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International
Fossil Algae
Association

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UNIVERSITÀ DEGLI STUDI DI MILANO
BICOCCA

6th Regional Symposium
1-5 July 2009
Milan - Italy

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ABSTRACT BOOK

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UNIVERSITA' DEGLI STUDI DI MILANO
BICOCCA

6th Regional Symposium
1-5 July 2009
Milan - Italy

In collaboration with:

University of Genova
Dip.Te.Ris

Edited by:

Daniela Basso, Annalisa Caragnano, Valentina Bracchi, and Francesca Benzoni

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Symposium presentation

The 6th Regional Symposium of the IFAA held in Milano, from 1 to 5 July 2009, follows the 5th Regional meeting in Ferrara (2005) and the 9th International Symposium held in Zagreb (2007).

The Symposium was jointly organized by the University of Milano-Bicocca, Department of Geological Sciences and Geotechnologies, and by the University of Genova, Dip.Te.Ris. Geologists and paleontologists of the University of Genova have been studying coralline-rich outcrops of the Tertiary Piedmont Basin since the end of the XIX Century (G. Rovereto, M. Airoldi, S. Conti, V.I. Mastrorilli), producing the scientific descriptions of dozens of new species, the types of which are housed in the Genova Dip.Te.Ris. The meeting offered a unique opportunity to highlight this invaluable historical and scientific legacy, that is the object of a long-lasting cooperation between the Milano-Bicocca and Genova Universities, through the presentation of a web page dedicated to the collections and their critical revision and through a post-symposium field-trip across some red algal outcrops of the Tertiary Piedmont Basin.

The scientific topics of the symposium covered any aspects of calcareous algae and microbialites, including their present-day distribution and abundance. In addition, we invited to present contributions to a cross-cut topic with strong implications in biology, palaeontology, sedimentology, geology and climatology: the quantification (in space or time, at any scale) of the carbonate production of calcareous algae.

Although calcareous algae commonly occur both in the present-day shelf environments at all latitudes and in the fossil record, we still need a tentative quantification of their abundance, in space and time. Calcareous algae are sensitive to the expected consequences of global change (increasing CO_2, sea-level rise, ocean acidification), and we emphasize the need of a better knowledge of the distribution of algae-dominated sediments and rocks, to serve as quantitative baseline for modelling the response of the oceans to the global change. For this reason we believe that the scientific contributions presented here are expected to impact the scientific community well beyond the group of fossil algae specialists.

Scientific topics

- Bio mineralization and algal- or microbe-induced sedimentation
- Stromatolites
- Taxonomy and systematics
- Evolutionary history
- Living vs. fossil
- Biogeography and palaeoclimatology
- Ecology and paleoecology and role in the global change
- Identification and quantification of living/fossil calcareous algae
- Biostratigraphy
- Taphonomy and diagenesis
- Significance of algae in hydrocarbon and mineral resources formation

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KEYNOTE LECTURE

Carbonate production by coralline algae and the global change

Daniela BASSO[1]

Key words: Corallinales, benthic environment, global change, carbonate factory.

The Intergovernmental Panel on Climate Change (International Panel on Climate Change, 2001) predicted that the atmospheric partial pressure of carbon dioxide (pCO_2) will be double that of pre-industrial levels by 2100 and will be considerably higher than at any time during the past few million years. Between 2100 and 2200, the atmospheric CO_2 concentration is expected to increase to the range of 1500 to 2100 ppm that is 100 times greater than the natural fluctuations seen over recent millennia, in contrast to the stability of the past 24 million years during which time levels have remained below 500 ppm (Pearson & Palmer, 2000).

As CO_2 dissolves in the surface ocean it reacts with water to form 'protons' (H^+) and dissolved inorganic carbon (DIC), which is the sum of the concentrations of carbonic acid (H_2CO_3), bicarbonate (HCO_3^-), and carbonate ions (CO_3^{2-}) stored in the ocean. With increasing atmospheric pCO_2, DIC will increase and the equilibrium of the carbonate system will shift to higher CO_2 and HCO_3^- levels, while CO_3^{2-} concentration and pH will decrease. These changes in carbonate chemistry, often referred to as 'ocean acidification', are already occurring. Current models predict that the pH of surface seawater will drop from 8.0 to 7.8 by the year 2100 (Royal Society, 2005). This dramatic change in seawater chemistry is likely to have a large impact on marine life and biogeochemical processes such as reduced biogenic marine carbonate mineral production and carbonate mineral dissolution.

Assessing the impact of decreasing pH on coastal ecosystems is priority and the focus here is on calcareous algae, and on coralline red algae in particular, as carbonate component of the sediment.

The precipitation of calcium carbonate is a source of CO_2, whereas carbonate dissolution results to lower it (Frankignoulle *et al*, 1994). Therefore, carbonate dissolution is expected to buffer ocean acidification and to play an important role in the global change, though it is likely that the natural process of carbonate dissolution will be too slow to neutralize the fossil fuel CO_2 (Broecker & Takahashi, 1977).

Calcium carbonate occurs in natural biogenic sediments as aragonite or calcite. Magnesium (Mg^{2+}) can substitute some of the Ca^{2+} in the lattice and the calcite containing >4% wt of $MgCO_3$ is conventionally defined high-Mg calcite or Mg-calcite. The extent to which a biogenic carbonate particle is prone to dissolution in seawater depends from several factors, among which the leading ones are mineralogy and the calcium carbonate saturation state Ω, which is dependent from the $[CO_3^{2-}]$. The solubility of $CaCO_3$ increases with depth. Presently, surface ocean waters are supersaturated with respect to both aragonite and calcite, but the aragonite and calcite saturation horizons of the world's oceans are moving to shallower depths at a rate of 1-2 m per year (Guinotte & Fabry, 2008) due to the rapid influx of anthropogenic CO_2 to the oceans. Aragonite is more soluble than calcite in the same seawater, but natural Mg-calcites containing > 8-12 mol% $MgCO_3$ are more soluble than aragonite, being the most sensitive responder to a lowering pH (Morse *et al*, 2006; Kuffner *et al*, 2008).

The recruitment rate and growth of crustose coralline algae is severely inhibited under elevated pCO_2 (Hall-Spencer *et al*, 2008). Corallinales, which are a major framework builder in temperate and cold water, are vulnerable to ocean acidification due to the solubility of their high magnesium calcite cell-walls (Kuffner *et al*, 2008).

Cool-water carbonate-rich sediments of the world shelf, often dominated by calcareous red algae, are a major $CaCO_3$ reservoir, that can react by dissolution to a decrease of the saturation state of the seawater (Morse *et al*, 2006). However, despite the occurrence of a suite of local data-base on various sediment characteristics, the algal carbonates have been not characterized and

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quantified on a large scale, therefore preventing any hypothesis on their role as buffer in a future scenario of acidified oceans.

Shelf sedimentary facies of the temperate and cold zones are enriched in calcite and Mg-calcite (from mollusks, forams and red algae).

By contrast, aragonite dominates the sediments of the tropical oceans (from corals and green algae). Existing deposits of highly soluble, Mg-calcite and aragonite sediments require quantification to assess their importance as a possible buffer to acidification.

What is the contribution of algae to this carbonate budget?

The scientific literature started to re-evaluate the geologic role of coralline algae in the seventies (Adey & McIntyre, 1973) since for many years the common occurrence of algal carbonates in non-tropical sediments was far to be a shared concept among geologists. More recently, some comprehensive books, reviews and a number of scientific papers on cool-water carbonates pointed out the importance of calcareous red algae as carbonate producer (among others: James & Clarke, 1997; Foster, 2001; Pedley & Carannante, 2006). In the nineties biologists started to quantify the growth of calcareous red algae by staining or other techniques, thus improving our knowledge at the organism level. However, modelling the response of the oceans to the global change require a quantification of the total carbonate and its mineralogy on regional scale. Large scale quantification of coralline algae in shelf carbonates is a challenge to the exploration of new methods of seafloor mapping, combined with analyses of sediment composition and mineralogy (Bracchi *et al*, 2009; Savini *et al*, 2009).

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KEYNOTE LECTURE

Impact of carbonate production by calcareous green algae

Bruno GRANIER[1]

Key words: Dasycladales, Bryopsidales, lagoon, bioherm, biostrome, beach-rock, washover fan, porosity, epigenesis, cementation.

While compiling information to get the latest state of the art data on carbonate production by green algae the author found that little original work had been published. In the literature there are only a number of short syntheses (Borowitzka, 1986; Segonzac, 1986), commonly in the form of chapters in books with more eclectic ends.

The key concept "the present is the key to the past" which is said to help us understand the fossil record has been called upon extensively but it has limitations as the following presentation of factual information demonstrates.

Some large unicellular benthic chlorophyta, mainly Bryopsidales (multinucleate cells) and Dasycladales (uninucleate cells), may have a mineralized "skeleton"; they are pigeon-holed as "calcareous green algae" (CGA). Calcification is mostly extracellular; it occurs outside the cell wall in the mucilage between the networks of adjacent filaments or on the main axis, laterals and reproductive organs. Intracellular calcification is less common: usually, it is restricted to the cysts, either discrete ("calcispheres") or aggregated into clusters (*e.g.* "spicules").

In most fossil and modern "CGA" this mineralization is aragonite, a metastable polymorph of $CaCO_3$. But in the fossil record it may consist of calcite, as for example in some dasycladalean species (*Clypeina sulcata*, *Falsolikanella campanensis*, *Megaporella boulangeri*, *Salpingoporella* (*Hensonella*) *dinarica*, *Zergabriella embergeri*, …).

In living representatives of the CGA the first layer coating the cell walls is minute granular aragonitic crystals less than 1 µm in size. The remaining space occupied by the mucilage is more or less filled with 10 µm-long aragonitic needles. These needles were considered an important source of lagoonal muds by Neuman and Land (1975) but they may be altered soon to crystals of aragonite (later becoming high-magnesian calcite) less than 1 µm in size, a process described as "early micritization" by Macintyre and Reid (1995). As a result less than 20% of the total carbonate in a *Halimeda* thallus retains the original acicular fabric (Macintyre & Reid, 1995). So it is difficult to estimate the direct contribution of these modern algae to lime muds. In another approach samples of plants are collected *in situ* in natural environments. They are dried and segregated into organic and mineral components which are weighed: for instance, Marszalek (1975) calculated that *Acetabularia antillana* could produce up to 720 g/m^2 per annum of calcium carbonate while Drew (1983, in Segonzac, 1986) found that *Halimeda* could produce 2,234 g/m^2 per annum. Obviously, this technique cannot be applied to fossils.

The degree of calcification sometimes used as a taxonomic criterion at the specific level may vary significantly within a single species depending on its stage of growth (age) and on environmental parameters. In addition, the calcareous coating will break up into large or small bioclasts depending on whether or not the living specimen was poorly (loose needles) or heavily (dense acicular network) calcified. If indeed a part of the largest fragments retains some features allowing their ascription to the category of allochems of phycological origin, most of them will be micritized and their origin consequently untraceable. Similarly the smaller remains are integrated into the muddy matrix.

In the fossil record bioclasts of CGA are usually very fractionated and scattered. They commonly represent less than 10% of the components of most of the carbonate microfacies characteristic of shallow-water environments. However there are few facies in which they are rather well preserved and can represent the main component of the rock (with a ratio greater than 25% of the total):

1. some low-energy mud-dominated fabrics characteristic of chlorophytic meadows, for

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example Tithonian *Clypeina sulcata* wackestones

2. some high-energy grain-dominated fabrics characteristic of beach and wash-storm deposits, like *Salpingoporella annulata* packstones from the Arab Fm, Holocene grainstones with *Acetabularia*, Liassic *Petrascula genotii* rudstones
3. algal biolithites, like the Tithonian *Neoteutloporella socialis* framestones, the Miocene and Holocene *Halimeda* baffle- and "false" grain- stones (see Braga *et al*, 1996; Martín *et al*, 1997; Granier *et al*, 1997), the Carboniferous *Anthracoporella spectabilis* framestones. Remark: Some bioherms may have been deposited originally as biostromes, that is the existing morphologic state is the result of a later differential compaction.

