboratories to investigate the carbonatogenetic role of microorganisms in confined environments and to clarify how microbial processes develop under stressed conditions. Submarine caves are cryptic habitats characterized by low light intensity, marked oligotrophy and low water circulation. They are colonized by cryptic communities, whose skeletons may form different types of bioconstructions, from small/thin biogenic crusts to large "biostalactites". These structures are usually strengthened and early lithified by microbialites.

In this research the biogenic crusts of Fara and Agios Vasilios caves (Lesvos Island, Greece) were analysed with optical microscopy, epifluorescence, SEM and EPMA. The walls and ceilings of the studied caves are covered mainly with sponges, coralline algae, scleractinian corals, serpulid polychaetes, and bryozoans. Skeletons of these organisms are often cemented together and form extensive crusts of variable thickness. The skeletal composition of these crusts change from the opening to the inner parts of the caves. Following gradients in environmental parameters and food availability, coralline algae and scleractinian corals dominate in the crusts close to the cave entrances, whereas serpulids, bryozoans and sponges are the main builders in the innermost cave sectors.

Demosponges are recognizable owing to the occurrence of siliceous spicules. Spicules are concentrated mainly in microcavities, left empty after the organic tissue decay of boring or insinuating/cavity filling sponges. Micrite is a minor component in these biotic crusts. The autochthonous micrite differs in amount and texture in comparison to that found in other Mediterranean submarine caves. Despite their difference in size, the nearly meter-sized biostalactites of the Kakoskali cave in Cyprus and the nearly decimeter-sized biostalactites of the Plemmirio area in Sicily, show a uniform style of growth. In both biostalactites, autochthonous peloidal to clotted peloidal micrite (accounting for 35% and 45% of the total volume, respectively) contributes to strengthen and stabilize the skeletal framework. The autochthonous micrite is confined to microcavities of the skeletal framework, particularly inside serpulid tubes and interspaces between skeletons. In these restricted microenvironments, suboxic/anoxic conditions could have promoted the development of anaerobic heterotrophic bacterial activity. Conversely, in Fara and Agios Vasilios caves, microcavities occurring inside crusts seem to have been largely produced and/or occupied by sponges. The large amount of sponges most likely reduces the availability of micro-niches/cavities favourable for the development of sulphate reducing bacteria, and hampers the carbonatogenetic processes. In Lesvos caves the small amount of autochthonous micrite seems to be linked to organomineralization of the decaying soft sponge tissues rather than to microbial metabolic processes. Therefore, this autochthonous micrite represents an organomineral deposit produced by carbonate precipitation in association with non-living organic substrates. It is supposed to form via Ca^{2+}-binding ability of acidic amino acids, particularly humic and fulvic acids, that may be derived from degraded sponges' organic matter during early diagenesis.

Paleoecology of Pleistocene coralgal reef terraces in the Danakil Depression (North Afar, Ethiopia)

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The Danakil depression is a rift basin located in the northern part of the Afar triangle. It is bordered to the west by the Ethiopian plateau and to the east by the Danakil horst. Since 2013, a team of Swiss-Ethiopian researchers has been studying the Quaternary sedimentary evolution of the area; especially the repeated transgressions of the Red Sea into the Danakil Depression. More than 30 coralgal reefs have been identified at the western margin of the basin. U/Th radio-isotopic datings on corals and *Tridacna* specimens confirm Red Sea incursions in the Danakil depression during the interglacial periods MIS (Marine Isotope Stage) 5e and MIS7. MIS7 reef terraces are well developed reef platforms while MIS5 reef terraces are patchy.

This specific study focuses on the systematics and paleoecology of Pleistocene fossil cnidarian to understand the response of the reef communities to environmental changes through space and time. Systematic identification of coral specimens collected from 13 coralgal reef terraces have been performed. In total 12 families, 29 genera and 60 species of scleractinian corals are described and identified from both episodes of marine flooding (incursion).

The paleoecology is examined by using the incipient line transect method on three different reef terraces which include the two marine episodes. Species richness and ranked relative abundance indicate distinctive taxonomic compositions for both MIS7 and MIS5 terraces. *Porites* is the prevailing genus in MIS7 terraces followed by *Caulastraea, Goniastrea, Platygyra, Echinopora, Dipsastrea, Pavona, Favites, Fungia* and *Pachyseris*. The genera *Stylopora and Acropora* are rare. Coralline red algae, echinoids and marine mollusks are associated with MIS7 coral reefs terraces. MIS5 coral patches are low diversity to monogeneric and dominance is variable from terrace to terrace. The most dominant genera are *Galaxia, Favites, Fungia and Goniastrea* with moderate occurrence of *Porites.* There are monospecific bivalve - gastropod beds and gypsum units overlying the MIS 5e corals.

The results show a significant variation in coral diversity and abundance within the MIS7reefs throughout time and no temporal changes in the coral communities can be observed for the MIS5 reef terraces.

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The middle Viséan (Mississippian, Livian) *martini* biostromes from eastern Belgium

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During the Viséan (mid Mississippian, lower Carboniferous), extended monospecific to oligospecific biostromes constructed by different species of the fasciculate rugose coral genus *Siphonodendron* occur in different parts of Ireland, in SW Spain, and Belgium. The Belgian *martini* biostromes, named after the eponymous species *Siphonodendron martini* (Milne-Edwards and Haime, 1851) are the oldest example of these biostromes. They occur as isochronous levels within the middle Lives Formation (Awirs Member, Livian Substage, middle Viséan) throughout the Namur-Diant Basin, and extend to the Boulonnais at the coast of the English Channel. Within the strongly cylic Lives Formation, the biostromes are most common in the lowermost two parasequences +1 and +2 of the Awirs Member, though extending up to parasequence +4.

In spite of the eye-catching development and wide distribution of the *martini* biostromes, detailed knowledge of their formation and variation is scanty. Therefore, lithostratigraphy and facies of the biostrome development was studied in sequence +2 of the Corphalie section, E of Huy. For study of the regional variability samples were taken from the type locality of the Lives Formation, at Lives Rock east of Namur, and few random samples from two additional sections (Engihoul, Moha).

The about 4.85 m thick section from Corphalie is a shallowing upwards cycle, further subdivided into three minor cycles. The lowermost minor cycle (1.73 m) consists of two thick, internally subdivided beds of bioturbated and parallel bedded limestone. Fine-grained *Issinella* packstone predominates in the lowermost bed; shallowing upward is clearly documented in Bed 2 by bioturbated mudstone at its base, and mud-cracked loferite at the top.

The second minor cycle starts with cross-bedded, fine- to medium-grained peloidal-bioclastic grainstone, partly bearing abundant foraminifers (Bed 3, 0.78 m). Above, almost suddenly *Siphonodendron martini* enters. It predominates in the 0.84 m thick Bed 4, the proper *S. martini* biostrome. In the section, all corals are reworked; corallites are embedded parallel to bedding planes and enriched in layers, mostly with decreasing abundances upwards. Corallite-rich layers are separated by peloidal-bioclastic packstone. Internal erosional surfaces occur. *S. martini* floatstone facies predominates, rudstone is rare. Besides, broken *Syringopora* corallites, crinoid ossicles, brachiopod shells, calcispheres, calcareous algae (*Issinella*, *Kamaena*, *Koninckopora*), and rare gastropods and bivalves, burrows and micritic intraclasts occur. In the overlying beds 5–7 (0.73 m), the abundance of *S. martini* decreases markedly. Packstone predominates. The topmost bed of the minor cycle still shows a final basal *S. martini* layer below oolitic grainstone. The attribution of these beds to the *martini* biostrome, therefore, remains arbitrary.

Above an expressed erosional surface, the third minor cycle (Beds 8–11, 0.81–0.90 m) shows at the base the only in situ boundstone encountered, a single, small *Siphonodendron*-microbe colony. Above, *Siphonodendron* is completely missing. Lithoclastic-peloidal-bioclastic grainstone to packstone and *Issinella* packstone is overlain by loferite/stromatolitic bindstone in the topmost Bed 11.

Bed 4 is considered to represent an allobiostrome to parabiostrome, consisting completely, or mostly, of reworked corallites. Reworking is also well documented in the skewness of the size distribution of corallite diameters from single layers, as well in slightly different sizes of corallites between layers. Summed up diameters from all layers result in an almost normal Gaussian distribution, albeit diameters are somewhat smaller than diameters generally indicated for the species, thus pointing to certain transport. According to facies, the biostrome grew in shallow inner platform settings engirding the London-Brabant massif. In height, it might have been restricted to single colonies. Storms repeatedly destroyed these thin biostromal thickets. Seawards of the biostrome girdle lagoonal algal meadows, mostly composed of *Issinella* developed. Landward, it was bordered by high-energetic oolitic foreshore sand bars and microbial tidal flats.

In the westernmost studied section at Lives Rock, diameters of the corallites are significantly thinner than in Corphalie. Packing of corallites appears to be lower. Sorting is skewed towards smaller corallites. Carbonate microfacies is less diverse. This indicates a less well developed biostrome further offshore in somewhat deeper water, or less expressed reworking. Including the random samples from Moha and Engihoul, the diameter of the corallites increases continuously from southwest to northeast, indicating increasing proximality, i.e. shallower environments closer to the coast.

A comparison of modern and MIS5e reef corals in Egypt

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In MIS5e, a substage in the last interglacial period, sea surface temperatures and sea level were higher than today, while coral species were largely identical to the modern ones. As current atmospheric CO2 concentration is increasing rapidly, the oceans are warming and reef corals are reaching their upper thermal limits. While biogeographic shifts from lower to higher latitudes have been suggested as a potential response of corals to climate change, a global decline is another possible outcome. The distribution and diversity of MIS5e reefs serve as a useful analogue to predict how reef corals will respond to elevated temperature in the future.

The Red Sea, with its wide latitudinal range and a high abundance of reef corals, is an ideal setting to compare MIS5e and modern reefs. By studying the corals from the last interglacial, we will be able to gain insights about the future responses of reef corals to higher temperatures. Here we present first results comparing MIS5e and modern reefs from the region around Marsa Alam, Egypt. Data was obtained using line intercept transects of 100 meter length. A lateral and vertical reef zonation, as documented for modern coral reefs in the Red Sea, was also observed in the fossil reefs. Among the most abundant corals in the MIS5e and modern reefs are species of the genera *Porites*, *Pocillopora*, and *Millepora*. Overall, our data supports that reefs from the last interglacial have a similar zonation and species composition as modern reefs in the Red Sea and, therefore, are well comparable.

Future field work will add data from a range of latitudes in the Red Sea to test whether a homogenization of modern coral communities already took place over the last decades. Furthermore, potential northward shifts during the last interglacial will be investigated and the results will be used to improve projections of coral diversity hotspots in the Red Sea under future, warmer conditions.

Scleractinian coral biomineralization and Mg/Ca in the changing ocean

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Phanerozoic changes in seawater Mg^{2+}/Ca^{2+} are thought to have played an important role in the evolutionary history of many marine calcifiers. Some researchers suggested that similarly as in experimental precipitation of calcium carbonate polymorphs, the low Mg^{2+}/Ca^{2+} seawater ratio facilitated formation of calcite, whereas higher Mg^{2+}/Ca^{2+} seawater ratios promoted formation of aragonite or high-magnesium calcite skeletons. One variant of this hypothesis is that $CaCO_3$ polymorph selection of newly evolved calcifying organisms was directly influenced by the seawater Mg^{2+}/Ca^{2+} ratio at the time of their origin. Therefore, one could expect that representatives of Micrabaciidae, scleractinian clade that first appeared in the fossil record of the Cretaceous, when the ocean Mg^{2+}/Ca^{2+} ratio was near the lowest in the Phanerozoic, should originally have calcite coralla.

However, contrary to this prediction, Cretaceous micrabaciids had entirely aragonitic skeletal mineralogy and microstructure identical to modern representatives of that group. Interestingly, despite the significant difference between the Cretaceous and modern ocean Mg^{2+}/Ca^{2+} molar ratios (<1 and >5 mmol/mol, respectively), the aragonitic skeletons of fossil and recent micrabaciids have also similar, relatively low concentration of magnesium. Although skeletal Mg^{2+}/Ca^{2+} ratio can be influenced by seawater temperature, extant micrabaciids collected across a broad range of depths have the same skeletal Mg^{2+}/Ca^{2+} ratios (averaging ~2.5 mmol/mol), regardless of the temperature. Moreover, micrabaciids usually have lower skeletal Mg^{2+}/Ca^{2+} ratio than non-micrabaciid taxa collected from the same localities. These observations raise the possibility that while the element composition of the fossil micrabaciids reflects the seawater chemistry at the time they first evolved skeletons, the low Mg^{2+}/Ca^{2+} ratio of their modern representatives remains as a physiological relict of that low-Mg Cretaceous sea. In overall, the microstructural and geochemical similarity between fossil and recent Micrabaciidae and their consistently aragonitic mineralogy suggest the high level of biological control over skeleton formation which has rendered at least this coral group unresponsive to major changes in ocean water composition during the past 70 m.y.

Another evidence against the dominant role of seawater chemistry in skeletal calcium carbonate polymorph selection are acroporids that emerged in the Paleocene when seawater Mg^{2+}/Ca^{2+} was below 2 (“calcitic conditions”) but consistently form aragonitic skeletons throughout the Cenozoic. However, there are also some opposite examples: originally aragonitic *Micrabacia* co-occurs in upper Cretaceous deposits of Poland with *Coelosmilia* whose skeleton was interpreted as originally calcitic. The environmental influence on skeleton formation (including polymorph selection) may therefore be taxon specific, which is partly supported by modern experimental data.

Late Ordovician stromatoporoids from the Beiguoshan Formation, Ordos Basin, North China: a preliminary study

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Stromatoporoids are the most common sessile organisms in the Late Ordovician reefs of the Ordos basin, North China. Four genera (*Labechia*, *Labechiella*, *Clathrodictyon* and *Ecclimadictyon*) have been reported previously in the 20th century, but the investigation is not in detail. Here in this study, we report the occurrence of five additional genera of stromatoporoids (*Cystostroma*, *Pseudostylodictyon*, *Pachystylostroma*, *Plexodictyon* and *Simplexodictyon*) from the Upper Ordovician Beiguoshan Formation (early-middle Katian) of the Ordos Basin, North China based on extensive field works. It is noteworthy that two typical Silurian genera (*Plexodictyon* and *Simplexodictyon*) are found to occur in the upper part of the formation, with conodont *Taoqupognathus beiguoshanensis*, indicating an obvious diversification of early clathrodictyid stromatoporoids during the middle Katian. It has been speculated that the lack of records of *Plexodictyon* and *Simplexodictyon* from Silurian to Devonian strata of North China is owing to: (1) the 'great hiatus' of the middle Paleozoic strata in the North China block, (2) previously inaccurate systematic work of Ordovician clathrodictyids and (3) lack of investigations on stromatoporoids in North China, as well as in other palaeocontinents of the Gondwana and adjacent region including South China, Tarim and Siberia. This study is a preliminary study that is expected to improve our understanding on early diversification and dispersal of clathrodictyids during Late Ordovician.

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Coral growth and bioerosion on ancient and modern turbid-water reefs in the Coral Triangle: How well do these potential reef refugia function?

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The Coral Triangle region of Southeast Asia hosts the highest marine diversity on Earth, yet the drivers responsible for the origins and maintenance of this global biodiversity hotspot are not fully understood. Recent studies of exceptionally preserved fossil assemblages from Indonesia and Malaysia suggest that much of the diversity is found in turbid water settings and that these so-called "marginal" habitats might be acting as cradles and refugia for reef biota during times of past environmental change. Ongoing work is showing that turbid water reefs can host highly diverse biota, but are the corals able to maintain carbonate budgets to allow significant reef building? In this study, we analysed coral growth and bioerosion rates using micro computed tomography of fossil and modern colonies from turbid and clear-water settings. The resulting data were compared with published growth rate data accessed on coraltraits.org. Overall, there is no significant difference in growth rates between colonies living in different habitats. For bioerosion, the abundance and distribution of common ichnotaxa within the colonies was also not significantly different between turbid and clear-water settings. These results suggest that coral communities living in turbid-water settings can deliver positive carbonate budgets required to build and maintain reef structure and provide one of the key ecosystem functions of coral reefs. These new data add to the increasing evidence that turbid reefs have played a significant role as ecological refugia since the Miocene and these habitats are home to important communities that will allow coral reefs and their diverse biota to persist during ongoing rapid anthropogenic climate change.

The evolution of the latitudinal biodiversity gradient in zooxanthellate corals

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Modern zooxanthellate coral (Z-coral) biodiversity decreases from tropical to polar regions. This latitudinal biodiversity gradient (LBG) is remarkably pervasive across numerous extant taxonomic groups. However, projected global warming of 2.0–4.8°C will have profound impacts on the distribution of organisms' abundance, diversity, and habitats, as well as the ecosystem services they provide. Rising sea surface temperatures brought about by global climate change have already caused substantial range shifts and ecological disturbances. However, as studies on extant taxa are based solely on short-term observations, it is difficult to determine the lasting macroecological consequences of global warming. The Z-coral fossil record offers the unique opportunity to study the long-term biogeographic responses of an organism and major reef ecosystem-engineer to warmer climate states. Despite its potential, this archive is intrinsically biased at both temporal and spatial scales due to incomplete sampling, variable preservation and stratigraphic completeness. Sample-standardisation methods exist to aid mitigation of problems associated with 'raw' occurrence data, yet they cannot account for the absence of data. Although some work has already considered the impact of climate change on reef coral biodiversity through time, and correcting for fossil bias, additional efforts are needed at the spatial scale to aid understanding of the evolution of the LBG. Ecological niche modelling (ENM) offers an opportunity to provide additional insights into this issue. ENM computes habitat suitability through relating occurrences to spatially-explicit environmental data, illuminating the potential geographic distribution of organisms. This allows for the identification of the potential prevalence of data absence within a spatial context. Recently made available general circulation models and digital elevation models provide such spatially explicit environmental data with global coverage, presenting a novel opportunity for palaeontological studies.

Here, using a global dataset of Z-coral genera and sampling standardisation, we evaluate how the LBG of scleractinian Z-corals has evolved over their evolutionary history, and examine the impact of environmental variables and sampling proxies on these observed spatiotemporal patterns. We identify past stratigraphic stages in which the LBG appears to have diverged from the present-day tropical peak in diversity. We then apply ENM to test whether these biogeographic patterns are the result of environmental forcing or fossil bias (i.e. absence). Our results show that a 'modern-type' LBG in Z-corals has not always been persistent through deep time. Whereas the modern LBG has likely been prevalent since the Miocene, a number of intervals from the deep-time record indicate transitions between temperate and tropical peaks in diversity. From our latitudinal regression analyses, we find environmental predictors to be poor predictors of generic diversity, whereas sampling proxies are moderate to strong predictors. Results from our ENM analyses highlight the need to account for fossil bias within a spatial context, due to poor geographic coverage in collections relative to predicted habitability.

