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Mesozoic dasycladalean algae from Romanian Carpathians: diversity, environment and palaeogeographic context

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Dasycladalean algae are important constituents of the shallow-water carbonate sediments of the Mesozoic. The Romanian Carpathians contain such deposits with an extensive development during the Triassic, Late Jurassic and Early Cretaceous.
From the Middle Triassic (Anisian-Ladinian) carbonate platform deposits are known in the Eastern Carpathians (Rarau and Persani Mountains), Southern Carpathians (Sasca zone) and Apuseni Mountains (Padurea Craiului massif). During Anisian the dasycladalean assemblages are dominated by species of the genera *Oligoporella* and *Physoporella*, and in Ladinian by *Diplopora* si *Teutloporella*. These assemblages developed most frequently in internal platform environments (lagoons) and comprise species with limited stratigraphical range, important for biostratigraphy. It is worth mentioning the global uniformity of these associations.

During the Upper Jurassic the dasycladalean assemblages of the Romanian Carpathians are related to the development of the carbonate platforms that generated to so-called Stramberk-type limestones (e.g., Haghimas, Piatra Craiului and Vanturarita Mountains in the Eastern and Southern Carpathians; Trascau massif in Apuseni Mountains). The dasycladalean assemblages developed either in inner platform environments, with dominance of the genus *Salpingoporella*, or in platform margin environments, where large species of the genera *Petrascula*, *Steinmanniporella* or *Triploporella* are dominant. The late Jurassic carbonate platforms extended also in the Neocomian.

A new stage of the shallow-water carbonate sedimentation developed during the Barremian-Aptian giving rise to the Urgonian carbonate platforms. In the Romanian Carpathians such platforms are known from Rarau, Haghimas and Persani Mountains (Eastern Carpathians), Dambovicioara and Resita-Moldova Noua zones (Southern Carpathians) and Apuseni Mountains (e.g., Bihor-Padurea Craiului unit). During the Early Cretaceous the dasycladalean algae reached their maximum of diversity, and beside *Triploporellaceae* (mostly *Salpingoporella* species) frequent *Dasycladaceae* are known (e.g., *Neomeris* and *Montiella*), present in both internal and external parts of the platforms. The Early Cretaceous seems to represent also a time interval with more dasycladalean provincialism. It is well known the southern-Tethyan affinity of *Salpingoporella dinarica* (a species which is not known from the Romanian Carpathians) as well as the existence of some species with limited palaeogeographic range to the Carpatho-Pontic area (e.g., *Kopetdagaria sphaerica* or *Conradella bakalovae*).

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Calcareous algae from the olistoliths at Poiana Zanoaga, northern part of Piatra Craiului Syncline (Southern Carpathians, Romania)

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The Piatra Craiului Massif is a major syncline structure in the Southern Carpathians. Its flanks consist of Middle and Upper Jurassic-Neocomian carbonate deposits, while the filling is represented by conglomerates assigned either to the Upper Aptian, or to the terminal

Albian (Vraconian)-Cenomanian (SANDULESCU et al. 1972, BUCUR et al. 2009). In the northern area of the syncline (Poiana Zanoaga) these conglomerates include large limestone olistoliths. The olistoliths were assigned by POPESCU (1967) and SANDULESCU et al. (1972, map 1:50.000, sheet 110b Zarnesti) partly to the Tithonian and partly to the Barremian. Most of blocks consist of peritidal deposits with frequent fenestral limestones. They contain relatively rare microfossils, including cuneolinid foraminifers documenting the Barremian age. Nevertheless, some of the olistoliths proved to be very rich in fossils, with the dominance of large dasycladaleans easily noticeable on alteration surfaces (eg., the olistolith from the peak known as 'Silha lui Caita').

The following microfacies types dominate the fossil-rich olistoliths from Poiana Zanoaga: coarse bioclastic grainstone, ooidic grainstone, fine peloidal bioclastic fenestral grainstone, intraclastic grainstone/packstone, bindstone with bacinellid structures and various bioclasts, coral-microbial boundstone, intraclastic wackestone (microbreccia).

The microfacies types indicate various sectors of the carbonate platform: from the platform margin (bioconstructions), to the external platform/open internal platform with high hydrodynamics (coarse bioclastic shoals), and to peritidal environments (microbial mats and fenestral structures).

