ABSTRACT BOOK

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Le Castella (KR), Italy, 2-6 September 2024

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13th Symposium on Fossil Algae

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ABSTRACT BOOK

Edited by:
Pietro Bazzicalupo
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Contents

Geological record of rhodolith-dominated deposits

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Keywords— Rhodolith/maerl beds, coralline algae, CO_2, ocean acidification, warming

Rhodolith beds are complex habitats from coastal areas to deep outer platform settings. Several studies highlight that these habitats are endangered as a consequence of global change, mostly due to global warming, CO2 content, and ocean acidification. In contrast, other metanalysis studies show that negative effects of global changes to the development of rhodolith beds are not clear yet.

From the oldest record of coralline algae in the Lower Cretaceous onwards, the global temperature, ocean pH, and CO2 content have varied, sometimes experiencing drastic shifts. Therefore, the geological record of coralline algae offers the possibility to analyze the long-term relative abundance of rhodolith beds and compare the patterns with the Cretaceous-to-Recent temperature, CO2 and pH estimations. Data, mostly concentrated in the Tethys-Paratethys-Mediterranean domain, were extracted from published papers. The oldest rhodolith beds, made up of nodules and unattached loose branching corallines, are from Albian (Lower Cretaceous) deposits. From the Coniacian (Upper Cretaceous) to the Langhian (Middle Miocene), the abundance of rhodolith beds fluctuated depicting a general increasing trend. This trend is punctuated by two substantial expansions in the Priabonian (Late Eocene) and during the Aquitanian-Langhian (Early-Middle Miocene). After the Langhian maximum, the number of rhodolith beds sharply declined to a minimum in the Zanclean (Early Pliocene). During the Pleistocene, their abundance recovered to values similar to those reached in the Langhian.

The general increase in rhodolith beds up to the Langhian maximum correlates well with global temperature and pCO_2 declines and with the ocean pH increase. The tectonic activity leading to important paleogeographic changes in the Tethys-Parathetys-Mediterranean realm might account for the Serravallian-Zanclean downfall of rhodolith-dominated deposits.

Our results show that these ecosystems survived successfully in a highly changing world. The rapid acclimation of particular taxa to environmental changes and the variable reaction of taxa distributed at different water depths could have been crucial to foster rhodolith-dominated deposits.

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Concentrations of *Paraphyllum amphiroaeforme*: Cretaceous analogues of modern maërl beds

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Keywords— Coralline algae, Vimport facies, Gilău Mountains, Romania

In the eastern part of the Gilău Mountains (northern Apuseni Mountains, Romania), about 3.5 km SW Gilău village, upper Santonian-lower Campanian (Upper Cretaceous) shallow-marine carbonates are exposed. The stratigraphic sequence consists of terrigenous deposits, $\sim$ 3.5 m thick, overlain by $\sim$ 13 m thick carbonates made up of centimeter- to decimeter-thick packstone-grainstone beds. These carbonates are dominated by rudists, corals (locally forming small bioconstructions), algae (corallines, dasycladaleans, and peyssonneliaceans), benthic foraminifera, serpulids, bryozoans, echinoids, and sponges. Occasionally, their siliciclastic content is relatively important. Among coralline algae, *Paraphyllum amphiroaeforme* is the most abundant species, followed by *Sporolithon* spp. The latter species occur as fragments of crusts and branches and forming rhodoliths dispersed in the sediment.

P. amphiroaeforme shows a distinctive branching growth habit internally characterized by long and thin cells in the core of the branches surrounded by a thin peripheral region made up of small, rectangular cells. Occasionally, dichotomous ramifications are preserved. A sorus with sporangial cavities fused together has been observed in one branch. *P. amphiroaeforme* occurs both as isolated branches dispersed in a packstone matrix and as dense concentrations of well-preserved loose branches in a packstone matrix. The growth form of *P. amphiroaeforme* makes these concentrations a close analogue of present-day maërl beds.

During the Aptian-Albian, *Paraphyllum amphiroaeforme* together with *P. primaevum, Kymalithon belgicum, Agardhiellopsis cretacea, Hemiphyllum atacicum* and *Sporolithon rude* dominated coralline algal assemblages. Poignant (1979) defined them as the "cortège caractéristique" of the so-called Vimport facies. In the central and western Tethys, the dominance of this algal assemblage lasted during the Upper Cretaceous. The former four species show similar growth forms and their concentrations are equivalent to the recent maërl beds. It is, therefore, most likely that during the Cretaceous they played similar ecosystem functioning roles as in the present-day.

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To be or not to be, the question of reproductions in Lower Jurassic Dasycladales, the case of *Palaeodasycladus elongatulus* (Praturlon) from Italy

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Keywords— Dasycladales, *Palaeodasycladus elongatulus*, Central Apennines, reproductive organs.

The Central Apennines is a mountain chain located in the Italian regions Lazio and Abruzzo. Stratigraphically the chain lies on a Triassic dolostone, and it is characterized by massive carbonates. The Latium-Abruzzi Domain is one of the paleogeographic domains in the Central Apennines includes the Lower Jurassic "Calcari a Palaeodasycladus" Formation. This Formation is characterized by shallow-water carbonates, biomicritical limestones and by the presence of oncoids, dasycladeans algae, ooids and fragments of gastropods or bivalvs. *Palaeodasycladus* is a typical genus of dasycladaleans algae that are found in Triassic-Jurassic (Norian-Pliensbachian) sediments of the Central Apennines.

The taxonomic history of the species related to *Palaeodasycladus* has been controversial. Diagnostic characters such as the shape of tallus, shape and dimensions of primary laterals, number of laterals, the kind and discontinuity of calcifications, and the kind and position of reproductive organs are a matter of debate. In the past, several authors proposed different attributions, for example including *P. elongatulus* into *Teutloporella* genus, which was then rejected due to the presence of third order laterals (Barattolo et al, 1994). Still, the main controversy is related to the attribution of *Palaeodasycladus elongatulus* Praturlon (1966) as a variety of *Palaeodasycladus mediterraneus* (PIA, 1920). Principal similarities between *P. elongatulus* and *P. mediterraneus* are the basic morphology and the arrangement and mode of ramification of the branches. The main differences stand in the shape of the thallus, which is thinner and slenderer in *P. elongatulus*, and the shape of laterals, specially of second and third order, which in *P. elongatulus* are very thin and long.

Here we analyze *Palaeodasycladus elongatulus* specimens occurring in samples taken in two different localities from Abruzzo Region: 1) Monte Palombo, type locality of the species, near Pescasseroli (41°50'31.12"N 13°48'39.45"E, samples BA.4415 and BA.4416) and 2) Corno Grande in the Gran Sasso massif (42°28'19"N 13°33'56"E, sample BA.598). The specimens analyzed are contained into 25 thin sections of limestone labelled DiSTAR-BA (Department of Earth Sciences Environment and Resources, University of Naples Federico II, Barattolo Collection). The genus *Palaeodasycladus* is characterized by a club-shaped thallus made by a wide rounded head attached to an almost cylindrical narrow stem. Primary laterals, when preserved, are rather inclined. Secondary and tertiary laterals would follow the primary ones. In the swollen upper portion of the thallus only tertiary laterals and part of the secondary ones are apparent. No trace of reproductive organs is detected. Therefore, we suppose cladosporous reproduction. The main difference between *Palaeodasycladus* and the coaeval *Eodasycladus* Cros and Lemoine, is the occurrence of one external gametophore set terminally to the primary lateral of this latter genus.

In keeping with the emended diagnosis, we suggest that several species formerly ascribed to *Palaeodasycladus* should be safely moved to *Eodasycladus* (Barattolo et al., 1994, 2012). *P. elongatulus* from type locality displays characters fitting well with the description given by Praturlon (1966) and the characters of the genus *Palaeodasycladus*. The specimens from the Gran Sasso are strictly comparable with those from type locality but clearly display terminal gametangia like in the genus *Eodasycladus*. Therefore, in the face of a morphological identity at species level the two populations studied should paradoxically belong to two different genera. A hypothesis to explain such a puzzling condition is prospected. Additional Lower Jurassic genera are here discussed for the presence of external gametangia.

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The oldest record of Hapalidiales in the Albian of Brazil

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Keywords— Brazil; Sergipe; Albian; Hapalidiales

The Sergipe basin is one of the coastal Brazilian basins generated by the opening of the southern Atlantic Ocean. Its sedimentary infill includes an upper carbonate marine unit spanning the upper Lower Cretaceous to Miocene interval. The oldest deposits belong to the Riachuelo Formation that has been ascribed to the Albian, on the basis of its ammonite fauna. This formation yielded a diversified association of calcareous red algae, including *Elianella* spp., *Pycnoporidium sinuosum, Paraphyllum amphiroaeforme, Polystrata alba, Heydrichia? poignantii*. One thin section bears several superimposed thin thalli showing a pseudoparenchymatous structure, dimerous thallus construction, monostromatic hypothallus with large cells, apparent cell fusions, rounded epithallial cells and multiporate conceptacle chambers. The affinity of this material with *"Lithophyllum" impositum* Lemoine 1930 from the Danian is discussed. The oldest hapalidiacean was identified in *"Lithothamnion angolense"* Romanes (1916) for a long time. However, *L. angolense* has been considered a *species inquirenda* by many authors (e.g., John et al., 2004). Based on the revision of *Marinella lugeoni* synonyms and the original illustrations of *Lithothamnion angolense* Romanes, the latter was considered as one of the many misidentification of *M. lugeoni* (Granier, 2016). On the contrary, the vegetative and reproductive anatomy of the Albian Brazilian material here presented allows its placement within the Hapalidiales W.A.Nelson et al., thus representing the oldest fossil record for this Order.