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Cystiphyllid rugose coral *Microplasma schmidti* Dybowski, 1874 from the Silurian of Saaremaa (Estonia)

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Microplasma schmidti Dybowski, 1873 can exist both as solitary and colonial form, and often individual specimens tend to form multiple buds and may be identified as primary colonial. The main aim of the research was to identify the features of the transition from a solitary to colonial forms. A collection of more than 50 specimens of *M. schmidti,* stored in the Tallinn University of Technology was studied. It is from the Sepise outcrop (Estonia, Saaremaa), Jaagarahu stage (Lower Silurian, Wenlock). This species is characterized by: a visible thin epitheca with deep grooves; short minor septa not going beyond the border of dissepimentarium, and long major septa reaching the center part of corallite and merged with an axis; separate dissepiments of various sizes and shapes (unlike those in *M. lovenianum*); tabulae are simple, straight, and similar to *M. gotlandicum*. The internal parts of skeleton of most specimens were studied using the classical method of cross sections and thin sections. Smaller parts with unusual types of growth, buds and small corals were also studied using x-ray microtomography scanner SkyScan 1172 that allows to create virtual thin transverse and longitudinal sections showing the skeleton changes of a smallest level (up to 100 sections per 1 mm of coral). The preservation of corallites did not allow us to study them using x-ray tomography because mostly all the space between skeleton elements is filled with matrix, which composition is similar to the skeleton and barely possible to be separated by the scanner. In order to increase the contrast between matrix and skeleton, CeO_2 was used as an additional component, filling the pores.

The sizes of corallites vary widely: solitary ones rarely reach sizes greater than 3 cm, some fragments of large colonies can be more than 10 cm. Three growth forms are known for *M. schmidti*: solitary, primary colonial with mass budding in the calice and colonial with parallel growth of corallites (columnar colonial). Single corallites are small and with frequent lateral budding. Among them, a single bud was found in the calice of the parental corallite in two specimens. The growth form is a multiple budding in a parental corallite calice, forming a primary colony. Growing buds are often parallel, of similar size and placed close to each other. Often in such cases a "secondary budding" is observed, in which new buds are placed in the calices of the newly formed buds, usually one or two, rarely more, mostly in embryonic state. The growth form consists of corallites of the colony growing parallelly to each other. In this case corallites are interconnected by hollow or filled with skeleton element pipes, and on the largest corallites of colonies budding is often observed. In the same time, the internal structure of septa, dissepiments and tabulae allow us to identify that all growth forms belong to one species, despite the different ways of budding and different types of colonial growth. Different types of growth of the colony and budding within the species suggest different processes (regeneration, vegetative reproduction and volume expansion), that have the same basis, in which all individual cases arise as a result of the separation of the newly formed skeleton elements of the initial stage, which features of symmetry are identified by the parental corallite construction of the initial position on the parental corallite. Apparently, each growth form is confined to specific environmental conditions, primarily to the type of sedimentation and substrate, water regime and living space.

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Intraspecific variability of *Parastriatopora celebrata* Klaamann (Northwestern Gorny Altai, Kuimov Formation, Wenlock, Russia)

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Population of Silurian tabulate corals collected from reef carbonates of the Altai were analysed. Tabulate corals and algae participated in the formation of Silurian reefs and dominated the paleocommunity of organisms in these ecosystems.

The species of tabulate corals is a set of paleopopulations that dwelled in a certain part of paleobasin, and we therefore should not only study and identify coral species in separate thin sections but also investigate the populations of the species and explore intraspecific variations. Some species of tabulate corals are widely known to have high variability based on the dependence of their morphological element parameters on changes in environmental characteristics.

The studied tabulate corals were collected in Silurian section of Kuimov Formation "Maragda 4", which is located in the northwestern part of Gorny Altai near the Cherny Anui village (Russia). The Kuimov Formation is aligned with the Homerian, Gorstian and Ludfodian stages. The Kuimov Formation consists mainly of carbonate and terrigenous-carbonate rocks. The "Maragda 4" section consists of alternating massive light gray and gray limestones and gray and dark gray clayey limestones. A total of 50 *Parastriatopora* specimens were selected from one layer of the section. *Parastriatopora* is one of the most widespread tabulate coral taxa in Llandovery and Wenlock Series of Siberian Platform (Russia). A total of 130 longitudinal and transversal thin sections were studied. In each thin section, we measured the diameter of corallites, the thickness of walls and stereozones, the diameter and number of mural pores in a row, the distance between tabulae and corallite differentiation. The differentiation was measured using the coefficient of corallite diameter variation (both young and mature) within a single corallum. The degree of corallite differentiation was measured using Pearson correlation coefficient. Our findings confirmed the description of *Parastriatopora celebrata* Klaamann, 1962 from the Landovery (Raikkula Formation) of Estonia. Compared to Estonian specimens, Altai specimens have wider mural pores (0.5 mm vs 0.2 mm) and stereozone (12 mm vs 5 mm).

Evolution of Altai *P. celebrata* was studied using normal probability plot and Kernal density (Past software). Normal probability plot compared our findings with theoretical normal distribution of data (straight line), and the dots should make almost a straight line. Kernal density was used to study the correlation of the two parameters.

We studied the variability of maximum and minimum diameters of corallites as well as stereozone variability. The mural pore diameter range was also established and found to be the most variable parameter. Taking into account the set of the parameters, we suggest to divide *Parastriatopora celebrata* Klaamann into two subspecies. Subspecies 1 should comprise the nominotypical *P. celebrata* Klaamann and a second new subspecies based on the Altai material. The latter has closer and bigger mural pores compared to those of Estonian subspecies. While identifying the maximum diameter of Altai subspecies mural pores, we found a number of populations with different diameters of mural pores (0.2, 0.3, 0.4 and 0.5 mm). As of other parameters (corallite diameter, tabulae distance, corallite differentiation, narrow stereozone, very rare septal spines), Estonian and Altai subspecies make up one species.

Reef development in the Paleozoic of Uzbekistan

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In many of the world's oil and gas basins, industrial accumulations of hydrocarbons are associated with buried fossil reef structures.

Reef structures formed as a result of complex interactions between marine organisms are known in the geological history since the Riphean to the present time.

Within the mountain range of South Fergana, the facies of the thick Devonian carbonate formations of Katrantau-Katranbashi are poorly studied, but attract attention, although the presence of organogenic structures in those sections cannot be ruled out.

The presence of organogenic structures in the Guzan and Karatau Mountains in the Late Carboniferous and Permian cannot be excluded. Buildups of those ages are known in the Karachatyr mountains, where they are described in the Dzhilginsay horizon (Kasimovium) of the late Carboniferous, and particularly in the early Permian.

The Akbulak reef is located along the southern slope of the western part of the Karachatyr ridge. It develops argillites and siltstones of the Early Permian Kerkidon Formation and reaches dimensions of more than a kilometer in width and up to 250 m in height. At the top of the reef carbonate lenses and lumps (calipers) of algae are distinguished. Massive limestones with abundant inclusions of brachiopod shells, gastropods, foraminifera and others biota were deposited on them with an uneven surface. The development of the buildup proceeded in several stages, probably with some interruptions, manifested in the form of intraformational changes, low-power erosion, causing its complex morphological structure.

The Kurtash ridge of organogenic structures consists of numerous domes 100 m high, stretches for 3-4 km along the northern slope of the West-Karachatir syncline.

Thus, the wide areal development and thickness of the Paleozoic sedimentary strata of the Fergana depression, among which reef structures are noticeably developed, make it possible to positively evaluate the prospects of their petroleum potential. The study of Paleozoic fossil reef structures will provide the necessary information that will contribute to more successful exploration for oil and gas.

The importance of Scleractinia in age determination and correlation of oil and gas carbonate formation of the Upper Jurassic of southern and western Uzbekistan

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The long-term and systematic studies of the species composition of scleractinian corals within the Upper Jurassic carbonates of Southern and Western Uzbekistan shows their wide distribution and their importance for stratigraphic dating and correlation.

It was previously believed that in the region, reef sediments form three bands extending from South-West Gissar to the west-north-west. The age of the reefs of these bands varies from middle-late Callovian to late Oxfordian in the southernmost band.

The Jurassic carbonates of southern and western Uzbekistan comprise a rich collection of Oxfordian and Kimmeridgian Scleractinia including: *Stephanastraea jurassica* Roniewicz*, Pleurophyllia trichotoma* de Fromentel*, Cladophyllia romea* Koby*, Heliocoenia etalloni* Koby, *H. abichi* Babaev, *Stylina pediculata* Koby, *S. lobata* (Munster)*, Aplosmilia grerarea* Fromentel, *Thecosmilia cartieri* Koby, *Th. vurguni* Babaev*, Isastraea explanata* (Goldfuss), *Synastraea dubia* Fromentel, *Dermoseris delgadoi* Koby, *Comoseris baltonensis* Roniewicz, *Calamophyliopsis flabellum* (Michelin), and *C. kyrvakarensic* (Babaev). *Calamophylliopsis flabellum* (Michelin) is the dominant colonial coral for late Oxfordian of the Lesser Caucasus. These species are known from the mid-late Oxfordian reef deposits of Azerbaijan, Georgia, the Caucasus, Romania, Poland, Germany, Switzerland, France, etc.

The studied coral fauna allows to identify biostratigraphically for the first time the upper reef limestones as Kimmeridgian in studied area and for the first time faunistically characterize it.

Linking coral traits to extinction risk: A scleractinian perspective

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The relatively low turnover rates of scleractinian corals in the fossil record are in stark contrast to the high level of extinction risk of modern reef corals as inferred from IUCN Red List. Several spatial and life-history traits are thought to influence coral extinction risk and have been shown to correspond well with IUCN Red List categorizations of extinction risk. Coral traits offer a largely untapped potential to understand not only extinction risk but also ecological responses to climate-related stressors in reef corals.

The fossil record provides the basis for an assessment of how well life-history traits correspond to actual extinctions. However, observed patterns of extinction are biased by taxonomic issues and sampling. Limited knowledge of life-history traits and overarching spatial and environmental traits further complicate the attribution of extinction to life-history traits. Fossilizable life-history traits that likely affect coral extinction risk are coloniality, corallite diameter, growth rate (linked to morphology), photosymbiosis, and colony longevity (linked to size).

Using scleractinian coral occurrence data from the Paleobiology Database and a preliminary list of coral traits (coloniality, inferred photosymbiosis, dominant growth morphology), we explored the correspondence between traits and genus-level extinctions at a stage-level stratigraphic resolution. We applied logistic regression to test for the effect of individual and combined life-history traits on extinction probability. Results were equivocal suggesting that the role of traits in determining extinction risk varies over time. We propose that machine-learning techniques applied in a phylogenetic context and to a finer taxonomic resolution will help overcome some obstacles in the quest for “supertraits”, which explain much of the variance in reef coral ecological processes and extinction risk.

New data on Lower Permian corals from the Southern Karavanke Mountains in Slovenia

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In 1898, E. Schellwien mentioned three species found in Upper Paleozoic rocks in Dovžanova Soteska (Karavanke Mts., Slovenia): *Caninia* aff. *kokscharowi* Stuckenberg, 1895, *Diphyphyllum* sp., and *Cyathaxonella* sp. Since the mid-20th century, corals of the Karavanke Mountains were studied by several authors. In the historical overview from 1933, F. Heritsch wrote: "Corals from the Trogkofel Limestone have never been described so far". To fill this gap, he described four species from Dovžanova Soteska in that paper: *Sinophyllum pendulum* Grabau, *Lopholasma illichense* Soshkina, *Amlexocarinia geyeri* Heritsch, and *Tachylasma aster* Grabau. Later the list of species was supplemented with *Carinthiaphyllum suessi* Heritsch, 1936. Summarizing previous works on Slovenia in 1965, Gräf and Ramovš mentioned twelve species. Some species are similar to taxa described in 1936 by Heritsch from Carnic Alps, naming: *Amandophyllum carnicum* (Heritsch), *A. ruedemanni* Heritsch, *A. smithi* Heritsch, *Carinthiaphyllum* cf. suessi, and *Wentzelophyllum* (?) *stillei* (Heritsch). Other were considered similar to Uralian fauna, i.e. *Amplexocarinia irginae* Soshkina, 1928, *Ufimia exceptatum* (Soshkina, 1928). *Preisingerella stegovnikensis* Kossovaya, Novak et Weyer, 2016 was described from slope facies of the Asselian-Sakmarian (Born Formation). The fauna of the Karavanke Mts. is characterized by the wide distribution of *Carinthiaphyllum* Heritsch. It contained two species, naming *C. crasseseptatum* Gräf at Ramovš, 1965 and *C. suessi* Heritsch, 1936 found in Javorniški Rovt and also in Ortnek in southern Slovenia.

Two levels with corals were recently studied in Dovžanova Soteska, 3.5 km NNE of the town of Tržič. The uppermost level of the Dovžanova Soteska Fm. contained small, non-dissepimental corals of *Sloveniaxon* Kossovaya et Weyer, 2012. Conodonts and fusulinids data indicated the late Early Asselian age. The overlying Born Fm. also contains rugose corals. They occur in patch reef facies on top of one of the rocky pyramids. It is built of massive light grey boundstone, mostly build of bioclasts (crinoid fragments, echinoid and sea-urchin spines), bryozoans, and smaller foraminifera, binded by *Tubiphytes* and algae in partly dolomitized dismicritic matrix (middle part of the Born Fm.). It includes accumulations of 'gregaria' corals, assigned to *C. crasseseptatum* and some small massive colonies. The main features of newly determined material are massive pseudocolumella with visible septal lamella, rather variable forms of pseudocolumella, and thickening of peripheral ends of septa at the outer wall. Some of septa show weakly developed naotic structure. Lonsdaleoid dissepiments are rare. Naotic structure was not mentioned in previous description of *C. crasseseptatum*. In 1979, W. Holzer and A. Ramovš assigned some specimens from the same locality in Dovžanova Soteska to *C. kahleri* Heritsch, 1936. It is without doubts, the same material that we have studied. The corallites from our new collection differ from the type of C. *kahleri* by higher number of septa, longer minor septa and more rows of interseptal dissepiments. One more species determined as *C.* sp.1 was found on Mt. Boč, the tectonically dislocated part of Karavanke Mts. in eastern Slovenia. It is characterized by specific structure of the peripheral part of pseudocolumella. Our data of the Slovenian corals suggests a higher endemism and specific differences compared to other regions outside the Mediterranean Province with the exception of the polyprovincial genera, such as *Sloveniaxon*, *Lophophyllidium* etc. It confirms an essential value of coral data for paleogeography and biostratigraphic correlation.

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Lower Carboniferous Rugosa from Kotelny Island (New-Siberian Islands, Arctic Russia)

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The Lower Carboniferous (early Tournaisian – Serpukhovian) Tas-Ary reference section on the western coast of Kotelny Island (Tas-Ary peninsula) yields corals of shallow shelf facies (mainly in its lower part). Three assemblages were observed in the 950 m thick, predominant carbonatic sequence (Tas-Ary Formation). The collections of >100 (sometimes fragmentary) Rugosa sampled in 2009-2014 by M.K. Danukalova, A.B. Kuzmichev and V.V. Eriklinzev were studied by O.L. Kossovaya and D. Weyer in St. Petersburg and in Berlin; the materials are stored in the Russian Geological Research Institute (VSEGEI) in St. Petersburg.

Two Rugosa communities are well dated in the Tournaisian. The older one (unit 9) with *Cyathoclisia*, *Lophophyllum*, *Eostrotion*, *Ekvasophyllum*, *Bifossularia* can be of late Lower Tournaisian or of Upper Tournaisian age; this is more precisely indicated by accompanying conodonts (*Siphonodella*, studied by Yu.A. Gatovsky) as Upper Hastarian (Upian and Cherepetian of the Russian scale). The younger one (units 12-14) with *Uralinia*, *Keyserlingophyllum*, *Sychnoelasma*, *Variaxon*, *Amplexizaphrentis*, *Zaphrufimia* is doubtless dated as Upper Tournaisian (Ivorian, or Kizelian/Kosvian of the Russian scale), with typical index fossil *Sychnoelasma* cf. *urbanowitschi* (Stuckenberg, 1895). Further coral records of no detailed stratigraphic importance are a Tabulata colony of *Syringopora* in the Lower Tournaisian unit 6, and many *Amplexizaphrentis* aff. *enniskilleni* (Milne-Edwards & Haime, 1851) in the Viséan units 17 and 20.

There exist only few neighbouring Tournaisian coral-bearing Siberian regions that are well studied and allow faunal comparisons. Most important would be the Lena river estuary, but the Rugosa described in 1965 by Ivanovskiy are mostly misidentified (some so-called *Sychnoelasma* are in reality Lophophyllidae, very similar to those from Kotelny Island). Rugosa from the eastern Taimyr (communicated by Rogozov) are predominant of Viséan age, but the Upper Tournaisian species *Amplexizaphrentis concrescens* Rogozov, 1972 and *Amplexizaphrentis hastatus* Rogozov, 1972 probably are members of the recently proposed genus *Zaphrufimia* Fedorowski, 2012 (Serpukhovian of Scotland and Poland) and conspecific with the new oldest records from Kotelny Island. *Bifossularia* Dobrolyubova, 1966 is typical in the Tournaisian of the Kusnezk region (there also together with *Uralinia*, *Keyserlingophyllum* and *Cyathoclisia*, as summarized by Doborlyubova and Kabakovich in 1966), but few isolated records exist from France (by Poty in 1989) and Germany (unpublished Weyer collection, Baltic Sea island of Rügen). Eastward connections towards Canada are indicated by *Ekvasophyllum*.

The genera *Uralinia* and *Keyserlingophyllum* would support the old idea of an Ural-China coral fauna province, which started to be destroyed, when Schindewolf (in a neglected faunal list of 1938) recorded these taxa in a rich community from Germany (Trogenau, Franconia province; first illustrated in 2001 by Weyer). His unpublished collections from ca. 1925 demonstrate that he knew a similar occurrence in the then German, now Polish province of Lower Silesia (near Srebna Gora, Sudetes Mts.). Later such faunal elements were described by Poty from Belgium and by Weyer from the German Baltic Sea island of Rügen.