The foraminifers we have identified: *Pseudocyclammina lituus*, *Charentia evoluta*, *Coscinophragma cribrosa*, *Mohlerina basiliensis*, *Protopeneroplis ultragranulata*, *Nautiloculina bronnimanni*, *Andersenolina alpina*, *Andesenolina* cf. *sagittaria* and *Andesenolina perconigi* document an Upper Tithonian-Berriasian age (eg., ARNAUD-VANNEAU et al. 1988, BUCUR & SASARAN 2005) for these limestones.

The calcareous algae are represented by *Petrascula bursiformis* (Etallon) (very frequent), *Petrascula* sp., *Pseudocymopolia* cf. *jurassica* Dragastan), *Salpingoporella pygmaea* (Guembel), *Suppiluliumaella* sp., *Terquemella* sp., and rare specimens of *Clypeina sulcata* (Alth), *Nipponophycus* sp. *Diversicallis dianae* Dragastan & Bucur as well as rivulariacean-type cyanobacteria. Among the problematic microorganisms, we have notices *Lithocodium aggregatum*, sometimes associated with the foraminifer *Troglotella incrustans*.

The above-mentioned calcareous algae are also typical for the Upper Tithonian-Berriasian interval (eg., BUCUR 1999).

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Lower Cretaceous calcareous algae form the Khur area, Central Iran

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Cretaceous strata are very thickly developed, widely distributed and superbly exposed in the Khur area of Central Iran. They are part of the sedimentary succession of the so-called Yazd Block, the western structural element of the Central-East Iranian Microcontinent (CEIM), an independent microplate within the complex Mesozoic plate tectonic mosaic of the Middle East. During the Cretaceous, the CEIM was detached from Eurasia and surrounded by small oceanic basins which opened and closed in response to (inferred) counter-clockwise rotational movements of the microplate.

The Cretaceous succession starts with conglomerates and sandstones of the up to 1000-m-thick Chah Palang Formation (Upper Jurassic?-lowermost Cretaceous) covering Palaeozoic-Triassic basement rocks or weakly metamorphic rocks of the Shemshak Group (Upper Triassic-Liassic). The levelling of the palaeo-relief continued with the following, up to 500-m-thick Noqreh Formation (interbedded terrestrial to marginal marine sediments) and the carbonate platform deposits of the Shah Kuh Formation (WILMSEN et al. 2013).

The calcareous algae discussed herein have been found in sample from the Noqreh and the Shah Kuh formations. The age of the two formations range between Barremian and Late Aptian, as indicated by the foraminiferal association: *Balkhania balkhanica* Mamontova, *Dictyoconus pachymarginalis* Schroeder and *Mesorbitolina texana* (Roemer).

The calcareous algae association comprise several species of Dasycladales [?*Clypeina* sp., *Deloffrella quercifoliipora* Granier & Michaud, *Montiella*? *elitzae* (Bakalova), *Morelletpora turgida* (Radoicic), *Neomeris* cf. *cretacea* Steinmann, *Neomeris* cf. *srivastavai* Granier, Dias-Brito & Bucur, *Pseudoactinoporella*? *iranica* Bucur, Rashidi & Senowbari-Daryan, *Terquemella* spp., ?*Triploporella* sp.] and Bryopsidales (*Boueina* cf. *hochstetteri* Toula, *Boueina* cf. *pygmaea* Pia, *Permocalculus minutus* Bucur, *Permocalculus* sp.).

This algal assemblage is generally similar to the one identified in the central-western part of the Yazd block (Aliabad area) by BUCUR et al. (2012) except for *Morelletpora turgida*. It is noteworthy that *Pseudoactinoporella*? *iranica* has now been identified for the first time ouside Aliabad, its type locality.

The algae from Khur area provide new data for comparisons between different regions of Central Iran (Ardekan, Aliabad, Khur) as well as additional data concerning the paleogeographic position of the Yazd Block and geodynamic history of the CEIM during Barremian and Aptian times.

Zeapora - an endemic Devonian 'praecodiacean' of Graz or a common tropical cosmopolitan?