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Coralline algae as framework builders of the Coralligenous "atolls" (Corsica Cape, Mediterranean Sea)

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Keywords— Corsica Cape; Coralligenous; Mediterranean; Last Glacial Cycle

Following reports of enigmatic structures (Pluquet, 2006), the exploration of the seafloor geomorphology off the Corsica Cape revealed the presence of 1417 "atoll"-shaped structures of unknown origin, mostly distributed in a restricted depth range of about 100 to 120 m. They are composed of a massive central coralligenous build-up (1 to 2 m in diameter and 0.2 to 0.6 m high) and a peripheral sedimentary crown of about 20 m in diameter, bordered by rhodoliths and coralligenous (Bonacorsi et al. 2012). In the framework of the campaigns of Andromède Océanologie (2021 to 2023) this extraordinary coralligenous morphotype has been further characterized and three cores have been collected by professional deep divers for the identification of the main building phases and framework builders. Living coralline algae were identified as *Mesophyllum sphaericum* and *Lithothamnion* spp. (Peña et al 2023). The sedimentological and paleontological analyses of the cores revealed that the internal structure of the central coralligenous build-ups is constituted of a porous skeletal framework of red calcareous algae and bryozoans, alternating with bioclastic packstones or floatstones with fragments of red calcareous algae in a micritic matrix. The radiocarbon ages measured on the coralline algae indicate that they were actively growing during the Last Glacial Maximum to Holocene transgression (Bard et al. in prep.). Two phases of accretion are identified in the cores, based on the species associations and the radiocarbon ages. In the glacial phase, the most important species is *Lithophyllum stictiforme*, accompanied by *?Spongites* sp., *Titanoderma pustulatum* and *Peyssonneliales*. The Holocene accretion phase is due to *Mesophyllum* sp. and *M. expansum*, with the sporadic occurrence of *Lithothamnion* sp., *Titanoderma* sp., *Lithophyllum* sp. and *Peyssonneliales*. In the most recent core layers, *M.* cf. *sphaericum* is rarely recorded. The structure of these coralligenous "atolls" is therefore a geohistorical recorder (Basso et al., 2022), showing a deepening upward, with the genera *Mesophyllum* and *Lithothamnion* having a deeper distribution than the genus *Lithophyllum*. The relationship between bioconstruction and destructive taphonomic processes controlled the accretion of the Corsican coralligenous "atolls". These atolls serve as an extraordinary example of in situ sclerobiont record, documenting changes over approximately 100 meters of increasing water depth.

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Calcareous nannoplankton inside coralligenous build-ups: the case of Marzamemi (SE, Sicily)

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Keywords— Coccolithophores, Coralligenous build-ups, Sediment traps, SE Sicily

Coralligenous reefs in the Mediterranean Sea constitute a biodiversity hotspot, characterised by an intricate algal skeletal framework that supports numerous organisms within its abundant cavities and crevices. The high porosity of these structures also functions as an efficient sediment trap, harboring potentially significant geological information.Two coralligenous build-ups, sampled during the "CRESCIBLUREEF" project at 36 and 37 meters water depth off the coast of Marzamemi (Sicily), have revealed the presence of calcareous nannoplankton within the sediment infill. This novel finding indicates the presence of both contemporary and reworked coccolithophores assemblages, deposited in the coralligenous structures through marine snow sedimentation and terrestrial weathering processes, respectively. Comparative analysis of the nannoplankton assemblages from the two build-ups highlights differences in sedimentation exposure across the local environments from which the build-ups were collected. This analysis suggests that coccolithophores could serve as valuable proxies for sedimentation processes in coastal settings.

Pleistocene rhodoliths from Northern Apennines: the case of Stirone and Enza rivers

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Keywords— red algae, rhodolith, Enza, Stirone

Several records of Plio-Quaternary build-ups and rhodalgal carbonates have been reported for Italy, and most of them are concentrated in the Southern part, whereas they are rare in the Northern regions. Here probably, the sediment load from rivers, present-day as well as in the past, is much higher, affecting the development of such biogenic carbonates, and this suggests that over the long time scale, high sedimentation rates hindered the development of such deposits. Despite this, we focus on some rare and local records of algal biogenic carbonates from the Pleistocene stratigraphic successions outcropping along Enza and Stirone Rivers (Northern Apennines, Italy). These marine deposits formed during the final phase of the Apennine orogenesis, at the southern edge of a paleo-basin, now corresponding to the Pianura Padana. We analyzed the coralline paleo-biodiversity and the main structural and morphological features associated with such deposits, with the aim of describing such active carbonate factories in similar shallow-water paleosettings. At Enza river, rhodoliths characterize a distinct horizon, forming a thick bed, whereas in the subsequent layers they are mainly reworked within medium-sized arenites and show very localized small pockets of re-colonization. Rhodoliths are of boxwork and praline morphotype, with a sub-spheroidal to spheroidal shape. Specimens are compact, and do not show evident macrocavities or, when present, they are filled by sediment. For this reason, the specimens identified as boxwork are very similar to praline, but being multi-specific, they formally correspond to this category. Moreover, pralines generally show a low degree of branching. Identification was challenging because of the bad preservation of specimens. The genus *Lithothamnion* is the most abundant, whereas *Lithophyllum, Mesophyllum* and unidentified Lithophylloidea occur, but mostly in the inner part (nucleus) of some rhodoliths and as very small fragments. In addition, the genus *Titanoderma* has been often recognized, thanks to the typical palisade cells. On the contrary, at least two samples are monospecific (*Lithophyllum racemus*) and show a typical globular shape. At Stirone river, rhodoliths sparsely occur in a poorly sorted medium to fine sand in correspondence of deposits containing *Pinna nobilis*. Rhodoliths are both boxworks and pralines. Shape is much more variable, with mostly spheroidal and sub-spheroidal samples, whereas some have a discoidal shape. Growth forms vary between encrusting and warty. Rhodoliths have nuclei mostly formed by old algal nodules, and more rarely large skeletal remains, or micrite. The inner structure often shows a concentric development, mostly for the rhodoliths with a spheroidal morphology, often enhanced by the occurrence of evident concentric darkened layers, possibly related to stasis during growth. Interestingly, at least six rhodoliths clearly showed a marked warty-to-lumpy growth-form close to the nuclei when present, with respect to the encrusting-type at the surface. Even for Stirone samples, the conservation is very low and often CCA do not preserve sufficient morphological traits to always reach a specific identification. Identified species are *Lithothamnion* sp., *Lithophyllum* sp., *Titanoderma* sp., with a rare occurrence of *Mesophyllum* sp. Also in this case, two rhodoliths are monospecific in *L. racemus*. The rhodoliths found at the Enza and Stirone rivers exhibit several similarities. Notably, in the Enza River, they have developed a bed. This research enhances our understanding of rhodoliths' ability to thrive and form structures even in seemingly unfavorable conditions, such as the muddy-sandy sediments found in restricted marine basins within orogenic contexts.

Coralline algae as a tool for identifying tsunami deposits

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Keywords— event bed, historical tsunami, Almería, SE Spain

Recognition of the processes that generated event shell beds is challenging due to the overlapping sedimentological and paleontological features of deposits produced by storms, hurricanes and tsunamis. A potential diagnostic trait of tsunami deposits is the mixture of fossil of organisms from different environments (Massari et al. 2009, Puga-Bernabeu & Aguirre 2017). Here we describe a shell bed whose coralline algal and mollusc components indicate a provenance of bioclasts from a wide depth range within the shelf. The shell bed is in the Aguadulce beach in the province of Almería in SE Spain. The bed remains almost permanently buried by sand artificially spread all over the beach for its nourishment and it is only temporarily exposed after storm floods in the small ravines reaching the beach. These temporal exposures show that the shell bed extends for more than 2 km along the beach and at least 30 m across and its top is at about 2 m above sea level. The shell bed shows a sharp and irregular base carving the underlying sands and conglomerates made of quartzite and dolostone clasts from the Betic basement in Sierra de Gádor. The maximum observable thickness is 70 cm, but the bed top is disrupted by the artificial spreading of sand. The landward end cannot be observed and seawards it peters out below low-angle cross-laminated sand dipping to the sea. Landwards from its maximum thickness the bed thins and splits in 3 intervals with a middle layer richer in sand. The bed is a conglomerate composed of a mixture of terrigenous clasts, bioclasts, and minor medieval pottery fragments. Pebble-sized components comprise up to 50 % of the sediment weight and the proportion of fine sand and finer particles is 5-12%. Dispersed quartzite and dolostone cobbles also occur. Bioclasts are mainly molluscs, followed by coralline red algae, and minor serpulids, echinoids, and bryozoans. Twenty-four bivalve genera were identified among the molluscs. Nineteen genera and several representatives of two families (Naticidae and Muricidae) were recognised among gastropods. Bivalve shells are all disarticulated and generally broken in varying degrees, with sharp edges. *Ditrupa* is the most common serpulid, although other members of the family are attached to shells and coralline algae. Coralline algae occur as branch fragments and as rhodoliths, up to 6.5 cm in size, with diverse degrees of fragmentation. Thin corallines also encrust pottery fragments. Rhodoliths vary from monospecific nodules (*Lithophyllum* gr. *incrustans*, *Lithophyllum* gr. *racemus* and *Lithothamnion minervae*) to multispecific rhodoliths of laminar thalli of Hapalidiales. Some thick branch fragments belong to *Lithothamnion valens*. Most branch fragments, however, are thin and correspond to the *Lithothamnion corallioides-Phymatolithon calcareum* group, which constitute 10 to 33% of grains in the granule fraction of the shell bed. Five calibrated radiocarbon ages of *Cardites antiquatus* shells range from 312 cal BC (2 σ cal BC 487- 142) to 1744 cal AD (2 σ cal AD 1575- 1925). According to their modern distribution, some bivalves, such as *Venus nux*, and thin branching corallines came from circalittoral settings, at depths of more than 30 m, while other came from shallow water or from specific environments, such as seagrass meadows (*Smaragdia viridis*). This wide range of paleonvironmental sources of bioclasts suggests that the event bed was produced by a tsunami. The youngest radiocarbon age is compatible with the event bed having been generated by a tsunami related to a swarm of earthquakes that affected the southern coast of Almería on the 13-01-1804. According to a report from those days the sea retreated 18 m in one of the quakes.