Paleoecology of heliolitid corals from Wellin bioherm (Eifelian, Dinant Synclinorium, Belgium): preliminary results

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Heliolitid tabulate corals from Wellin have been studied in respect to their growth patterns and colony development. The Wellin bioherm occurs within the uppermost Eifelian sediments, cropping out in southern parts of the Dinant Synclinorium in Belgium. It is located c.a. 40 km SE from Dinant. It is a part of the Wellin member of the Upper Eifelian – Lower Givetian Hanonet Formation, known for its abundant fauna of corals, stromatoporoids, brachiopods, and bryozoans.

Heliolitid corals are very abundant. They are small to medium sized (ranging between 3.4 cm and 17.2 cm in diameter). They mostly represent bulbous, domal, and irregular growth forms. Rejuvenations and following radical changes of the growth direction often occur. Growth interruption surfaces are very common within the coralla. They constitute dark layers that in cross-section show how the shape of the colony changed as it grew. These surfaces can be clean, but are often accompanied by sediment or encrusting organisms – mainly stromatoporoid sponges and alveolitid tabulates. Stromatoporoid encrusters commonly co-occur with syringoporid tabulate symbionts, growing inside the sponge body. In some cases, the encrusters were later overgrown by the heliolitid, following its recovery after the growth interruption.

The abundant growth interruption surfaces consisting of sediment, as well as the common rejuvenations and changes of the growth direction, point to episodically increased sediment input. According to previous studies, it is very likely that at least some representatives of the genus *Heliolites* could be able to survive temporary sediment cover. The higher sediment input could be caused by the increased water energy e.g. during storms. The abundant growth interruption surfaces were also observed in the Devonian heliolitids from Morocco, Poland, and other localities in Belgium.

The interactions between heliolitids and their encrusters, settling on the surface of the colony during growth interruption, could suggest a competition for space between benthic organisms. The capability of heliolitids to survive sediment-derived growth interruption and to overgrow their epibionts, imply that these corals were very resistant. Heliolitids competing with stromatoporoids and overgrowing each other are also known from the Givetian of Morocco.

The continuation of the study of heliolitids from Wellin will include detailed taxonomy and further paleoecological analysis. The paleoecology of this group of tabulates is not very well understood, as the research of heliolitids in the past was often more focused on their taxonomy.

A new Bathonian coral fauna in Lorraine (Middle Jurassic, France)

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During the Jurassic period, the distribution and development of coral environments were highly unequal among stages, suggesting complex interactions between evolutionary processes and environmental fluctuations. Bathonian is an age during which the development of coral environments was rather weak. At a global scale, reefs are rare and most of the Bathonian coral faunas correspond to ancient coral meadows rather than true reefs. Among the classical Bathonian localities Kachchh (India) Saint Gaultier (Indre, France), Fairford (England) Madagascar (Morondava basin) deserve to be mentioned as examples.

The present communication brings some new light on this poorly known period with the discovery of a new fauna distributed in two different Bathonian stratigraphic units in the northern part of the French Lorraine near Longuyon. A large set of corals was collected by one of us (B. M.) and by A. Navel† in agricultural lands for many years. The collection is accompanied by an extensive and rich sampling of other macrofossils allowing a precise biochronology. A first stratigraphic unit belongs to the *Caillasse à Anabacia* Formation (Zigzag zone, Lower Bathonian) and has provided the richest collection (1096 specimens). The facies of the *Caillasse à Anabacia* is well known in Lorraine for the abundance of *Chomatoseris*. In the investigated area, a bed just above this formation, indicated on the local geological map and observed by AN & BM provides locally a rich fauna of *Montlivaltia*. Another stratigraphic unit is a very local lateral calcareous development of the *Caillasse à rhynchonelles* Formation assigned to the Retrocostatum zone, Upper Bathonian. This unit has provided a much less numerous collection of corals (20).

The outcrop was at a paleolatitude higher than 30°N. It was backed on the southern shore of the Brabant-London Land.

Concerning the first stratigraphic unit, colonies are generally of small size, with their own form only occasionally distorted by neighbouring colonies. The calicular surface is often naturally observable suggesting a rather loose matrix, the texture of which is dominantly a packstone (occasionally grainstone) rich in bioclasts and ferruginous ooids. The taxonomic study is undertaken, some thin sections have been made and allow a first approach of the faunal composition. In the order of their decreasing abundance the taxa belong to *Isastrea, Hexaflos, Dimorpharaea,* Actinastreidae gen. indet.*, Microsolena, Chomatoseris, Montlivaltia, Kobya, Periseris, Thamnasteria.*

Numerous colonies (196) belong to a new species of the genus *Hexaflos* and lead to a new understanding of the mode of life of this genus that was known only from Iran.

Among the remarkable absences we note plocoid (stylinid or cyathophorid), meandroid and phaceloid forms suggesting that oversedimentation and turbidity do not explain the rather moderate diversity and the short lifespan of colonies. The regular growth bands of some colonies of *Microsolena* suggest a slow annual growth. Corals colonised a rather soft and granular substrate. Very numerous colonies are incrusted by oysters and serpulids, more rarely by unilamellar bryozoans. A significant proportion is also impacted by bioerosion (mainly *Gastrochaenolites*).

After the necessary correction due to more or less typological results available from the literature, comparison with Kachchh, St Gaultier, Fairford or Madagascar point to a lower richness despite the very extensive sampling. The lower diversity cannot be explained only by the high paleolatitude as Fairford was still higher to the North. The new fauna of Lorraine brings a reference more to back a general statement on the Bathonian fauna apparently characterised by a weak carbonate skeletal production compared to Bajocian or Oxfordian stages which were periods of extensive reefal development. The hypothesis of a lowered pH of ocean waters should be investigated.

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Cambro-Ordovician sponge-microbial reefs following the archaeocyath extinction

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Sponges are common reef-building components during the early Paleozoic. The early Cambrian archaeocyath sponges were the earliest globally flourished skeletal reef builders. Following the archaeocyath extinction by the end-early Cambrian, the mid-late Cambrian has been considered to be microbial-dominant interval without skeletal reef builders. Studies in the 21st century demonstrate that sponges were important reef builders in between archaeocyath extinction and the late Middle Ordovician diversification of Paleozoic-type reef builders such as rugose and tabulate corals, stromatoporoids, and algae (Great Ordovician Biodiversification Event). Two major types of sponges are known from the mid-Cambrian to the mid-Ordovician successions: lithistid sponges and keratose-like sponges.

Lithistid sponges, a polyphyletic group of hypercalcified sponges, first occurred during the late Cambrian Series 2 and formed reefs with microbes from the mid-Cambrian to the mid-Ordovician. These lithistid sponge-microbial reefs are the dominant reef types that developed in the aftermath of archaeocyath extinction. All known Cambrian and Ordovician lithistid sponges belong to the Family Anthaspidellidae, suggesting their monophyletic relationships. Three genera (*Rankenella*, *Gallatinospongia* and *Wilbernicyathus*) have been described from Cambrian deposits, together with other yet undescribed examples. On the other hand, Ordovician reef-building lithistids are largely represented by single genus *Archaeoscyphia*. These lithistids often formed reef frameworks of mound-shaped bioherms, and formed complex sponge-microbial associations similar to those of archaeocyaths.

Keratose-like sponges, preserved as fibrous sparitic networks embedded within micrites, are recently described fossils that are not yet widely known to the research community. They resemble modern keratose sponges consisting of spongin fibers without spicules. The keratose-like sponges are often found from lower Paleozoic successions worldwide, as well as mid-upper Paleozoic and lower Mesozoic successions. They are also common reef-building component during the early Paleozoic, forming sponge-microbial reefs as well as "stromatolite"-like alternation of sponges and microbes, though they are most commonly found from reefal crypts. Further studies are required to understand their geologic distributions as well as their paleoecological significance.

It has been suggested that widespread occurrence of sponge-microbial reef-building associations during the early Paleozoic was largely due to changes in seawater oxygen level controlled by global temperature fluctuations. Low-oxygen conditions induced by "greenhouse" conditions during the mid-Cambrian to the mid-Ordovician would have favored development of sponges and microbes, which are both tolerant of such harsh conditions. In contrast, other metazoan reef builders would have been suppressed and only developed as temperature declined and seawater became oxygenated, together with the Great Ordovician Biodiversification Event.

Biotic interactions between corals and stromatoporoids from the upper-uppermost Famennian (Devonian) Etoucun Formation, Huilong, South China: Implications for the recovery of metazoan reefal community after the F-F crisis

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Biotic interactions between corals and stromatoporoids are important to understand Paleozoic reef structure and evolution through time. Extensive reef complexes occurred globally in the Givetian and Frasnian, characterized by various forms of coral-stromatoporoid associations. However, the metazoan reefs suffered greatly in the global Frasnian/Famennian biotic crisis and little is known about the coral-stromatoporoid relationships in the Famennian. In this study, we document biotic interactions between corals and stromatoporoids from the upper-uppermost Famennian (Devonian) Etoucun Formation, Huilong, South China, which indicates the recovery of metazoan reefal community in the latest Famennian, approximately 13 Ma after the F-F crisis.

The upper-uppermost Famennian Etoucun Formation at Huilong, which is the stratotype section for the regional Shaodongian stage of South China, is characterized by thick-bedded to massive peloidal limestone containing abundant stromatoporoids, syringoporoid tabulates, rugose corals, gastropods, and oncolites, indicating open to restricted carbonate platform environments. Two foraminifer biozones, corresponding to DFZ4-DFZ6 and DFZ7, respectively, are recognized in the formation, and each contains different stromatoporoid and syringoporoid tabulate coral assemblages. In the former foraminifer zone, biotic interactions are relatively rare and include: stromatoporoid *Labechia* and *Gerronostroma* encrusting *Cystophrentis* rugose corals; endobionts auloporids embedded in the skeleton of stromatoporoid *Gerronostroma*, indicating a syn-vivo interaction; syringoporoid tabulate coral *Chia* settling on the growth surface of stromatoporoid *Platiferostroma*. In the latter foraminifer zone, biotic interactions are much more frequent and include: syringoporoid *Fuchungopora* settling on the growth surface of stromatoporoid *Gerronostroma* and conversely, fouled by the latter genus; stromatoporoid *Labechia* encrusting syringoporoids; overgrowth between stromatoporoids *Gerronostroma* and *Stylostroma*. These associations, combining with the development of stromatoporoid biostromes in the DFZ7, indicate an obvious recovery of metazoan reefs in the uppermost Famennian, although the scale and complexity is much less than those of the Givetian and Frasnian ones.

Endosymbionts in late Mississippian (Carboniferous) rugose corals from South China

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Evidence of symbiotic interactions of organisms through time helps us to better understand the evolutionary history of the ecosystem, exploitation of ecospace, and formation of specific niches. Endosymbiotic interactions between corals (Tabulata and Rugosa) and other macro-organisms in the Palaeozoic have been frequently found. They are most easily recognized when organisms caused changes in the growth of the coral skeleton, especially in a process called 'bioclaustration', when the endosymbionts were almost or totally overgrown by the hosts, resulting in internal tubes or cavities. Abundance and diversity of endosymbiosis in corals during the Palaeozoic peaked in the Middle Devonian. It dropped dramatically in the Late Devonian. Despite the fact that the diversity and abundance of corals recovered in the Mississippian, bioclaustrations caused by endosymbiotic worms and tentaculitoid tubeworms were missing and the ecospace apparently was vacant.

The Hezhou Formation of the Wangjiacun section, Chaohu, Anhui province, South China, yields a diversified rugose coral fauna. It comprises *Koninckophyllum*, *Yuanophyllum*, *Bothrophyllum*, *Arachnolasma*, *Dibunophyllum*, *Axophyllum*, *Siphonophyllia*, cf. *Empachyphyllum*, *Lithostrotion* and on the upper part, *Aulina*. The coral assemblage in general is typical for of the *Yuanophyllum* Zone of South China, indicating a late Viséan to Serpukhovian age. In the collection of 126 specimens, two solitary corals, ? *Yuanophyllum* and ?*Dibunophyllum*, were found having symbiotic relationship with large soft-bodied worm-like organisms. The U-shaped tube of the endosymbiont contains a membraneous epidermis and relicts of a probable cuticulo-muscular tube. The corals reacted with skeletal encasement of the infesting organism and irregular, in part dense growth of additional skeletal elements adjacent to it. This evidence proves the syn-vivo interactions between the endosymbionts and the hosts.

The discovery is the first of such an endosymbiotic, parasitic or commensalic relation of solitary rugose corals after the Frasnian-Famennian Boundary Event. Moreover, it proves the extraordinarily rare persistence of bioclaustrations in corals after the Hangenberg Event at the Devonian-Carboniferous boundary.

Mineralogical and geochemical baseline screening of Antarctic carbonate secreting corals

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Intense sampling of the Ross Sea during oceanographic cruises (e.g. Graceful) of the Italian Program for Antarctic Research (PNRA) has revealed rich benthic ecosystems at bathyal depths with an important contribution from corals. Scleractinian corals, stylasterids and octocorals comprise among their taxa framework builders and hence important benthic habitat forming groups. We analyze the skeletal structure of the different coral groups and species with thinsections and SEM imaging, to provide an architectural baseline for the preservation assessment for pre-Modern and fossil material from the Ross Sea area. The mineralogy of corals is investigated at bulk resolution from skeletal powder samples with x-ray diffractometry, as well as with high spatial resolution (μm) from Raman-spectroscopy mapping. Raman spectra and XRD data show typical peak shifts for varying Mg content in calcite and can be used for paleothermometry and biomineralization studies. Today the Ross Sea provides the coldest marine environment on the planet and the isotopic and elemental compositions provide important extreme endmembers for temperature equations and other proxy calibrations. One of the key-targets of our research is hence to analyze elemental compositions of XRD-bulk powders with solution-ICPMS, as well as for their oxygen isotope and stable carbon isotope composition. Overall mineralogical data show known patterns with scleractinians secreting aragonitic skeletons and bamboo corals secreting high-Mg calcite stems. Stylasterids expose variable mineralogies, comprising low-Mg calcite and aragonite. Species with published mixed calcitic-aragonitic compositions are currently scrutinized to evaluate the validity of these earlier data. In either case the low carbonate saturation state of the modern Ross Sea, amplified further by anthropogenic CO_2 emissions, lead to fast dissolution of aragonitic and low-Mg calcite skeletons, but does not affect their primary mineralogical constitution.

Exceptionally well-preserved alcyonarian from the Lower Wenlock (Silurian) of Gotland, Sweden

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Paleozoic records of Alcyonaria are still scarce and typically represented by individual sclerite occurrences of disintegrated specimens. Here, we report on an exceptionally well-preserved individual of the Alcyonarian octocoral *Atractosella* sp. from the Silurian of Gotland in Sweden, which unveils its original body shape. Brachiopod $\delta^{13}C$ values of 2.45 ± 0.14 ‰ V-PDB from *Atrypa reticularis* unequivocally pinpoint the stratigraphic position of the sample within the *Phaulactis* layer at the base of the Upper Visby Beds (Lower Wenlock), coincident with the Ireviken event. Lithology, lateral facies distribution, fossil content and tabulate coral growth forms, indicate a deeper-water mesophotic setting with a soft-bottom environment below the storm-wave base. The calcareous sclerites have been found on a marl-bedding plane, which shows signs of transport by bottom currents. Sizes, distribution and orientation of 348 sclerites have been mapped on the bedding plane surface. Sclerite lengths range from 0.6 to 6.7 mm, with an average of 2.3 ± 1.1 mm. Sclerites outside the body shape of the alcyonarian fossil are randomly distributed with a low areal density. Weak local sorting due to bottom currents, remains far beyond the higher degree *en echelon* orientation and high areal density, within the alcyonarian itself. Outline and shape indicate a free-standing colony with a stem diameter of ~1 cm diameter and >7 cm height, with a y-shaped bifurcation(s). Architecture and branching pattern are strikingly similar to modern alcyonarians. Spicule morphology allow an assignment to the genus *Atractosella*, which has further records from the Upper Wenlock of Wales (*A. siluriensis*) and of Gotland (*A. cataractaca*), as well as from the late Llandovery of Scotland (*A. andrea*). Our finding provides currently one of the earliest known alcyonarian body-fossils.

Cnidaria and Porifera fossils in the Late Ediacaran deposits in Ukraine

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Information about the findings of Cnidaria and Porifera as representatives of stem groups in Precambrian sediments is not widely represented in scientific publications. This situation is quite understandable for several reasons. First of all, the finds of Precambrian fossils are relatively rare. Furthermore, the identification of the genetic affiliation of these remains is very difficult due to the absence of mineralized skeletons in the organisms of that time. There are several examples of taxon descriptions as possible representatives of these groups of animals. In Lagerstätte Mistaken Point (Newfoundland, Canada), *Haootia quadriformis* Liu et al., 2014 is described. In addition, traces of horizontal and vertical movement of organisms with a hemispherical body shape in the sediment were found there. These fossil remains look like movement traces of Cenozoic polyps. Similar specimens were described from the deposits of the Mohyliv Formation of the Late Ediacaran in Podillia (Ukraine) as early as 1983.

The author has been studying many outcrops of Ediacaran sediments in Ukraine for more than 20 years. The main purpose of the study is to reconstruct of the biodiversity model in the cold-water sea during the Ediacaran Period and to study the evolutionary trends in the conditions of ecosystem changes before the "Cambrian explosion". About five thousand slabs with fossil remains of the organic world of the Late Precambrian were collected.

Among the material found there are about 100 slabs with numerous Domichnia that are casts of probable polyps, which are ancestors of modern Actiniaria. Their morphology is different, namely: *Bergaueria hemispherica*, *B. perata*, *B. radiata*, *Conichnus conicus* etc. These Domichnia are localized on two levels of the Mohyliv Formation and one level of the Nahoryany Formation. Very interesting are the finds of the taxon *Astropolichnus* sp. that are similar to remains from the Cambrian sediments of Spain, India and the Czech Republic. The author also found fossils of three-dimensional casts of organisms with conical shape that were immersed in silty deposits (argillites, siltstone). They show a slit-like depression (apparently mouth) in the central part of the bodies. The marginal zone is covered with radial partitions (probably septa). Thin radial grooves (likely tentacles) branch out from the outer edge of some specimens. The combination of these morphological elements is typical only for polyps and has no analogues among the Precambrian biota. An unexpected finding is two body casts with a six-rayed structure (as in Anthozoa) in the siltstones of the Nahoryany Formation.