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In his 1894 monograph on Devonian fossils of the Graz Palaeozoic Karl A. PENECKE (1858-1944) designated by monotypy the new genus *Zeapora*. He assigned it to cyclostomate bryozoans because the representative feature, 'a hollow central axis surrounded by only one row of prismatic cells', he thought to be unique for the bryozoan order. The history of *Zeapora* is one with many problems concerning the systematic assignment: RUKHIN (1938) included it in his new stromatoporoid family Amphiporidae, BASSLER (1953) assigned it to the Trepostomates, SOKOLOV (1955) to thamnoporid tabulate corals, FLUEGEL (1959) to dasycladacean and finally HUBMANN (2000) to halimedalean algae. The confusing story about *Zeapora's* systematics and its little adequate taxonomic description was probably the reason why this genus was ignored by palaeo-phycologists. Thus, *Zeapora* had the sad fate to remain endemic over 100 years! However, in our opinion younger synonyms of *Zeapora* PENECKE 1894 are hidden among Devonian algal genera, i.e. *Botrys* SCHIRSCHOVA 1985 and *Litanaella* SHUYSKY & SCHIRSCHOVA 1987. Both genera were recorded from the Lower to Middle Devonian (Emsian and Eifelian). Occurrences of *Botrys* are known from the eastern slopes of Northern Urals (Karpinsky horizon), and from Bosnia (Klek). Findings of *Litanaella* are reported from the eastern slopes of Northern Urals (Parminsky lot, Ivdel' region), Dinant Syncline, Belgium (Couvin Lmst.), New South Wales, Australia (Sulcor Lmst.), and Southern Tien Shan, Usbekistan (Norbonak Beds). The compilation of these localities on a Devonian geographic base map results in a peculiar distribution within the equatorial belt comparable to present-day *Halimeda*. This distribution pattern can be well explained by circum-equatorial currents.

Silurian non-calcified algal flora from the Kalana Lagerstaette, Estonia

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The non-calcified algal floras were probably widespread in the Paleozoic seas, but this view can be proved with exceptionally preserved fossils only.
The non-mineralized or weakly calcified algal species are rarely preserved and have been found in few Lagerstaetten only. Therefore the extent of their stratigraphic ranges and richness of their geologic history has probably been strongly been underestimated.
Up to now only 14 species of non-mineralized algae have previously been reported from the entire Silurian System around the world.

The Early Silurian algal Lagerstaette in Kalana, Estonia, has revealed rich non-mineralized algal flora, which on the basis of external morphology are assigned to Rhodophyta and Chlorophyta. Most of the material occurs within the light to dark brown organic-rich, microlaminated, partly dolomitized limestones.
Kalana quarry in Central Estonia is by far the richest and best preserved algal deposit in the Early Paleozoic. In the Kalana material we can distinguish at least ten morphological species. This marks a considerably higher diversity than has been documented in the Cambro-Silurian strata up to now.

The most common algal fossil in these shelf carbonates is a red algal species *Leveilleites hartnageli*, which was originally described by Foerste in 1923 from roughly coeval sediments in southern Ontario, Canada.

The thalli of this type are up to 7 cm high, with a 1-2 mm wide axis. Each specimen has 10-20 primary branches, most of them about equal in length and 12-25 mm long. These branches bear 10-30 so called tufts, consisting of 20-30 up to 1 mm long laterals and arranged in either side of the 1st-order laterals. We are able to designate two distinct macroscopic phases (a haploid and diploid phase) of the life cycle of *Leveillites*.
Many algal fossil of Kalana - *Medusaegraptus* sp., *Chaetocladus* sp., *Inopinatella* sp., and *Cymopolia* sp. - belong to the green algae of the order Dasycladales. Dasyclads are unicellular and radially symmetrical macroalgae with siphonous organization. This highly diverse group has a long geological history, but is dominated by calcareous forms.

The fossil evidence from the Kalana Lagerstaette suggests, that some of the algae may have maintained their basic morphology almost unaltered for over 400 million years, with the main innovation being the extracellularly laid calcium carbonate skeleton and the algal floras were probably widespread in the Paleozoic seas.

Non-geniculate coralline algae and foraminifers as main constituents in microfacies types of 'Leitha Limestone', Middle Miocene, north-eastern Leithagebirge, Austria

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The Historic Quarry Project aimed at the identification and investigation of natural stones that proved historically important for buildings and monuments by means of linking their quarry provenance with their applications. In this respect, Leitha Limestone, being one of the most famous building stones in Vienna, Bratislava and Graz, was chosen. To fill the blind spot due to the military inaccessibility of abandoned quarries distributed between Kaisersteinbruch and south of Bruck/Leitha these were selected for investigation and a permitted field trip carried out. Moreover, quarries in the Ruster Hills (e.g., so called Roemersteinbruch St. Margarethen) and in southern Styria (subsurface Roemerbruch Aflenz) were also part of the excursion. Further samples of Leitha Limestone quarries from Nußdorf (Vienna) and Pfaffenberg (Deutsch-Altenburg) were studied for comparison.

Carbonate microfacies analysis of 70 thin sections by stereo microscope was applied, quantity estimations are based on comparison charts.