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Exceptionally preserved Jurassic dasycladalean algae found in limestones with black pebbles from Romanian Carpathians

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Keywords— calcareous algae, black pebbles, Upper Jurassic

The occurrence of blackened bioclasts has been observed and doccumented in both recent carbonate deposits (e.g. Kendall and Skipwith, 1969; Strasser, 1984) and ancient limestones (e.g., Strasser & Davaud, 1983; Hips et al., 2011). Blackened bioclasts are commonly associated with carbonate deposits containing black pebbles, either as intrinsic components of the pebbles themselves or as discrete elements within the carbonate deposit. In two regions of Romania (the Transylvanides of the Apuseni Mountains and the Haţeg-Pui area of the Southern Carpathians) we discovered blackened bioclasts, including dasycladalean algae, embedded in limestones with black pebbles. Our work aims to illustrate how the blackening process has brought to light certain morphological characteristics of dasycladales, features that are usually obscured by diagenetic transformations. In the Apuseni Mountains, blackened algae were found in Upper Jurassic limestones that make up an olistolith incorporated in Upper Cretaceous deposits. The limestones mainly consit of reef- slope coarse grainstones and rudstones and contain some levels with black pebbles. Specimens of *Neoteutloporella socialis* that were strongly or moderately blackened were identified along with black pebbles. The blackening process is likely due to meteoric diagenesis processes, and the blackening agent was the organic matter, as indicated by the presence of kerogen detected through RAMAN spectroscopy. The transformation of aragonite from the initial skeleton of *Neoteutloporella* into low-magnesian calcite was influenced by the presence of organic matter. This organic matter was adsorbed at the surface of the calcite crystals of micritic size, hindering their further growth. The dissolved organic matter, in a colloidal or very finely granular state, utilized the porosity of the algal skeleton, including the axial cavity, the pores corresponding to the lateral ramifications and the uncalcified space between the laterals, as access routes. After the blackening process, the organic matter settled around the laterals, both inside and outside them, as well as around the main axis, outlining the space initially occupied by the organic membrane that enclosed the cell. This process led to the exceptional preservation of the morphological features of the algae. The primary, short, ovoid laterals are clearly visible, from which 4-6 long secondary laterals emerge, exibiting several constrictions and slightly widening outwards. While the terminal part of most of laterals is not preserved, it is likely that their termination is of the phloiophore type and not trichophore, as assumed by De Castro (1993). In the Upper Jurassic limestones from Ohaba Ponor (Haţeg-Pui area) in the Southern Carpathians, blackened bioclasts have been also found. A section of these limestones contains a level with black pebbles along with numerous other colored bioclasts ranging from light brown to black. Among these black pebbles, a dasycladalean alga, identified as a new genus and species, was found. This alga was first documented by De Castro in 1997 (p. 200, pl.4, figs. 1-3). In this situation, the blackening of the bioclasts is believed to be linked to pedogenetic processes that affected the subaerially exposed carbonate deposits (see Strasser & Davaud, 1983 for details). The organic matter outlined the morphological features of the new alga, which has a cylindrical thallus, with a wide axial cavity, and relatively short cylindrical primary laterals. From these, 2-3 secondary cylindrical laterals emerge, each having two segments separated by slight constriction. A notable feature is the collective sheaths that surround two or three secondary laterals near their detachment from the primary laterals. It is worth noting that the new alga is likely to form "microreef"-like aggregations similar to *Neoteutloporella socialis*. In conclusion, the blackening processes of the dasycladalean algae within certain levels with black pebbles highlight morphological aspects of the thallus, facilitating a better understanding of its morphology.

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The incursion of diatoms in microbialites and their fossil record

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Keywords— microfossils, carbonates, recent analogues

Non-marine diatoms are a conspicuous component of recent sediments (Winsborough, 1990; Golubic & Abad, 2012; Gischler et al., 2008; Spadafora et al., 2010; Chacon et al., 2015), especially in travertines of hydrothermal settings (Jones et al., 2007) and microbialites, where they are in close interaction with cyanobacteria and sedimentary particles. Results reported in this work derive from thrombolites and oncoids from Cuatro Cienegas, northern Mexico. Typical macrostructures in these microbial carbonates include dome-shaped thrombolites, large discoidal mounds, massive irregular bioherms and laminated oncoids. Vertically-oriented bundles of a monotypic population of filamentous cyanobacteria concentrates between 2-4 cm below the thrombolitic surface. Diatoms as *Amphora ovalis*, *Epithermia adnata*, *Tabellaria flocculosa*, *Diatomella* sp. and *Fragilaria* sp., are found along the vertical profile of domal thrombolites, and in association with filamentous cyanobacteria. Biofilm remains and connecting organic fibers attach to peloids, euhedral precipitates and other amorphous sedimentary particles and diatom fragments, producing heterogeneous fabrics. The analyzed microfabrics shows constructive and destructive textures as well as microbial sediments inside the carbonate framestones, where simultaneous but antagonist processes may be acting on the same substrate: carbonate mineralization and dissolution by endolithic cyanobacteria. This work also discusses the evolutionary incursion of diatoms in microbial carbonates, their comparison with other microbial carbonates and their potential role in in mat stabilization.

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New multiscale insights on the growth of Cryogenian microbial dolostones

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Keywords— filamentous cyanobacteria, organomineralisation, primary dolomite precipitation, Neoproterozoic, Flinders Ranges

Trapping and binding of sediment are commonly viewed as the principal process for the growth of laminar microbialites. This study proposes an alternative microbially-induced carbonate precipitation accretion model for reefal dolo-microbialites from the Arkaroola reef formed during a Cryogenian interglacial period in the Adelaide Rift Complex (South Australia). Petrography study demonstrates disorganised, grumous microfabrics comprising micropeloids (clots), microcolumns and micritic threads in subtidal reefal dolostones. Nano- to microscale characterisation of these microfabrics through combined scanning electron microscopy and energy dispersive spectroscopy (SEM-EDS) as well as nano-scale secondary ion mass spectroscopy (NanoSIMS) reveal tubular bacterial sheaths, planar extracellular polymeric substances (EPS), as well as filamentous and spherical bacteriomorphs interpreted as a mixed community of filamentous cyanobacteria with methanogenic and sulfate-reducing bacteria. These microbial relics are found in direct contact with nano-sized flaky clays, cryptocrystalline dolomite, and pyrite spherulites. The close spatial association between observed biotic components and mineral phases implies microbial metabolic processes resulted in the organomineralisation (e.g., authigenic nano-sized flaky clays) of bacterial surfaces facilitating their long-term preservation in dolostones. This study proposes that authigenic clays lowered the kinetic barrier for the synsedimentary precipitation of cryptocrystalline primary dolomite giving structural integrity to the collectively formed solid primary grumous microframework. The latter would serve as a template for further precipitation of later diagenetic dolomite. The assemblage of biotic components and synsedimentary precipitated mineral phases observed at the biotic-mineralogical interface highlights the potential of microbial relic discovery in other Precambrian dolostones using high-resolution analytical techniques.

Algal buildups in the marine Neogene to Quaternary sediments of Andaman-Nicobar Basin, Northeast Indian Ocean: A comprehensive account from the onshore sequence

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Keywords— Calcareous algae, Phytoplankton, Burdigalian-Gelasian, Andaman-Nicobar Basin, NE Indian Ocean.

On different islands of Andaman-Nicobar Basin in the Northeast Indian Ocean, marine Neogene sediments are well exposed. Most of the sediments are marginal to deep water origin and some are of shallow water. This is evident from the lithological features, characteristics of the facies and microfossil content. From the tectonics history of this region signifies that owing to uplift of the islands during the Neogene or transgressive and regressive cycles in the Neogene these islands archive both shallow and deep-water sediments. Most of the outcrops on Havelock, Neil (in Ritchie's Archipelago) and Car Nicobar islands contain moderate to well preserved planktonic algae represented by siliceous diatoms, silicoflagellates and calcareous nannofossils characteristics of marginal to deep water environment. However, in some islands namely Neil Island in Ritchie's Archipelago, Hut Bay (Middle Andaman Island) and Car Nicobar Island shallow marine sediments are also well exposed and that is evidenced by the presence of benthic calcareous algae and shallow benthic foraminifera etc. Almost all the outcrops of the onshore Neogene sediments of Andaman-Nicobar Basin have been dated based on calcareous nannofossil and radiolarian events alongside index planktonic foraminiferal taxa. The calcareous nannofossil bioevents recorded from the Miocene outcrops on Havelock Island indicate Burdigalian-Langhian age based on the characteristic marker taxa of NN4 Zone of Martini (1971) that corresponds to CNM6-CNM7 Zone of Backman et al. (2012). These sediments also contain moderate to well preserved planktonic algae namely diatoms and silicoflagellates. The Serravallian sediments (Middle Miocene) exposed in Hut Bay (Middle Andaman Island) is characterized by the occurrence of non-geniculate coralline red algal genera *Lithothamnion, Mesophyllum, Lithoporella, Lithophyllum, Titanoderma, Phymatolithon, Spongites, Neogoniolithon* and *Sporolithon*, and geniculate red algae referable to *Corallina, Jania* and *Amphiroa*. In addition, halimedacean green algae also have been recorded from the Serravallian sediments. In some of the outcrops on this island the coralline red algae are abundantly forming rhodoliths. Moreover, well preserved benthic foraminifera and other biogenic components are also evident in thin sections. The Serravallian sediments of Hut Bay (Middle Andaman Island) have been dated based on the planktonic formaninferal biostratigraphy i.e., FO (Base) of *Globorotalia fohsi fohsi* and LO (Top) of *Globorotalia fohsi robusta*. The late Miocene (Tortonian and Messinian) sediments outcropping on Neil Island of Ritchie's Archipelago yielded diverse assemblage of planktonic algae represented by well preserved diatoms, silicoflagellates and calcareous nannofossils. On the basis of calcareous nannofossil bioevents the age of the late Miocene outcrops are correlatable to NN11 Zone to NN12 zones of Martini (1971) corresponding to CNM16 to CNM17 zones of Backman et al. (2012) that is indicative of Tortonian to Messinian age. The Pliocene sediments are well exposed on the Car Nicobar Island and are manifested in different outcrops. Two outcrops on Car Nicobar Island yielded well preserved calcareous nannofossils belonging to Zanclean age correlatable to NN12-NN13 zones of Martini (1971) that correspond to CNPL1 Zone of Backman et al. (2012). One of the outcrops also archives very few planktonic algae i.e., diatoms and silicoflagellates. However, another outcrop on Car Nicobar Island is represented by well preserved coralline red algae belonging to the non-geniculate genera *Lithothamnion, Mesophyllum, Phymatolithon, Lithophyllum, Spongites* and *Lithoporella* and geniculate forms comparable to the genera *Amphiroa, Corallina* and *Jania*. In thin section analysis it has been observed that along with coralline red algae the hard, creamish white to yellowish, fossiliferous limestones contain wide array of benthic foraminifera and has been dated as Piacenzian (Pliocene). The fine to medium grained, compact to porous, buff coloured, foraminiferal-algal limestone of the Gelasin (Pleistocene) sediments outcropping on the west coast of Neil Island (Ritchie's Archipelago) com-

prises of fragments of foraminifera, corals and coralline red algae. Owing to poor preservation potential most of the coralline algal forms are identifiable upto the generic level based on available morphological features. The non-geniculate algal forms belong to the genera *Lithothamnion*, other indeterminate *Melobesioideae, Lithophyllum* and *Lithoporella* and the geniculate forms are assignable to the genera *Amphiroa, Corallina* and *Jania*. Based on the presence of planktonic formaminifera *Globorotalia tosaensis* a Pleistocene age has been assigned for this outcrop on the west coast of Neil Island. The aforementioned account on both the benthic calcareous algae and planktonic algae (phytoplankton) attempted to provide a comprehensive account of the algal buildups both in shallow marine as well as deep water sediments deposited during the latest early Miocene (Burdigalian) to Pleistocene (Gelasian) in the Andaman-Nicobar Basin. Number of significant events took place during this time slice both globally as well as in the study area. During this time slice the earth experienced major climatic and oceanographic changes. There was uplift of Himalaya accompanied by development of Bengal Fan, optimum climatic condition during Middle Miocene (MMCO), intensification and weakening of South Asian Monsoon (SAM) and closing and opening of seaways. The microfossils preserved in the sediments are capable of interpreting many of these significant events. Moreover, the rate of sedimentation during this time slice was also varied that is evident from the present analysis.