Some fossils are similar to the remains of Porifera from the Cambrian sediments. Such material is collected from argillites of the Lomoziv Beds in the Mohyliv Formation. One trace has a conical shape and consists of a frame of needle-shaped elements (probably spicules) connected by cross bars. This organism resembles *Leptomitella conica* Chen et al., 1989 (Demospongia) from the Cambrian sediments in China. Clusters of fragmented, needle-like elements similar to remnants of various Cambrian Demospongia were also detected there. At the same stratigraphic level, the author found three specimens of an unusual organism that consists of an attachment disk from which short rhizoids branch out and a cup-shaped body with the two-layer structure. The layers are interconnected by vertical partitions that is similar to Archaeocyatha.

The possible Precambrian findings of Cnidaria and Porifera provide an answer to one of the most important questions of paleontology: "How to explain the phenomenon of the mass appearance of macrobiota diversity at the beginning of the Cambrian Period?" Probably, many stem groups had soft-bodied ancestors in Precambrian biotic association. The author found evidence of the existence of organisms with the morphology of Cnidaria and Porifera, and remnants of organisms that are probably the ancestral forms of Lophotrochozoa, Chordata, Protista, problematic Vendobionta and various Metaphyta in sediments of the Late Ediacaran.

Mediterranean Miocene *Madrepora* provides a geochemical snapshot of the past

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The Miocene deposits of the Turin Hills in NW Italy preserve a situation where mass gravity deposits contain aphotic coral and deep-water molluscs intermixed with shallow-water elements. In many cases these assemblages are preserved in coarse siliciclastic sediments and often preserved as molds. In Valle Ceppi south of Turin, fragments of the framework forming cold-water coral *Madrepora oculata* have been exceptionally preserved in their original aragonitic mineralogy. This opened the rare occasion for a geochemical investigation to estimate bottom water temperatures. Strontium isotope dating gave an $^{87}Sr/^{86}Sr$-age centered between 20.0 and 19.5 Million years, corresponding to the Lower Miocene. The lower Burdigalian molluscan fauna associated with the corals indicate a higher connectivity to the Atlantic Ocean, comprising bathyal character species *Acesta miocenica*. Likewise, the higher diversity of bathyal corals and bivalves and their key taxa suggest a stronger connectivity to the Atlantic fauna during the Burdigalian, than during modern day conditions of the Mediterranean basin. Stable isotope sampling of *Madrepora oculata* showed a strict linear correlation of $\delta^{18}O$ and $\delta^{13}C$, indicative of a strong kinetic vital effect. This pattern is characteristic also for modern cold-water coral aragonite and can be taken as a further indication for a reliable aragonite preservation. This linear trend can be used for temperature reconstructions with the lines-technique, which yielded a deep-water estimate of ~12°C. Calcite $\delta^{18}O$ of co-occurring *Acesta miocenica*, which precipitate $\delta^{18}O$ in equilibrium with seawater, further enforce this result. Laser-ablation profiles of the coral were used to extract element compositions. Li/Ca ratios permitted temperature estimates of ~11°C, based on a modern Atlantic coral calibration. The characteristic covariation of Mg/Ca, U/Ca and stable isotopes observed in modern corals could not be recorded. While the isotopic patterns are reliable, the elemental composition does show an influence of diagenesis, despite the aragonite preservation. This is in particular visible by relatively low U-concentrations, indicative of leaching. Fossil corals hence need a careful look, with a multi-proxy geochemical approach and a microstructural analyzes of the preserved skeletal mineralogy.

Middle-Upper Pleistocene deep water corals from bathyal depths in the Strait of Sicily, Mediterranean Sea

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Quaternary-age extant deep-water corals occur at many sites of the Mediterranean basin, with Early to Middle Pleistocene (s.l.) occurrences reported from outcrops in southern Italy (Sicily and Calabria) and Greek islands (Rhodes and Karpathos). Pleistocene-age scleractinian corals are also commonly reported from submerged situations in the Mediterranean Sea. U/Th dating proved that these corals are considerably younger, by large pertaining to the last glacial epoch.

Sampling of the Strait of Sicily seabed during cruises MARCOS and DECORS of RV *Urania* intercepted deposits containing a rich and diversified benthic fauna, dominated by molluscs, brachiopods, octocorals and scleractinians. Noticeably, piston coring and grab sampling in 436 m water depth at 36°40.565' N-11°47.53' E recovered a fossil fauna closely resembling the bathyal benthic assemblages described from the southern Italy Pleistocene outcrops. The fortunate occurrence of the solitary infaunal scleractinian *Flabellum* provided an opportunity to date this submerged fossil fauna using $^{87}Sr/^{86}Sr$ isotopic values, attesting an age of ca. 700,000 y BP. In the same location, we also sampled *Flabellum macandrewi* and *Fungiacyathus* cf. *fragilis* which have been subjected to U/Th dating, resulting ca. 14-15,000 years old.

Differently from scleractinians like *Lophelia pertusa* (=*Desmophyllum pertusum*), *Madrepora oculata* or *Desmophyllum dianthus*, these extant corals still live at present in the Atlantic Ocean but no longer in the Mediterranean Sea. Their presence in this basin seems by now confirmed only at colder times in the Pleistocene, suggesting that they are more sensitive to temperature than many other deep-water corals.

Temporal variability of cold-water coral habitats from the Porcupine Bank Canyon NE Atlantic, using ROV-vibrocoring, CT-scanning and PSA: preliminary results

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Cold water corals (CWCs) trap current-suspended particles from their environment, which become deposited in and around the coral framework. This results in the growth of topographic features called CWC mounds, which contain a record of paleoenvironmental change through time. Here, we present a project within the MMMonkey_Pro research programme, which focuses on the temporal development and paleoenvironmental history of CWC habitats in submarine canyons (reefs, gardens, mounds and coral-derived tallus slopes). This oral presentation shows work completed to date on the project which started in January, 2018.

A number of ROV-mounted vibrocore samples have been retrieved from a range of CWC habitat types within the Porcupine Bank Canyon (PBC), NE Atlantic. These cores have been scanned using dual energy computed-tomography (CT) following, and further developing, a novel methodology. This has created comprehensive imagery of the internal architecture of the CWCs, as representative of reef development stages. The extrapolated data is processed using Amira software and coral core-specific algorithms, revealing variables such as matrix:coral ratio, coral-fragmentation, coral-fragment orientation and size. The cores have been further logged and subsampled for high-resolution laser granulometry and composition (CaCO3% and Organic%). In late 2019, a chronostratigraphic framework will be constructed by subjecting planktonic foraminifera and coral pieces to 14C AMS and U/Th dating, respectively. Moreover, benthic foraminiferal assemblages will be classified.

This unique multidisciplinary ensemble approach, will uncover the controls on mound cessation and development related to the dual energy, CT-identified reef development stages. For the first time, we aim to shed light on what controls the formation of different CWC habitats in the PBC.

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Tournaisian rugose corals of the Donets Basin

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Tournaisian sedimentary rocks are exposed in the southern part of the Donets Basin (Ukraine), where they are dominated by shallow-water platform limestone. The lower Carboniferous corals of this area were studied in detail by N.P. Vassilyuk. From the Tournaisian she described *Campophyllum caninoides* Sibly (Tb zone), *Cyathoclisia modavensis* Salée (Tc zone) and *Calmiussiphyllum calmiussi* Vassilyuk (Va zone). Moreover, Vassilyuk listed corals previously reported from the lower Carboniferous of the Donets Basin by other researchers (K.I. Lissitzin, I.I. Gorsky, V.D. Fomichev). Lissitzin provided only fragmentary data on Tournaisian rugose corals. Corals studies by Gorsky and Fomichev were not finished; no images or descriptions of Tournaisian corals have been published and their collections were irretrievably lost.

Later, in a joint publication on zonal framework of the Lower Carboniferous of the Donets Basin, Vassilyuk has added to the Tournaisian rugose corals list in this area two species - *Cyathoclisia tabernaculum uralensis* Sayutina and *Amplexus* aff. *A. cornuformis* Ludwig.

Recently V. Ogar described *Keyserlingophyllum obliquum* (Keyserling) from the Tournaisian of the Donets Basin whereas *Conilophyllum priscum* (Münster) and *Corphalia simplex* (Perna) are documented here for the first time.

Our current work on the Tournaisian rugose corals of the Donets Basin allows some emendations. Within addition to *Keyserlingophyllum, Siphonophyllia cylindrica* Scouler in McCoy and *Uralina* sp. are identified. A new species of *Merlewoodia* Picket, documented for the first time in the Donets Basin, occurred in the same stratigraphic level. This genus was described from the Tournaisian and Viséan of eastern Australia and recently was identified in the latest Tournaisian and late Viséan of Belgium and eastern Morocco. The early growth stages of this new species show thick septa, shortened cardinal and counter septa, and pinnate septal arrangement whereas the adult stages display the tendency septal thinning and the occurrence of peripheral pseudonaotic structures.

In the middle part of Tournaisian *Aulokoninckophyllum* sp. (Td zone) and *Caninophyllum patulum* (Michelin) (Tc zone) are identified.

Non-dissepimented rugose corals *Proheterelasma omaliusi* (Milne-Edwards & Haime), *Zaphrentites delanouei* Milne-Edwards & Haime, *Zaphrentites parallela* (Carruthers) *Sychnoelasma konincki* (Milne-Edwards & Haime) and *Amplexus coralloides* Sowerby were found at different stratigraphic levels of the Tournaisian.

Calmiussiphyllum calmiussi is abundant in black bituminous shales interbedded with dark-gray argillaceous limestone of Dokuchayevian horizon (Va zone). This unit is the uppermost of the Tournaisian of the Donets Basin. The thickness of the horizon is only 6 m. The majorities of corals recovered from the shale are very poorly preserved, deformed and recrystallized, so their early stages of growth are still unknown. The study of some specimens with sufficient preservation demonstrates a long cardinal septum in the early stages of growth, which gradually shortened with increasing of corallite diameter. Minor septa and dissepiments appear later.

In these sediments *Caninophyllum kosvensis* (Degtyarev) and *Merlewoodia* with pinnate septal arrangement, shortened cardinal and counter septa were also found.

Our update of the taxonomic composition of the Tournaisian solitary rugose corals of the Donets Basin makes comparison with other regions of the world (West Europe, the Urals, China, Turkey and Iran) possible and allows constraining the palaeobiogeographic reconstructions.

The effect of gravity on coral symmetry

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At studying of coral symmetry, the main attention is paid to clarifying the role of heredity in preservation of symmetry types. In some cases, symmetry is considered as having a taxonomic value. For example, different type of septa insertion serves for many investigators as argument for opposition of the Rugosa and Scleractinia. In other cases, symmetry is only the integral characteristic of a population. So, the swimming larvae of modern corals have always well-defined bilateral symmetry, but at the adult animals, which are attached to substrate, the septa arrangement is radial.

We study the Heliolitida of the South Tien Shan for many years using the technique of oriented thin sections. Description of geological sections and sampling were made from successive layers. For clarifying of the genesis of the group and place definition of the Heliolitida in the general system of Paleozoic corals, we have used a comprehensive analysis: the comparison of morphology of the Heliolitida, Tabulata and Rugosa was carried out from the standpoint of the concept of the sum of common features, and the variability of a number of forms has been investigated; desynchronization of the variability of separate features was analyzed, and the patterns of colonial growth and cyclomorphosis of corals were studied. As a result, the author concluded that these groups developed from a common ancestor (presumably a Corallomedusa) by pedomorphosis. Also we showed that the presence of auloporoidity, which Sokolov considered as the evidence of relationship of Tabulata, Heliolitida and Rugosa, is not so much an indicator of relationship, as it indicates the generality of the processes to which Paleozoic corals underwent at the beginning of their formation. The auloporoidity is the curvature of the conical bases of corallites in the initial stage of growth (the structure inherent in the genus *Aulopora*). The small sizes of the ancient initial forms prove that not adult polyps, but larvae, which settled to the bottom, were subjected to calcification. They gave rise to the first calcite polyps, which were bent by their own weight or sea currents. According to Beklemishev, if mechanical force (strong currents, lateral attachment) acts perpendicular to the direction of gravity, the greater stability of the body is achieved by the curvature of the axis, leading to the appearance of bilateral symmetry in sessile primary radial animals.

It should be mention here, without considering the different influencing reasons, the rule established by Shafranovsky who has analyzed different types of natural symmetry: *everything that grows and moves horizontally and obliquely has bilateral symmetry; everything that, being attached, grows vertically, has radial symmetry.* We can see this in many Rugosa: in the initial stages of growth, when the corallites bend, their cross sections are oval, and they transform into rounded ones, when the growth of the corallites changes to vertical. The same goes for larvae symmetry: they have bilateral symmetry because they swim horizontally, and a polyp should have radial symmetry because it grows vertically. Radial symmetry in moving Metazoa develops due to active swimming in all directions (like Medusa).

Many researchers are not familiar with the rule of Shafranovsky, so they do not consider the effects of gravity on coral symmetry. For example, some authors exclude environmental control on growth rhythm in some Alveolitidae and specify that causes of differences between individual corallites remain unknown. Bottoms are usually located perpendicular to the direction of growth of the coral. If corallite grows vertically (as at Favositidae), the bottoms are deposited horizontally, that is, perpendicular to the direction of gravity. Such a position is most stable in this situation as the compensating ("neutralizing") effect of gravity. Since the effect of gravity is compensated, seasonal influence comes to the first plane; therefore, the zoning of growth manifests itself. In curving corallites (alveolitoid structure), the rhythm of growth is violated, veiled.

Gravity plays a primary role, and heredity plays the secondary role, because gravity acts all the time (constantly), but for fixation of the heredity, the long time is needed.

Stories from the past – prospects for the future: Whither the coral reef?

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The transition from an idiographic to a nomothetic approach to paleontology was championed by Stephen J. Gould and helped to crystallize the synthetic approach to paleobiology that characterizes our discipline. While systematic studies of biota through time continues to be a cornerstone of paleontological inquiry, studies of the fossil record have been used to test a plethora of ecological and evolutionary theory. Similarly, while this theory continues to be tested, we have recently entered a new realm of emphasis in paleobiology that encompasses the application of paleontological methods and data to tackle questions of immediate application in understanding the environmental and biotic crises we now face globally. Addressing these questions transcends any particular organism or time period. Here I provide a number of examples from my paleontological work on the marine fossil record, slanted toward corals and reefs, that connects data from the fossil record with real world application to the living biota. These examples encompass biotic response to climate change and other human impacts, extinction risk, historical ecology and the rise of novel communities. The application of time series data, at multiple time scales across a wide range of organisms, even extinct ones, is crucial to predicting a future world.

The upper Mississippian of the Montagne Noire (south Central Massif, France): a small endemic coral area controlled by reefal facies

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In the Montagne Noire, uppermost Viséan and Serpukhovian limestones (respectively Roque Redonde and Roc de Murviel Formations) correspond to microbial reefs exposed as olistolites. They yield abundant and diversified rugose coral faunas belonging to two stratigraphical assemblages (upper RC8 and RC9 rugose coral zones).

Some of the most common uppermost Viséan rugose corals belong to genera widespread and common in the Western European Province (that also includes North African and Nova Scotia): *Axophyllum*, *Clisiophyllum*, *Diphyphyllum*, *Lithostrotion*, *Siphonodendron*, *Solenodendron*, fasciculate *Lonsdaleia*, *Nemistium* and *Palaeosmilia*. Other ones, which are common in the same province, are uncommon in the Montagne Noire such as *Palastraea* (both species *regia* and *carbonaria*), *Pareynia* and *Siphonophyllia*, and moreover, typical uppermost Viséan corals, such as lonsdaleids with a cerioid habitus (*Actinocyathus*), *Dibunophyllum bipartitum* and *Thysanophyllum*, were not found. In opposite, uppermost Viséan corals, abundant in the Montagne Noire, are very rare elsewhere, such as *Kizilia* or *Melanophyllidium*.

The Serpukhovian coral fauna of the Montagne Noire shows close relationships with the uppermost Viséan one, and some of the Serpukhovian taxa could be phylogenetically linked (such as *Serraphyllum* which possibly evolved from one of the upper Viséan local species of *Lonsdaleia*). This fauna also comprises common taxa, which are either widespread, such as *Axophyllum*, *Siphonodendron*, *Lithostrotion*, or uncommon outside the area or endemic (*Kizilia, Melanophyllidium*, *Serraphyllum*). It includes also a colonial heterocoral known only there and in Pyrenees. The widespread Serpukhovian coral genera *Actinocyathus* and *Dibunophyllum* are absent in the Montagne Noire, but the latter is abundant in slightly younger Serpukhovian strata in Serre de Castet (central Pyrenees), which probably belongs to the same palaeogeographical unit.

Therefore, both the uppermost Viséan and the Serpukhovian of the Montagne Noire comprise abundant endemic species, whereas taxa characteristic for the northern part of the Western European Province (such as *Thysanophyllum* or *Actinocyathus*) are missing. This suggests that the Montagne Noire was a small, partially endemic, southern area in the Western European Province. However, some of the common species in the Montagne Noire (such as *Kizilia* and *Pareynia*) are only documented from reefal facies elsewhere (e.g. in Morocco and Belgium). The absence of species (e.g. *Dibunophyllum bipartitum*) that are common in non-reefal facies of the Pyrenees suggests that the coral assemblages are strongly controlled by the presence or absence of late Viséan-Serpukhovian reefal facies. Nevertheless, endemism could be due to the palaeogeographical location of the Montagne Noire area, more open to the Paleo-Tethys Ocean, whereas the other areas were developed in more continental platforms.

Unpuzzling pH up-regulation and calcification in corals growing at CO_2 Mediterranean vents

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Corals exert a strong biological control over their calcification processes, but there is a lack of knowledge on their capability of long-term acclimatization to ocean acidification (OA). We used a dual geochemical proxy approach to estimate the calcifying fluid pH (pH_{cf}) and carbonate chemistry of a Mediterranean coral (*Balanophyllia europaea*) naturally growing along a pH gradient. The pH_{cf} derived from skeletal boron isotopic composition ($\delta^{11}B$) was homogeneous along the gradient, exhibiting an increased up-regulation capability with increasing acidification. Also, carbonate ion concentration derived from B/Ca was homogeneous regardless of seawater pH. Furthermore, gross calcification rate (GCR), estimated by a "bio-inorganic model" (IpHRAC), was homogeneous with decreasing pH. This determined an apparently unresolved puzzle with the previously observed decrease in net calcification rates on the same specimens along this gradient. However, on the contrary, the homogeneous GCR was in agreement with the previous results in which the 'building blocks' produced by the biomineralization process were substantially unaffected by increased acidification. Furthermore, the pH up-regulation observed in this study provides a substantial contribution in solving the puzzle. In fact, it confirms the previous hypothesis that less building blocks are produced with increasing acidification by showing that *B. europaea* likely produces less building blocks because part of its energy is used to maintain elevated calcifying fluid pH with increasing acidity. Thus, the ability of scleractinian corals to maintain elevated pH_{cf} relative to ambient seawater might not always be sufficient to counteract declines in net calcification under ocean acidification scenarios.