Many papers state that “aragonite recrystallizes into calcite” although both phenomena, “recrystallization into calcite” (mosaic calcite with ghost structures) or “preservation as aragonite”, are rarely the final state of fossil algae. In outcrop, *i.e.* in the vadose zone, geologists commonly collect molds filled with a drusy calcite cement; in the phreatic zone, subsurface geologists find a huge number of empty molds. Dissolution of the aragonite leads to the formation of moldic vugs followed by the deposition of calcitic cements. Consider the following numbers:

Aragonite → Calcite
mol. wt = 100 → mol. wt = 100
density = 2.93 → density = 2.71
vol = 100/2.93 = 34.1 → vol = 100/2.71 = 36.8

In a closed system, the dissolution of aragonite creates an equivalent volume of porosity but the subsequent precipitation of calcite result in a decrease of the ultimate porosity with respect to the original porosity because of the larger volume occupied by calcite (the solid phase will be increased by approximately 8%).

To summarize: CGA's contribution to carbonate production is already difficult to estimate for modern species (at least for the finer particles, *i.e.* the muddy matrix) but it is even harder for fossil species where most coarse particles have lost their original texture. On the other hand, in the subsurface rocks fossil CGA, along with other originally aragonitic bioclasts, are great contributors to the development of secondary porosity and to subsequent cementation by calcite.

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KEYNOTE LECTURE

Asking stromatolite questions: what are they, how have they formed, how have they changed through time?

Robert RIDING[1]

Key words: abiogenic, analogues, hybrid, morphotypes, stromatolite, thrombolite.

In 1908 Ernst Kalkowsky introduced the term '*stromatolith*' to describe layered metre-size carbonate columns and domes in German Triassic desert lake deposits. But similar and older examples were already known by then. Cambrian stromatolites at Saratoga Springs in New York had been interpreted as skeletons of simple animals and named *Cryptozoon*. Kalkowsky interpreted his Triassic stromatolites as microbial. This was immediately challenged by the suggestion that they are inorganic precipitates. During the following decades, present-day examples found in freshwater lakes and shallow marine environments strongly supported Kalkowsky's interpretation, and stromatolites became widely regarded as lithified microbial mats. Interest in them deepened with the recognition of early Archaean examples; raising the possibility that stromatolites could be among the first signs of life on Earth. But doubts about their biogenicity have persisted and pose a question that has proved hard to either confirm or deny. After a hundred years, these contrasting perspectives of stromatolites - as lithified microbial mats, and as diverse authigenic crusts - continue to complicate definition and interpretation of these widespread deposits.

Many Precambrian stromatolites contain precipitated abiogenic crusts, both with and without microbial mats. Regular, even layering of sparry microfabrics probably reflects significant abiogenic precipitation. Dark-light layers appear to represent alternations of micritic lithified mat and sparry abiogenic crust. These 'hybrid stromatolites' are common in the early-mid Proterozoic, e.g., in some *Baicalia* and *Conophyton*. In contrast, many Phanerozoic stromatolites appear essentially to be lithified microbial mats; they are characterized by uneven fine-grained layers with clotted and peloidal - and locally calcified filament - microfabrics. These successive developments, from sparry through 'hybrid' to mat stromatolites, suggest progressive decline in abiogenic precipitation and increase in lithified mat components through time. Presumably these in turn reflect changes in seawater chemistry and mat growth. Large - metric, even decametric - evenly layered domical or conical stromatolites were not uncommon between 3000 and 1000 Ma ago. They seem to lack present-day analogues. Probably they reflect rapid accretion stimulated by high rates of carbonate precipitation, and in some cases rapid mat accretion too. Millimetric alternation of mat and abiogenic precipitates in 'hybrid' stromatolites may reflect seasonal changes.

During the mid-Proterozoic there was a revolution in stromatolite development. Sparry abiogenic fabrics declined and mat fabrics acquired calcified cyanobacteria such as *Girvanella*. This microbial calcification disrupted lamination and transformed some stromatolites into thrombolites. At the same time, carbonate mud became common, suggesting increase in 'whiting' precipitation in the water column. This Mesoproterozoic development of cyanobacterial sheath calcification and biogenic whitings could reflect acquisition of CO_2-concentrating mechanisms in cyanobacteria stimulated by decline in atmospheric CO_2. Whiting mud provided abundant fine-grained substrate in which 'molar tooth' structures developed. These changes coincided with reduction in stromatolite size and increase in shape complexity. Stromatolite shape reflects original synoptic relief, determined by accretion rate relative to adjacent sediment. Low relative accretion rate results in low relief and complex shape; high relative accretion rate results in high relief and simple shape. In this view, mid-Proterozoic increase in morphotypic diversity, e.g., in branched stromatolites, is not a proxy for overall stromatolite abundance. Instead it reflects the result of lower synoptic relief due to reduced relative accretion rate. Stromatolite accretion

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relative to the adjacent sediment was probably reduced by lowered microbial growth and synsedimentary lithification, as well as by increase in ambient allochthonous accumulation of the fine-grained sediment produced by biogenic whitings.

Calcified cyanobacteria and other microbes continued to contribute to significant thrombolite and dendrolite formation in the Cambrian and Early Ordovician. Subsequent development of algal and metazoan skeletal reef builders inhibited microbial dome-column formation by overgrowing microbial carbonates. Irregular microbial crusts remained common in reefs, but classic domes and columns became scarce except in the immediate aftermaths of Mass Extinction events (‘disaster biotas’), and also in ecological refuges, as in present-day examples at Shark Bay and Lee Stocking Island. Long-term overall post-Cambrian decline in microbial carbonate abundance probably mainly reflects this competition from reef overgrowth coupled with decline in seawater saturation state that slowed lithification and therefore accretion. Direct grazing of mats is likely to have been a subordinate factor so long as microbial mats were well lithified.

Cenozoic reduction in seawater saturation state made stromatolite mats more prone to grazers. At the same time it made them softer and more able to trap particulate sediment. This trapping ability was probably enhanced by the rise of microalgae such as diatoms. A result of these changes was the development of large coarse-grained ‘stromatolitic thrombolite’ domes and columns in wave- and current-swept environments such as Shark Bay (Australia) and Lee Stocking Island (Bahamas) where grains are delivered to the tops of columns up to 2 m in height. The coarse and crudely layered fabrics prominent in some of these columns are not closely comparable with most ancient stromatolites or with Neoproterozoic-Early Palaeozoic thrombolites. They are therefore distinctive ‘new-fashioned’ microbial carbonates, although their external form can be strikingly similar to that of some very old stromatolites – a testament to the constancy of morphotypic development in accretionary structures.

Many questions remain concerning stromatolites and related abiogenic and biogenic authigenic crusts at the sediment-water interface. Not least, how to satisfactorily define structures that – during 3500 Ma of history – have included abiogenic and biogenic components, and in some cases intimate alternations of both. The way forward is no doubt to further understand the changes in atmospheric composition, seawater chemistry, mat evolution and abiotic-biotic interactions that have moulded and melded these sensitive archives of geobiological change over much of Earth history.

Palaeoenvironmental and stratigraphic significance of rhodolith beds in the Carboneras Basin (Almería, SE Spain)

Julio AGUIRRE[1], Juan C. BRAGA[1], José M. MARTÍN[1], Christian BETZLER[2]

Key words: rhodolith beds, Pliocene, Carboneras Basin, Spain.

Lower Pliocene deposits from the Carboneras Basin (Almería, SE Spain) mostly comprise temperate platform carbonates. Physiographical and hydrodynamic conditions along the palaeomargins gave way to different platform types: a) a distally steepened ramp, affected by southerly wind-driven storms, developed at the northern margin; b) a gently dipping homoclinal ramp occurred at the protected western margin; and c) a spit platform formed at the southern margin.

The Pliocene deposits can be divided into three subunits differently represented in the three margins that correspond, from bottom to top, to lowstand, transgressive and highstand system tract deposits. The lowstand and transgressive deposits consist of carbonates while the highstand system tract deposits are siliciclastics.

The carbonates are largely dominated by coralline algae together with barnacles, molluscs, echinoids, bryozoans, solitary corals and serpulids. They can be attributed to bryomol, rhodalgal and barnamol temperate carbonate lithofacies. Non-geniculate coralline algae occur mostly as rhodoliths or as loose branches. Locally, they also form small bioconstructions. Rhodoliths are spherical to ellipsoidal in shape and consist of warty to fruticose thalli. The algal assemblages are dominated by *Lithothamnion*, *Mesophyllum*, *Phymatolithon calcareum*, *Lithophyllum incrustans-racemus* and *L. pustulatum*. Scarce fragments of *Sporolithon* sp and mastophoroids are also present.

Rhodoliths occur dispersed in the sediments or in dense concentrations forming rhodolith beds. These beds occur preferentially at the top of the transgressive system tract deposits. This stratigraphic position indicates that these concentrations successfully developed at times of starved sedimentation during maximum flooding. Rhodolith beds are also locally present within the transgressive deposits. Finally, rhodolith beds developed on the leeside of the spit platform. Here, rhodoliths formed in a sheltered depression between the spit platform and the palaeocoast.

We conclude that terrigenous starvation seems to be a major factor controlling the development of rhodolith beds.

Coralline algal-bryozoan-bivalve build-ups occur in the outer ramp at the western margin of the Carboneras Basin. They include vertical pillars (up to 40 cm wide and 90 cm in height) and irregular patches (up to 2 m high and 7 m wide). The coralline algae forming these build-ups are mostly *Mesophyllum* and *Lithothamnion*, followed by *Lithophyllum*. These algae occur as encrusting and warty thalli binding the skeletal grains of accompanying organisms and strengthening the bioconstructions. These structures were formed in the outer ramp, in a low energy setting.

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Unravelling the evolutionary history of coralline algae (Rhodophyta, Corallinales): phylogeny, molecular clocks and the fossil record

Julio AGUIRRE[1], Francisco PERFECTTI[2], Juan C. BRAGA[1]

Key words: molecular clocks, corallines, phylogeny, evolution.

Two important targets when deciphering the evolutionary history of a particular group of organisms are to obtain a reliable molecular phylogeny and a continuous and complete fossil record. Thus, the timing of splitting events in the phylogenetic tree, based on molecular clocks can be confidently contrasted with the first occurrences of taxa in the geological record. Coralline algae (Rhodophyta, Corallinales) have an excellent fossil record and an accurate phylogeny of the group has recently been proposed. We present for the first time a combined approach that brings together the fossil record, molecular clock data and phylogeny of corallines to understand their evolutionary history.

The maximum likelihood and the Bayesian phylogenetic trees have been obtained using molecular data compiled by Harvey *et al* (2003). In both analyses, the topology of the resulting trees was identical. The rate of molecular change has been estimated with a penalized maximum likelihood approach using the program r8s, version 1.50. These molecular clocks can be applied to calculate the absolute rate of molecular change and to estimate the time of branch divergences in the phylogenetic tree.

Analyses of confidence intervals of sporolithaceans, hapalidiaceans and lithophylloids demonstrate that their first occurrences are very close to their observed appearance, indicating a very complete stratigraphic record. Therefore, first occurrence data are used to confidently constrain the age of the branching events in the phylogeny using molecular clocks.