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How petrographic observations change our view point on the ooids .

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Keywords— ooids, aragonite, high-Mg calcite, leaching, recrystallization

Even today, petrographic analysis of thin sections under an optical microscope reveals that there is much to be gleaned from microbial carbonates (e.g., Granier, 2014; Granier et al., 2014). This was the core idea behind the Kalkowsky Project (Granier & Lapointe, 2021, 2022a, 2022b, 2024a, 2024b; Granier et al., 2022). For almost a decade, the author explored the oolithic world through this classical approach. For instance, the yellow tinge of the cortical layers of aragonite or high-Mg calcite ooids is a relict of a primary organic presence. The term "fibrite" was introduced to refer to the yellowish "fibrous calcite" of the cortical layers of high-Mg calcite ooids when the latter retained their original mineralogy (Granier & Lapointe, 2021). In the literature, there are mostly reports about aragonite ooids affected by leaching and cementing, or by recrystallisation. However, both aragonite and high-Mg calcite are unstable. Accordingly, high-Mg calcite ooids may also be affected by leaching and cementing or by recrystallisation, as documented by Granier and Lapointe (*op.cit.*). The so-called 'two-phase'/'bimineralic' ooids likely had cortices made of high-Mg calcite only. The organic matter within discrete cortical layers was various oxidized, implying differential diagenetic alterations. Finally, contrary to earlier reports, it has been shown that the synsedimentary breakage of ooids, which is known to occur in both aragonitic and calcitic ooids with radial fabrics, is not related to attrition/mechanical impacts, hypersalinity, or desiccation.

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The Jurassic/Cretaceous boundary crisis: The view point of a paleophycologist

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The Jurassic/Cretaceous boundary is indeed a topic of ongoing debate, with two primary viewpoints on its precise location. The conservative perspective, often misattributed as Kilian's view, places the boundary at the Tithonian/Berriasian transition. Conversely, the reformist perspective, which revives the historical Oppel-Orbigny view, argues for the Berriasian/Valanginian boundary as the system boundary. This latter view has gained renewed attention (Granier, 2019a, 2019b; Énay, 2020; Granier et al., 2020). Recently, Erba and Parente (2024) noted that "in shallow-water platforms, Dasycladales (...) experienced a decline in species diversity across both the Weissert Event and the OAE 1a." Hereafter, we focus on the older of these events. Most Late Jurassic Dasycladales went extinct before or at the Berriasian/Valanginian boundary (Granier, 2019c). Despite the low confidence in calibrating Dasycladales stratigraphic ranges to the ammonite scale, this extinction event occurred approximately 5 million years before the Weissert Event. Importantly, no significant biological crisis is noted at the still undefined Tithonian/Berriasian boundary, while a documented crisis at the Berriasian/Valanginian boundary for Dasycladales and other shallow-water Tethys biota (e.g., the large benthic foraminifers) supports the candidacy of this stage boundary as the system boundary.

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The earliest known Charophyceae from Late Ordovician and its implications on the derivation of land plants

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Keywords— charophyte algae; Ordovician; streptophyte algae; Charophyceae; land plant; embryophytes

The emergence of land plants (embryophytes) signifies a pivotal transition in Earth's biogeochemical cycles. It has been postulated that the evolutionary transition from streptophyte algae to land plant, or canalization of an embryonic form of meiosis, was completed during the Middle Ordovician. However, the absence of undisputed streptophyte algal fossils (e.g. Charophyceae) earlier than the late Silurian have hindered understanding of a derivation for land plants from streptophyte algae. Here, we describe the currently earliest known Charophyceae fossil from early and middle Katian (Late Ordovician, 453–449 Ma) marine limestones in the Tarim and Ordos basins of northwestern China and assign it to Sycidiales based on morphological and phylogenetic analyses. This discovery confirms that early Charophyceae exhibit key morphological innovations associated with evolutionary transitions between streptophyte algae and land plants prior to the Late Ordovician, and provides crucial fossil evidence for the derivation of land plants.

Innovative geobiological and technological characterisation of coralligenous build-ups

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Keywords— bioconstructions, coralligenous, geobiology, technological innovation.

Bioconstructions are geobiological bodies formed by in situ growth of colonial/gregarious skeletal organisms and represent habitats that host a great variety of benthic organisms. They comprise a wide array of dynamic phenomena, resulting from the balance between the action of building, demolishing, and dwelling organisms on a relatively large temporal scale. Among the bioconstructed habitats of the Mediterranean Sea, Coralligenous is undoubtedly the most important ecosystem because of its extent, complexity and heterogeneity, which supports very high levels of biodiversity (Bracchi et al., 2022). Coralligenous is a hard biogenic substrate mainly produced by the superposition of several generation of calcareous red algae, living in dim light condition (Basso et al., 2022). Nevertheless, these bioconstructions are characterized by a low accretion rate and a high sensitivity to natural and anthropic impacts, including climate changes. For these reasons, Coralligenous has since long time been the object of special interest by the UNEP RAC/SPA and considered among the priority habitats for monitoring and conservation by the EU. In the frame of the project "FISR2019_04543 CRESCIBLUREEF – *"Grown in the blue: new technologies for knowledge and conservation of Mediterranean reefs"*, an innovative ROV-based technology for minimally invasive sampling of marine bioconstructions, consistently with the principles of the Europe Blue Growth Strategy, has been developed. This underwater coring device, driven via a specifically designed control interface which contains information such as core rotation speed, drilling depth and tool magazine positioning, is characterized by three main modules: i) core drilling head, containing an innovative quick release system that engages core bits with a custom chuck; ii) anchoring system, enabling the stable connection between ROV and bioconstruction during sampling operations; iii) tool change mechanism, an automatic rotating turret that provides the storage of the core samples after every coring operation. In the new project "Tech4You PP2.3.1: Development of tools and applications for integrated marine communities and substrates monitoring", the system will be upgraded with integration of robotic and AI-based computer vision technologies for accurate 3D reconstruction, sampling, and mapping of marine bioconstructions. Using the protocol proposed by Cipriani et al. (2024), coralligenous core samples, collected from Marzamemi (Sicily, Italy) with ROV-based technologies, were compared with data obtained from coralligenous build-ups sampled in the same area by scuba-divers. The study revealed a primary framework mainly produced by crustose coralline algae, whereas serpulids and bryozoans participated subordinately to the formation of the structure. Sponges seemed to contribute to the general morphologies, regulating the direction of growth of encrusting organisms and altering the internal body of the build-ups through bio-erosive processes. Remains of sponges were testified by spicules and carbonaceous amorphous substances preserved in microcavities. The non-skeletal components were distinguished under light microscope examination and UV epifluorescence in autochthonous and allochthonous (detrital) micrite (Cipriani et al., 2024). Comparison between microfacies of core-samples and those of "tale quale" build-ups revealed no significant differences in term of abundance and relationship between skeletal frame-builders and non-skeletal carbonate components, despite the much smaller size of the core sample. These results, although preliminary, allow to consider the ROV-based system as a powerful tool to obtain representative samples of bioconstructions for geobiological, environmental and paleoenvironmental studies without making invasive sampling, which would damage these fragile and delicate ecosystems. Moreover, an integrated geochemical/geobiological approach has been utilized in order to investigate the balance between the algal reef status and environmental

parameters and to identify possible proxies for short- and long-term environmental studies. This multidisciplinary approach showed an evident relationship between chemical composition of the carbonate minerals and the waters in which Coralligenous forms. Positive anomalies in heavy metals were found in bioconstructions and surrounding seawaters. Such enrichments could result from pollutants introduced into the marine system by human activities and recorded by the components of the bioconstructions. These data, although preliminary, allow to consider coralligenous build-ups as environmental database that continuously record environmental disturbance (both natural and anthropic), enabling temporal reconstruction of the marine environment over time.

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Depth-related controls on the quantitative composition of rhodolith matrix builders in the high Arctic

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Keywords— point counting, polar carbonates, rhodoliths, taxonomic composition, X-ray micro-computed tomography.

The calcareous matrix of rhodoliths can be composed of one or more crustose coralline algal (CCA) taxa as well as a mixed assemblage of various encrusting organisms. Morphology analyses of the inner arrangement and assemblages of organisms forming rhodoliths can provide valuable information to reconstruct palaeoenvironmental and palaeoclimatic condition (Basso et al. 1998, Aguirre et al. 2017) Descriptive studies on modern and fossil rhodoliths assume associations with water depth. Here we explore the quantitative biological composition of calcareous rhodolith matrices along a bathymetric gradient at the Arctic Svalbard archipelago. We hypothesize that (1) the composition of calcareous rhodolith matrices is taxonomically quantifiable and that (2) this quantitative composition is controlled by water depth, implying that (3) the matrix composition could be used for (palaeo-)bathymetrical reconstructions. Using a methodological combination of virtual micro-CT cross-sections with a modified point counting approach, we distinguished five different taxonomic groups: CCA, bivalves, serpulids, bryozoans, and balanids. The identified matrix component CCA is mainly represented by the species *Boreolithothamnion glaciale* Kjellman Gabrielson et al. (2023) (Basionym *Lithothamnion glaciale* Kjellman, 1883), which is the dominant CCA species in Mosselbukta. The identified matrix component bivalves are represented by the drilling bivalve species *Hiatella arctica* (Linnaeus, 1767). The other taxa, serpulids (family Serpulidae), balanids (family Balanidae), and bryozoans (phylum Bryozoa) could not be identified to species level. While water depth does not influence the general taxon richness as well as the abundance of bivalves, it significantly affects the proportional matrix composition of encrusting organisms by a combination of environmental factors and biological interactions. The decrease in CCA skeletal material with increasing water depth is significantly governed by impaired irradiance conditions. Regular rhodolith movement in shallow waters fosters the proportion of CCA, while decreased movement in deeper waters spurs the proportion of heterotrophic encrusters. This results from post-mortem fouling of dead rhodolith parts followed by a recolonization with slow-growing CCA. Our results highlight new mechanisms controlling the biogenic composition of calcareous rhodolith matrices and the potential of quantitative matrix compositions for palaeogeography and -bathymetry. However, it also stresses the importance of sufficiently large sample sizes, ideally deriving from different facies types. The introduced methodological combination allows for a straightforward and non-destructive identification and quantification of rhodolith matrix components and also provides a new tool for rhodolith-focused quantitative research from a more general perspective.