From the 30 quarries that were subject to general survey, rock samples were taken for macroscopic identification and some of them chosen for preparation of thin sections. From 12 of these quarries additional cores (35 mm diameter, up to 15 cm long) were drilled. The core samples served for geophysical and geotechnical laboratory tests and for thin sections as well.

The field investigations and quarry descriptions contribute to the mineral raw-materials archive and database of the Geological Survey. Based on the available geological maps the Leitha Limestone succession covers a basement relief, which occurs as topographical heights, called Schieferberg, Zeilerberg and Königsberg with Semmeringquarzit and Middle Triassic dolomite and with the latter cropping out as erosional and quarry relics south of Kaisersteinbruch. Although the map differentiates between Badenian 'Leithakalk' and Sarmatian 'detritaerer Leithakalk', this was not obviously recognizable in the field.

The thin sections were grouped according to their microfacies characteristics and resulted in: Micro-breccias and conglomerates with reworked dolomite basement rocks, (par-)autochthonous bioclastic corallinacean-bryozoan boundstones as well as bryozoan-serpulid boundstones, pack- and rudstones with mainly corallinacean algae and eventually rhodolithes, well sorted grain- and rudstones (detrital calcareous sandstones) with varying amounts of corallinacean algae, bioclasts, foraminifers and lithoclasts. Occasionally important are mixed carbonate-siliciclastic types. Few samples are dominated by molluscs. Some textures, cements and diagenetic features are indicative of special environments. Concerning the coralline algae flora, up to now, mainly *Lithothamnium*, *Lithophyllum* and *Sporolithon* were recognized.

A preliminary age differentiation between Badenian and Sarmatian is mainly based on foraminifers and the occurrence of ooids.

It can be concluded that the microfossil record in the thin-sections from these isolated samples could be identified to a limited extend. The resulting microfacies types were tested for their regional extent. For further investigation, the significance of these samples should be proven as they should serve for recognition in stone monuments, and for lithostratigraphical contribution.

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Microbial carbonates in Miocene reefs in the Mahakam Delta in East Kalimantan, Borneo, Indonesia

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Microbial carbonates are deposits that form by the activity of bentic microbial communities. Microbialites usually form domical, columnar or conical structures and can have laminated, clotted, dendritic or homogenous macrofabric. They have a broad distribution and can grow in a variety of different environments such as hot springs, freshwater lakes, hypersaline lakes, reefs and other marine environments. This research focuses on microbialites associated to coral reefs.

Coral patch reefs in the Miocene Mahakam Delta in East Kalimantan (Borneo, Indonesia) grew in shallow marine turbid waters. These patch reefs developed from delta front to deeper (prodelta) settings in areas with temporary reduced siliciclastic input. Langhian reef deposits are well exposed in limestone quarries in the Samarinda area and locally include microbial carbonates. Two different types of microbial carbonates have been found around Samarinda in two localities 2 km apart.

These sections were logged in detail and 208 samples were collected. Meso and macrostructure of microbialites were identified at the outcrops. Thin sections from carbonate samples were examined under optical microscope and microfacies were classified using the DUNHAM (1962) and EMBRY & KLOVAN (1971) terms. The carbonate content was analyzed using Total Inorganic Carbon analysis, with 12% carbon as a standard for carbon calibration. In the northern section, microbialites occur as low-relief domes, up to 2 m wide and 0.5 m high, with internal lamination, developed around large coral fragments at the transition from reef deposits to fine-grained siliciclastics.

The second type of microbialites has been found in the southern locality as decimeter-scale nodules ('megaoncoids') formed around nuclei of large coral fragments. Small nodules were bound together into bigger nodules. Microbial micrite with laminated to digitated fabrics intergrew with coralline algae to form the thick covers of these 'megaoncoids', which laterally change into coral boundstones.

In both sections microbialites are not components of the reef framework. They grew around large coral fragments on the flanks of the patch reefs. The microbialites that form low relief domes developed on a nearly flat, stable seafloor seawards of the patch reef. The 'megaoncoids' in the southern section formed as a result of downslope movement of coral fragments coated by microbialite/coralline algal crust. The steep slope at the flank of the patch reef favoured falling and overturning of encrusted corals and continued growth of microbial crusts on other sides of nodules.

Lower Cretaceous calcareous algae from Herisht Mount (Ardakan area, Central Iran)

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In spite of the several publications in the last decade, little is known about Lower Cretaceous calcareous algae from Iran. The calcareous algae association described here adds to the knowledge on algal paleobiodiversity in Central Iran, and brings new insights into the regional paleogeographic framework during the Lower Cretaceous.