Constraining past environmental changes of cold-water coral mounds with geochemical proxies in calcareous organisms

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Cold-water coral (CWC) reefs and mounds are and have been biodiversity hot spots of the deep sea. The information of how the oceans integrity has changed around these unique structures is therefore a priority target to understand how CWC mounds will develop under on-going climate change.

A convenient possibility to reconstruct the paleoenvironment during periods of CWC mound growth is to extract geochemical proxies from biologically mediated carbonates. Frequently occurring calcareous organisms in CWC mounds are Scleractinia (e.g., *Lophelia pertusa*, *Madrepora oculata*, *Desmphyllum dianthus*) and Foraminifera (e.g., *Cibicides*/*Cibicidoides* spp.), whereas also other calcareous organisms have the potential to serve as proxy carrier such as bivalves (e.g., *Acesta excavata*) and brachiopods (e.g. *Terebratulina retusa*). Here, we focus on the probably most abundant types, i.e. the cold-water Scleractinia and Foraminifera and present an overview of the geochemical proxies (selection) which have been and can be used in these aragonitic and calcitic skeletons from CWC mounds. The focus is on proxies for temperature, salinity, seawater density, seawater carbonate systems parameters (pH, CO_3^{2-}), nutrients, oxygen and water mass tracers.

Revisiting the long-term biodiversity dynamics of reef builders in a novel Bayesian framework

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Stony corals and coralline sponges are the dominant metazoan reef builders of the Phanerozoic. Both groups have a very volatile fossil record. Whether this volatility is driven by genuine biological signals or preservation bias is still unclear. This, however, imposes severe problems for reconstructing biodiversity dynamics over geological time scales. Although classical sampling-standardisation can help reveal primary signals, a Bayesian framework may be more rigorous. Here we apply PyRate, a computer program to simultaneously estimate speciation, extinction, and preservation rates from fossil occurrence data using a Bayesian framework, on Permian to Jurassic coralline sponges and corals. Occurrence data were obtained from the Paleobiology Database and changes in preservation rates were set to occur across geological epochs. Focusing on extinction dynamics, we find that coralline sponges were much less affected at the end-Permian mass extinction than corals, whereas both groups were similarly affected at the end-Triassic mass extinction. This might indicate that the end-Permian and end-Triassic extinctions are less similar than commonly assumed, perhaps due to a different combination of climate-related stressors across those crises. As the differential extinction of corals and sponges is also evident in the Toarcian crisis, we hypothesise that deoxygenation is a key factor responsible for the greater extinction rates of corals in the end-Permian and Toarcian crises.

Miocene coral biogeography in the Indian Ocean

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The present centre of coral diversity in the Western Indian Ocean is defined by the northern Mozambique Channel with an extension northward to Mafia Island in Tanzania (Eastern Africa). The geological and evolutionary history of this hotspot of marine biodiversity remains so far completely obscure, because Cenozoic fossil reef communities of this area are not well-known. Here we report on a new reef coral assemblage of Messinian (6.8-6.0 Ma) age from the Mikindani Formation in southern coastal Tanzania. The siliciclastic Mikindani Formation represents the Rovuma Delta, one of the largest Cenozoic delta systems on Africa`s east coast. In terms of recent coral biogeography, it is part of the Central (or "Core") Ecoregion of the Western Indian Ocean biogeographic province, which hosts the maximum of coral richness in the Western Indo-West Pacific. A total of 16 coral taxa with 9 coral species and 12 coral genera are documented from the studied outcrop. At the species level, the studied coral assemblage from Tanzania shows close affinities with the Recent Western Indian Ocean biogeographic province and Central Indo-West Pacific biogeographic region as well as with the Miocene of Indonesia. Faunistic relations with the Oligocene-early Miocene of Somalia, which is also part of the Western Indian Ocean biogeographic province today, do, however, not exist. The different biogeographic affinities of the East African coral faunas during the Oligocene-early Miocene and the Messinian-Recent indicate that the Western Indian Ocean Province was not existent in its present form during the Oligocene-early Miocene and must have developed by the connection of the region to the Coral Triangle in Southeast Asia before the end of Miocene time. The biogeographic change coincides with the onset and intensification of the Miocene Indian Ocean Equatorial Jet between 14 and 9 Ma in response to the narrowing of the Indonesian Gateway. Our results indicate that the East African hotspot of coral diversity originated during the middle to late Miocene as a satellite population of the Coral Triangle.

Coral sclerochronology and geochemistry during the Middle Miocene Climate Transition

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The rise of atmospheric pCO_2 due to anthropogenic burning of fossil fuels is unprecedented in the last 300 million years (Ma). In addition to ocean warming, rising pCO_2 causes ocean acidification, which endangers calcification in many marine calcareous biota such as reef corals. Nevertheless, coral reefs were more widespread-than-present during periods with high pCO_2 in the geological past, because pCO_2 changes were likely slow allowing the oceanic carbonate system to maintain high saturation with calcium carbonate. For testing model predictions on the long-term carbonate buffering capacity of the oceans coral calcification data from such periods are mandatory, but detailed coral calcification records from deep geological time are still lacking because the porous aragonitic skeletons of scleractinian corals, as a general rule, quickly undergo biological and diagenetic degradation. Here we present high resolution (0.1 mm sampling distance) calcification (skeletal density and extension), stable isotope ($\delta^{18}O$, $\delta^{13}C$) and element/Ca (Sr/Ca, U/Ca, B/Ca and Ba/Ca) data from two fossil *Porites* corals of late Langhian – early Serravallian age (ca 14 – 13 Ma) that were discovered at Pötzleinsdorf and Drasenhofen in the Vienna Basin (Austria). According to careful screening procedures (SEM, XRD, X-radiography), the corals under study are in a rather pristine state of preservation retaining their original skeletal aragonite, pore space and microstructural details. This exceptional state of preservation makes them the oldest scleractinian corals known so far suited for combined radiodensitometry, stable isotope and LA-ICP-MS analyses. The corals investigated represent the Middle Miocene Climate Transition (MMCT), a phase of major global cooling at ca 15 – 13 Ma following the Middle Miocene Climatic Optimum (MMCO), which was the warmest episode of the Neogene. Climate models assume atmospheric CO_2 concentrations of 400 ppmv during the MMCO, which decreased to 200 ppmv at the end of the MMCT. The sclerochronological records presented by us offer a rare opportunity to study the responses of reef coral calcification during this time of global pCO_2 and climatic turnover.

Palaeoenvironmental and palaeoecological reconstructions of an Upper Jurassic carbonate reef based on quantitative analysis of composition and coral assemblages (Upper Tithonian Mt. Bardia Formation, eastern Sardinia, Italy)

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The Late Jurassic is reported as a time of large development of reef systems, with a great diffusion and differentiation in the Tethys realm. Corals, sponges, microencrusters, microbialites, and bioclastic debris represent the main Jurassic reef builders and components, widespread in various palaeobiogeographic domains. Despite the common co-occurrence of these reef components, they combined in various proportions, giving rise to an extraordinary number of compositionally different reef types. However, in the geological record, the relationship between controlling factors and reef type occurrence is rarely straightforward and the reconstruction of palaeoenvironmental and palaeoecological conditions controlling the composition of the reef facies remains a challenge. This is particularly true where the role of different components (skeletal and non-skeletal) in reef building is not clearly deciphered and additional information, e.g. isotopic records, depositional profile and architecture or reef body geometry reconstruction is prevented.

This work investigates a portion of a poorly documented upper Tithonian reef (Lower Mt. Bardia Reef, LBR) developed along the northern platform margin of the eastern Sardinia Platform (ESP). The LBR was probably one of the most southerly reefs of the northern Tethys margin, and this study provides the first comprehensive description of facies and internal structure, giving insights for the depositional setting.

In this area, a portion of the platform margin is spectacularly exposed along three sawed quarry surfaces that record a total thickness of a few tens of metres and nearly 100 m^2. The quarry exposures provide an excellent opportunity to study in detail, and perform quantitative analysis on the components of the reef, the facies, the biotic association, and its internal architecture, providing insights on reef palaeoenvironment.

The main reef components are represented by carbonate (bioclastic) debris, microbialites and microencrusters, and reef-building organisms (mainly corals and stromatoporoids). These components combine in various proportions, forming several facies and facies associations. Ten reef facies, grouped into three main Facies Associations have been identified. The distribution and arrangement of facies reveal a sedimentary evolution, evolving from a microframework-dominated reef to a carbonate debris-dominated one, with the internal reef architecture evolving from massive, then patchy, and finally to coarsely stratified and roughly bedded. Coral morphology analysis and diversity indices reveal an extraordinary coral richness (55 genera, 21 families), in which genera *Microsolena*, "*Pseudocoenia"*, *Cladophyllia* and *Ovalastrea* are the most abundant but do not dominate. The near tropical palaeolatitude and the palaeogeographic position far from terrigenous inputs are inferred as main ecological parameters promoting a thriving coral community. However, at the scale of single facies, different corals and skeleton assemblages alternated according to the presence of microframework *vs* carbonate bioclastic debris.

The coral assemblages, the reef components and facies indicate that the investigated portion of the LBR corresponds to a shallow back-reef zone, characterized by well-lit and generally low-energy hydrodynamic conditions, possibly developed in back position with respect to a higher-energy zone that was closer to the edge of the platform. In this depositional context, the arrival of large amounts of debris and the evolving internal architecture are interpreted as the result of the infilling process of the back-reef zone due to the progradation of a sand apron, during a long-term regional regressive phase.

Finding of the colonial coral *Lonsdaleia carnica* from the late Mississippian Kirchbach Formation of the Carnic Alps (Austria)

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A large (65 cm) limestone boulder has been recorded at Plunger turn from Wipfelalm to Kirchbach Wipfel at an altitude of 1,650 to 1,670 m in the Kirchbach Formation (Carboniferous) at the Carnic Alps. It is regarded as an olistolith, shows reefal facies and contains a diverse assemblage of invertebrates and algae. The main building organisms in the boulder are rugose corals of the species *Lonsdaleia carnica* Rodríguez, Schönlaub and Kabon. Other main building organisms are bryozoans of the genus *Fistulipora*, tabulate corals of the genus *Multithecopora*, and varied red (ungdarellaceans), green (*Anatolipora*, and incertae algae (*Aphralysia* and *Fasciella*). Cyanobacteria masses of the genus *Girvanella* are also common. Accessory components are highly diverse, including crinoids, brachiopods, molluscs, trilobites, ostracods, worm tubes (*Thartharella*) and foraminifers (*Endothyra* and *Tetrataxis*). The fossil assemblage is composed mostly of long-range genera; consequently, no precise age is given. The most probable age is Serpukhovian, but latest Viséan cannot be discarded.

Microfacies are diverse in one single block: mostly bafflestone, bindstone, packstone and wackestone. A polymictic limestone breccia shows erosive contact on the built microfacies. Fragmentation is common in many bioclasts, indicating an environment of high energy, but most fragmentation can be interpreted as produced during the shift of the block in submarine debris flows. The presence of abundant micrite and micropeloidal texture of microbial origin indicates long periods of quiet water. If periods of high energy affected to the environment, they were not persistent, allowing the deposition of fine calcareous lime during the quiet periods. In addition, crinoidal rests show long portions of stems with articulated plates, indicating that their first sedimentation was in an environment with low water movement.

Since the limestone slab was transported from a shallow water platform into the flysch basin of the Hochwipfel Formation, the time of deposition might be slightly younger. To conclude, a Serpukhovian or even an early Bashkirian age is suggested for the Kirchbach Formation interbedded in the synorogenic Hochwipfel Formation, which, according to Herbert Kabon, roughly coincides with the appearance of the floral subgenus *Mesocalamites* at the base of the Serpukhovian.

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Donezella-Chaetetes mounds in the Valdeteja Formation (Bashkirian) at Truébano, Cantabrian Mountains, Northern Spain

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The Bashkirian-lower Moscovian Valdeteja Formation crops out in the Cantabrian Zone of the Iberian Massif out. It has been described as pale grey limestone with a diverse fossil content, calcareous breccias and massive limestone composed of algal and bacterial mounds. Outstanding outcrops of that formation appear near the village of Truébano (León Province, North Spain) at the old coal mine "Mina Rosario", which shows interbedded siltstones and coal beds containing coal balls.

The results of the paleontological and sedimentological study of the strata above the coal beds are presented in this paper. On this matter, the employed methodology was a detailed description of the outcrop, logging of the sedimentary succession, paleontological and sedimentological sampling and the study of the macrofauna, thin sections and palinomorph samples.

The measured section above the coal seam is 10.2 m thick. Dark grey, massive to well-bedded limestones interbedded with thin marl beds are dominant in that interval. The main components of the limestones are the algospongia *Donezella* that are mostly reworked in the lower beds and in growth position in the upper beds. Other main building components of the limestones are chaetetids and cyanobacteria. Additional common components of the rocks are foraminifers, cyanobacteria, echinoderms, red algae, algospongia and worm tubes. More scarcely, solitary corals, bryozoans, trilobites and gastropods also occur.

Foraminifera are abundant, mostly belonging to Fusulinida and Endothyrida, but also Archaeodiscida are present there. The palinomorph samples yielded scarce, bad preserved, unidentifiable spores and highly degraded organic matter.

An interbedded layer of quarz sandstones occur at the upper part of the sequence. It has some hundreds of meters of lateral continuity and lacks paleontological content.

Two microfacies have been identified, 1) packstone of reworked algospongia; 2) boundstone of *Donezella*, *Girvanella* and chaetetids. The identified environment is a calcareous platform above the fair weather wave base, subtidal zone, with development of "algal" mounds. The composition and components distribution of both microfacies fit well with "algal" mounds previously described in other outcrops of the Valdeteja Formation, with the exception of the participation of chaetetids as main building component in some beds.

The assemblage of foraminifers allows an identification of early Bashkirian (Severokeltmenian - Prikamian) for the studied outcrop.

These results, along with the analysis of the strata below the coal bed, lead to a better understanding of the Valdeteja Formation and the environment where the "algal" mounds developed.

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Revision of *Metriophyllum* Milne-Edwards & Haime, 1850 and *Lindstroemia* Nicholson & Thomson, 1876 (Anthozoa, Rugosa, Devonian)

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Many ancient Rugosa genera are still waiting for redefinition after revision of their type and topotype materials – in spite of the enormous amount of work already done in this field throughout the world. Among countless pioneers, we all remember the outstanding efforts of the British school around William Dickson Lang (1878-1966) and Stanley Smith (1883-1955), summarized in the catalogue of Lang, Smith & Thomas. Urgent future tasks are cases such as *Densiphyllum* Dybowski, 1873 (Silurian) or *Tachylasma* Grabau, 1922 (Permian), concerning derived family names (Densiphyllinae Dybowski, 1873, Tachylasmatidae Grabau, 1928) and even a suborder name (Tachylasmatina Fedorowski, 1973).

Metriophyllum was "revised" (based on "topotypes" from Ferques, Boulonnais, in the North of France) three times (Smith 1945, Holwill 1964, Weyer 1970). But these authors were not aware of the existence of two different, quite homoeomorphic genera in the local lower Frasnian (in slightly different levels). They also wrongly referred to the morphology (without antiseptal triad), not identical with the lost lectotype. New collections enable us to propose a neotype for the type species *Metriophyllum bouchardi* Milne-Edwards & Haime, 1850 (Ferques Formation). Main diagnostic features are the trabicular septal microstructure, and the triad formed by the antiseptum and its two neighbouring long minor septa; all other minor septa are short and become reduced during the calicular ontogenesis (then being hidden within the archaeotheca). The older "*Metriophyllum*-II" (Beaulieu Formation) has no such triad and will be revised as a new genus and species in a separate publication.

Lindstroemia with type species *Lindstroemia columnaris* Nicholson & Thomson, 1876 had been proposed without locality data (only "Devonian rocks of North America"); thus nobody could provide topotypes. Some originally included Ordovician and Silurian species are meanwhile transferred to *Dalmanophyllum* Lang & Smith, 1939 and *Bodophyllum* Neuman, 1969 (suborder Streptelasmatina). Nicholson's type series is preserved in the Royal Museum of Scotland in Edinburgh and labelled "Erie, New York". These common Rugosa (upper Hamilton Group) were again described by Simpson as *Stereolasma rectum* (Hall, 1843) and *Lopholasma carinatum* Simpson, 1900. A transverse syntype section is chosen as lectotype, thus declaring the genus *Lindstroemia* as a senior synonym of *Lopholasma* Simpson, 1900.

At first, we thought of accepting both *Metriophyllum* and *Lindstroemia*, separated only by the strongly shortened cardinal septum in the latter taxon, but a weak shortening also occurs in the type species *Metriophyllum bouchardi* - such differences are gradual. An undescribed Devonian plesiomorph ancestor with unshortened cardinal septum exists: this new genus is also ancestral to the Lower Carboniferous *Drewerelasma* Weyer, 1973.

The new taxonomy accepts a family Lindstroemiidae Počta, 1902 (synonyms: Metriophyllidae Hill, 1939, Stereolasmatidae Fomichev, 1953). The included genera are for the moment: *Nichlavalla* Weyer, 1996, *Metriophyllum* Milne-Edwards & Haime, 1850 (synonyms: *Lindstroemia* Nicholson & Thomson, 1876, *Lopholasma* Simpson, 1900), *Stereolasma* Simpson, 1900, *Metrioplexus* Glinski, 1963, *Metrionaxon* Glinski, 1963, *Saleelasma* Weyer, 1970, *Drewerelasma* Weyer, 1973.

Also suborder names, as used in today's best handbook, must be changed, though they are not yet governed by the present International Code of Zoological Nomenclature. The Metriophyllina Spasskiy, 1965 lose their name-giving taxon and are renamed Cyathaxoniina Spasskiy, 1977. The genus *Metriophyllum* becomes a member of the Zaphrentoidina Wang, 1950 (synonyms: Zaphrentoidina Schouppé & Stacul, 1959, Metriophyllina Spasskiy, 1965, Stereolasmatina Hill, 1981, Hapsiphyllina Nudds, 2001).