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Oxygenation and marine microbial carbonates

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Keywords— Archean, hybrid carbonates, invertebrates, Phanerozoic

Localized removal of dissolved iron by oxygen was a key control on early marine Ca-carbonate precipitation in the Archean. Thick carbonate platforms, ∼2.9–2.8 Ga in Canada, preserve three co-existing depositional environments: (i) offshore anoxic iron-rich seawater, precipitating Fe-carbonate, (ii) a narrow chemocline mixing zone variously precipitating interlayered aragonite, calcite and Fe-oxide, (iii) onshore iron poor seawater precipitating aragonite and calcite in isolated 'Oxygen Oases'. Abundant Fe^2+ superseded the effect of Mg^2+ on Ca-carbonate mineralogy. Only when sufficient Fe^2+ was removed by oxygen did the relative concentrations of Mg^2+ and Ca^2+ determine $CaCO_3$ mineralogy, and the progressive removal of dissolved iron allowed the precipitation of first aragonite and then calcite. The most likely source of sufficient oxygen was oxygenic photosynthesis by marine cyanobacteria. This may have promoted precipitation of water column 'whiting' mud and calcification of benthic stromatolites. The oldest recorded stromatolites occur ∼3.7 Ga. They were locally abundant on early carbonate platforms and ∼2.8 Ga formed hybrid carbonates associated with precipitated seafloor crystal crusts at platform margin chemoclines. Stromatolites increased in abundance with platform thickness during the Archean, and remained major components of shallow water carbonate platforms that expanded in epeiric seas during the Proterozoic. Gradual increase in shallow marine oxygenation, that began locally in the Archean, continued and expanded in the Proterozoic and increased in the Paleozoic. Shallow marine benthic microbial carbonate sediments declined significantly in abundance during the Neoproterozoic, but remained locally common in the Cambrian. Microbial carbonates show episodic decline throughout the Phanerozoic, with intervals of microbial carbonate abundance and invertebrate diversity broadly alternating with one-another. This pattern supports suggestions that microbial carbonate abundance declined as calcified invertebrates increased. Comparisons of microbial carbonate abundance and invertebrate diversity with estimates of changes in sea-surface temperature and marine dissolved oxygen suggest that microbial carbonate abundance and invertebrate diversity fluctuated with oxygen availability. It appears that intervals of both low marine invertebrate diversity and low dissolved oxygen, e.g., during the early Ordovician, late Devonian, early Triassic, and early-mid Jurassic, favored the formation of microbial carbonates. Low oxygen levels likely stimulated anaerobic metabolisms that favored carbonate precipitation. These observations suggest that, together with shallow marine temperature and carbonate saturation state, the level of dissolved oxygen significantly influenced secular patterns of marine microbial carbonate abundance during the Phanerozoic. Overall, these patterns appear to reflect the long-term influence of oxygenation on (i) Ca-carbonate precipitation in Archean Fe-rich seas, and (ii) the rise of eukaryotes. Microbial carbonate abundance increased during the first of these effects, and declined during the second.

Palaeocene-Eocene coralline red algae and green algae from the Shella Formation of East Khasi Hills, Shillong Plateau, Meghalaya, NE India

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Keywords— Calcareous algae, Palaeocene-Eocene, Shella Formation, Shillong Plateau, NE India.

In the southern corner of North East India, the Shillong Plateau is situated that is bordered by the plains of Bangladesh. The East Khasi Hills of Meghalaya is surrounded in the north by Cherra Plateau and east by West Jaintia Hills, plains of Bangladesh in the southern and South West Khasi Hills in the west. In the southwestern part of Shillong Plateau carbonate sediments are very well developed and ranges in age from late Palaeocene to Middle Eocene. The Shella Formation overlies the Langpar Formation and is overlain by Kopili Formation. There are three alternating sandstone and three limestone members within the Shella Formation. These are Therria Sandstone (Lower Sylhet Sandstone), Lakadong Limestone (Lower Sylhet Limestone), Lakadong Sandstone (Middle Sylhet Sandstone), Umlatdoh Limestone (Middle Sylhet Limestone), Narpuh Sandstone (Upper Sylhet Sandstone) and Prang Limestone (Upper Sylhet Limestone) in chronological stratigraphic sequence order from older to younger that depicts change of facies from arenaceous to calcareous. The limestone units of Shella Formation are rich in carbonate fossils with dominance of benthic foraminifera. Study of the samples from the limestone units in thin sections from the study area yielded non-geniculate coralline algae belonging to the genera *Lithothamnion, Mesophyllum* (Family Hapalidiaceae), *Lithoporella* (Family Mastophoraceae), *Titanoderma* (Family Lithophyllaceae), *Distichoplax, Corallina, Jania* (Family Corallinaceae) and *Sporolithon* (Family Sporolithaceae). The calcareous green algae are represented by the genera *Halimeda* (Family Halimedaceae) and *Ovulites* (Family Udoteaceae). The calcareous algal assemblages of three limestone units of Shella Formation differ in their composition. Moreover, the characteristics of the facies and depositional environment are also different. The lowermost Lakadong Limestone unit of Shella Formation is dominated by species of *Lithothamnion, Distichoplax, Corallina, Jania* and *Sporolithon* along with miliolid benthic foraminifera and larger benthic foraminifera. The Middle Sylhet Limestone i.e., the Umlatdoh Limestone is characterized by the preponderance of calcareous green algae belonging to the genera *Halimeda* and *Ovulites* along with miliolid benthic foraminifera. The topmost limestone unit of Shella Formation i.e., the Prang Limestone unit is dominated by the species of non-geniculate coralline algal genera *Lithothamnion, Mesophyllum, Lithoporella, Titanoderma* and *Sporolithon*. Dominance of larger foraminifera is also a characteristic feature of the Prang Limestone unit. The compositions of the calcareous algal assemblages of all the three limestone units are different and that is also substantiated by the characteristics of the lithofacies. In order to examine the depositional environment of the Shella Formation, both the biofacies and the lithofacies analysis can through an insight by this study. Based on the benthic foraminiferal assemblage an early Palaeocene to Middle Eocene age has been estimated for the Shella Formation. During the transition from late Paleocene to early Eocene (around 55.6 Ma) one of the warmest event i.e., Palaeocene-Eocene Thermal Maximum (PETM) took place on Planet Earth. It has been predicted that this unusual change in climate owing to elevated CO_2 in the atmosphere possessed negative impact in the calcification of biogenic carbonates that influenced dwarfism as an adaptation as smaller organisms are more resistant to adverse condition. An attempt also has been made how this study can through some light on this significant event.

Calcareous bioconstructions formation during MIS 5 in the central Mediterranean (Capo Colonna, Calabria, Southern Italy): an algal, metazoan, and microbial framebuilders consortium

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Keywords— Bioconstructions, Coralligenous, Mäerl, Micrites, Microbialites

The last interglacial (MIS 5) transgressive-regressive deposits of the Capo Colonna marine terrace provide a good fossil example of a Central Mediterranean infra/circa-littoral setting, characterized by both calcareous coralline algae-dominated low-relief bioherms and biostromes, equivalent respectively to the modern coralligenous and mäerl habitats (Nalin and Massari, 2009; Bracchi et al., 2014). The skeletal primary framework of the bioherms, consists of laminar to massive encrusting coralline red algae acting as main bioconstructors, with minor bryozoans, encrusting foraminifera, and serpulids as secondary frame-builders. Whereas, the autochthonous mäerl tabular beds are mainly composed of free branched coralline red algae rudstone. A variable amount of sandy bioclastic sediment is laterally interbedded with the bioconstructions and tends to be entrapped in their cavities and pockets. All sedimentary sub-facies of the bioconstructions and associated sediment are rich in autochthonous syn-sedimentary microbial-mediated micrite, forming aphanitic, peloidal, clotted peloidal, and filamentous fabrics. Microbial micrite can also trap and bind a variable amount of grains, or be a secondary component of the sandy sediment as micritic rims surrounding the clasts. All these early-lithified micrites show the typical nanostructure of the primary microbial mediated carbonates, rather than a detrital mud particles accumulation, as they consist of nanospheres coalescing into subhedral microcrystals that replace both microbial cells (present with several morphological types) and extracellular substances (Perri et al., 2012). This in turn implies the original widespread presence of benthic lithifying microbial biofilms which colonized both the cavities of the skeletal framework of the bioconstructions, and the intergranular space of the associated sediment. These microbial communities, thanks to the metabolic processes of the microorganisms that induced the carbonate precipitation, significantly contributed to the early cementation of all the studied deposits.

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In situ decrease in rhodolith growth is associated with Arctic climate change

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Keywords— Calcification; global warming; ecosystem engineers; micro-computed tomography; rhodoliths

Rhodoliths built by crustose coralline algae (CCA) are ecosystem engineers of global importance. In the Arctic photic zone, their three-dimensional growth emulates the habitat complexity of coral reefs but with a far slower growth rate, growing at micrometres per year rather than millimetres. While climate change is known to exert various impacts on the CCA's calcite skeleton, including geochemical and structural alterations, field observations of net growth over decade-long timescales are lacking. Here, we use a temporally-explicit model to show that rising ocean temperatures over nearly 100 years were associated with reduced rhodolith growth at different depths in the Arctic. Over the past 90 years, the median growth rate was 85 µm yr^{-}1 but each °C increase in summer seawater temperature decreased growth by a mean of 8.9 µm (95% CIs = 1.32 - 16.60 µm °C^{-}1, p <0.05). The decrease was expressed for rhodolith occurrences in 11 and 27 m water depth but not at 46 m, also having the shortest time series (1991 – 2015). Although increasing temperatures can spur plant growth, we suggest anthropogenic climate change has either exceeded the population thermal optimum for these CCA, or synergistic effects of warming, ocean acidification, and/or increasing turbidity impair rhodolith growth. Rhodoliths built by calcitic CCA are important habitat providers worldwide, so decreased growth would lead to yet another facet of anthropogenic habitat loss.