The results show an outstanding coincidence between the phylogeny and the first occurrence of different taxa in the stratigraphic record. The family Sporolithaceae is the ancestral group in the phylogeny. The oldest coralline is *Sporolithon rude* (Hauterivian). The subsequent monophyletic taxon branching in the phylogeny is the family Hapalidiaceae, as well as in the fossil record as shown by the first record of *Lithothamnion angolense* (Late Aptian). Within this family, the node separating *Mesophyllum* from the similar genus *Synarthrophyton* is dated as 75.17 Ma (Maastrichtian; Late Cretaceous) according to the molecular clocks. The species *Mesophyllum vignyense* is the oldest record of the genus, coincidently found in Maastrichtian and Paleocene sediments.

The Corallinaceae (Mastophoroideae, Lithophylloideae, Metagoniolithoideae and Corallinoideae) is the most recent family splitting in the phylogeny: estimated molecular age is 99.45 Ma (base of Cenomanian). *Lithophyllum ? shebae* from the Cretaceous is characterized by the presence of uniporate tetra-bisporangial conceptacles and poor definition of lateral cell walls. These characters make it reasonable to consider this species as a member of the subfamily Mastophoroideae, in agreement with the timing obtained using molecular clocks.

The first unquestionable member of the subfamily Lithophylloideae recorded so far is *Lithophyllum premoluccense* var. *cretacicum* from the Late Cretaceous. The age estimated by molecular clocks for the origin of lithophylloids is 73.49 Ma, fitting the observed fossil record and the age obtained with the confidence intervals for the origin of the subfamily. The species *Pseudoamphiroa propria* is another encrusting coralline alga from the Maastrichtian-Thanetian that shows no cell fusions.

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Rhodolith beds in a shallow-water carbonate reef lagoon on Moorea, French Polynesia

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Key words: coralline red algae, ecology, Recent, French Polynesia.

The term rhodolith was first applied to algal nodules from a very shallow bay in Bermuda (Bosellini and Ginsburg, 1971, initially introduced the term rhodolite), and rhodoliths have been recorded in coral reefs from the Atlantic, Indian and Pacific oceans (Bosence, 1983). The occurrence of rhodoliths in shallow-water tropical settings, however, has been overlooked in the last years, and ancient examples of rhodolith concentrations have been uncritically assigned to relatively deep water palaeoenvironments.

Here we report the significant occurrence of nodules of living algae in the shallow lagoon between the motus (low, small islands) Tiahura and Fareone, Moorea, French Polynesia (Central Pacific Ocean). The nodules have been studied in a 150 m x 30 m sampling area within a bathymetric range from 1 to 2.2 m. They range in mean diameter from 2 to 9 cm and show a wide variety of shapes. They typically consist of several thick coralline algal plants encrusting coral fragments. In many cases, the coral nucleus is relatively large compared to the algal covering and controls the nodule shape (algal coated pebbles in the sense of Steneck, 1986). Other nodules are mainly made up of corallines (true rhodoliths in the sense of Steneck, 1986) and are sub-spheroidal to sub-discoidal/sub-ellipsoidal in shape. Coralline growth-forms tend to be encrusting in the inner part of the algal covering and pass outwards to warty/lumpy and fruticose. Thick encrusting to lumpy plants of *Hydrolithon onkodes* are the most common components in the algal coverings, followed by branching growths of *Neogoniolithon frutescens* and *Lithophyllum* of the *Lithophyllum kotschyanum* species group. *Hydrolithon reinboldii* and *Lithophyllum prototypum* also occur as minor elements.

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Quantification of the coralline carbonate in a Serravallian outcrop of the TPB

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Key words: Corallinales, rhodolith pavement, Miocene, Tertiary Piedmont Basin

Coralline algae are a common component of both present-day and fossil sediments and our knowledge is increased daily from investigations on their biology, ecology and paleoecology, and geochemistry.

However, despite their common occurrence, the comparison among different fossil coralline algae outcrops is still difficult, mainly because of a lack of unequivocal methods for the description and quantification of the algal contribution to the total sediment/rock. Further difficulties arise in the case of comparison between modern marine sediments and observations from the geologic record, because of the different cultural background of researchers that imposes the use of sectorial and inhomogeneous definitions.

We tested a method for algal quantification on a rhodolith pavement outcropping at Stazzano (Alessandria). The Serravallian section of the central part of the TPB is made of outer shelf silty marl and siltstone grading upwards to inner shelf sandstone (hybrid arenites) and fine conglomerate followed by sandy-silty and silty sediments, in which are interbedded slumps and conglomeratic/biocalciruditic lenticular bodies (Ghibaudo *et al*, 1985). The Stazzano lithostratigraphic section (upper Serravallian) shows the silty deposits in which the channels filled by rhodolithic rudstone and floatstone are cut. The fossil fauna includes echinoids, brachiopods, mollusks, annelids, bryozoans, and benthic and planctonic foraminifers (Fravega & Vannucci, 1982).

Most (93%) rhodoliths recovered from this section have a spheroidal shape (Vannucci, 1980; Fravega *et al*, 1993) and a diameter ranging between 2-6 cm (Quaranta *et al*, 2009). Rhodoliths up to 10 cm are not rare.

We obtained a suite of digital photographs of the surface of rhodolith-bearing strata and we elaborated them by Image-J in order to obtain a map of the algal surface represented in each photograph. On a total analized surface of 11.5 m^2 we could count a mean of about 27.3 % of algal thalli for a total algal surface of about 3.2 m^2.

The maximum thickness of the rhodolith-bearing outcrop is 7 m. We calculated the corresponding amount of algal carbonate and compared this result with data from present-day rhodolith facies of the Mediterranean sea.

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Crustose coralline algae *vs.* Scleractinia in reefal coral communities around Arabia

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Key words: crustose coralline algae, Scleractinia, upwelling, phase-shift, Yemen, Qatar.

Zooxanthellate reef building Scleractina are considered the main builders of the biogenic framework of modern tropical as well as deep water coral reefs. Crustose Coralline Algae (CCA), together with some invertebrates depositing calcareous skeletons, or shells, have been defined as binders of such framework. In general, scleractinian corals are known to grow faster than CCA and to dominate over the reef hard substrate, while CCA are commonly observed but seldom dominant in reefs.

Recent observations during the study of the ecology of reef coral communities in Yemen, north-western Gulf of Aden, and Qatar, in the Gulf, indicate that CCA may locally represent up to more than 50% of the living cover, or even outcompete corals, when either particular environmental conditions, or a combination of these and human activity, occur.

These observations on the extant reefs may provide additional useful keys to interpret the environmental factors behind the changes in relative dominance between CCA and scleractinian corals in the fossil record.

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OAE1a coeval *Lithocodium-Bacinella* binding of coral rubble piles in the Early Aptian of the western Maestrat Basin (E Iberia)

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Key words: *Lithocodium-Bacinella*, coral rubble, OAE1a, trophic level, Aptian, Maestrat Basin, E Iberia.

A widespread horizon consisting of several amalgamated storm-induced coral rubble deposits completely encrusted by *Lithocodium aggregatum* Elliott and *Bacinella irregularis* Radoičić lies in the middle of the marls of the Forcall Formation, in the Galve sub-basin (western Maestrat Basin; Iberian Chain, eastern Spain). These limestones bearing microencrusters (up to 5 m thick) cover an area of at least 120 km^2 and were dated by means of ammonites as the upper part of the *Deshayesites weissi* biozone (Early Aptian).

Moreover, a high-resolution $\delta^{13}C$ and $\delta^{18}O$ geochemical analysis carried out on bulk rock samples following standard techniques along the sedimentary succession studied shows how these encrusted storm deposits are clearly contemporaneous with the oceanic anoxic event 1a (OAE1a), and coincident with the probable Early Aptian thermal maximum (see Bover-Arnal *et al.*, under review).

The calcareous microorganisms *Lithocodium aggregatum* and *Bacinella irregularis* conform a well-known microproblematicum association, which is commonly found in the margins of the Tethys throughout the Late Triassic-Middle Cretaceous time slice. Various taxonomic interpretations have been discussed for these microencrusters (see Immenhauser *et al.*, 2005; Cherchi & Schroeder, 2006), and the aim of this contribution is to contribute with remarks on the palaeoenvironmental conditions where they thrived during Early Aptian times. The aforementioned problematic microorganisms are dominant microencrusters in the rubble piles analyzed. This fact not only notes the pioneer character of these microorganisms but also suggests a rather restrictive environment given that from all Early Aptian encrusting communities only the *Lithocodium-Bacinella* crusts could grow stabilizing and binding the rubble, and hence, favouring the lithification and preservation of these deposits. This functional role, which since the Paleocene is mostly reserved to the crustose coralline algae, during this Early Aptian case study was performed by the *Lithocodium-Bacinella* consortium. However, and in contrast to the coralline red algae, which normally only overgrow the rubble piles superficially and laterally, the *Lithocodium-Bacinella* crusts analyzed bound the rubble interior as well. These microorganisms have been commonly interpreted as photophile biota (e.g., Dupraz & Strasser, 1999), nevertheless, the fact that the skeletal debris observed are completely surrounded by microproblematicum crusts could suggest a certain ability of these encrusters in thriving even in the shade.

On the other hand, assuming a photophilic habitat for the *Lithocodium-Bacinella* consortium, animal activity or water motion could have caused the overturning of the encrusted skeletal debris permitting the microproblematicum crusts to grow in all directions around the coral fragments. These possibilities seem to be discardable because normally the *Lithocodium-Bacinella* crusts do not display abrasion, erosive surfaces or oncoid morphologies in the rocks studied. Furthermore, these characteristics, together with the absence of cements acting as binding agents also hint that this facies was deposited below fair-weather wave base at least.

The prolific occurrence of benthic foraminifera such as the orbitolinid *Palorbitolina lenticularis* is also worth noting. The orbitolines observed display large-sized discoidal forms and agglutinate abundant silt-sized quartz grains.

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According to Immenhauser *et al*. (1999), these morphological features may reflect deep and/or turbid environments. Therefore, and although the *Lithocodium-Bacinella* facies have been often associated to shallow, clear and oligotrophic waters (e.g., Dupraz & Strasser, 1999), the possibility that in this particular case study the *Lithocodium-Bacinella* consortium grew in relatively deep and/or turbid conditions should not be ruled out.

In this regard, the *Lithocodium aggregatum* crusts also exhibit agglutinated quartz particles sporadically. The presence of detrital quartz, which also characterizes the micritic matrix, should be indicative of strong terrigenous inputs. These siliciclastic fluxes could have been linked to an accelerated hydrological cycle resulting in an enhanced continental weathering and runoff due to the intensified greenhouse conditions that might have led to the OAE1a (Weissert *et al*., 1998).

In line with this hypothesis, the transfer of quartz from hinterland to the basin was probably accompanied by large amounts of clay, which might have brought turbid conditions and elevated nutrient levels, increased by probable upwelling processes (Vogt, 1989). According to Hallock & Schlager (1986), these nutrient-rich conditions may also be supported by the reduced rates of carbonate production observed and the strong bioerosion present in both skeletal debris and *Lithocodium-Bacinella* crusts. In addition, Vilas *et al*. (1995) also proposed a possible link between the widespread development of *Palorbitolina lenticularis* facies and increased nutrient fluxes.

Moreover, the aforementioned global warming event could have induced frequent hurricanes and/or severe tropical storms, which might have razed carbonate platforms dominated by corals developed during this time interval in the Galve sub-basin and/or surrounding areas resulting in the formation of these resedimented deposits. All these data seem to display a sedimentary record of the upper *Deshayesites weissi* biozone largely influenced by intensified greenhouse conditions, storm events and high nutrient concentrations.