Implications of some geographically marginal reef coral assemblages from the Cenozoic of northwestern Europe, southern Australia and New Zealand: light or temperature?

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Biogeographical interest in the Cenozoic history of reef corals (i.e. zooxanthellate and zooxanthellate-like corals) has long focused, understandably, on the origins of the high-diversity regions of the central reef coral belt, particularly the Caribbean and the Coral Triangle of the Indo-Pacific. Ecologically however, current concerns with the effects of global warming on reef corals and coral reefs has been driving research into possible ecological refuges like 'mesophotic' habitats (30-160 m depth). Geographically marginal (i.e. higher latitude) reef coral assemblages (GMRCAs) are also of interest for similar reasons. A widespread idea is that while current global warming could cause regional extinctions of reef corals in the core low-latitude regions of the reef coral belt, this might be offset by their colonisation of higher latitude habitats, as and when these become warm enough to sustain them.

An obvious question therefore, is whether fossil GMRCAs provide support for this idea. We have been prompted to consider this through relatively new fossil coral collections made by us, together with existing related collections in the Natural History Museum, London. In particular, these consist of corals from these study areas: Eocene of northwestern Europe (southern England and northern France) at palaeolatitude 46.1-48.4°N, late Oligocene of southern South Island, New Zealand at c.46°S, and early-to-mid Miocene Nullarbor Limestone of southern Australia (c.40°S). We present a summary of these records with provisional identifications and palaeoenvironmental context. The assemblages are not necessarily associated with reefs and in any case, we focus here on marginal corals not marginal reefs.

Drawing also on Recent patterns, we use simple analysis to (1) establish whether GMRCAs have been characterised by particular taxa through time (allowing for evolutionary turnover), (2) document evidence from past GMRCAs for changes in latitudinal limits of reef corals through the Cenozoic, and (3) assess whether these changes relate to global climatic fluctuations. Typical marginal taxa include at various times, poritids, *Siderastraea*, and various 'faviids' *sensu lato*, often mixed with azooxanthellates. Acroporids notably occurred in our Eocene examples from northwestern Europe though they are missing from highest z-coral latitudes today. The foregoing assemblages indicate that the geographical limits of reef corals in the past have fluctuated by up to 18°N and 6°S beyond known respective modern latitude limits (cf. Bermuda c.32°N and northern Tasmania c.40°S). In some cases (e.g. Miocene of the southern margins of Australia) latitudinal expansion coincided with global warming, and thus supports the idea of higher-latitude refuges. On the other hand, recent work on the important z-coral *Acropora* has concluded that their latitudinal limits today are ultimately determined not by climatic factors but by minimum threshold values of solar radiation over winter. Intriguingly, this points to limited scope for expansion beyond present-day latitudes. We discuss ways of resolving these apparently conflicting models.

Tabulate corals from the Shuruk Formation (Upper Ordovician) and Uchkuduk Formation (Lower Silurian) of the Kuldzhuktau Mountains (Kyzylkum Desert)

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In the Kuldzhuktau Mountains the Upper Ordovician and Lower Silurian are represented by all series but due to strong tectonic deformations they are mostly preserved in isolated blocks with faulted contacts and often cannot be observed in continuous sequence. The Upper Ordovician deposits are exposed in the southern and eastern parts of the Kuldzhuktau Mountains where they are referred to the Kazaksu, Shuruk and Oidynbulak Formations. The best documented Upper Ordovician sequence is exposed in the southern part of the Kuldzhuktau Mountains near the Uchkuduk Well where it is referred to the Shuruk Formation. The Shuruk Formation comprises mainly argillites, siltstones and sandstones with some units of conglomerates and limestones which in the upper part of the formation contain tabulate corals including *Lyopora regularis* KIM, *Catenipora tapaensis* (Sokolov), *Agetolites asiaticus* Kim, *Agetolites pjatkovi* Kim, *Palaeofavosites schmidti* Sokolov, *Palaeofavosites globosus* Sokolov, *Palaeofavosites corrugatus* Sokolov, *Palaeofavosites maximus* Tschernyshev, *Palaeofavosites gothlandicaformis* Rukhin, *Palaeofavosites abstrusus* Klaamann, *Palaeofavosites uchkudukiensis* Dzjubo, *Palaeofavosites raritabulatus* Sokolov, *Palaeofavosites* cf. *alveolaris* (Goldfuss), *Multisolenia* cf. *prisca* Sokolov, *Plasmoporella bifida* Bondarenko, *Acdalopora elegantis* Kovalevskii, *Acdalopora breviana* Yü, *Acdalopora* cf. *sokolovi* Bondarenko, S*telliporella* sp., *Protaraea* sp., and the algae *Dimorphosiphon magnum* Gnilovskaya and *Vermiporella* sp. are widespread in the Upper Ordovician of Central Asia, Kazakhstan, Estonia and China.

The Lower Silurian deposits are exposed in the western, southern and eastern parts of the Kuldzhuktau Mountains where they are referred to the Yangikazgan, Darbaza, Dzhangeldy and Uchkuduk formations. The best documented Lower Silurian sequence is also exposed in the southern part of the Kuldzhuktau Mountains near the Uchkuduk Well where it is referred to the Uchkuduk Formation of the Upper Wenlock. The Uchkuduk Formation consists of argillaceous limestones with some units of siliceous. The formation contains tabulate corals including *Palaefavosites* aff. *raikulaensis* Sokolov, *Palaeofavosites* aff. *forbesiformis* Sokolov, *Palaeofavosites felix* Sokolov, *Favosites moyeroensis* Sokolov et Tesakov, *Favosites caelestis* Klaamann, *Favosites* cf. *gothlandicus* Lamark, *Favosites* aff. *adaverensis* Sokolov, *Favosites favosiformis* Sokolov, *Favosites* sp. (aff. *hirsutus* Tchernychev.), *Multisolenia frivola* Klaamann, *Antherolites hemiseptosus* Leleshus, *Mesofavosites obliquus major* Sokolov *Mesofavosites* cf. *verus* Lelshus., *Mesofavosites* ex gr. *obliquus* Sokolov, *Mesofavosites* ex gr. *bonus* Sokolov, *Mesofavosites anuiensis* Dzjubo, *Mesofavosites isokudukiensis* Dzjubo, *Catenipora* cf. *compressa* Sokolov, *Catenipora gothlandica* Yabe, *Halysites* cf. *catenularius* Linne., *Rotalites nuratensis* (Chekhovich), *Pseudoplasmopora* sp., *Innapora* aff. *incredula* (Chernova in Kovalevskyi), *Hemiplasmopora communicata* Ospanova, *Hemiplasmopora* sp. The tabulate assemblages are considered to be Upper Wenlock in age in agreement with occurrences of stromatoporoids, rugose corals, brachiopods and crinoids. The studied collection is represented by widely distributed Wenlock taxa showing relations with described tabulate associations from the Wenlock of the Baltic region, the Urals, Kazakhstan, Siberia, Podolia and Central Asia.

Reef refugia out of the shadows: 30 million years of turbid reefs in the Coral Triangle

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The Coral Triangle region of SE Asia contains the most diverse marine ecosystems on earth. To date most of the mechanisms proposed to explain this hotspot remain untested due to a lack of paleontological data. Furthermore, coral reefs throughout the tropics are severely impacted by anthropogenic environmental change, and therefore active research initiatives are under way to document the response of reef systems to a variety of stressors to help develop priorities for management, mitigation and adaptation. One urgent research priority is the identification of potential ecological refugia – sites able to support diversity and ecological functions over timescales that would allow reefs to adapt, or until mitigation strategies are sufficiently established so that impacts dissipate. Deep mesophotic reefs have been identified as one such potential refugia, but recent work suggests that shallow turbid mesophotic habitats may play a similar critical role. However, contemporary ecological studies struggle to deliver the necessary data to assess species resilience and shifts in such refugia locations because of the timescales over which ecological processes operate. To address this temporal data vacuum and to quantify the viability of shallow water turbid habitats as long-term environmental change refugia, we have focused on the study of the long-term history of turbid reef habitats in the Coral Triangle (CT) region of SE Asia. We have compiled novel data on the ecology, and evolution of reef corals and the environments in which they have lived under the shallow mesophotic conditions that characterised sites within this region during the past 30 million years. This allows us to assess the potential for these habitats to serve as refugia and to do so within the only region globally that has suitable well-preserved palaeontological records. By integrating data from ancient and modern assemblages and applying newly developed tools from biostratigraphy, geochemistry, and phylogenetics we aim to: 1) test the timescales over which coral communities that occupy shallow turbid habitats have persisted, and their response to long-term environmental change such as intervals of increased ocean temperature or rapid sea level change – thus providing a unique test of their long-term ecological resilience; and (2) test how capable the taxa characteristic of these past marginal habitats have been at expanding into proximal clear-water reef settings – thus providing a test of the ecological flexibility of these corals to recolonise clear-water habitat space.

Our large-scale studies of Late Cenozoic reef corals from Eastern Borneo have revealed that the first coral assemblages that occurred in the region were mainly low-relief patch reefs that developed in environmental conditions of low light and high sediment inputs. These shallow turbid habitats hosted a high coral diversity with 100 morphospecies of 55 genera in the Oligocene (9 outcrops, Sabah, Malaysia) and 234 morphospecies of 79 genera in the Miocene (49 outcrops, East Kalimantan, Indonesia). Our analyses have shown that there is no significant faunal turnover at generic level within the studied time interval as 85% of extant genera were already present by the early Miocene. In January and April 2019, we identified and surveyed a mosaic of modern turbid reefs in the region (Darvel Bay, Sabah), gathering a comprehensive new data set that includes about 12 hs of video transects of 750 m^2 of reefs and over 200 coral samples. Preliminary comparisons of ancient turbid reefs with their analogous modern habitats of Eastern Borneo show similarities in richness and fauna composition. Our observations suggest that turbid reefs have played an important role during the origination and maintenance of coral diversity in the Coral Triangle. Moreover, there is increasing evidence that these so-called 'marginal' habitats may act as crucial ecological refugia as Coral Triangle ecosystems respond to ongoing anthropogenic environmental change.

The NHM Fossil Porifera Collection

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Sponges are sessile benthic, filter-feeding metazoans animals that have specific cells to pump unidirectional water flows through their bodies. They have colonized all aquatic habitats, but their success is in seawater. Their tolerance allows them to live in both deep and shallow waters and in cold and warm waters. Thus, the ability to adapt in any environment. The sponge fossil record extends to 635 million years ago, and is considered the oldest multicellular animals to inhabit the Earth. The importance of these animals is their structure, which allowed them to survive until Recent times and their role in the marine environment preventing harmful ecosystems changes.

The NHM has more than 71,000 fossil sponges from all around the world (Africa, Antarctica, Australia, Asia, Central America, Europe, the Middle East, North America, Russia and South America); whose stratigraphical record goes from the Cambrian to Pleistocene. More than 2,000 of them are types and figured specimens and include numerous historical specimens such as the Hinde and Parkinson specimens, published in Hinde and Parkinson's monographs in 1883 and 1808 respectively. The NHM Porifera Collection is the best in the world for Mesozoic sponges and will be very useful to track changes through geological time in the geographical distributions of major sponge clades.

This Collection covers most of the Porifera groups such as non-lithistid demosponges; lithistids; hexactinellids; calcareous; archaeocyaths; and stromatoporoids.

Although non-lithistid demosponges are not normally preserved as fossils, spongin fibers may leave imprints that are found from the Cambrian until Recent. Unlike, lithistid massive skeletons are easier to preserve in the geological record. These reached their greatest dominance in the Cretaceous. The NHM has the most important collection of Cretaceous sponges in the world, with hundreds of non-lithistid demosponges and more than 10,000 lithistids, mostly from Europe and North America. These will be useful to unveil the diverging silicification levels.

Hexactinellids are siliceous sponges that also spread from the Cambrian to Recent. They have been found living in both cold deep and warm shallow waters and have been defined as the oldest lineage of animals alive on earth today. The NHM Porifera Collection has almost a quarter of fossils of this group, mainly from the Mesozoic of Europe.

Calcareous sponges have skeletons with spicules of calcium carbonate that have persisted, as the previous groups, from the Cambrian to Recent and have the biggest diversification in the Cretaceous. Their Mesozoic representation highlights in the NHM Porifera Collection and represents the third biggest group of sponges. Most of them are from Europe, but there are representatives from Asia, South America and the Middle East as well.

Archaeocyaths characterize the first substantial diversification of the phylum Porifera, to which they are now generally assigned as a distinct Porifera class. They flourished in carbonate shelf and reef environments of the early Cambrian and a depauperate stock persisted into the late Cambrian. The Archaeocytha Collection at the NHM contains more than 600 specimens, mainly from Antarctica, Australia, Canada, Morocco, Sardinia, Siberia, Spain and USA. This is one of the richest and most important Archaeocyatha Collections in the world, including a mixture of over 100 cavity slides and thin sections. About a hundred type and figured specimens are present among these specimens (such as Hill, 1965 and Debrenne, 1966).

The extinct class of non-spiculate poriferans Stromatoporoidea appeared for first time in the Middle Ordovician and became abundant and widespread through Silurian and Devonian until they disappeared in the Cretaceous. The NHM Porifera Collection has more than 7000 specimens and contains the most outstanding Silurian stromatoporoids such as the historical Nicholson Collection (1885-1892) on British stromatoporoids.

New data on the Serpukhovian coral assemblages from the northwestern part of the Moscow Basin (Russia)

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Lower Carboniferous rocks are well exposed in the northwestern part of the Moscow Basin. The Serpukhovian Stage is widely represented in that region and it is composed of three lithostratigraphic units: Rovnoe Formation (Tarusian Regional Stage), Poneretka Formation (Steshevian Regional Stage) and Uglovka Formation (Protvian Regional Stage). Coral assemblages from those units are largely known since the last century, but new research in two quarries in the region have provided several rugose and tabulate corals that improve the knowledge on the regional paleontology.

The Zarech'e Quarry is located 7.8 km South-West from Uglovka town and contains marly limestone belonging to the upper part of the Poneretka Formation. The coral assemblage from that quarry shows a low diversity. It is composed of scarce specimens of the tabulate genus *Syringopora*, uncommon specimens of the solitary rugosan species *Dibunophyllum bipartitum* and common specimens of the colonial rugosan genus *Actinocyathus*. Within the last genus, there are representatives of two different species groups, *A. floriformis* and *A. crassiconus*.

The Uglovka Quarry is located 4 km South of Uglovka town and contains limestones and dolomites belonging to the Uglovka Formation. The Uglovka assemblage is composed of common tabulate syringoporoids belonging to the genera *Syringopora* and *Pleurosiphonella*, scarce solitary rugosans of the genera *Dibunophyllum* and *Haplolasma* and common colonial rugosans of the genera *Actinocyathus*, *Lonsdaleia* and *Schoenophyllum*.

The Zarech'e Quarry contains a rich foraminiferal assemblage, where it can be highlighted the occurrence of *Brenckleina rugosa* and narrow *Eostaffellina paraprotvae*, which suggest a Steshevian Substage in the early Serpukhovian. Samples of the Uglovka Quarry contain more evolved assemblages, with common large and rounded *Eostaffellina*, including *E. actuosa* and *E. protvae*, which allow to assign it to the Protvian Substage in the late Serpukhovian.

A free-living coral fauna from the Campanian of western Jamaica

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In the Caribbean, free-living coral communities inhabiting generally soft or mobile substrates are well known from the Modern, Quaternary and Neogene. Indeed, at times in the Neogene, these types of corals constitute a significant part of overall coral diversity in the region. Older free-living coral associations, however, are poorly understood, leaving large gaps in our knowledge of these important coral faunas.

The present study involves ongoing research focusing on a diverse coral association collected from Campanian aged units of the Green Island Inlier of western Jamaica. A calcareous mudrock unit from this area yields a rich fauna of well-preserved molluscs and what appears to be one of the oldest free-living coral communities in the Caribbean. Comparing colony form and growth in these corals to that of more recent analogs can provide critical information concerning their life habit and paleoenvironment.

The coral association includes a thin branched octocoral and approximately 10 different scleractinians. Two tympanoid solitary forms are found cemented to rudist or other bivalve fragments while the rest of the species show little or no attachment surfaces. There are meandroid, plocoid and cerioid circumrotary corals than range up to 5 cm in diameter. These appear remarkably similar to small, spherical colonies found in modern Caribbean grass flat habitats. There are also a series of large turbinate and flabellate forms. One of the most common species are small (5-7 cm diameter), flat-based, domal, hydnophoroid colonies that are homeomorphic with the Cretaceous Tethyan genus, *Aspidiscus*. Sectioning and morphometrics of this form have illustrated its unique pattern of astogenetic development. It develops first as a trochoid, attached coral up to ~2.5 cm high then the growth direction shifts 90^{0}, the colony expands and domes upward, while partially enveloping the trochoid portion that forms the new flat base of the colony.

On the whole, dominant growth forms in the fauna are comparable to modern analogs found in soft substrate habitats. The richness of the fauna suggests that these free-living associations were important parts of Caribbean coral communities in the Campanian.

A solitary coral and large benthic foraminifera association from the Late Eocene of Jamaica

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There are many records of solitary discoidal corals attached at their base to large benthic foramanifera from the Cretaceous through the Paleogene throughout the Tethyan region. In the Eocene, especially, there are numerous examples from throughout the Mediterranean and Indo-Pacific. These typically involve discoid scleractinians, such as members of the Family Cyclolitidae, with their base centered on a large disc or lens-shaped foraminiferan, often *Nummulites* sp. or *Discocyclina* sp. To date, there are no reports of this coral-foraminifera association from the Caribbean. This may be due to the fact that there are very few reports of small discoidal scleractinians from the Caribbean or perhaps because the taxonomic make-up of the foraminiferal fauna is distinct from that of the Tethyan region.

This study presents the first record of a discoid coral settling on foraminifera from the Caribbean. Our material comes from the Late Eocene Somerset Formation near the community of Philadelphia in the parish of St. Ann, Jamaica. The Somerset Formation is a pure carbonate comprised of grainstones and packstones characterized by the abundant fusiform, large foraminiferan, *Fabularia verseyi*. The unit yields a small fauna of mouldic examples of chiefly thin-branched colonial corals and some solitary species. The studied locality is unusual in that it includes some corals preserved as casts. It also contains a flood of the lens-shaped foraminifer, *Lepidocyclina* sp., many of which attain diameters of greater than 1.5 cm.