Herisht Mount is located 14 km north of Ardakan town (Central Iran). Geologically, the area belongs to the Yazd tectonic block. The studied section is about 640 m-thick; it contains conglomerates at the base followed by 40 m-thick limestones. They are covered by a 63 m-thick green shale level, followed by several hundreds of stratified limestones with mollusks, foraminifers, and calcareous algae.

The foraminiferal association with *Balkhania balkhanica* (Mamontova), *Charentia cuvillieri* Neumann, *Everticyclammina* hedbergi (Maync), *Dictyoconus pachymarginalis* Schroeder, *Mayncina bulgarica* Laug, Peybernes & Rey, *Mesorbitolina texana* (Roemer), *Praeorbitolina cormyi* Schroeder, *Sabaudia minuta* (Hofker), *Torremiroella hispanica* Brun & Canerot and *Vercorsella scarsellai* (De Castro), indicates a Barremian-Aptian age for the whole succession.

Green algae (Dasycladales and Bryopsidales) dominate the calcareous algae association, consisting of ?*Conradella bakalovae* (Conrad & Peybernes), *Cylindroporella ivanovici* (Sokac), *Deloffrella quercifoliipora* Granier & Michaud, ?*Griphoporella cretacea* (Dragastan), *Kopetdagaria sphaerica* Maslov, *Montiella*? *elitzae* (Bakalova), *Morelletpora turgida* (Radoicic), *Neomeris* cf. *cretacea* Steinmann, *Salpingoporella* cf. *muehlbergii* (Lorenz), *Salpingoporella* sp., *Terquemella* div. sp., *Arabicodium* sp., *Boueina hostetteri* Toula, *Boueina* sp., ?*Halimeda fluegeli* Bucur, *Permocalculus* cf. *irenae* Elliott and *Permocalculus minutus* Bucur. The green algae are rarely accompanied by red algae: *Marinella lugeoni* Pfender, *Parachaetetes asvapatii* Pia, *Pycnoporidium* sp., *Polystrata alba* (Pfender) or the microproblematic *Carpathoporella occidentalis* Dragastan.

The algae association from Herisht Mount contains several species that were previously identified in Aliabad area (south-west from Yazd, BUCUR et al., 2012); exception is made by *Morelletpora turgida*. Nevertheless, the latter has been also identified in samples from Khur region (see Bucur et al., this volume), thus it can be considered as a common species for the whole Yazd tectonic block.

This algae association developed in depositional environments ranging from internal shelf to shelf margin. The presence of the identified species, corroborated with the absence of species *Salpingoporella dinarica* indicates a paleogeographic affinity with the central-northern Tethys domain during the Lower Cretaceous.

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Late Cretaceous (Maastrichtian) dasycladalean algae from the Naghan area (Zagros Mountains, SW Iran): Preliminary results

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In the Zagros Mountains of southwest Iran, Campanian-Maastrichtian shallow water limestones that locally may pass the K/T boundary are known as Tarbur Formation. Biostratigraphic zonations of the Tarbur Formation are based on larger benthic foraminifera. The study area is located approximately 50 km south of Naghan town near Gandomkar village. Within the Early-Middle Maastrichtian interval of the Tarbur Formation, inner platform wackestones contain a rather diverse association of dasycladalean algae with *Uteria* sp., *Salpingoporella* div. sp., *Pseudocymopolia anadyomenea* (Elliott), *Cymopolia* sp. and further undetermined taxa currently under study. The material studied contains well-preserved specimens of *P. anadyomenea*, the type-species of the genus *Pseudocymopolia* Elliott yielding further data on this poorly known taxon that seems to the be palaeobiogeographically restricted to the northern rim of the Arabian plate.

Algal assemblage of some small Permian patch reefs from the Sirjan area, (south Iran)

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Permian deposits of Sannandj-Sirjan structural belt (STOECKLIN, 1968) are composed of three formations: Vajnan formation at the base, followed by the Abadeh formation in the middle and the Surmaq formation at the top. According to the Sirjan geological map (SABZEHEI et al., 1997) the basal part of the Permian deposits in south part of Sannandaj-Sirjan belt is called Jamal formation, a general terminus for the whole Permian sediments in central Iran. The name Jamal Formation was introduced by STOECKLIN et al. (1965) for the Permian strata in a section (type section) at the southern flank of the Mount Jamal (33° 21'N, 57° 19'E), about 60 km south of the town of Tabas.