Another plausible explanation for the siliciclastic inputs observed and the resedimented facies analyzed could be, at least in part, regional uplift processes. However, nowadays this possibility requires further work at a regional scale. Although the microproblematicum *Lithocodium-Bacinella* did not form buildups in the outcrops studied, these results seem to be in a strong agreement with the nutrient/productivity event model hypothesised by Immenhauser *et al*. (2005) for the Early Aptian, and as well OAE1a coeval, *Lithocodium-Bacinella* facies from Oman.

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Calcareous algae and other biogenic carbonates in selected acoustic facies of the continental shelf: Pontian Islands, Tyrrhenian Sea, Italy

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Key words: biogenic carbonate, Northwestern Mediterranean, rhodolith.

The Intergovernmental Panel of Climate Change (2001) provides an increase of atmospheric CO_2 concentration ranging from nowadays 350ppm to 660ppm in 2065 (Sarmiento *et al*, 1998). The ocean absorbs carbon dioxide from the atmosphere, so increasing atmospheric carbon dioxide concentration will lead to increasing dissolved inorganic carbon, and hence acidification and lower carbonate saturation states. Bio-calcification induces shifts in the seawater carbonate equilibrium which generates dissolved CO_2 and is therefore a source of CO_2 to seawater (Gattuso *et al*, 1995; Kuffner *et al*, 2007). In this scenario of seawater acidification the marine calcifying organism, for example coralline algae, molluscs and foraminifera, will have difficulties producing the skeletons and shells (Gattuso *et al*, 1995; Kuffner *et al*, 2007). Biogenic Mg calcite, the carbonate phase deposited by coralline algae, can be more soluble than aragonite, and could be more susceptible to acidification of seawater and to decreasing seawater calcium carbonate saturation state (Kuffner *et al*, 2007). Under a global change scenario, therefore, marine aragonite and the coralline algal component of the carbonate reservoir are expected to be the first to respond as buffer by dissolution.

The carbonate content and production, both at the species level and at the community level is here quantified in the area of the Pontian Islands continental shelf, in the channel between Ponza and Palmarola islands and along the west cost of Palmarola island. The aim of the present study is to provide a predictive model for assemblages deposited in biogenic carbonate sediments for different acoustic facies and a tentative quantification of the algal Mg calcite presently the seafloor. Different acoustic facies were identified after acoustic seafloor mapping by DF 1000 Side Scan Sonar during two cruises in 1997 and in 2001 (Sañé Schepisi *et al*, 2003). On the basis of available grab samples collected in the same area, the benthic environment was interpreted to belong to the Coastal Detritic Biocoenosis (DC) and the Coarse Sand and Fine Gravel under Bottom Currents (SGCF) (Basso, 1998). For each acoustic facies recognized in the Pontian area (high backscattering facies, low backscattering facies and heterogeneous facies) we analyzed some grab samples in order to describe the biogenic components and carbonate phases of the marine sediments. X-ray diffraction (XRD) analyses and EDTA-titrations were conducted for each selected sample for carbonate mineralogy (calcite, Mg calcite, and aragonite). Percentage calculation of components was made on thin sections of the sediment. The results of these analyses were used to quantify the role of each carbonate producer in the three different acoustic facies. The areal distribution of coralline algae and other major benthic components is mapped and an estimate of the algal carbonate presently occurring at the seafloor is provided.

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Coralline algae (Corallinales, Rhodophyta) from Oligocene carbonates in the Malaguide Complex (SE Spain)

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Key words: Corallinales, Rhodophyta, Oligocene, Malaguide Complex, Betic Cordillera, SE Spain.

Coralline algae are common components of Oligocene shallow-water carbonates from the Malaguide Complex in Sierra Espuña in Murcia (SE Spain). The Malaguide Complex is the uppermost of the three stacked tectonic complexes that constitute the Internal Zones of the Betic Cordillera, which comprise a crustal wedge emplaced against the southern Iberian margin during the early Miocene. The most complete and best-exposed successions of Cenozoic rocks from the Malaguide Complex crop out in Sierra Espuña, where the top unit includes thick conglomerates (up to 600 m) intercalating algal limestones with larger benthic foraminifers, which change laterally and upwards to marls interbedded with turbiditic calcarenites, sandstones, and conglomerates (Martín-Martín, 1996). The occurrence of *Nummulites* cf. *vascus* suggests a Rupelian–early Chattian age for the algal limestones (SBZ 21-SBZ 22B of Cahuzac and Poignant, 1997) at the three studied outcrops. Corallines occur as rhodoliths, loose branching thalli, and fragments of foliose plants in a packstone matrix rich in larger benthic foraminifers. Rhodoliths are mainly made up of encrusting to warty thalli of several species of *Lithothamnion*, *Sporolithon*, *Lithoporella*, and minor *Spongites*, *Karpathia*, and the peyssonneliacean *Polystrata*. Fragments of zooxanthellate corals, bivalves, and bryozoans are the nuclei of rhodoliths. The identifiable loose coralline branches correspond to *Spongites* and *Subterraniphyllum*, while fragments of foliose plants seem to belong mainly to *Neogoniolithon*. The algal limestones formed in a shallow platform mainly occupied by fan deltas that accumulated terrigenous sediments eroded from the Malaguide Mesozoic and Palaeogene substrate. The larger-benthic-foraminifer assemblages indicate an upward deepening of the carbonate depositional environment.

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Large dasycladalean algae from the Upper Jurassic limestones of Apuseni Mountains, and their paleoenvironmantal significance

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Key words: Dasycladales, paleoenvironment, Upper Jurassic, Romania.

The dasycladalean algae presented here were collected from two different regions of the Apuseni Mountains: Şerbota Hill (near Aştileu, northern part of Pădurea Craiului), and Sănduleşti quarry (the northern end of Trascău Mountains).

Within the Upper Jurassic succession from Aştileu area, two main facies associations have been separated: 1) distal shelf (offshore) facies, identified in the lower part of the succession, and 2) shallow water, external carbonate platform facies (bioclastic shoals), in the upper part.

The dasycladalean assemblage, represented by *Salpingoporella pygmaea, Salpingoporella annulata, Campbelliella striata, Neoteutloporella socialis* and species of the genus *Petrascula* (most probably *P. piai* and *P. buesiformis*), was found in the upper part of the succession. The large dasycladales (*Petrascula* specimens) have been found in ooidic-pisoidic or coarse intraclastic-bioclastic grainstone with frequent echinoderm fragments. Here, the dasycladaleans are surrounded by a microbial cortex and/or are encrusted by foraminifera and cyanobacteria. The incrustations point to a relatively low energy paleoenvironment (protected areas between the submarine dunes) from where the algae were reworked into the higher energy environment (inside the dunes). Other large specimens, but devoid of a microbial cortex, are abraded by erosion. They indicate a continuous wave action on the submarine dunes. The large intraclasts with fragments of *Neoteutloporella socialis*, point to the proximity of small reefs. The smaller dasycladaleans (e.g. *Salpingoporella* sp.) frequently constitute the ooids' core, or they are present as fragments.

The sedimentological and micropaleontological data indicate that the large dasycladaleans from Aştileu area developed on the submarine dunes as well as in the protected areas between the dunes in the external part of the Bihor-Pădurea Craiului Upper Jurassic carbonate platform.

In Sănduleşti area, the assemblage of dasycladalean algae consist of: *Linoporella kapelensis*, *Salpingoporella pygmaea*, *Clypeina sulcata*, *Petrascula piai* and *Anisoporella*? *cretacea*. In the limestone from Sănduleşti, two main facies types have been also separated: 1) carbonate breccia and microbreccia consisting mainly of reefal intraclasts, and 2) coral-microbial bioconstructions. The breccia/microbreccia levels consist of coarse „reefal" intraclasts included in a fine-grained carbonate matrix. In most cases the top of the carbonate breccia/microbreccia is intensely encrusted by microbialites. The reef bioconstructions are made up mostly by corals, microbialites and sponges. Bryozoans, encrusting microorganisms (*Trogrotella incrustans, Thaumatoporella parvovesiculifera*, *Crescentiella morronensis*, *Radiomura cautica*, *Koskinobullina socialis*, *Lithocodium aggregatum*), and annelid worms also contributed to the development of the reefal framework. Syndepositional (radiaxial fibrous) cement that is frequently associated with the microbialites played an important role in the framework development. The facies associations from Sănduleşti area are characteristic for a reef-slope environment located near the shelf crest. They outline the paleoslope of a carbonate platform developed in this region on an island-arc topography during the Upper Jurassic-Lower Cretaceous.

The two case studies bring supplementary arguments to the statement that large dasycladaleans developed mostly in external carbonate platform environments (reef environment and its derivates, or bioclastic shoals on the platform margins) (cf. Bucur & Săsăran, 2005 and references herein)

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Taxonomic revision of *Pseudoepimastopora* Endo 1960 and its Upper Jurassic to Lower Cretaceous representatives

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Key words: Dasycladales, Taxonomy, Upper Jurassic, Lower Cretaceous.

For a long time, records of dasycladalean algae having a weak or partial calcification mostly limited to the distal part of their laterals, and which are frequently found only as fragments, are problematic regarding their systematic attribution (e.g. Bucur *et al*, 2005). This group also contains *Pseudoepimastopora jurassica* Endo 1961 and *Pseudoepimastopora cretacea* Dragastan 1967, taxa with a complicated systematic history.

Pseudoepimastopora cretacea was described by Dragastan (1967) from the Lower Cretaceous limestone of Vârciorog area, Pădurea Craiului (Northern Apuseni Mountains). Following the emendation of the genus *Pseudoepimastopora* (Roux, 1979) and its subsequent invalidation (Granier & Deloffre, 1993), the alga was assigned to other genera. Bucur (1992) attributed *P. cretacea* to the aspondyle genus *Epimastoporella* Roux starting from the apparent aspondyle distribution of the laterals and from their morphology, and emended the species diagnosis. The identification of supplementary better preserved specimens from the type area (Vârciorog region) conducted the same author (Bucur, 1995) to reconsider the lateral arrangement and their morphology (euspondyle and vesiculiform, respectively) and to assign the alga to the genus *Anisoporella* Botteron (which, by definition has vesiculiform laterals in an euspondyle arrangement). The author also gave a new emended diagnosis of the species.

Nevertheless, as specified by Radoičić (2005), *Anisoporella* includes dasycladalean algae with vesiculiform laterals and euspondyle arrangement, but with double verticils, a feature not present in *P. cretacea* which has simple euspondyle verticils (see also Helm *et al* 2003). Finally, Bucur *et al* (2005) mentioned that the morphological features of the skeleton of this alga are closer to those of the genus *Griphoporella* as described and emended by Barattolo *et al* (1993). Further well preserved specimens from Romanian Carpathians (Pădurea Craiului in Apuseni Mounatins, and Perşani Mountains in East Carpathians) allowed us a more detailed morphological study of the alga. Based on this new material we propose the transfer of the species to the genus *Griphoporella*, provide a new emended diagnosis, and enlarge the stratigraphic range of this species from the Oxfordian to Upper Aptian-Albian.

A comparable systematic odyssey can be stated for *Pseudoepimastopora jurassica* described by Endo (1961) from the Upper Jurassic of Japan (see Senowbari-Daryan *et al,* 1994; Bucur 2000; Schlagintweit *et al,* 2005, for details). New material of *P. jurassica* is presented from the Upper Jurassic of the Northern Calcareous Alps.