The earliest calcareous peyssonneliacean red algae fossils from Ordovician: systematics, evolutionary and paleoecological significance

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Keywords— Peyssonneliales, calcareous algae, Ordovician, Red algal evolution, reef building.

Peyssonnelialeans are a taxon of crustose red algae that grow on rocky or microbial substrates and are the taxon of Rhodymeniophycidae that can deposit aragonite crystals in their cell walls. The Rhodymeniophycidae is one of the most diverse taxa of the Florideophyceae in the Rhodophyta. Molecular clock analysis suggests that Peyssonneliales diverged from their sister group Gigartinales within the Rhodymeniophycidae clade at about 300 Ma. Until now, however, the earliest known undisputed fossil Peyssonneliales are from the Lower Cretaceous (Albian, 113-110.5 Ma). Here we report the earliest peyssonelialean algal fossils, one new genus and two new species. They occur in the Upper Ordovician (∼450 Ma) reef facies of Lianglitag Formation in the Tarim Basin, Northwest China. The new genus had a pseudoparenchymatous organization consisting in a single system of dividing filaments showing a feather-like arrangement in longitudinal section. Its preservation suggests that the skeleton was originally composed of aragonite that is now replaced by calcite. The crustose habit, the pseudorparenchymatous organization and the aragonite calcification are characteristic of Peyssonneliales. The record of this new genus advances the fossil record of the large subclass Rhodymenophycidae by 340 Ma. Additionally, they possess significan paleoecological importance and can form reef-building communities with diverse green algae (*Vermiporella, Aphroporella*, etc.), *Solenopora*, stromoforaminifera, cyanobacteria for constructing reef skeletons and providing growth substrates for crinoids, bryozoans, etc. They play an important leading role in the process of reef building. Peyssonnelialeans not only exhibit barrier deposition and bonding effect of calcareous algae, but also has a strong wave resistance structure and a new function of leading the construction of lattice reefs, indicating that the dominant reef-building community in the late Ordovician was the addition of calcareous red algae, which explains the complexity of reef-building community composition during the process of GOBE. It holds immense significance for understanding Paleozoic forms of reef building and ecosystem evolution.

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Coralline algal assemblages from the Sierra de Marmolance (Middle Miocene, SE Spain)

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Keywords— Langhian-Serravallian, Betic Cordillera, Huéscar, Granada

The Sierra de Marmolance is an NNE-SSW-trending ridge located about 4 km WNW of Huéscar, in the Granada province (SE Spain). The Marmolance succession consists of ∼300 m thick limestone beds, gently dipping to the W-SW, which overlie and interfinger with pelagic marls. Based on planktonic foraminiferal assemblages, the succession ranges from the Burdigalian-Langhian transition (M5b biozone of Wade et al., 2011) in the lower part to the Langhian-Serravallian boundary (M7 biozone of Wade et al., 2011) in the top. The limestones consist of packstone-rudstone beds locally displaying crossbedding, with variable amounts of siliciclastics, generally increasing toward the top. Micropaleontological and lithofacies analyses were made in several stratigraphic sections. The major bioclastic components are coralline algae, larger and small benthic foraminifera, echinoids, bryozoans, corals, and bivalves, with minor serpulids and barnacles.

Coralline algae are the most abundant components in all facies except in distal planktonic foraminifer packstones. They occur mostly as fragments or, less frequently, as rhodoliths. *Hapalidiales* is the dominant group, being *Mesophyllum*, represented by *Mesophyllum roveretoi* and *Mesophyllum* sp., the most abundant genus. *Lithothamnion* group corallioides, *Lithothamnion ramossissimum*, and other undifferentiated species of the genus are the second most abundant taxa. *Sporolithon* sp., *Lithoporella minus*, *Subterraniphyllum thomasii* and several geniculate species complete the coralline algal assemblages, which are similar to those found in other closely located Middle Miocene carbonates (Aguirre and Braga, 2022).

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Geomorphology, Holocene developmental history and fate of the Coralligenous reef from the SE Sicilian shelf

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Keywords— algal reef, Holocene, Mediterranean Sea, radiocarbon dating

Coralligenous algal reefs (C) are biogenic rocks that, throughout their accretion, may document the natural environmental history of the continental shelves and their recent human-induced impacts. The national Italian project "CRESCIBLUREEF" explored the complex interplay between geological, oceanographic, and biological processes shaping the development of C reefs. The origin and evolution of C reefs offshore Marzamemi are linked to the region's tectonic and climatic history. Vertical tectonic movements combined with eustatism have created four submerged terraces, as revealed by high-resolution bathymetric mapping. C build-ups are unevenly distributed, forming clusters of discrete columns or decimeter-sized hybrid banks down to 45 meters of water depth (wd), often on inherited topographies. Between 45 and 65 meters of wd, only patches of discrete columns are found. From 65 to 80 meters wd, fine sedimentation and turbidity inhibit C development, while below 80 meters wd, build-ups reappear as isolated columns grouped on a submerged terrace.

We collected four build-ups at depths of 36, 37, 47.7, and 85 m wd. A comprehensive analysis of their living associations, internal structure, composition, density, and radiocarbon age is providing extensive data on the Holocene inception of C reefs, their paleodepth, and development style along the shelf. The deepest sample, at 85 m wd, is significantly affected by fine sedimentation, with its sclerobiont living association primarily consisting of annelids and bryozoans, and sponges dominating the biomass. At 85 m the suboptimal water transparency hinders the development of the few crustose calcareous algae surviving there. Conversely, the internal composition of all sampled build-ups is dominated by coralline algae, witnessing the deepening as consequence of the Holocene sea level rise. The present-day shift in primary habitat formers in deep build-ups raises questions about identifying C reefs in these deep, animal-dominated environments.

Depth-density-age gradient revealed by CT-scan on four coralligenous build-ups

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Keywords— Coralligenous build-ups, CT-scan, SE Sicily

Crustose coralline algae form coralligenous build-ups, representing a critical ecosystem within the Mediterranean shelf. These biogenic structures serve as habitats for a diverse assemblage of epifaunal and infaunal organisms, which engage in spatial competition, influencing reef accretion or its structural integrity via bioerosive processes. Four coralligenous build-ups were sampled, within the CRESCIBLUREEF project, at depths of 36, 37, 47.7 and 85 meters from different shelf environments. In this study we analyse, with the use of Computer-Tomography (CT) scanning the internal architecture of the build-ups. The CT analysis revealed four density categories of the skeletal framework: Low, Medium, High and Ultra-High. Total porosity was also assessed. The coralligenous were then sectioned to validate the four categories through visual inspection and thin section analysis. The results indicate a pronounced porosity across the structure, classified as primary, bioerosional and enhanced porosity. A notable depth-dependent density gradient was observed, with deeper build-ups exhibiting higher proportions of lithified material relative to their shallower counterparts. These findings imply a correlation between the build-up age and density, suggesting a trend of increasing density with current seawater depth and potentially with chronological aging. The high-resolution analysis highlights the complex growth patterns of the build-ups. Comprehending the structural attributes, including density and porosity, offers crucial insights into palaeoenvironmental contexts and provides a foundational framework for the analysis and interpretation of ancient biogenic structures within the fossil record.

On the ability of crustose coralline algae to build-up: extraordinary seascapes from Mediterranean mesophotic

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Keywords— algal reefs, rhodoliths, autogenic bioengineering, Linosa, Licosa

Crustose Coralline Algae (CCA) are the most important autogenic habitat engineers of the Mediterranean Sea, distributed from shallow water down to deep mesophotic (150 m of water depth), due to the exceptional transparency of seawater in some areas of this basin. They are able to form both hard biogenic substrates (intertidal rims and subtidal algal reefs) and rhodolith beds on mobile substrates. Algal reefs (= Coralligenous) are considered the most dynamic and volumetrically dominant benthic mesophotic ecosystem of the Mediterranean Sea, produced by the accretion of CCA and minor invertebrates, primarily bryozoans, sponges and serpulids. Under the term Coralligenous, we include the pre-Coralligenous, the "infralittoral" or in enclave Coralligenous and the circalittoral Coralligenous, that develops under sciaphilic conditions (= mesophotic), both as bioconstructions placed on vertical cliff (*Coralligène d'horizon inférieur de la roche littorale*), and on a sub-horizontal, originally soft substrate (= along the sub-horizontal shelf) (*Coralligène de plateau*). On sub-horizontal shelves, it forms isolated discrete columns, or individual sub-metrical to metrical structures, sometimes coalescent, more squat- or more pillar-shaped, up to tabular build-ups, square-km large. In all these cases, Coralligenous forms framestones, with different degrees of lithification and porosity, but generally characterized by dm-to-m vertical development with respect to the surrounding seafloor, attributable to the growth activity of CCA during the Holocene. Rhodoliths are biogenic carbonate nodules made by CCA, forming extensive beds in the circalittoral detritic bottoms, more rarely in the infralittoral zone. Although the scientific exploration of the Mediterranean started many decades ago, the most recent research efforts yielded some interesting surprises such as the discovery of new facies of CCA bioconstructions. This is the case of Linosa island (Sicily Channel, Italy), where coralligenous de plateau occurs, between 80 and 100 m of water depth, in the form of multiple planar to conical mono- up to multilayered structures, with an elevation of 20-30 cm, and a concave to convex arrangement, developing on a sedimentary biodetritic bottom, rich in rhodoliths. CORSUB project (PRIN project number 2022RKHBMB *Next Generation EU*) is aimed at exploring anomalous seafloor morphologies occurring offshore Licosa Promontory (Tyrrhenian Sea, Italy), and possibly of biogenic origin. Preliminary results of the first oceanographic cruise (June 2024) led us to identify clusters of geometric seafloor features between 80 and 85 m water depth in correspondence of submarine terraces. Each feature has a hexagonal shape, with a diameter of 10-15 m. The surface is apparently dominated by CCA in the form of rhodoliths and small build-ups. This study underlines that our knowledge on the capability of CCA to build-up and shape the seafloor is far from being fully explored, promoting the observation of present-day seafloor, also as a tool to better interpret our fossil record and the changes of marine paleo-biodiversity through time.