The Permian deposits in the south of the town of Sirjan were studied by Sabzehei et al. (1997). Permian sediments in Sirjan area are divided to three units: The basal part is metamorphic, a kind of schist and started with red conglomerate, sandstone, and meta basic lava with angular unconformity surface. The middle and upper part are carbonatic units. The middle carbonate member is 351 m thick and is composed of medium to thick bedded gray limestone that crashed after the tectonic event. This member indicates shallow water deposits containing algae, fusulinids, sponges, bryozoans, brachiopods, and etc. The thickness of the upper part is about 224 m thick and the rocks are composed mainly by medium to thick bedded limestone. This unite contains carbonatic particles derived from the shallow water carbonates and deposited in the deeper water basinal sediments. The debris contains algae, sponges, fusulinid and some deeper water particles with calcisphaerids. The shallow water carbonates were transported by gravitational flows into the deeper marine deposits (turbidites).

Permian sediments were sampled in a section, about 60 km south of the town of Sirjan. 250 specimens were collected from carbonatic layers. There are some small reefal structures in the middle carbonate unit, which are composed mainly of dasycladales and phylloid algae, microbial crusts, bryozoans and sponges. Numerous thin sections were made from these reefal carbonate blocks. Two phylloid algal taxa were recognized. One of them assigned to *Anchicodium* sp., the second one (undeterminable) is strongly recrystallized, only some parts of the border are still recognizeable. These two taxa are extremely abundant algae within the small patch reefs. Most important dasycladales algae in carbonate layers and blocks are: *Mizzia velebitana* SCHUBERT 1908, *Gyroporella niponica* ENDO & HASHIMOTO 1955, *Physoporella* sp., *Epimastoporella* sp., *Paraepimastopora* sp., *Antracoporella* sp. Microbial crusts, without recognizable internal structure, are also very abundant.

Cyanobacterial 'whiting' origin of Devonian-Mississippian carbonate mud mounds?

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Carbonate mud mounds are unusually abundant in the Late Devonian-Early Mississippian. A sediment baffling origin has been suggested, but a suitable source of off-mound carbonate mud has been difficult to identify. Late Devonian changes in atmospheric composition, particularly pCO_2 reduction and pO_2 increase, may have been sufficiently large to induce CO_2 concentrating mechanisms (CCM) in phytoplankton. CCM act to maintain photosynthesis, and include active transport of HCO^{3-} into the cells that can lead to extracellular pH rise and precipitation of fine-grained carbonate ('whitings') in the water column when carbonate saturation state is sufficiently elevated. It is proposed that Late Devonian-Early Mississippian whitings promoted mound development by generating mud off-mound whose import substantially augmented any on-mound carbonate production. Coeval increase in benthic calcified cyanobacteria supports elevated carbonate saturation state and CCM induction, and potential increase in primary productivity stimulated by CCM induction is consistent with organic carbon rich anoxic sediments and large positive δ^{13}CPDB excursions at this time.

A number of the sedimentary features commonly associated with Late Devonian-Early Mississippian mud mounds are consistent with current-driven accumulation of fine-grained carbonate. These include: (i) formation in a wide range of water depths; (ii) orientation, asymmetry, lateral progradation and amalgamation, (iii) grainstone haloes; (iv) presence of current-reliant filter feeders (bryozoans, crinoids, sponges); (v) layered structure; (vi) collapse structures (stromatactis and slumps). Carbonate mud derived from phytoplanktic whitings can be rich in organic matter. This could have promoted microbial lithification (e.g., by bacterial sulfate reduction) that contributed to the formation of clotted-peloidal microfabric. Thus, whiting processes could have been the primary mud source and also have created conditions favoring syndepositional on-mound early lithification. In this view, on- and off-mound microbial processes were mutually related, with off-mound mud production being mediated by cyanobacterial oxygenic photosynthesis and on-mound lithification mediated by heterotrophic mineralization of whiting organic matter.

Peritidal cyclical sequences of Kimmeridgian-Berriasian-?Valanginian limestones from Piatra Craiului Massif (Romania); the role of microbialites and rivulariacean-type cyanobacteria

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The Kimmeridgian-Berriasian-?Valanginian limestones from Piatra Craiului Massif are part of the sedimentary cover of the Getic Nappe from Southern Carpathians. Within the Piatra Craiului carbonate succession, three major types of depositional systems have been separated which can be followed from base to the top: (1) slope and shelf margin system; (2) open shelf system (offshore) and (3) coastal and shoreline system.