The discoid solitary scleractinian in this unit has only been found preserved as moulds and thus cannot be identified to species level. Its size, septal arrangement and the porosity of the septa suggest that it is a cyclolitiid. One specimen is 3 cm in diameter and its base is centered on a *Lepidocyclina* specimen 7.3 mm in diameter.

This indicates an extension of the range of these discoid corals into the Caribbean in the Eocene and an extension of their particular settling behaviour as well. It is interesting to note that this coral/foraminifera association involves the genus *Lepidocyclina,* a genus that is evidently not a part of these associations recorded from Mediterranean or Indo-Pacific. This may suggest that in these associations the particular foraminiferal taxon is less important than its size, shape and availability.

From the product to the process: Fine-scale skeletal structures of scleractinian corals and their relevance to biomineralization models, geochemical sampling strategies, and phylogenetic reconstructions

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Interpretation of biomineralization processes based solely on the end product - the skeleton - may seem a breakneck task. This is because the biologically controlled mineralization involves cascades of intermediate phases and the activity of a myriad of organic macromolecules, of which only a fraction is embedded and/or have been identified in the biomineral skeleton; the final product of these processes. Conversely, however, often some tiny differences in skeletal structures provide a hint of distinct biomineralization process, which only in this way can be better characterized. An example is distinct skeletal microstructures of two scleractinian coral groups - gardineriids and micrabaciids - which prompted their inclusion in molecular phylogeny studies that resulted in discovery of their basal position among all other clades of Scleractinia.

This presentation is devoted to the identification of processes involved in the formation of two distinct skeleton regions traditionally referred to as "centers of calcification" (CoC) and "fibers". These structures can be distinguished in all well-preserved skeletons of modern and fossil corals as mostly nanogranular CoCs (in fossils often diagenetically altered) and fibers composed of larger crystals. They occur in essentially all of skeletal parts, including septa, thecal and axial structures witnessing the universal mechanism of hexacorallian mineralization. Elemental labelling of growing skeleton (modern *Stylophora* and *Galaxea*) shows that, contrary to the traditional interpretation that CoCs are formed first in a two-step growth process and subsequently overgrown by fibers, both structures are in fact formed simultaneously but they exhibit very different growth dynamics. The formation rate of CoC is distinctly higher than fibers, which justifies referring to these two structural elements as rapid accretion deposists (RADs) and thickening deposits (TDs), respectively. The structure of RADs is remarkably similar in all scleractinian clades, whereas TDs very often show patterns reflecting the complex calicoblastic ectoderm topography. For that reason, TDs patterns often bear stronger phylogenetic signal than distribution pattern of RADs (but the latter can also be distinct e.g., in flabelliids or dendrophylliids) and may support some well-defined molecular clades, e.g., acroporiids, micrabaciids, flabellids, lobophylliids, pocilloporiids. Furthermore, contrary to some established coral skeleton growth models, the accretion of skeletal layers in corals living in the photic zone takes place simultaneously in RADs and TDs areas during the day and night; this has a significant implication for strategies of precise geochemical skeletal sampling. Tips of septal face granulations, septal edge dentitions, or sharp growing edges, are areas formed primarily by RADs, whereas structures directly adjoining to them are composed of TDs. The skeletal organic matrix in the RADs and TDs regions has different proteomic characteristics, which points to biochemically distinct calicoblastic cell activity in these two regions. The adjacent TDs fibers may show clear boundaries (traditional concept of trabeculae) or show smooth transition (even in the ontogeny of a single skeletal element). Because "trabeculae" are only derivative of differences in the growth dynamics between RADs and TDs, while most relevant information for biomineralization control is included in RADs and TDs structural patterns and their biogeochemical composition, it is not surprising that phylogenetic reconstructions based on the traditional understanding of microstructures have failed in confrontation with modern molecular phylogenetics.

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Phylogenetic and functional significance of the lateral dissepiments of Carboniferous echigophyllid corals from the Akiyoshi Terrane, Southwest Japan

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The Akiyoshi Terrane contains several exotic limestone blocks that were accumulated on the top of isolated seamounts in Panthalassa Ocean during the Early Carboniferous to the late Middle Permian. *Echigophyllum giganteum* was described by Hayasaka in 1925 from the Omi limestone of the Akiyoshi Terrane. Since then, variable growth forms of echigophyllid corals have been examined from the lower Viséan to the Kasimovian in the Akiyoshi Terrane.

The lateral dissepiment is a peculiar character of echigophyllid corals and usually develop on thickened part of septa during the middle to late ontogenic stages. The naotic dissepiments, which are similar to those of Australian Early Carboniferous corals such as *Naoides* and *Symplectophyllum*, occur also in echigophyllid corals from the early Viséan tuffaceous limestones in the Akiyoshi Terrane.

Lateral dissepiments rarely occur in the thickened part of major septa in solitary echigophyllid corals from middle to late Viséan tuffaceous limestones and volcanic conglomerate beds deposited near top of volcanic seamount, which indicate a severe environment. Large dissepimented solitary form that has wide dissepimentarium composed of lateral dissepiments also occur in shallow oolitic limestone during the Late Viséan transgression.

Serpukhovian echigophyllid corals are still solitary forms with a diameter up to 20 mm. Dendroid echigophyllid corals also occur in shallow mounds, which have small corallites with a diameter up to 15 mm. The lateral dissepiments occur in the peripheral area of the corallite, where the septa become thin.

After the regression event, at the mid-Carboniferous boundary, reef complex was dominated on the top of sea mounts. Late Bashkirian echigophyllid corals with colonial forms by peripheral parricidal increasing occur in the reef front facies, as one of reef builders, which have large corallites up to 50 mm in diameter. Numerous lateral dissepiments occur in a wide dissepimentarium where septa are thickened in the inner margin and become thinning towards the wide peripheral area. The dense calcite tissue replaces the vesicular space of lateral dissepiment, which might have two advantages: 1) even in an oligotrophic environment, nutritional energy is useable effectively for skeletal secretion, and 2) keeping strength of the corallites in a high wave-energy environment. These large *Echigophyllum giganteum* could extend up to the Moscovian.

In contrast, in the Kasimovian an asteroid compound form of echigophyllid corals, is associated with abundant ammonoids in the channels of reef edge environment. Corallites are directly connected with each other, and lateral dissepiments develop in the thinner septal areas in a wide dissepimentarium, which might facilitate nutrients intake and also strength of the skeleton in shallow-water, high energy environments.

Echigophyllid corals were thus adapted to the isolated volcanic seamount and the high energy environment of an oceanic reef, during the early Viséan to the Kasimovian.

Pleistocene corals as neotectonics markers in the Red Sea Rift

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Coral reef carbonates represent a significant component of the syn- and post-rift coastal sedimentary record of the Red Sea rift. Fossil scleractinians embedded in reefal limestones and/or associated with poorly cemented sediments permit not only the reconstruction of the former depositional environment, such as the identification of a past shoreline or reef-edge, but at times provide the needed material for dating purposes. The combination of resolving the paleoenvironmental situation and the timing is of paramount importance to disclose the tectonic behavior of the coastal zone.

We have applied this approach to various situations along the Red Sea proper and Gulf of Aqaba, including tectonic islands. Examples of such are: (i) Zabargad island, whose previously-undated Old Reef Limestones have been attributed to the Pleistocene, based on $^{87}Sr/^{86}Sr$ isotopic values, setting an age for its emergence at sea-level, and whose U/Th-dated coral terraces have demonstrated minimum neotectonics since the last interglacial (<125 k BP); (ii) the Saudi sector of the Gulf of Aqaba whose U/Th dating of coral terraces has documented a strong uplift of the coastline since the last interglacial, with paleoseismicity implications. To date, un-recrystallized fossil scleractinians have proved to be excellent markers to assess with a high degree of precision the neotectonics of the Red Sea Rift.

Carbonate Mounds of the Western Melilla Mound Field (Moroccan Mediterranean margin): sedimentary facies and environmental control

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This work was carried out within the framework of the international program of the European Science foundation "COld -water CARbonate mounds in shallow and Deep Time" (COCARDE). It presents the sedimentological and geochemical study of two gravity cores taken from the carbonate mound from the secondary cluster and the main cluster of the western Melilla mound field, that were collected during the MD 194 oceanographic cruise on the R/V Marion-Dufresne (June 2013), funded by the EU FP7 Eurofleets Project GATEWAY.

Binocular microscope investigations, were carried out on 42 samples together with calcium carbonate content, (by calcimetry), particle size, mineralogical (by X-ray diffraction on total rock and fraction <2 μm) and geochemical studies.

The results of this work show that these carbonate mounds are "skeletal mounds", and that the four facies indentified can be related to "Cluster Reef". These facies consist of a dominant matrix and a biogenic phase composed of scleractinian cold-water corals dominated by *M. oculata* and *L. pertusa.*

The matrix is of mixed type: siliciclastic/carbonate (muddy micrite and/or micritic mud) composed of calcite, quartz, kaolinite, illite and chlorite with accessory minerals such as: aragonite, dolomite, feldspar and smectite. The carbonate content ranges from 27 to 47% in the main cluster mound, and from 19 to 43% in the secondary cluster mound. The siliciclastic phase is characterized by the dominance of a very fine fraction (<63μm) and a sandy fraction not exceeding 5%. The carbonate phase consists of micrite and a biogenic fraction composed of bioclasts, e.g., foraminifera and coral fragments. Carbonates partly derive from interbasinal sources: 1) the degradation and bio erosion of corals skeletons and shells and, 2) chemical and microbiological precipitation. The source of the siliciclastic components are out cropping geological formations of the kert and Boudinar basin, the Temsamane massif, the Gourougou and Cap des Trois Frouches volcanoes forming the hinterland of the Betoya Bay and the Sahara. The transport was provided by winds and fluvial currents that were relayed by bottom currents, the anticyclonic eddy and upwelling currents.

The evolution of the carbonate mounds during the Pleistocene and Holocene was controlled by tectonics, climatic fluctuations (e.g. Dryas and the Holocene climate optimum), eustatic variations and hydrodynamic regime.

Extinctions and recovery of corals during the Pliensbachian-Toarcian crisis

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The transition from the Pliensbachian Stage to the Toarcian Stage of the Early Jurassic is followed by a global Oceanic Anoxic Event during the lower Toarcian (TOAE for Toarcian Oceanic Anoxic Event). This moment corresponds to a time of massive organic matter fossilization globally that, in places, produced source rocks of petroleum interest, as well as second-order maximal flooding zone in eustatic sea level. The TOAE is also interpreted as a global carbon-cycle perturbation event associated with an oceanic acidification and correlated with the eruption of the Karoo-Ferrar large igneous provinces in southern Pangea (present-day Southern Africa and Southern America). The event corresponds to a period of global warming that directly follows a global cooling in the Pliensbachian. This worldwide ecological perturbation probably disturbed the biosphere to a degree that is still poorly quantified, with some notable exceptions such as ammonite, foraminifera, and bivalve studies. Furthermore, poor stratigraphic definition generally makes it difficult to distinguish the biotic effect of the Pliensbachian-Toarcian boundary from the TOAE. Concerning corals, purely bibliographic studies suggest a significant extinction event for this group at the same period. Corals are generally valuable indicators for major ecological disruptions, especially in the case of the big-five biotic crises and the current sixth one. Until now, the Pliensbachian-Toarcian extinction has been considered as a second-order crisis event, but more extensive paleontological work requires a reassessment of the coral turnover.

In the context of a thesis, fossilized corals have been collected in the field in Morocco and Italy in a well-defined sedimentological context before and after the Pliensbachian-Toarcian boundary. Sampling was conducted with the aim of quantifying the diversity and as far as possible, the intraspecific variability. The data were statistical analyzed to provide quantifications of the taxonomic variability and to compare populations in analyses of diversity, extinctions, and appearances of taxa. In total, 107 species have been described (including at least 19 new species) as part of 60 genera (including 5 new ones) among 22 families (including a new one).

According to this study, the relatively cold, organic matter-rich waters of the Pliensbachian epicontinental seas contained coral faunas with a strong affinity to Triassic faunas (in terms of genera and families). They shared the ecological niches of the western Tethyan inner platforms with the lithiotids, a group of highly specialised reefal bivalves that demonstrated a stupendous evolutionary success during the same period. Collected data attest to conditions that required corals to adapt and diversify during unfavourable times, which were beneficial to solitary and phaceloid forms but detrimental to the highly integrated forms.

During the Lower Toarcian, global warming of oceanic waters associated with the almost total extinction of the competitors predated an explosion of diversity. This radiation was critical for the future of corals, with the appearance of faunal assemblages similar to typical Middle and Upper Jurassic assemblages (in terms of genera, families and colonial morphologies). For corals, the event occurs in two steps, with the first phase during the Pliensbachian –Toarcian transition and a second phase at the onset of the TOAE. Ultimately, this pulsed event led to the extinction of approximately 97% of the Pliensbachian coral species.

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Exceptional diversity of deep-sea corals, bryozoans and serpulids from the Great Bahama Bank

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During the last two decades cold-water coral (CWC) bioconstructions and the related deep-sea carbonate mounds have been subject of intensive research. Data collected in hundreds of oceanographic cruises have highly increased our knowledge on the ecology of frame-building deep-sea corals and on the environmental factors that allow them to create large bioconstructions. CWC habitats are well known for hosting diverse ecosystems. However, modern and fossil calcifying organisms associated with CWC communities are still poorly understood despite their importance as indicators of environmental and paleoenvironmental modifications through space and time.

This study focuses on benthic associations collected, through box-coring and ROV diving, from the Great Bahama Bank (GBB) slope during the MSM20-4 oceanographic cruise carried out in 2012 aboard the R/V Maria S. Merian. In this area mound-like structures up to 50 m high occur at around 580–680 m depth. Most of them consist of rocky cores covered by up to 2 m-thick coral-rich deposits. Live coral ecosystems seem presently restricted to depths shallower than 630 m, but the large amount of coral rubble occurring on deeper mounds implies the existence of deeper flourishing coral bioconstructions in the recent past.

Stylasterids, calcifying octocorals, solitary scleractinians, bryozoans and serpulids, associated to three frame-building CWC species (*Desmophyllum pertusum, Enallopsammia profunda* and *Madrepora oculata*), have been analysed in detail. With respect to the typical CWC mounds from the NE Atlantic (such as the Porcupine Seabight) and the Mediterranean (Santa Maria di Leuca, Alboran Sea), the GBB benthic associations are characterized by higher diversified corals found both as living and dead specimens. Both the diversity and the relative high abundance of dendrophylliids hint at affinities with upper Miocene deposits from the Mediterranean. However, further studies need to be carried on the fossil record to confirm this hypothesis. Also bryozoans and especially serpulids are highly diversified. Bryozoans consist of at least 60 species of cyclostomes and cheilostomes, including 25 collected with living specimens. Most of them are new species and/or belong to still undescribed genera, as demonstrated by the family Cribrilinidae, represented by four species strictly associated with corals, leading to the description of two new species (*Glabrilaria hirsuta* Rosso, 2018 and *G. polita* Rosso, 2018) and one new genus (*Teresaspis* Rosso, 2018). Among serpulids and spirorbids, more than thirty species have been recognized of which one third with living specimens. Most of them belong to genera with a wide geographical and stratigraphical distribution going back to the Early Ceonozoic (*Vitreotubus*) and even to the Mesozoic (*Janita, Protula, Placostegus, Neovermilia, Neomicrorbis*). Several species are new to science and some of them have very particular features of uncertain generic attribution. Due to the little data available worldwide on bryozoans and serpulids associated to CWC, comparisons with other regions and with fossil associations are at this stage very difficult. However, it is worth noting that several taxa at genus or higher rank are absent in the present-day Mediterranean while affinities have been observed with some Early Pleistocene Mediterranean deposits.

Morphological characters and ontogenetic development of deep-sea species of the genus *Caryophyllia*

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The genus *Caryophyllia* is known from shallow- to deep-waters in all oceans and seas of the planet and it includes 66 valid Recent species. Though frequently reported as fossil, at least since the Upper Jurassic, the distribution of valid *Caryophyllia* species in the paleontological record is still unknown. Only considering the Neogene and Pleistocene deposits of the Mediterranean, over 100 species are mentioned in the ancient literature but they have never been revised following modern taxonomic concepts.

The diagnostic taxonomic character that distinguishes the genus *Caryophyllia* from the other genera of the family Caryophylliidae is the presence of pali before the penultimate, rarely the antepenultimate cycle of septa. Mitochondrial 16S rRNA phylogeny analyses of modern species support grouping *Caryophyllia* in one clade, however, two other taxa included in this clade (*Crispatotrochus rugosus* and *Dasmosmilia lymani*) do not develop pali (*Crispatotrochus*) or develop structures called paliform lobes before all but the last septal cycle. The distinction between pali and paliform lobes remains ambiguous not only in *Caryophyllia* but in several other scleractinian taxa. For that reason, precise documentation of ontogenetic development of both skeletal structures is of general importance for scleractinian coral researchers.

This study aims at describing the morphological variability and ontogenetic development of deep-sea *Caryophyllia* species collected from Pleistocene deposits of southern Italy and from modern seafloors of the Mediterranean and the NE Atlantic. By analysing SEM and micro-CT images, as well as polished and thin sections, particular attention has been devoted to (1) the micromorphology of the coral wall and calicular features and (2) the arrangement and ontogenetic development of pali.

The role of Oligocene-Miocene staghorn corals (*Acropora*) of Florida USA in Cenozoic reef diversification and change

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The staghorn coral genus *Acropora* has come to dominate coral diversity and even influence the architecture of modern reefs, however its species are particularly vulnerable to environmental change associated with elevated sea surface temperatures and human activities. *Acropora* has a geo-history of strongly persistent morphological lineages, beginning in the Western Tethys at least 60 million years ago and tracking major geographical shifts to appear and diversify in new locations in the world's oceans. Although only two species of *Acropor*a remain in the western Atlantic today, the fossil record there indicates that diversification also occurred in the region. Here we explore one of the centres of this diversification, in what is now the North American state of Florida, finding up to six well-defined species, from reefal deposits from the early Oligocene to the Miocene-Pliocene turnover event (a passage of 28.6 mya). The two current western Atlantic species *Acropora palmata* and *A. cervicornis* became the only representatives of the group outside of the Indo-Pacific from around the time of the Miocene-Pliocene turnover. We also examine specimens from Georgia and coastal Mexico in the same time period. We allocate the fossil species to putative species groups and examine their history and biogeography to ask what impact these lineages may have had on the evolution and biogeography of the genus *Acropora* and its smaller sister genus *Isopora* in the Indo-Pacific.