Exceptionally preserved algae from the Lower Ordovician Cabrières Biota (France)

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Keywords— Algae, Cabrières Biota, Lagerstätte, Montagne Noire, Ordovician

The Cabrières Biota is a new Lagerstätte recently found in the Lower Ordovician of the southern Montagne Noire (France). It comprises an assemblage of brachiopods, conulariids, echinoderms, graptolites, hyoliths, molluscs, sponges, trace fossils and trilobites, together with lightly sclerotized arthropods, palaeoscolecid worms and various unidentified soft-bodied taxa (Saleh et al., 2024, in press). Algal remains are also present and consist of fragments of branched elements, as well as a rare, filamentous, yet undescribed form. The new record consists in a very thin (0.2–0.4 mm in diameter), straight to sinuous form with a square section, bearing a well-marked longitudinal groove. Contrary to the situation in other algae from the Cabrières Biota (Saleh et al., 2024, in press), it is preserved as a black, coalified, tridimensional ribbon. The studied material was collected in Floian strata (Baltograptus minutus graptolite Biozone), but identical remains of the same new algae also occur in coeval shales from the lower part of the Landeyran Formation in the Mont Peyroux nappe (western part of the Montagne Noire).

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Fossilised biofilm growth model for cryptic *Frutexites* in Late Devonian reef complexes of the Lennard Shelf, Western Australia

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Keywords— ferromanganiferous dendrites, calcimicrobes, permineralised EPS, Canning Basin

Dendritic *Frutexites* is described from fore-reef slope facies of the exhumed Late Devonian reef complexes of the Lennard Shelf, Western Australia. Conventional microscopy and high-resolution imaging techniques, such as scanning electron microscopy (SEM), X-ray micro-computerised tomography, and X-ray fluorescence microscopy reveal the morphology and composition of these dendritic microstructures. Two *Frutexites* types were analysed in this study. Type I lines an early marine cement-filled cavity in fore-reef grainstone facies. It comprises slender dendrites with spheroidal to laminated textures formed primarily of coccoid and filamentous bacteria embedded in sheets of extracellular polymeric substances (EPS). Type II grew sheltered in between bioclasts on a toe-of-slope hardground. The opaqueness of its ferriferous dendrites obscures original internal textures but SEM revealed bacilliform and filamentous bacteria set in an amorphous EPS sheet. Both *Frutexites* types are the result of the consecutive growth and permineralisation of biofilms composed of mixed bacterial communities growing in cryptic habitats. A model is proposed for the growth of cryptic *Frutexites* including different stage of permineralisation: 1) Fe-Mn-Al-Si mineralisation within the EPS sheet resulting in an iron-manganese-organic composite; 2) more stable iron and/or manganese precipitates (e.g. hematite); 3) closely packed spheres of Fe-Al clay. The initial stages of permineralisation are microbially-induced through degradational processes, whereas the later transformation from nanograins to larger Fe/Mn-(oxhydr)oxides was likely abiotic through Ostwald-ripening guided dissolution and regrowth processes. Elemental mapping shows a homogenous distribution of major and trace elements within the dendrites suggesting an ongoing availability of these elements in the surrounding seawater (e.g. Fe, Mn, Ba) and sediments (e.g. Al, Ti, V, Cr). These higher resolution data show that *Frutexites* in the fore-reef slope facies along the Lennard Shelf were likely constructed by non-phototrophic, Fe- and Mn-oxidising coccoidal, bacilliform and filamentous bacteria under very low hydrodynamic energy conditions.

Paleogene Peyssonneliales: more diversity than meets the eye?

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Keywords— Paleocene; Red Calcareous Algae; Bioconstructions; Taxonomy; Morphology

Peyssonneliales are a common and often dominant component of the calcareous algal assemblage of early Paleogene fossil reefs. The vast majority of these algae are usually identified as *Polystrata alba*. This fossil taxa belongs to the still existing genus *Polystrata*, which includes several living species. The analysis of a large number of specimens of Peyssonneliales from the Danian of central Italy highlighted the common presence of structures resembling isolated sporangial cavities buried within the thallus. Further comprehensive analyses of a large set of early Paleogene specimens, ranging from Slovenia to Pakistan, indicate that these cavities, located well within the thallus surface, indeed represent reproductive structures. These structures differ from the known reproductive anatomy of certain living members of the genus *Polystrata* (e.g., *Polystrata dura*). This in turn suggests that it is best to proceed cautiously when assigning fossil algae displaying these features to *Polystrata alba*. As this type of reproductive anatomy occurs relatively commonly in the observed early Paleogene material, it is likely that a portion of the observed "*Polystrata*-like" algae should not be included in *Polystrata alba*. This would imply that, similarly to extant assemblages, early Paleogene shallow-water tropical red calcareous algal assemblages were probably characterised by a taxonomic richness greater than what could be initially assumed.

Experimental vs. natural Mg-smectite precipitation in modern microbialites: the case study of the alkaline Bagno dell'Acqua lake (Pantelleria Island, Italy)

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Keywords— biomineralization; biosignature; Mg-smectite; organo-sedimentary deposits; alkaline lake

Microbialites are present in different aquatic environments such as inland fluvial, lacustrine water, marine coasts and marine extreme environments, and coastal lagoon when specific biogeochemical conditions occur. Microbial activity has been documented in various lacustrine environments suggesting its fundamental role in the precipitation of minerals and, therefore, in the formation of organo-deposits such as microbialites. Many studies are currently focused to document how the association of microbes and extracellular polymeric substance (EPS) may influence the authigenic Mg-clay formation and the subsequent carbonate deposition in growing microbialites in lacustrine environments. Microbial organisms have a fundamental role in microbialite formation depending on the complex interplay between environmental and biological factors (e.g., pH, water composition, temperature, salinity, type of microbial community). We investigated the present-day microbialites of the alkaline Bagno dell'Acqua Lake (Pantelleria Island, Italy) using X-ray diffraction (XRD) and scanning electron microscopy energy-dispersive X-ray spectroscopy (SEM-EDX). Submerged microbialites sampling was conducted in June 2019, May 2022, and February 2023, mainly in the north-eastern, eastern, and south-western sectors of the lake with a total of 11 sampling sites. During the field campaigns, in situ water electrolytic conductivity, temperature, Eh and pH measurements were performed. Generally, the microbialites appear roughly laminated and vary from soft to partly consolidated. They show a vertical layering that from top to bottom is composed of a 1mm thick light brown layer overlying a millimetric-thick well-defined green layer and centimetric thick white layer. The scanning electron microscope (SEM-EDX) observations showed variable mineral assemblages including sediment phases such as quartz, feldspar, amphibole but also highlighted substantial amounts of Mg-smectite, in association with carbonate minerals and particles showing a multi-elemental spectra characterized by high Si and subordinate Al, Mg, Na, Ca and Fe. To investigate the role of bacteria in inducing the neoformation of clay and carbonate minerals we performed, for the first time, laboratory experiments where microbes belonging to phylum Firmicutes (*Bacillus* sp.), from natural microbialites, were deposited onto solid B4HLU media containing filtered lake water, incubated at 28°C for 34 days, then analyzed through SEM-EDX. The aggregates resulting from the experiments, having dimensions in the order of few microns, displayed morphological and chemical similarities with natural microbialites, such as planar flake morphologies typical of clay minerals and EDX spectra compatible with the presence of smectites/Mg-smectite phases; carbon-rich multi-elements (Al, Mg, Na, Ca, K, Fe) up to Ca-carbonate compositions were also revealed by EDX analysis. These results updates the list of the natural sites where the association "EPS versus clay-minerals formation" finds suitable conditions for minerals authigenesis as already observed in other saline and alkaline lacustrine and marine environments (e.g., Leguey et al., 2010; Léveillé et al., 2002; Perri et al., 2022). On these bases we propose that the mineral sequence leading to the lithification of the Bagno dell'Acqua microbialites includes an initial phase in which the microbial community, mainly composed of phyla of Bacteria and diatoms produce a dense network of EPS, which represents an important substrate

for the precipitation of clay minerals due its capacity to attract cations, such as Si, Al, Ca, Mg and Fe that develop amorphous nanoparticles, which have been considered to represent the basis for clay minerals nucleation and growth. The initial microenvironmental condition inhibits the precipitation of $CaCO_3$ and increase the Ca^2+ concentration. The dissolution of diatoms frustules due to the elevated pH leads to a local enrichment in SiO_3 favoring Mg-smectite precipitation. Then, the degradation of the EPS and organic matter leads to the release of Ca^2+ cations with consequent carbonate minerals precipitation. The obtained results provide a better understanding of the natural conditions suitable for development of Mg-smectite microbialites and these findings raised the importance of future research into the wide mechanisms of Mg-clay biomineralitation.

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A protocol for marine bioconstructions mapping: case study of Isola Capo Rizzuto (Calabria, Italy)

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Keywords— bioconstructions, benthic habitat mapping, GIS-based protocol.

The main bioconstructions along the Mediterranean continental shelf are coralligenous build-ups, vermetid reefs, deep-sea cold-water corals, sabellariid build-ups and polychaeta/bryozoan bioconstructions. These temperate reefs form in a wide range of marine settings, from shallow to deep water and from open to confined sectors and constitute important archives of recent environmental and climate changes. Coralligenous is a biocenotic complex mainly produced by the accumulation of calcareous encrusting algae growing in dim light conditions, able to form 3D biogenic build-ups. Coralligenous contributes to seascape shaping through geological times, producing various morphotypes and causing geomorphological changes of the seafloor (Marchese et al., 2020). Based upon the nature of the substrates, Coralligenous morphotypes have been categorized mainly in two groups: i) banks, flat frameworks mainly built over horizontal substrata; ii) rims, structures on submarine vertical cliffs or surrounding the opening of submarine caves. Moreover, Bracchi et al. (2017), using a shape geometry descriptor, proposed a new categorization for Coralligenous morphotypes on sub-horizontal substrate in tabular bank, discrete relief and hybrid bank. Although coralligenous bioconstructions are present along almost all Mediterranean continental shelf, their distribution is still underestimated and has been mapped only in few areas. In addition, due to its importance as a hot spot of biodiversity, the European Community considers the Coralligenous to be among the most important habitats to monitor and protect, also considering its low accretion rate and its high sensitivity to natural and anthropic impacts (Cipriani et al., 2024). For all these reasons, seabed mapping can provide a useful tool for seascape characterization and habitat mapping of Coralligenous, Posidonia meadows and other vulnerable settings. In particular, acoustic instruments such as high-resolution swath bathymetry sounder (including backscatter), side scan sonar and acoustic profiling are optimal instruments because they allow to quickly recognize and identify the extension of benthic habitats on the seabed and thus map their distribution without making mechanical samples, which would damage this delicate ecosystem. In this work, a semi-automated GIS-based protocol for benthic habitat mapping were proposed and tested in shallow coastal water of Capo Bianco, within the Isola Capo Rizzuto Marine Protected Area. The method combines high resolution bathymetric and backscatter data obtained by MBES surveys with geomorphological and geomorphometric indices to develop innovative approaches for eco-geomorphological and geobiological studies. Particularly, the entire spatial dataset was integrated into QGIS and geomorphometric analysis was performed with SAGA Next Gen Providerand GDAL. To discriminate the areas covered by coralligenous bioconstructions from Posidonia meadows and surrounding seascape, backscatter values, together with water depth, slope, seafloor roughness and profile curvature, were imported and queried into PostgreSQL. The extraction of Coralligenous build-ups was subsequently performed using the Topographic Position Index (TPI) at the finest possible scale according to the DEM and using a threshold value in order to maintain the high resolution of the extraction and reduce the occurrences of artifacts. Resulting raster were re-classified and polygonised and the remaining artifacts were manually detected. For each coralligenous polygon, the Shape Index (SI) was calculated in order to distinguish between banks and discrete relief, following the approach proposed by Bracchi et al. (2017). Height's estimation involved complex DEM filtering operations performed with SAGA. These algorithms, through the setting of several input parameters, aimed to derive a "reference surface" from which the depth of each build-up could be subtracted. After estimating the height of each build-up relative to the seabed on which it developed, area and volume of each polygon was calculated