The carbonate deposits belonging to the slope and shelf margin system are represented by reef breccias and bioconstructions. The bioconstuctions associated with gravity flows indicate a shelf slope environment related to the external flanks of the carbonate platform. Within the bioconstructions microbialites and encrusting organisms played an important role.

The middle and upper part of the succession is composed of normal and restrictive marine subtidal limestones. The vertical distribution of subtidal facies, reflects cyclic changes in wather depth. The first record in these deposits is marked by a fluctuation of the environmental deepening (from shallow to deeper domains) and/or ecological changes in the depositional environment (from restrictive to open marine conditions and returning to restrictive conditions).

In the upper part of the succession the peritidal limestones are dominant. The typical facies and facies associations for the peritidal environment are separated in three depositional subtypes: subtidal, intertidal and supratidal. The vertical stacking of the identified facies reflects cyclical changes in water depth. The deposits contain marine and marine restrictive facies acumulated in high or low energy environments. The facies evolution of individual beds or bed sets, indicates a transition between the three depositional zones, represented by lagoons, ponds, beaches, tidal bars, algal-microbial mats and swamps. Rivulariacean-type cyanobacteria played an important role in the carbonate accumulation.

The vertical succession of the carbonate deposits from Piatra Craiului indicate the existence of a gradual transition from slope and shelf margin to subtidal and shoreline facies. This fact indicates the progradation of the carbonate platform during the Lower Cretaceous. In the same time, due to the radical reduction of the accomodation space on the carbonate platform, the main carbonate sedimentary production was generated by cyanobacteria.

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A coastal paradise for Aptian microbialites (Early Cretaceous, N Spain)

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Microbial carbonates are remarkably diverse and abundant in the early Aptian (~120 Myr) coastal carbonates of the Leza Fm (La Rioja, N Spain). They show a great variety of macro- and microfabrics, associated with differing sedimentary environments. This provides a unique opportunity to study the factors underlying development of microbial fabrics and structures.

The Leza Fm is part of the Early Cretaceous Cameros rift basin. Sedimentological analysis reveals that it was deposited in a system of carbonate coastal-wetlands with variable fresh- and seawater influence, composed of: a) carbonate water-bodies with charophytes and dasyclads; b) palustrine plains with common paleosols; c) siliciclastic alluvial environments; d) oncoid channels; e) carbonate water-bodies with ostracodes and miliolids; f) tidally-influenced water-bodies; and g) restricted carbonate-evaporite water-bodies. These environments interfinger throughout the unit, but also show a general retrogradational trend.

Most of the sedimentary environments of the Leza Fm are rich in microbial carbonates: (1) *Oncoids* are common in small channels and facies with strong freshwater influence, and have microfabrics dominated by calcified filaments. (2) *Skeletal stromatolites* occur in the western outcrops associated with cross-bedded sandy grainstones with charophytes and rare dasyclads. They have domical morphologies and well-calcified filamentous microfabrics. (3) *Fragments of dendrolites* are common throughout the coastal-lake facies with charophytes and dasyclads, showing microstructures of delicate branching calcified filaments. (4) *Thrombolites* occur in dasyclad-dominated coastal-lake carbonates of the western outcrops. Their microfabrics are commonly diagenetically altered, but show relict peloidal micrite and calcified filaments. (5) *Fenestral laminites* are common in facies with ostracodes and miliolids in the western outcrops. They show undulose lamination marked by elongate fenestrae. Vertical cracks and vadose calcite cements are common. Their microfabrics are micritic, clotted-peloidal and agglutinated, with some filament relicts. (6) *Agglutinated oolitic stromatolites* are found in tidally-influenced eastern outcrops with ostracodes and miliolids. They show domical morphologies and microfabrics dominated by trapped ooids and bioclasts and clotted-peloidal micrite. Calcified filaments are rare.

A clear link between particular facies and microbialite types is observed. For example, filamentous microfabrics (oncoids, skeletal stromatolites, dendrolite fragments) occur in freshwater-dominated facies, whereas non-filamentous microfabrics (thrombolites, fenestral laminites, agglutinated stromatolites) are found in facies with stronger marine influence. Thus, microbialite variability in the Leza Fm reflects the diversity of sedimentary environments. We conclude that at this time, coastal-wetlands at the crossroads of marine and freshwater realms provided a broad variety of hydrochemical and hydrodynamic settings that could promote the development of differing microbial communities and products.