Other species belong most probably to genus *Griphoporella* are *Epimastopora cekici* Radoičić and *Gyroporella lukicae* Sokač and Velić. *Epiastopora cekici* was described by Radoičić (1970) from the Lower Cretaceous of south Herzegovina as an aspondyle dasycladale. However, we think that its aspondylity is only apparent, and it has an euspondyle arrangement of the laterals (see Radoičić, 1970, pl.VI, fig. 1; Mancinelli, 1992, Pl. IV, fig.10). *Gyroporella lukicae* was also described from Lower Cretaceous deposists (Sokač & Velić, 1982) but, following the diagnosis and the illustrations, it has a an euspondyle arrangement. It was assigned to the genus *Anisoporella* by Senowbari-Daryan *et al.* (1994), the same authors considering also the possible synonymy between *G. lukicae* and *P. cretacea* (with *A. lukicae* as a junior synonym).

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Growth rate in culture of some Mediterranean calcareous red algae (nongeniculate Corallinales)

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Key words: coralline red algae, Northwestern Mediterranean, culture conditions.

The global carbon cycle is directly linked to Global Climate Change (Schlesinger, 1991). Increasing of CO_2 atmospheric levels is producing an acidification of the ocean water (Sarmiento *et al*, 1998; Riebesell, 2004; Kuffner *et al*, 2007), while decreasing seawater pH is expected to affect marine organisms in several ways. Marine calcifying organisms, for example coralline red algae, foraminifers and molluscs, are expected to undergo a decrease in thallus and shell calcification (Kuffner *et al*, 2007).

Coralline red algae are widely distributed in the Earth Oceans from Poles to Tropics along the whole photic zone (Fabricius & De'ath, 2001). In the Mediterranean Sea they are the major framework builder (Pérès, 1982).

Despite their importance in the global carbon cycle, few studies on coralline algae growth rate are available. Some pilot investigations of tank growth of *Lithophyllum stictaeforme* (Areschoug) Hauck and *Mesophyllum lichenoides* (Ellis) Lemoine collected from the coralligenous of the Ligurian Sea, yielded preliminary data of 10-60µm/yr thickening for *M. lichenoides* and 21-80µm/yr for *L. stictaeforme* and marginal elongation 1290-3260µm/yr for *M. lichenoides* (Basso & Rodondi, 2007).

We present here the results of further experiments of tank growth of corallines collected in July 2007 at 10 m depth along the western rocky coast of Bonassola (SP). Samples have been Alizarin-S stained (2,5g/l for 24h) and cultured until November 2008 in a 70l tank of artificial seawater. Water temperature, salinity and pH were recorded and controlled during the culture experiment. Samples were kept under an artificial irradiation of 10,97 µmol m^{-2} s^{-1} during 7 hours/day.

After three months of culture, some coralline algae germinations occurred on the walls. In nine month they grew an average of 13 mm^2 (SD 7) per month.

After fifteen months (November 2008), corallines were recovered and immersed under tap water for 12h to remove their natural pigments (Rivera *et al*, 2004). Thin sections were obtained from each sample and the growth rate measured as the distance from the Alizarin mark to the living surface of the algae. We provide evidence that *L. stictaeforme* and *M. lichenoides* grow preferentially in length rather than thickness, and the growth is not homogeneous along the edge of the thallus.

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Algal mats from the Cupido Formation, northeastern Mexico

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Key words: mats, algae, Cupido Formation, Mexico.

The Cupido Formation, a massive carbonate platform deposited from the Hauterivian through the Lower Aptian (Alfonso-Zwanziger, 1978), extends from northeastern Mexico to western Florida (Guzzy-Arredondo *et al*, 2007), is well-exposed in several localities of Coahuila and Nuevo Leon, Mexico (Guzzy-Arredondo *et al*, 2007). This formation is equivalent to the Tamaulipas Inferior Formation, underlying the Taraises Formation and overlain by La Peña Formation. Moderately laminated algal mats are found in the outcrop of Puerto Mexico, Coahuila, within the packstone facies of rudist bivalves and other marine microbiota. It has been shown that other localities of the Cupido Formation present microbial mounds with a significant sponge contribution (Murillo-Muneton & Dorobek, 2003). Some other fossil remains of macroscopic calcareous algae, whose taxonomic affinity remains to be determined, have been found in association with the rudists shells. The rudists fragments preserved in different geometrical planes show a marked size variation and density distribution. In this work a first description and analysis of the mats and the fossil algae impressions is presented in the context of their paleoenvironmental significance.

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Calcareous algae from Middle Ordovician limestones Bachu Area (Tarim basin, Western China)

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Key words: calcareous algae, Ordovician, Tarim, China.

In the Bachu area in the Tarim Basin of Western China, Ordovician limestone sequences of great thickness (up to 2000 m) can be observed. The Upper Qiulitag Formation (Lower Ordovician) and the Yijianfang Formation (Middle Ordovician) are separated by the so called T_7^4 boundary which is developed as corrosional unconformity caused by a marked sea level drop in Early-Middle Ordovician.

The Upper Qiulitag Formation (Lower Ordovician; 931 m thickness) is well represented in the Dabantag standard section. It consists of an alternating sequence of micritic limestone and calcarenites. In the Upper part locally fine-crystalline dolomites are intercalated. The lower part is predominantly composed of light grey to grey (medium to thick-bedded) fine-crystalline dolomite in which fine-crystalline calcirudites are intercalated. Silica nodules and bands commonly occur in the limestones deposited in a semi-enclosed-open platform facies. Organisms are composed of a few cephalopods (*Protocycloceras* sp. and *Ormoceras* sp.), some trilobites (*Megalaspides* sp.) as well as gastropods (*Maclurites crassus*). Six conodont zones can be analysed within the Upper Qiulitag Formation.

T_7^4 boundary has a descending influence on the underlying Lower Ordovician strata of the Upper Qiulitag Formation resulting in the formation of karst reservoirs for hydrocarbons. Locally patch reefs are found indicating the beginning development of a high energy tidal to platform margin depositional environment. In outcrops the limestones of the T_7^4 boundary, from which the samples analyzed were taken, are characterized by slightly laminated and locally nodular limestones.

The overlying Yijianfang Formation (Middle Ordovician; 54 m thickness) is characterized by grey, dark grey thick-bedded matrix-rich bioclastic limestone and light grey to grey-white thick-bedded weakly silicified limestone rich in *Calathium* and receptaculitids, representing a platform margin reefal facies. Besides abundant cephalopods and trilobites a small number of echinoderms, brachiopods, gastropods and sponges can be found. Organic reefs dominated by *Calathium* and *Receptaculites* of undeterminable taxonomic positions occur mainly in the lower part of the Yijianfang Formation. The platform margin environment is developing towards North to a characteristic platform environment with common organic reefs.

Thus the samples analyzed from the T_7^4 boundary mark the transition from an open marine deeper environment to shallow marine high energy environment characterized also by calcareous algae which can be used as biostratigraphic marker microfossils. The algae assemblage contains dasycladaleans (*Dasyporella, Rhabdoporella, Vermiporella,* and other unidentified taxa), Cyanobacteria (*Girvanella*) and problematic microfossils (*Nuia sibirica,* and cyanobacterial-like microorganisms).

Ordovician algae from Tarim Basin were already described by Riding & Fan (2001) from the subsurface Middle-Late Ordovician of the Northern Tarim Uplift. The algal assemblage we present here is situated at the Early-Middle Ordovician boundary, improving thus our knowledge on the Ordovician microflora of Tarim.

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Piriferella verrucosa (Sokač, 1996) nov. comb. from the Upper Jurassic of the Northern Calcareous Alps, Austria

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Key words: dasycladalean algae, *Salpingoporella*, *Piriferella*, Taxonomy, Upper Jurassic, Austria.

The dasycladalean alga *Salpingoporella verrucosa* was described by Sokač (1996) from the Upper Barremian (Lower Cretaceous) of the Dinaric Karst. This species is characterized by uncompressed laterals closed at the tips and forming wart-like protrusions at the outer thallus surface. Regarded as “not a *Salpingoporella*, possibly a species of *Piriferella* Sokač, 1996”, it was excluded from the critical taxonomic revision of the genus *Salpingoporella* Pia, 1918 provided by Carras *et al* (2006). Material deriving from Upper Tithonian (Upper Jurassic) shallow-water carbonates of the Northern Calcareous Alps of Austria brings new data on the species in question.

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Piriferella somalica (Dasycladaceae, calcareous green algae) from Tithonian deposits in the Northern Calcareous Alps – Synonymy followed by an emendation of *Piriferella* Sokač 1996 and *Similiclypeina* Bucur 1993

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Key words: dasycladalean algae, *Piriferella*, *Similiclypeina*, Taxonomy, Upper Jurassic, Austria.

Material deriving from Upper Tithonian (Upper Jurassic) shallow-water carbonates of the Northern Calcareous Alps (NCA) of Austria extends the range of the dasycladalean alga *Piriferella somalica* (Conrad *et al*, 1983) Sokač 1996. Initially, this taxonomically simple alga was described by Conrad *et al* (1983) from Upper Barremian/Bedoulian deposits of the African Plate as a new species of the genus *Clypeina* Michelin 1845. Subsequently, the species was assigned by different authors to the genera *Holosporella* Pia 1925, *Similiclypeina* Bucur 1993 and *Piriferella* Sokač 1996, resulting in an undesirable confusion.

In this study, biometric measurements are carried out on the following: (1) specimens illustrated by Conrad *et al*, (1983); (2) the new, herein illustrated specimens from the NCA; (3) a number of specimens illustrated by Sokač (1996) under the name of *Salpingoporella verrucosa* (a new species), *Piriferella spinosa* (a new genus and new species) and *Piriferella somalica* (a new combination). Drawing a parallel, further measurements are carried out on specimens of *Clypeina radici*, as illustrated by Sokač (1986), and several specimens of *Piriferella paucicalcarea* (Conrad, 1970), n. comb.

As a result, the genus *Piriferella* is emended, while *Salpingoporella verrucosa* and *Piriferella spinosa* are shown to be junior synonyms of *Piriferella somalica*. Also the genus *Similiclypeina* and type-species *S. conradi* Bucur 1993 are emended. An interpretative epitype is chosen among the original paratypes to better illustrate the unusual characters of this interesting species found in the Barremian of Romania.

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Rhodolith bottoms from the Pleistocene of Bivio Scordia (SE Sicily)

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Key words: rhodoliths, Pleistocene, Paleoecology; SE Sicily.

Pleistocene sediments with abundant free living coralline red algae (Corallinales, Rhodophyta) widely crop out all through south-eastern Sicily (Di Geronimo *et al*, 2000; 2003; Di Geronimo, 2006). Studied levels are from Bivio Scordia (SE Sicily, Italy), in the northern side of the Hyblean plateau and belong to Early Pleistocene calcarenites, interbedded within volcanic rocks (Pedley *et al*, 2001).

Frequent and abundant rhodoliths are the main biogenic component, associated with faunistic elements such as brachiopods and bryozoans; internal moulds of molluscs are also common. Mostly of the recovered coralline algae, reaching to 10 cm in diameter, are well preserved spheroidal rhodoliths with laminar to columnar morphologies. Moreover, several algal coatings on nucleus constituted by volcanic pebbles and subordinate pralines, are present. Articles of geniculate red algae rarely co-occur.

A total of sixteen species have been detected, mainly belonging to the subfamily of the Melobesioideae, and subordinately to the Mastophorideae and Lithophylloideae.

As a whole, the composition of the coralline algal palaeocommunity together with ecological information gained by shapes and growth forms of rhodoliths, point towards a circalittoral palaeoenvironment swept by currents ascribed to the Coastal Detritic Biocoenosis (Pérès, 1982).