using vector field operations implemented in QGIS. In conclusion, the benthic habitat mapping protocol proposed in this work has proven capable not only of identifying marine bioconstructions, but also of quantitatively defining their three-dimensional distribution in terms of area, volume and height relative to the substrate from which they developed. For these reasons, it represents a powerful tool for accurately delineating their spatial extent and evaluating their evolution over time in response to natural and or/anthropogenic changes. Furthermore, combining this mapping protocol with minimally invasive sampling systems and geobiological/geochemical characterization of marine bioconstructions, a potent instrument for monitoring, protecting and enhancing these delicate ecosystems could be obtained.

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Upper Jurassic calcareous algae in a large olistolith from the Transylvanides (Southern Apuseni Mountains, Romania)

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Keywords— calcareous algae, microfacies, Tithonian

The studied succession is located in the Măgura Geomalului Hill. It consists mainly of a large olistolith wich is embedded in Upper Cretaceous deposits of the Transylvanides (Southern Apuseni Mountains). The eastern part of the Southern Apuseni Montains comprises Jurassic island arc type igneous rocks, Upper Jurassic-Lower Cretaceous carbonates, Barremian-Aptian flysh formations, Albian wildflysh deposits and Upper Cretaceous molasses (Ianovici et al., 1976). The large olistolith from Măgura Geomalului, probably detached from the Bedeleu carbonate platform, is embedded in the Uppermost Albian-Coniacian Rîmeţi Formation, a post tectonic unit of the Transylvanides. Seventy-seven samples were collected from the Geomal Quarry and 104 thin sections were prepared. Thin section analysis was performed and the following microfacies types were identified: MF 1 – coral-microbial boundstone, containing encrusting organisms and stromatolitic microbial structures; MF 2 – boundstone with packstone-grainstone type internal sediment; it contains dasycladalean algae, calcareous sponges and cyanobacteria; MF 3 – bioclastic grainstone-rudstone with black pebbles; it is represented by a coarse limestone, also containing corals, echinoderm fragments, encrusting organisms, dasycladalean algae, udoteacean algae, foraminifera, and various extraclasts; MF 4 – bioclastic floatstone with encrusting organisms, corals and sponges; MF 5 – peloidal bioclastic wackestone-packstone with stromatolitic microbial structures, rare dasycladalean algae and syn-depositional cement. The paleontological assemblage consisting of foraminifera (*Bullopora* sp., *Charentia evoluta, Coscinoconus alpinus, Everticyclammina virguliana, Frentzenella involute, Iberopora bodeuri, Mohlerina basiliensis, Protopeneroplis striata, Protopeneroplis ultragranulata, Reophax rhaxelloides, Troglotella incrustans*), encrusting organisms (cf. *Bacanella floriformis, Crescentiella morronensis, Koskinobulina socialis, Labes atramentosa, Radiomura cautica*), calcareous sponges (*Calcistella* cf. *jachenhausenesis, Cylicopsis verticalis, Murania reitneri, Neuropora gigantea, Neuropora lusitanica, Perturbatacrusta leini, Radiomura cautica, Sarsteinia* sp., *Thalamopora lusitanica, Tubuliella fluegeli*) and worm tubes (*Mercierella dacica, Terebella lapilloides*) indicates a Late Jurassic (Tithonian) age. This age assignment is also supported by the algae assemblage which contains dasycladaleans [*Aloisalthella sulcata* (Alth), *Campbelliella striata* (Carozzi), *Chinianella scheimpflugi* (Hofmann), *Linoporella capriotica* (Oppemheim), *Neoteutloporella socialis* (Praturlon), *Petrascula bugesiaca* (Bernier), *Petrascula bursiformis* (Etallon), *Salpingoporella annulata* (Carozzi), *Salpingoporella pygmaea* (Gümbel), *Steinmanniporella* cf. *kapelensis* (Sokac & Nikler), *Terquemella* sp., *Triploporella remesi* (Steinmann), *Uragiella* cf. *suprajurassica* (Gümbel)], udoteaceans (*Boueina* sp., *Carpathocodium* sp., *Nipponophycus ramosus* Yabe & Toyama) and the incertae *Thaumatoporella parvovesiculifera* (Raineri). The facies associations indicate a shelf margin, slope environment. Dasycladalean algae are frequent within MF 3 (bioclastic grainstone-rudstone with black pebbles). Some large dasycladalean algae (e.g. *Petrascula bursiformis, Triploporella remesi*) as well as the "colonial" *Neoteutloporella socialis* could be frequent in such high energy environments (Bucur & Săsăran, 2005; Schlagintweit, 2011). Together with *Nipponophycus ramosus* they can be considered as a reefal-perireefal algae assemblage frequently reworked on the upper slope.

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Coralline algae of the Slovak Neogene Basins, distribution and morphology-based taxonomy

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Keywords— on-geniculate coralline algae, Slovak Neogene Basins, Badenian, Central Paratethys, taxonomy, distribution

Non-geniculate coralline algae from the Badenian limestones of Slovak Neogene Basins are well known. Their taxonomy and distribution were the topic of few papers (e.g. Coletti et al. 2016; Hrabovský 2013, Hrabovský et al. 2019). However, these papers do not cover many other outcrops of coralline algal assemblages in the Vienna, Danube and East Slovak basins. Here, we have analysed non-geniculate coralline algal assemblages from limestone outcrops of the East Slovak Basin – outcrop Kosihovce, Danube Basin – outcrops Kamenica nad Hronom and Modrý Majer, and Vienna Basins – outcrops Rohožník, Vrchná Hora, Borský Mikuláš and Devínska Kobyla. Our results suggest that the hard substrate assemblage (Modrý Majer and Rohožník) differs from the soft bottom assemblages as well as there are differences in the spatial distribution in the soft bottom assemblages. Most obvious are differences in the distribution of the genera *Lithothamnion*, *Phymatolithon* and mesophyllacean coralline algae. Moreover, our results suggest that the genus *Mesophyllum* is the only genus of mesophyllacean coralline algae confirmed to occur in the Upper Badenian Limestones, as suggested by the presence of specialized pore canal cells morphology and gametophytes.

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Late Messinian enigmatic microbial texture from Salento Peninsula (southern Italy): nature and palaeoenvironmental setting of filamentous dendrolites

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Keywords— microbialites, dendrolites, late Messinian, Mediterranean

During the late Messinian the Mediterranean basin underwent deep environmental and biotic changes, related to the closure of the connection with the Atlantic Ocean and the onset of the so called "salinity crisis". This phase had a major impact on the carbonate platforms, that in several areas registered the deposition of thick successions of microbial carbonates. Upper Messinian microbialites have been recently described in the Leuca Cape, at the southern extremity of the Salento Peninsula (south-eastern Italy) (Vescogni et al., 2022). A preliminary description of this unit has been provided, with an account of its stratigraphic architecture, facies characterization and age determination. Six facies of microbial origin have been identified, some of them showing particular meso- and micro-fabrics so far never reported for the late Messinian of the Mediterranean area. The present study focus on small dendritic growth-forms. These dendrolites are enclosed in a stratigraphic interval that rests on limestone/marl deposits; at the base a very irregular erosive contact delimits a depression with a length of 42 m and a maximum thickness of 1.4 m. The succession starts with massive, strongly bioturbated packstone containing mainly mollusks, echinoderms, miliolids and Elphidium. These deposits were than cut by a second erosion surface, that created a further concave depression filled by fine-grained wackestone with similar bioclastic content. In these sediments dendrolites are frequently found as scattered fragments, usually some mm in size, with irregular to lobate shape. Sometimes they are preserved as ellipsoidal structures, few cm in size, with stubby, outward directed branches forming digitate growth-forms. At microfabric scale dendrolites show a sparry calcite texture, containing traces of dark filaments, irregularly arranged and preserved singularly or as disordinate tangles. Sometimes the ellipsoidal aggregates are coated by some mm-thick crusts made of micrite clots. Under UV-excitation, dendrolites show a bright fluorescence, indicating the presence of organic remains intimately associated to the microstructure. The digitated shape, the occurrence of dark filaments and the bright epifluorescence strongly suggest a biotic, microbial origin for the Salento dendrolites. The sedimentary, stratigraphic, and palaeontological data suggest the formation of these microbialites in a small, protected lagoon, with shallow-water, normal marine salinity and moderate to low hydrodynamic conditions. This small basin was possibly crossed by channels, that facilitated periodic events of erosion and resedimentation. Salento dendrolites can be compared with present-day filamentous dendrolites, commonly indicated as microbial shrubs or tufts. They are arborescent, variously elongated structures, few centimeters of maximum height, with a microfabric made by an upward-oriented tangle of cyanobacterial filaments. Filamentous dendrolites are known from hydrothermal, hypersaline and super-saturated environments. One of the best documented examples is described in Hamelin Pool, Western Australia, where ephemeral growth-forms of dendrolites develop in the mid to lower intertidal zone (Suosaari et al., 2018). This type of microbialites has a low degree of calcification and thus a very limited preservation potential, therefore only present-day examples are known. For these reason the late Messinian filamentous dendrolites of the Salento Peninsula can be considered as the first finding of these microbialites in the fossil record; their originally fragile structure could be the reason why they are predominantly preserved as scattered fragments.

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