Methods, results and conclusion: Specimens were examined in the Florida Museum of Natural History, University of Florida, Gainesville, Florida and the United States National Museum of Natural History (USNM), Smithsonian Institution, Washington DC. Specimens borrowed from USNM were also used for study in Australia. Material examined included types of already named species and collections of unidentified material from both museums. Two new species discovered from the lower Oligocene Suwannee Limestone, are possibly the oldest species of *Acropora* to date in the Americas and other species from Miocene deposits indicate a diversification of the genus in North America. We discuss this Florida material in comparison with the other material from the North American continent, including Georgia USA and Mexico.

Latest Permian rugose corals from West Tibet (Xizang) of Southwest China and end-Permian extinction of rugose corals

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We described in this study a special rugose coral fauna from the Gyanyima section in the Ngari region of southwestern Tibet (Xizang), South West China. This coral fauna is assigned to three genera and 11 species, including a new genus and seven new species. They are: *Waagenophyllum* (*Waagenophyllum*) *ngariense* He, *W*. (*W*.) *elegantulum* He, *W*. (*W*.) *minutum* Zhao, *W*. (*W*.) *tachtabulasicum* Ilyina, *W*. (*W*.) *gyanyimaense* n. sp., *W*. (*W*.) *intermedium* n. sp., *Waagenophyllum* (*Liangshanophyllum*) *clisicolumellum* n. sp., *Ipciphyllum naoticum* n. sp., *I. floricolumellum* n. sp., *I. zandaense* n. sp. and *Gyanyimaphyllum crassiseptatum* n. gen. n. sp. Ontogeny and intraspecific variation are given special attention when describing and discussing these taxa. Coral reefs, with *Waagenophyllum* as the major skeletal reef builder, occur in several horizons in the uppermost part of the section. The accompanying foraminifers indicate the rugose coral fauna is a Late Permian Changhsingian age. Therefore, this is possibly one of the latest Permian rugose coral reefs in the world known up to now.

Rugose corals are major benthic fossils in the Paleozoic and are considered sensitive indicators of environmental changes. There was a dramatic extinction of these corals at the end of the Permian; all the taxa in this group disappeared below the Permian–Triassic boundary. Using the published data and the results of our recent studies, the extinction patterns of these Permian corals, in China, are summarized. Depending on the changes in the depositional environments, there are four different extinction patterns of rugose corals at the end of the Permian. The general pattern from the Middle Permian (Guadalupian) to the end of the Permian is the disappearance first of massive forms, followed by fasciculate forms, and lastly solitary forms. The other three patterns differ from this general pattern as follows: (1) first fasciculate forms disappear, then massive forms, and last small solitary corals; (2) massive forms disappear first in the middle Changhsingian and fasciculate forms persisted until the end of the Changhsingian, and there are no small solitary forms; and (3) only small solitary corals occur in the Lopingian and survived until the end of Permian.

Preserved live-live interactions in Middle Permian fasciculate rugose coral clusters (Oman Mountains) – Is it real?

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In the fossil record, the recognition and differentiation of live-live interactions is difficult to prove, as neighbouring reefbuilders preserved in rocks must not have grown at the same time.

In this study, the fasciculate rugose coral *Praewentzelella regulare,* found in exceptionally preserved Middle Permian reef blocks of the Oman Mountains, provides evidence for intraspecific biotic interactions. The body of data presented here includes:

(1) quantitative outcrop data of coral coverage and distribution patterns of rugose coral calixes,

(2) serially cut slabs of one reef block which allow to detect spatial trends in framework development like vertical coral growth or encrustation/erosion patterns

(3) complementary petrographic observations from thin sections.

The data will be used to discuss whether or not aggressive live-live interactions between different individuals of the rugose coral *Praewentzelella regulare* have the potential to be recognized in fossil reef assemblages.

Coral composition and diversity of Mississippian coral bioconstructions

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During the Phanerozoic, the most persistent development of metazoan-reef ecosystems occurred from the Ordovician to Devonian, when stromatoporoids and corals were dominant constituents. This stromatoporoid-coral ecosystem collapsed and disappeared during the Late Devonian Frasnian-Famennian and end-Devonian Hangenberg mass extinction events, respectively. The succeeding Mississippian has been viewed as a metazoan "reef gap", dominated by microbial bioconstructions. Recent studies recognized a variety of metazoan reef types in the middle-late Mississippian (Visean-Serpukhovian stages), which are constructed mainly by corals. In this study, the coral genera and species of global Mississippian coral bioconstructions were comprehensively reviewed in high resolution, in order to unravel the changes in the coral composition and diversity of the coral bioconstructions during this time. In total, 64 species belonging to 33 genera were documented. The dominant constituent is colonial rugose corals, with 44 species of 16 genera. During the early Visean, the diversity of reef corals is low, and it is limited to few species of colonial rugose (*Siphonodendron*) and tabulate (*Michelinia* and *Syringopora*) corals. In the middle Visean, their diversity is slightly higher, with increased species diversity in colonial rugose corals majorly in the genera *Siphonodendron* and *Lithostrotion* and few solitary rugose and tabulate coral species. During the early late Visean (Asbian Substage), the diversity of reef corals dramatically increases and reaches into a peak value during the late Asbian. This phenomenon is present in colonial rugose, solitary rugose and tabulate corals, but again the driving factor is the massive appearance of *Siphonodendron* and *Lithostrotion* species. The increase in the late Asbian reef coral diversity is consistent with the proliferation of coral-reef ecosystems during this time. Then, the diversity of reef corals gradually decreases continuously into the Serpukhovian. In the late late Visean (Brigantian Substage), reef corals are characterized by colonial rugose coral species of the genera *Siphonodendron*, *Lithostrotion* and *Diphyphyllum*. During the Serpukhovian, reef corals consist of various genera and species without a dominant component, but species of *Siphonodendron* almost disappear from the coral bioconstructions. This overall latest Visean-Serpukhovian falling trend of reef coral diversity corresponds to the decline of coral-reef ecosystems during this interval, and their collapse at the end of the Serpukhovian.

A Slowly Closing Taphonomic Window: Patterns in the Fossil Record of Cnidarian Medusae

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Jellyfish (cnidarian medusae) occur in immense numbers in modern oceans, with some taxa having a virtually global occurrence. Due to their remarkable reproductive capacity, medusan populations can quickly "bloom" to very large sizes when conditions are favourable, to the extent that jellyfish blooms have become a significant issue for people and economies in some regions.

In spite of their abundance in modern marine settings, medusae have a very poor fossil record, because they possess almost no mineralized hard parts and quickly decay or are scavenged after death. Medusae have been around since at least the early Cambrian, yet even in the hundreds of known *Konservat-Lagerstätten* the Cnidaria are among the rarest major metazoan phyla. Although there have been some new discoveries of fossil medusae in recent years, they are still only known from about 12 distinct fossil deposits (or groups of related deposits), where their presence is an indicator of very unusual preservational conditions.

The fossil jellyfish literature is marred by a very high "noise to signal ratio": many of the things that have been published as medusae actually represent other phenomena, such as scratch circles, gas release structures, trace fossils, and other body fossils. To develop a good understanding of the actual jellyfish fossil record, we have been working over the past decade to review all occurrences. In each case we have applied recognition criteria that include both morphology of the structure, and evidence that the palaeoenvironment and taphonomy are consistent with interpretation as a preserved medusan.

From this curated record, we have assessed taphonomic patterns through time, to understand the factors that permitted (or prohibited) preservation of these unusual fossils. All fossil medusan occurrences are within a limited suite of palaeoenvironmental settings: deeper mud-dominated subtidal settings, shallow to emergent sandy coasts, and muddy lagoons or estuaries. In the Cambrian and Ordovician, several jellyfish occurrences are known from varied environments, including deeper shelf, sandy beach, and muddy lagoon to tidal flat settings. In the later Palaeozoic, medusae were no longer preserved in coastal sands, but they still occur in lagoon/estuary and in restricted subtidal facies. Jurassic jellyfish are sometimes splendidly preserved, but only in muddy lagoon settings. The sole post-Jurassic medusan occurrence is in the Eocene Monte Bolca *Lagerstätte* of northern Italy, which also represents a lagoonal environment. No definite jellyfish fossils are known from the last forty-plus million years. Recent discoveries of additional fossil medusans have confirmed this picture, as all are from periods and facies in which jellyfish fossils were already known.

The palaeoenvironmental pattern of fossil jellyfish distribution indicates that they had the potential to be preserved (though rarely) in a variety of environmental settings in the early Palaeozoic, but that the range of settings gradually diminished through the Palaeozoic and Mesozoic, with jellyfish preservation becoming virtually impossible by the mid-Cenozoic. We can thus think of jellyfish fossilization as a "taphonomic window", which was never open very wide in comparison with the preservation of other groups, but which progressively closed as conditions changed in various marine environments.

These changes were probably mostly related to the evolution of other groups of organisms. Notably, shoreline scavengers such as eurypterids, euthycarcinoids, and gastropods had evolved by the later Palaeozoic, and these were joined in the Mesozoic by shore crabs and birds. Also, burrowing of marginal marine substrates has increased considerably in intensity and depth through the Phanerozoic: Cambrian nearshore ichnofaunas were largely limited to the outer parts of marginal-marine environments, but these moved toward land from the Ordovician onward. Both shallow and deep marine substrates saw the development of more complex, deeper, more pervasive burrowing.

These patterns in the evolution of "jellyfish scavengers" and "jellyfish disturbers" were undoubtedly associated with evolution of the communities of microbial and small invertebrate decomposers inhabiting the upper parts of marine substrates, resulting in a considerable increase in the efficiency of organic degradation in the environments where medusae were occasionally fossilized in previous times. In the modern world, dead jellyfish are now either eaten or decay quickly; is there anywhere on Earth today where a jellyfish might become a fossil?

The medusan fossil record is sparse, but it still reveals substantial and significant information about cnidarian evolution, and also about changing processes in the marine realm.

Preservational Settings of Fossil Jellyfish (Cnidarian Medusae) in Upper Carboniferous (Pennsylvanian) Strata of the North-Central United States

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The palaeoenvironmental occurrence of fossil cnidarian medusae (jellyfish) changed through geological time, as preservational conditions became less favourable through the Phanerozoic. The broad distribution of medusan fossils from various marine palaeoenvironments in the Cambrian was, by the Jurassic, replaced by occurrence only in muddy lagoonal settings such as those of the Solnhofen lithographic limestones. The several known medusan occurrences during the Carboniferous Period, an approximate midpoint between these extremes, strongly impact our understanding of factors that affected the jellyfish fossil record.

In the North American midcontinent, exceptionally preserved medusae occur in shales, but in two very distinct types of palaeoenvironmental settings. The first setting includes the well-known jellyfish from siderite nodules of the Francis Creek Shale of Illinois (Middle Pennsylvanian, Moscovian), part of the Mazon Creek Lagerstätte. This unit was deposited in a tidally-influenced proximal marine to estuarine setting, and the medusae are associated with a great diversity of other fossils representing marine, brackish, freshwater, and terrestrial environments.

Medusae preserved in the second palaeoenvironmental setting occur in black and grey shales representing subtidal shelf palaeoenvironments. These include an Indiana exposure of the Mecca Quarry Shale (Middle Pennsylvanian, Moscovian) that was deposited in offshore to nearshore shallow marine conditions, and Iowa and Nebraska exposures of the Stark Shale (Upper Pennsylvanian, Kasimovian) that represent offshore locations and shallow (<10 m) to intermediate depths. In both units, medusae are associated with other fossils such as inarticulate brachiopods, ammonoids, arthropods, fishes, and plants.

In the Mazon Creek, pyrite- and siderite-mantled fossils were preserved by rapid burial and early mineralization. Two medusan taxa are known: *Anthracomedusa turnbulli* (a cubozoan) and *Octomedusa pieckorum* (a hydrozoan or scyphozoan); other forms previously described as medusae should be re-assigned to other cnidarian or non-cnidarian groups. Fossils within the nodules have relief, with the lower portion of each nodule preserving an impression of the underside of the organism. Careful examination indicates varying degrees of decay, and the best fossils formed very early in the decay process. Some fossils possess thin films of dark microcrystalline pyrite on their surfaces.

Interestingly, the jellyfish from the Mecca Quarry Shale, *Anthracomedusa* sp. cf. *A. turnbulli,* belongs to the same cubozoan genus as some of the Mazon Creek medusae, allowing the different modes of preservation to be compared. In the Mecca Quarry Shale specimen, the incorporating black shale is weakly carbonaceous, with minor barite cement and authigenic pyrite and phosphatic skeletal material. The fossil is a compression, but the body cavity is filled with quartz sand that had been ingested by the animal before or during death (probably in an emergent sandy coastal setting, prior to transportation to and redeposition in the shelf muds). Authigenic sphalerite forms cements and mantles grains from within the body cavity, and along the margins of interpreted organs. The eye and associated structures are primarily composed of fine gypsum or anhydrite. Margins of pedalia and tentacles are defined by sphalerite overgrowths, with elevated carbon levels in the axis of the tentacle, which is darker black relative to the host rock.

The medusae from the Stark Shale, *Prothysanostoma eleanorae* and *Prothysanostoma*? sp., are both interpreted as stem-group rhizostomes. In the latter specimen, the margins of its oral arms are clad in minor authigenic sphalerite and silt-sized quartz, with rare authigenic pyrite. Its preservational characteristics are thus similar to those of the Mecca Quarry Shale cubozoan. The unusual mineralogy might be a clue to understanding soft-tissue preservation in these black shales; these units are unusually enriched with minerals incorporating heavy metals and it seems that these, particularly sphalerite, could have fostered early soft-tissue mineralization in these rare fossils.

State of the Art of Scleractinian Taxonomy

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The taxonomy of Scleractinia reflects the progress of our knowledge about them. Since the first data on these organisms, more than four centuries ago, until the middle of the 19th century, the taxonomy's development was insignificant. It then grew exponentially but is far from addressing all known concerns. It exemplifies the S-curve phenomenon and requires additional attention. Initially, taxa were based on brief morphological descriptions of scarce material found in wave casts on beaches or captured during fishing. The taxonomy was purely typological. In the beginning of the 20th century, investigators entered into the scleractinian natural habitat and established corallum variability, which caused difficulties for species identification, and led to introducing the intraspecific category of forma. Skeletal microstructure was applied as the basis of higher classification. Paleontologists took a leading role in Scleractinia taxonomy. T. W. Vaughan with J. W. Wells published in 1943 a genus-level treatise. In 1956, J. W. Wells followed with another genus-level treatise. By paying attention to micromorphology and microstructure of classical collections and new field work, J. Alloiteau founded the Parisian coral school, whose members studied scleractinians and other corals of all geological periods, and he published a genus-level treatise. It became evident that reliable sampling is the first *condicio sine qua non* for a successful coral taxonomy. His successor J.-P. Chevalier also started studying extant corals, realizing the most complete research on skeletal variability and synthesis of scleractinian knowledge ever produced, accompanied by a genus-level treatise. The two leading schools were publishing in different languages and unfortunately did not apply the same research methodology. An actuopaleontological study on Cuban Scleractinia established frequent good coral presence to a depth of 70 m and deeper, helping disprove the ecological axiom that, in tropical waters, the coral world disappeared after 40 m. The sampling strategy to collect all phenotypes established intermediate coralla that "didn't fit in the drawers" of described discrete morphospecies. The researcher's focus moved from thinking about static coral species to the dynamics of coral speciation. J. E. N. Veron's team, dedicated to living corals, published a series of monographs on Indo-Pacific Scleractinia, their zoography and phenotypic variability. The end of the 1970s brought international symmetry in rejection of the typological species concept by several coral researtchers. The toolbox for coral taxonomy was enriched by the end of the century with surprises from extant representatives: reticulate speciation, molecular systematics, harmonising skeletal and molecular data, introgressive hybridisation, and ecology. A holistic species approach gave rise to integrative taxonomy.

Frequently, taxonomic operations are accompanied by nomenclature procedures. The latter are guided by the International Commission on Zoological Nomenclature and its Code. Taxonomic decisions are subjective by virtue of being dependent on researchers and require refinement. Applying both taxonomic procedures, "lumping" or "splitting" is equally correct when justified. Taxonomy gains efficiency by applying the concept of phenoide as a graphic presentation of structure and dynamic of species, and when coral variability receives attention on different levels of biological organization, in all aspects (phenotypic, genotypic, ontogenetic, pathological, reproductive, and hybridization). Phenotypic plasticity and intraspecific variation are not the same thing. Future studies are needed to understand the nature of the relationship between morphological and genetic distances.

Evolution shapes biodiversity in different ways (morphology, genetics, behavior and physiology). Understanding of the speciation process progressed through the concepts of fixism, evolutionism, reproductive isolation and hybridization. The latter is not less beneficial than mutation, because it can speed speciation. In fact, it has been proven to be active, which makes its elucidation important during this global decline of coral life. The concept of a "Tree of Life" transforms into a notion of a "Tangled Tree." Evolution is promoted by innovations and not recovery, which should shape the taxonomy of higher categories. The Scleractinia taxonomy is complicated by a holobiont nature of intricate symbiosis, in three players, as well by chimerism, bidirectional sex change and hermaphroditic spawning by gonochoric species. Our understanding, and the taxonomy, would benefit from collaborations on scleractinian historical ecology, symmetry, patterns, color, life history, reproduction, apoptosis, participation in reefs, sources of biodiversity, the evolutionary role of natural selection, the probability of aesthetic selection and coloniality as a primitive form of social selection of these organisms.

Line intercept transects and photo-quadrats in MIS5e coral reefs: a methodological comparison

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All over the world, corals are suffering as a consequence of global warming due to increased atmospheric CO_2 concentrations. For monitoring and prediction of future trends it is necessary to quantify the amount and speed of this change statistically. Line intercept transects (LIT) and photo-quadrats (PQ) are both methods widely used in modern coral reef monitoring. PQs are more time consuming, but are more precise for assessing coral cover and biodiversity. Comparison of fossil and modern reefs is key for the understanding of future responses of reef corals to climate change on a community level. An application of the same methods in the modern and fossil reefs allows direct comparison. The application of PQs in fossil reefs might result in different outcomes when analyzing coral biodiversity and composition. To evaluate whether the applied method affects the data in a significant amount, we analyzed a fossil coral reef from the last interglacial in Egypt using both, LIT and PQ. The results highlight where the two methods differ and where they deliver identical results, aiding in the decision when the extra effort needed for PQs over LITs is a worthwhile investment or not.

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