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A photo-atlas of Thanetian, Ypresian, Bartonian and Priabonian Dasycladales of the Paris basin

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Key words: Dasycladales, calcareous algae, photo-atlas, Thanetian, Ypresian, Bartonian, Priabonian, Paris basin, France.

Following the publication of the photo-atlas of living Dasycladales (Berger, 2006) and their fossil representatives from the Lutetian of the French Cenozoic basins (Génot, 2009), we now propose a photo-atlas concerning the Thanetian, Ypresian, Bartonian and Priabonian algae of the Paris basin. This third atlas will be published in "Carnets de Géologie" and will contain 117 unpublished photos and 28 drawings of 17 species that lived in this area during Paleogene times.

Calcareous coatings of the specimens have been extracted from the sandy sediments and examined under the electron microscope.

The photographs illustrate the main morphological features of the species. Their identification depends on the amount of calcification which varies greatly in the several species:

- laterals and large ovoid gametophores are entirely calcified in *Cymopolia zitteli*,
- laterals with numerous divisions are calcified but fertile organs are unknown in *Belzungia borneti*,
- pluricystic elongated gametophores are the only calcified organs in *Acicularia eocaenica* and *Ac. parvula*,
- gametophores and secondary laterals are well calcified and distal ends of primary laterals are rarely calcified in *Neomeris arenularia* and *N. scrobiculata*,
- groups of small gametophores and parts of the axial cavity are calcified but laterals are not calcified in *Carpenterella morelleti* and *Jodotella thilense*,
- cluster of small gametophores are calcified and laterals are partially calcified in *Jodotella veslensis*,
- gametophores and secondary laterals are well calcified while the primary
- laterals are still unknown in *Neomeris craniphora* and *N. herouvalensis*,
- some parts of the laterals are preserved within the segments of *Uteria encrinella* but gametophores are not calcified,
- the whole thallus is calcified in *Zittelina dactyloporoides*: axial cavity, laterals and pluricystic gametophores….

The stratigraphical range and the time of maximum abundance are indicated for each species.

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Lutetian Dasycladales of Cotentin (Normandy, France)

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Key words: Dasycladales, Lutetian, Cotentin, France.

First studies of the Eocene Dasycladales of Cotentin have been published by Lucien and Jean Morellet in 1917. *Cymopolia elongata*, *C. dollfusi*, *Larvaria encrinula*, *Lemoinella bureaui* and *Belzungia terquemi* were described, discovered in the Auversian sediments, now considered as Upper Lutetian, of several localities of the Manche department (Fresville, Hauteville, Orglandes and Port-Bréhay).

In 1939, after the revision of the Parker collection (Natural History Museum of London), L. and J. Morellet described a new species, *Cymopolia edwardsi*, and undetermined *Cymopolia*, *Neomeris* and *Acicularia* species, mainly coming from Hauteville. They also proposed a detailed study of *Larvaria encrinula* (this species will be later assigned to the genus Neomeris) . More recently, the morphological features of *Cymopolia dollfusi* were precised and illustrated, and a new species of *Acicularia* (*A. modesta*) was described (Génot, 1987).

The discoveries and the study of new specimens lead us to propose more information on some of the previously quoted species. Among our main results: 1) we point out the great variability of the external aspect of the segments of *Cymopolia dollfusi*: elongated cylinders or short and wide segments, with a neck-shaped lower extremity on some of them. 2) the comparison of *Neomeris encrinula* with *N. auversiensis*, a Bartonian species of the Paris basin, allows us to conclude that these species probably belong to the same one. 3) a new species is introduced, *Neomeris delicatula*, a weakly calcified alga characterized by the very great diameter of its axial cavity and by its ovoid pedunculated gametophores inside rounded calcareous envelops.

Cotentin Lutetian species lived in shallow littoral marine environments associated with numerous Pelecypods, Gastropods, Echinoderms and Foraminifers.

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Calcareous algae from the Yaila Series near Bilohirsk (Crimea, Ukraine)

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Key words: Dasycladales, Foraminifera, stratigraphy, Tithonian, Berriasian, Crimea, Ukraine.

Five kilometers south of the town of Bilohirsk (also known as Belogorsk), limestones of the Yaila Series (Tithonian-Berriasian) are exploited in a quarry at the foot of a small (397 m) hill. Some rock samples were collected there in 1994 during an exploratory mission.

Microfacies textures range from wackestones to grainstones; the allochems consist mostly of bioclasts (foraminifera and calcareous algae). Diagenetic features such as micritic envelopes with sedimentary infills document repeated stages of subaerial exposures.

The paleophycological assemblage consists of *Diversocallis* sp., *Permocalculus* sp., *Thaumatoporella parvovesiculifera*, *Terquemella* sp., *Salpingoporella* sp., *Actinoporella podolica*, *Rajkaella iailaensis*, *Petrascula* (?) sp. [or *Suppiluliumaella* (?) sp.], *Pseudoclypeina* sp., ...

Foraminifers (Gorbachik, 1971; Krajewski & Olszewska, 2007) associated with these algae include *Anchispirocyclina lusitanica* (macrospheric specimens), *Pseudocyclammina lituus*, *Dobrogelina ovidi*, *Protopeneroplis trochangulata* [? = *Hoeglundina* (?) *ultragranulata*], *Mohlerina basiliensis*, *Trocholina* sp. [= *Andersenolina* sp., also quoted as *Coscinoconus* sp. in old micropaleontological publications], miliolids and various agglutinating forms.

This initial investigation offers an opportunity to review some "algae" originally described by V.P. Maslov (1958a-b, 1965) and to discuss the biostratigraphic value of some microfossils, particularly of those that may help to discriminate Tithonian from Berriasian strata in carbonate platform environments.

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PETRALGA project (Phase III): transfer of the database on the web

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Key words: Dasycladales, Corallinales, taxonomy, database, Web 2.0, MediaWiki, Permian, Triassic, Cretaceous, Cenozoic.

The PETRALGA (**PE**rmien & **TR**iassic **ALGA**e) project was initiated almost 20 years ago to provide tools useful by both Scientific Institutions and Industry. That was Phase I in which data were exchanged by post and conference. Ten years ago the project was transferred to the web and displayed by classical HTML (but as there was no database attached all hypertext links had to be manually inserted). That was Phase II.

"Web 2.0" does not imply an entirely new version of the World Wide Web, but is rather a modification of the way the Web can be used. MediaWiki is but one of the many collaborative tools which facilitate communication and information sharing within a community. One of the main advance in the MediaWiki version of the project, or Phase III, is that it runs on MySQL (Structured Query Language), a well-known open-source database management system. Similar project using MediaWiki are currently built for other fossil groups such as **Palyweb**, dedicated to palynomorphs from pre-Mesozoic levels (Steemans & Breuer, 2007):
http://www.palyweb.ulg.ac.be/wiki/
or **eForams**, dedicated to foraminifers (Hottinger et al., 2006):
http://eforams.icsr.agh.edu.pl/

As a main sub-project, we shall complete an exhaustive catalogue of the dasycladalean algae from the Permian and Triassic periods, the apogee of occurrence for this Order with about 60 genera and about 240 valid published species. An early version can be accessed at:
http://www.univ-brest.fr/geosciences/wiki/petralga/

For each species, sub-species or variety, the catalogue will provide a file including the following subject heads:

- **Systematics**: taxonomy, type (holotype, paratypes, lectotype, syntypes, neotype, location of collection, ...), type-level and type-locality, original diagnosis and/or description, and emended diagnosis and description, a new description and eventually new diagnosis (many species were described in the early XXth century and before, the terms used in the protologue are out of date or no longer usable), comments;
- **Synonymy distribution**: geographic distribution of localities worldwide, stratigraphic range and fossil associations;
- **Photomicrographs**: type-specimen mandatory and new Illustrations desirable, possibly including schematic reconstructions;

At the genus level, as at the species level, the catalogue will provide one discrete file:

- **Systematics and synonymy**: taxonomy, type-species, original diagnosis and/or description, eventually amended diagnosis and description, new description and eventually new diagnosis (as many genera have been described in the early XXth century and before, terms used in the protologue are outdated or no longer fit with the studied material), comments.

In addition, these taxa will be set in order at the genus, sub-tribe or tribe levels (in relation to the number of species, sub-species or varieties) and, for each group, the catalogue will provide:

- a summary table of the stratigraphic range of the species
- a summary table of their main characters and parameters
- a determination key

Finally, a full bibliography and a glossary will be provided.

Early contributions to PETRALGA include: Granier (1993), Granier & Deloffre (1995), Hofmann & Granier (1995), Bucur (1997), Granier & Grgasović (2000), and Granier & Hofmann (2002).

During the course of the project some colleagues were retired (from scientific institutions or industry) and stopped keeping

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abreast of advances in the fossil algae; others passed away. So this work is dedicated to the memories of Erik Flügel, Zbigniew Kotański and Momčilo Milanović who contributed to the project from its very beginning.

In parallel with the PETRALGA project we shall also run a RHODALGA project, dedicated to the red algae (mostly Mesozoic and Cenozoic species):
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Calcareous algae (and *problematica*) from the Paleocene of Libya - Part 1

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Key words: Dasycladales, Paleocene, Lybia, Sirte basin.

Calcareous algae of the Paleogene in the Paris and Mons basins are well known owing to the work of the Morellet brothers at the beginning of the XXth century (1913, 1922). Following this promising start but few and scattered data were published until the last score of years of the century. Then in the 80's and 90's intensive research resumed. For example: 1) P. Génot's memoirs (1978, 1980, 1987) in which he revisited the Morellet brothers' material and published supplementary data on it, 2) the catalogue "Algues Dasycladales du Cénozoïque" (Deloffre & Génot, 1982), and 3) new significant contributions on Slovenia, Italy and Irak (some of which were written by R. Radoičić and F. Barattolo, see Barattolo, 2002).

But there were few reports on North African associations: Egypt (Pfender, 1940; Massieux, 1966a-b), and Morocco (Granier *et al*, 1997), after J. Kuss & G. Herbig (1993) had released new data on both Egypt and Morocco. In their work they compared these areas, but the "no alga land" of Algeria, Libya and Tunisia separated them. The purpose of this ongoing study is to bridge that gap and to draw a more detailed map of the distribution of these algae in Paleocene times.

While investigating thin sections from the collections of Jean Cuvillier, Raoul Deloffre, Jacques Emberger and Juliette Pfender, we found rich assemblages of calcareous algae from the Paleocene of Libya. Our understanding is that most of the material possibly came from exploration wells drilled before 1973. Therefore, in consideration of breaches of confidentiality, we do not divulge certain details.

In the studied material we found a number of *microproblematica* from the Cretaceous known as *Pieninia oblonga*. They are sometimes arranged in a pattern which definitively reveals their alcyonarian origin.

We also identified *Parachaetetes asvapatii* / *Elianella elegans* in association with certain echinoid (Cidaroida) spines which in section have a discrete undulating cortical zone which parallels the ornamentation (longitudinal crests) and a central part with a rather homogenous stereom, although radiating lineations can be seen. These undulations were erroneously interpreted as the nemathecia (reproductive structures) of *Parachaetetes* and the stereom was considered the vegetative part of the thallus thought to be sterile filaments (Aguirre & Barattolo, 2001: Pl. 1, fig. 1-4). Our specimens of "*Elianella*" have in part been leached away: in some patches there are no remains while in others filaments of cells are separated by porous intervals.