Furthermore, the early Aptian was a period of microbialite abundance in many carbonate platforms located as far afield as Arabia, Western Europe, and the Pacific Ocean. Global oceanographic and climatic changes have been suggested as possible causal factors. Comparison of the Leza Fm transitional-coastal setting with coeval carbonate platforms could help to further understand these early Aptian microbialite paradises.

Microbial carbonate reef components in the mid-Triassic Italian Dolomites: A biogeochemical approach

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Triassic carbonate buildups of the Dolomites have for decades been regarded as classic examples of ancient coral reefs and have been the subject of extensive research. During the mid-Triassic reefs underwent important changes, evolving from reefs mainly composed by sponges, seafloor crusts, and calcimicrobes such as *Shamovella*, to more modern-looking coral-algal associations with clotted-peloidal crusts. We examined good examples of both types at Punta Grohmann and Alpe di Specie. The Punta Grohmann samples of high-rise platform margin reef rock are from erratic 'Cipit Boulders' in Late Ladinian-Middle Carnian basinal sediments (Wengen and San Cassiano formations). These blocks escaped the extensive dolomitization that affected the buildups, and preserved their original mineralogy and organic content. The Alpe di Specie samples are from small Late Carnian patch reefs in the Heiligkreutz Formation, and are widely regarded as in situ or nearly in situ. Their coral-sponge-algal framework cavities contain distinctive clotted-peloidal micrite microfabric. Despite their small size, these bioherms are among the earliest examples of skeletal framework reefs whose major components are broadly comparable with those of present-day tropical coralgal reefs. We carried out biogeochemical analyses on selected samples from both localities to characterize the organic matter and bacterial metabolic signatures. These included UV epifluorescence observations, Total Organic Carbon (TOC) content, FT-IR spectroscopy and biomarkers analyses. Rare Earth Elements (REE) distributions were also investigated to determine the oxidation state in which these deposits precipitated.

The Punta Grohmann and Alpe di Specie reefs are not very different in age but show significant differences in components, structure and fabrics, reflecting contrasting depositional environments. Punta Grohmann sponge-microbial reefs contain biomarkers for various bacteria including cyanobacteria but lack specific molecules typical of sulfate-reducing bacteria. This suggests that aerobic bacteria were able to directly degrade the organic matter from primary producers, and is consistent with well-oxygenated depositional conditions indicated by REE values, and with the high-energy platform margin setting in which they formed. Alpe di Specie scleractinian patch reefs contain sulfate reducing bacteria biomarkers and REE values indicative of sub-oxic conditions. These are consistent with their autochthonous clotted-peloidal crusts and the more muddy low energy conditions under which they formed. Their small growth cavities that apparently favored formation of clotted-peloidal sediments resemble those of present-day autochthonous reef crusts induced by sulfate reducing bacteria.

The division of the morphological groups of the Li Mei calcareous algal bioherms, Western Hunan, China

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In the late Early Cambrian, during deposition of the Qingxudong Formation, a homoclinal carbonate ramp was developed over what is now Li Mei village, Western Hunan Province. The ramp comprised three different sedimentary facies associations, which are referred to as the inner, mid- and outer ramp zones. A series of calcareous algal bioherms were developed in the mid-ramp zone.

The bioherm contains nineteen species of calcareous algae. The major constituent algae in the bioherm facies are *Epiphyton*, *Renalcis*, *Botomaella*, *Razumoviskia*, *Proaulopora*, *Batinevia*, *Chabakovia*, *Bija*, *Nicholsonia*, and *Girvanalla*.

The bioherm algae can be divided into four groups and seven sub-groups based on comparative morphology: (1)botryoide group; (2) dendritic group(sub-groups: i. short and small dendritic, ii. Cluster and ball-shaped dendritic, iii. Dendritic); (3) tubiform group(sub-groups: i. fan-like tubiform, ii. Isolated and loosely associated tubes, iii. Cluster tubiform, iv. Tangled, coiled and mass-like tubiform); (4) blanket hair-like group.

Since morphological groups can be environmental indicators, one or several algal morphological groups and/or sub-groups can be assigned to either of four algal environment zones in the bioherm: (1) low-energy zone-developed at the bottom and periphery of the bioherm; (2) & (3) relatively high-energy zone-located in the middle part of the bioherm; (4) very high-energy zone-developed on the top of the bioherm.

The division of the morphological groups of the Li Mei calcareous algal Bioherms are of great importance in determining sedimentary microfacies, and analyzing the correlations between algae morphology and sedimentary environment.