The assemblage also includes *Thyrsoporella* sp., *Triploporella* sp., *Sarosiella* sp., *Cymopolia* sp., *Neomeris* sp., *Orioporella* sp., *Clypeina* sp. *Uteria* sp., *Acicularia* sp., *Terquemella* sp., ? *Frederica* sp.. They will be illustrated and discussed during the symposium presentation, and in forthcoming papers. Libyan phycological assemblages of Paleocene age are very similar to those found in Iraq, that is both areas are on the southern margin of the Tethys, *i.e.* they are sited on the carbonate platforms developed on the northern margin of the African-Arabian plate.

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"New studies on Triassic Siphoneae verticillatae" by Julius von PIA - The XXIst century edition

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Key words: Dasycladales, Triassic, Pia, PETRALGA, *Macroporella*, *Teutloporella*, *Oligoporella*, *Kantia*, *Physoporella*.

Before J. von Pia published his 1920 seminal memoir, "Die Siphoneae verticillatae vom Karbon bis zur Kreide", the 1961 French version of which became a paleontological "best seller", he had written an early memoir on the fossil algae. This, his first comprehensive palaeophycological work was based on the dissertation for his PhD, defended on March 28, 1911. This memoir was published the following year as "Neue Studien über die triadischen Siphoneae verticillatae". Unlike the 1920 memoir this 1912 book was never translated and consequently never attained the popularity of its follower. However for those who study Triassic algae it should be "the" reference as the author introduced 4 new genera, some based on previously undescribed species, while others were erected on species previously referred to other genera:

- Descriptions of the genus *Macroporella*, of its type-species *M. dinarica*, and of the species *M. alpina* and *M.* (?) *helvetica*;
- Descriptions of the genus *Teutloporella* based on the species *Gastrochaena herculea* Stoppani, 1857, and of the species *T. gigantea* and *T.* (?) *tenuis*. Transferred to this new genus the species *Chaetetes triasinus* Schauroth, 1859, and *Diplopora vicentina* Tornquist, 1899, along with a description of the variety *nana* for that species.
- Descriptions of the genus *Oligoporella*, of its type-species *O. pilosa*, and of the species *O. serripora* and *O. prisca*.
- Descriptions of the genus *Kantia*, of its type-species *K. philosophi*, and of the species *K. hexaster* and *K. dolomitica*.

In addition he emended the genus *Physoporella* Steinmann, 1903, and transferred to it the species *Gyroporella dissita* Gümbel, 1872, and *G. minutula* Gümbel, 1872.

Finally he transfered the species *Gyroporella debilis* Gümbel, 1872, to the genus *Diplopora* Schafhäutl, 1863.

We prepared an English version of the text, revised the presentation of the original illustrations, and added new ones. Accordingly the original 24 text-figures and 7 plates [II-VIII] were converted into 125 discrete photomigraphs, 5 figures and 56 videos. The volume will be published as an e-book by “Carnets de Géologie”.

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Observations on living calcareous algae from San Salvador Island, Bahamas, and correlation with their fossil counterparts

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Key words: calcareous algae, San Salvador, Bahamas.

San Salvador Island is a small isolated carbonate platform in the Bahamas archipelago. The island is composed of a thin veneer of Pleistocene and Holocene carbonate rocks, predominantly eolianites overlying thick succession of Mesozoic and Tertiary limestones and dolomites. A large area of the island is covered by mostly hypersaline lakes that formed in depressions between the dune ridges. San Salvador is surrounded by barrier reefs with protected lagoons behind them. Sea-water temperature ranges from 24 to 30 ^{o}C.

The study focuses on modern calcareous algae, particularly Dasycladales, from the paleontologist's perspective, in order to better understand their present contribution to carbonate sediments, as well as to compare these algae with their possible fossil counterparts. Investigated localities are include: Long Lake, Fernardez Bay (Telephone Pole Reef), French Bay, Pigeon Creek, Rice Bay and Graham's Harbor (North Point and Dump reef).

Calcareous algae have been found in diverse environments. The most common are *Halimeda* and *Penicillus*. They are widespread, especially in protected lagoons with soft bottom, in both barren and grass-covered areas. They can be also found on patch reefs, in tidal channels and near beaches just below the low-tide level. Other green algae are also common, as *Rhipocephalus*, *Udotea* and *Avrainvillea*. Dasycladales are much less common then Bryopsidales. Among them the most common species is *Batophora occidentalis*. Relatively common are *Acetabularia crenulata* and *Dasycladus vermicularis*. Calcified species *Cymopolia barbata* and *Neomeris annulata* are very rare. All of the observed Dasycladales live attached to hard substrate (rock, corals, pebbles, shell fragments) and occur in bushes composed of several individuals. *Batophora* has been found in lagoon environment, but mostly near beaches, commonly in small pools between callianassid mounds. It also occurs on mangrove roots above low tide level and in hypersaline lake. *Acetabularia* and *Dasycladus* have been found in the same lagoon environment as *Batophora*, but not above sea level.

Cymopolia has been found near shore, where it swings with waves, firmly attached to the substratum.

Calcification types vary among different algae. Some algae (*Halimeda, Neomeris, Cymopolia*) form distinct calcareous skeletons that they use for protection against predators. Postmortem disintegration of these skeletons leads to formation of sand-to-mud-size carbonate sediments. Other algae (*Penicillus, Avrainvillea, Rhipocephalus*, *Udotea*, *Padina*) precipitate small aragonite crystals that aggregate on the surface of the alga and between filaments. Young algae are therefore green, being whiter as aragonite precipitates. Following death, the aragonite envelope breaks down forming mud-size particles. Acetabularia form very thin aragonite envelope that also disintegrates into mud-sized particles, but genetically is closer to the first type of calcification. Non-calcified dasyclads *Batophora* and *Dasycladus* act as bafflers, collecting sand and mud-sized particles. The amount of sediment that they baffle is small compared to sea-grasses, but in the geological past, before the appearance of sea-grasses, the non-calcified algae likely were the main sediment-bafflers, although they haven't been preserved as fossils.

Contribution of Bryopsidales to modern carbonate sediments is well known. Our investigations support previous data on exceptional importance of calcareous algae in formation of sand-to-mud-size carbonate particles. Since the scarcity of calcified Dasycladales prevents an estimation of their contribution to carbonate sediments, living Halimedaceans can be used as their analogues. In Mesozoic and Paleozoic times, when Dasycladales were much more abundant then Bryopsidales, their role in production of carbonates was probably significant.

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Acoustic mapping of rhodolith-dominated carbonates at Punta Chivato, Mexico

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Key words: Gulf of California, coralline red algae, rhodalgal, acoustic mapping.

Rhodolith-dominated carbonate environments have not only been described globally from a wide range of Recent shallow marine settings, but they are also important components of the Cenozoic fossil record. In the present-day warm-temperate Gulf of California, Mexico, a number of rhodolith-dominated carbonate systems thrive under mesotrophic conditions. Punta Chivato is the northernmost and largest of a series of well-developed rhodalgal carbonate factories in the Gulf of California, yielding average abundances of up to 38% rhodolith-derived coralline red algal components in the carbonate sediment fraction. Siliciclastic influx is negligible at this site away from the coastlines and above 40 m depth, the maximum depth of prolific carbonate formation.

A detailed sedimentologic study combined with acoustic seafloor mapping (QTC View mapping system - Quester Tangent Corporation) indicates the presence of an extensive wave-dominated rhodolith bed at water depths shallower than 10 m. Rhodolith beds are loosely defined as accumulations of living and dead unattached coralline red algae (Foster *et al*, 1997; Steller & Foster, 1995). Acoustic mapping shows that the rhodolith bed and associated marginal rhodolith facies occupy >16 km^3 of the study area. The location of the acoustically mapped rhodolith bed closely corresponds to the distribution of coarse grain sizes >2 mm. Both the grain size distribution and the acoustic map give a better representation of the position and extent of the living rhodolith bed (confirmed by seafloor observations) than the distribution of rhodoliths and rhodolith-derived fragments as determined by point counting analysis of sediments. Reasons are that the predominant grain size has an important influence on the acoustic return signal (Riegl & Purkis, 2005). Entire rhodoliths will therefore have a different acoustic character as sediments with mainly rhodolith fragments, or sediments dominated by mollusks or bryozoa. Hence, as previously shown by Birkett *et al* (1998) and Hetzinger *et al* (2006) acoustic sediment mapping is a useful approach for detecting and delimiting the extent of modern rhodolith beds.

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High-resolution analysis of trace elements in encrusting coralline red algae by laser ablation ICP-MS

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Key words: paleoclimate, Bering Sea, proxy archive, LA-ICP-MS.

Coralline red algae are ideal extratropical marine climate recorders owing to their common occurrence not only in the tropics, but also in mid- to high latitude oceans. Coralline red algae archive past climate information along fixed annual growth increments in a high Mg-calcite skeleton. Live-collected specimens have yielded radiometrically-determined ages of up to 850 years and recent calibration experiments have demonstrated the value of a number of coralline algal species as paleothermometers (Halfar *et al*, 2008; Kamenos *et al*, 2008). Annually- to seasonally-resolved stable oxygen isotope and Mg/Ca records have provided up to century-scale climate reconstructions (Halfar *et al*, 2007; Hetzinger *et al*, in press).

Here we present high-resolution Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) elemental ratios (Mg/Ca, Sr/Ca, Ba/Ca, U/Ca, Pb/Ca) from the encrusting coralline red algal genus *Clathromorphum*. Specimens were live-collected between the 1960's and 2008 from the North Atlantic and North Pacific Oceans and elemental ratios were measured in sub-monthly resolution to provide century-scale proxy records. Duplicate transects were analyzed in multiple specimens in order to assess the robustness of the proxy data. The reproducibility is excellent and LA-ICP-MS results were validated by comparison to electron microprobe measured elemental ratios and bulk sample ICP-OES data. In particular, algal Mg/Ca ratios show a high degree of correlation with local seawater temperatures on different timescales, providing further evidence for the temperature dependency of algal Mg/Ca variations and their use as a valuable paleothermometer. Hence, this study demonstrates the feasibility of extracting high-resolution geochemical signals from coralline red algae using laser ablation ICP-MS. This technique allows rapid continuous sampling of the algal surface with unprecedented resolution and provides a valuable tool for future analysis of algal-derived environmental records.

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Chronostratigaphy and algal facies variability of the Fahliyan Formation across the Kazerun Fault (Zagros Basin, SW Iran): a preliminary report

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Key words: Iran, Zagros Basin, Kazerun Fault, Fahliyan Formation, Dasycladales, facies.

Based on calcareous green algae and accompanying benthic foraminifera, the facies variability of the Lower Cretaceous Fahliyan Formation is investigated across the Kazerun Fault. Three outcrops, namely Kuz-e-kuh, Fahliyan and Dasht-e-Gul, were measured and sampled west and east of the N-E oriented Kazerun fault. The latter important feature has a regional extent. It truncates the main trend of the Zagros Fold Trust Belt and has controlled the sedimentation and subsidence of the neighboring basins and sub basins. The Fahliyan Formation essentially consists of thick to massive limestone beds, in the lower part, grading to thin or laminated limestone beds in the upper part. Originally, the Fahliyan Formation was assigned a Neocomian to Barremian age (Gollestaneh, 1965, 1974; Wynd, 1965). In this study, based on foraminifers and abundant, well preserved assemblages of Dasycladales (calcareous green algae), three new biozones are identified in the Fahliyan Formation, respectively assigned to the Berriasian, the Valanginian (Early Valanginian probably) and the Hauterivian.

Three shallow water facies groups, that is reefal to inter-reefal, shoal and lagoonal, are identified in the Fahliyan Formation. The shoal and lagoonal facies form thick to massive beds containing highly diversified dasycladalean algae such as *Salpingoporella annulata*, *S. granieri*, *S. istriana*, *S. katzeri*, *S. circassa*, *S. inopinata*, S. aff. *piriniae*, rare *S. pygmaea*, *Actinoporella podolica*, *Actinoporella jaffrezoi*, *Clypeina* gr. *solkani/parasolkani*, *Otternstella lemmensis*, *Zergabriella embergeri* and *Holosporella arabica*, associated with patches of *Lithocodium* (cyanobacteria) and Bacinella (incertae sedis). Corresponding to the shoal and lagoonal facies, medium to highly bioturbated beds, up to 1 m-thick, are found mainly east of the Kazerun Fault, in the Berriasian and the Early Valanginian. The depositional environment was around the fair-weather wave-base, roughly 5 to 10m of water, on a low angle carbonate ramp.

By contrast, time-equivalent, reefal to inter-reefal and accompanying shoal deposits are found west of the Kazerun Fault, with two principal types of facies: bioclast-pelloidal grainstones with fenestral structures, and subordinate wackestones/packstones. The main reefal facies essentially consists of bioclasts, benthic foraminifera and *Lithocodium* mounds, associated with rare dasycladalean algae such as *Salpingoporella* aff. *piriniae*, *S. pygmaea*, *S. annulata* and *S. inopinata*, and with *Cayeuxia* sp. West of the Kazerun Fault, the shoal deposits consists of wackestones and packstones with *S. granieri*, *S. istriana*, *S. annulata*, very low cone Trocholinids, sponge spicules and aptychi of ammonites, denoting open sea influences. These facies were deposited below the fair-weather wave-base, in an estimated water depth of 10-30m. This means that during the Berriasian – Valanginian, the area east of the Kazerun Fault was significantly shallower than that to the west, as a result of fault displacement producing horsts and grabens in the studied area.

In the Hauterivian interval, dasycladalean algae are accompanied by stratigraphically significant benthic foraminifera such as *Choffatella decipiens*, denoting an open marine environment (Immenhauser *et al*, 2004) and *Campanellula capuensis*, a marker of the Hauterivian stage (Velic, 2007). Both are present west and east of the Kazerun Fault. West of the fault, the bedding pattern of the Hauterivian interval is thinner, with abundant *Choffatella*, echinoid remains, and sponge spicules, while the calcareous green algae only consist of some broken pieces of Dasycladales. East of the fault, on the other hand, the Hauterivian interval yields *Salpingoporella biokovensis*, indicating an open lagoon to back-reef environment (Carras *et al*, 2006).

This sedimentological and paleontological data shows that also during the Hauterivian the area extending east of the fault was shallower than to the west. Three depositional sequences are

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present in the Fahliyan Formation, which are quite comparable to the time-equivalent pattern in the Arabian Plate pattern (Sharland *et al*, 2004). Local tectonic developments, however, resulted in different rates of subsidence: the sequences are thicker west of the Kazerun fault, calling for a higher influx of nutrients and an increasing effectiveness of the carbonate factory.

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Rhodoliths in the deep fore-reef to insular shelf areas around Okinawa-jima, Ryukyu Islands, Japan

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Key words: rhodolith, coralline algae, encrusting foraminifer, fore-reef, shelf, Ryukyu Islands.

The distribution, abundance, composition and growth history of rhodoliths are investigated on the basis of 224 grab and 12 dredge samples and 202 submarine photographs taken from 231 sites ranging in depth from 15 to 970 m around Okinawa-jima, Ryukyu Islands. The rhodoliths are found to grow at depths from 50 to 135 m and reworked, altered rhodoliths are recovered down at depth of 140 m. Mean rhodolith cover on the sea bottom is 45 % where they occur (n = 57).

These rhodoliths are spheroidal, ellipsoidal or rarely disc-like in shape, predominantly with mean diameters of less than 10 cm, and internally composed mainly of nongeniculate coralline algae and an encrusting foraminifer *Acervulina inhaerens*. The rhodoliths have envelopes of well-preserved, concentric to irregular laminations or, much more commonly, are bored and display various degrees of bioerosion. Borings are open to fully infilled with poorly- to well-indurated micrite/bioclast mixtures. The bioerosion becomes more extensive with increasing depth and progressively much more pervasive at depths greater than 90 m.

The rhodoliths are covered with nongeniculate coralline algae and *A. inhaerens* associated with other epilithic skeletal and non-skeletal organisms. The living biotic cover is relatively high down to depths of about 100 m; below this, the cover decreases rapidly with increasing depth. Rhodoliths with similar size, shape, and composition are commonly found on other deep fore-reef to shelf margins, or on banks and seamounts of tropical reef regions, implying fore-reef rhodoliths can be relatively accurate palaeoenvironmental indicators.

Rhodoliths in Quaternary reef deposits in the Ryukyus and Huon Peninsula, Papua New Guinea, are fossil counterparts of modern fore-reef rhodoliths.

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Biogenic carbonate sedimentation in the pelagic eastern Mediterranean: the role of planktonic calcareous algae

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Key words: coccolithophores, carbonate, flux.

$CaCO_3$ accumulation at the deep-sea floor represents the balance between deposition, which is subject in the geological time to variations of biogenic carbonate production in surface waters, and dissolution which is controlled by bottom water saturation state as well as by the metabolic release of CO_2 to the sediment pore-waters.

Estimating the relative contribution of different calcifying organisms to the total $CaCO_3$ production in the oceans has now become a key theme in oceanographic and paleoclimatic research (Sprengel *et al*, 2002; Baumann & Böckel, 2003; Ramaswamya & Gaye, 2006).

In the pelagic environment, coccolithophores play an important role in the carbonate cycle: in fact they contribute to both the organic carbon pump, through photosynthesis, and the carbonate pump, through calcification. On the short time scale, the production of calcium carbonate is a source of CO_2 to the marine environment, while dissolution at the sea-floor is considered to be the mechanisms for CO_2 storage in the marine reservoir. However, on the long-term, burial of biogenic carbonate particles into the marine sediments acts as a sink for carbon: sedimentary carbonates are the largest reservoir of carbon on Earth and hence play a vital role in the global carbon cycle.

On a wide scale, it is assumed that coccoliths contribute to up to 40-80% to the pelagic carbonate sedimentation, which approximates 1/3 of the total carbonate production in the oceans (Milliman, 1993).

Several attempts have been made to calculate the $CaCO_3$ contribution from coccolith associations in different oceanographic settings as well as in past geologic units, focusing in particular on the contribution from each coccolith species (e.g. Sprengel et al., 2002). However such quantification is made difficult by the small size of coccoliths, so that they cannot be i.e. separated and weighted. Therefore, several approaches have been developed to calculate species-specific coccolith volume, based on calculations of the coccolith surface area, average thickness and presence of peculiar structures. Noteworthy is the shape concept of Young & Ziveri (2000), who calculated each species' volume as dependent on a shape factor and a linear measurement.

Besides, new techniques based on coccolith birefringence under polarized light have been also developed (e.g. Beaufort, 2005)

We present here some results from coccolith-carbonate fluxes and paleofluxes in the eastern Mediterranean sea, as derived from the analysis of sediment traps and sediment cores.

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Changing communities of coralline red algae from the Lower Oligocene of the Colli Berici, Italy: Implications for palaeoecology and sea level change

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Key words: coralline algae, taxonomy, ecology, Oligocene, Italy.

The Lower Oligocene shallow-water carbonates of the Castelgomberto formation (Monti Berici, Italy, Southern Alps) contain a rich coralline red algal flora. The Castelgomberto formation crops out along the eastern margin of the Monti Berici. Palaeogeographically, the Monti Berici belongs to the south-eastern part of the Lessini Shelf.

Microfacies analysis of thin sections was conducted in order to reconstruct the palaeoecology of the coralline red algae. The carbonates contain rudstones with packstone to wackestone matrix. Non geniculate red algae are the dominant component. Six genera of non geniculate red algae are identified: *Lithoporella melobesioides*, *Mesophyllum*, *Neogoniolithon*, *Spongites*, *Sporolithon* and *Subterraniphyllum*. The plants form crusts, rhodoliths and maërl. Non-algal components include larger, smaller benthic and planctonic foraminfera, furthermore, bryozoans, corals and echinoderms.

Four facies are distinguished according to the components and the habit of the coralline algae: (1) coralline algal facies, (2) coralline algal - coral facies, (3) coralline algal - large foraminiferal facies and a (4) maërl facies. The coralline algae are interpreted with respect to biotic interactions, substrate stability, water depth, light availability and hydrodynamic energy. The possible implications of the changing distributions of algal communities for interpreting sea-level change is discussed.

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The *Salpingoporella dinarica* acme and the chemistry of the early Aptian ocean

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Key words: Dasycladales, biocalcification, ocean chemistry, Aptian.

All the extant species of dasycladalean green algae produce an aragonitic skeleton and it is widely held that this mineralogy characterized also fossil representatives of this group. There are few notable exceptions to this rule, the most commonly cited being *Salpingoporella dinarica*, whose pristine low-Mg calcite mineralogy was demonstrated by Simmons *et al* (1991). Empirical evidence from the mineralogy of marine inorganic precipitates, and modelling results, suggest that the chemistry of the Phanerozoic ocean has oscillated between two modes: inorganic precipitation of calcite was favoured when the Mg/Ca ratio of the ocean was < 2, whereas aragonite and high-Mg calcite were preferentially precipitated when Mg/Ca was > 5 (like in the present ocean) (Sandberg, 1983). More recently it has been suggested that also the biomineralization of marine hypercalcifiers (like corals and calcareous algae) conforms to this rule (Stanley & Hardie, 1998).

Both geochemical modelling and fluid inclusion data suggest that in the Barremian-Aptian interval the Mg/Ca ratio of the ocean reached its Mesozoic minimum value at about 1.1-1.3. *S. dinarica* is a very common microfossil in the Aptian carbonate platform successions of the Tethyan realm and it is therefore tempting to attribute its peculiar calcitic mineralogy to the low Mg/Ca ratio of the ocean. However there are at least two lines of evidence conflicting with such explanation: 1) “normal” aragonitic dasycladales were extremely diverse and abundant in the Barremian–Aptian; 2) codiacean green algae grown in Cretaceous seawater produced a skeleton made largely of aragonite, with only a minor percentage of calcite (Ries, 2005).

The calcitic mineralogy is not the only peculiar aspect of *S. dinarica*. This species is known to reach peak, rock-forming, abundance at a particular stratigraphic level in the Aptian. Its acme is widely used by biostratigraphers of peri-tethyan platforms as a correlative event. Nonetheless peak abundance of *S. dinarica* is generally taken as indicative of extreme local palaeoenvironmental conditions.

The aim of this paper is to explore the relations between the acme of *S. dinarica* and the chemistry of the early Aptian ocean. High-resolution carbon isotope stratigraphy will be used to demonstrate that peak abundance is reached at the same time in different successions and to draw precise correlations with palaeoceanographic events recorded by coeval deep-water sections.

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Microbial buildups of the Zechstein Basin (Upper Permian, Central Europe)

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Key words: stromatolites, reefs, Zechstein, Permian, Central Europe.

Carbonate build ups are present in various regions of the Zechstein Basin from England, Den-mark, Poland, the Netherlands and Germany. They are 10 to 20 m high near the coast and up to 120 m in deeper waters. They are built by micro-orga-nisms, most likely cyanobacteria forming mats or stromatolitic crusts at the respective surface of the sediment. Laminar or concentrical crusts are the most typical features of the buildups. They were phototrophic organisms due to the growth pattern of uneven or inclined surfaces. Sides and roofs of synsedimentary caves are also draped with mats which may be produced by chemotrophic orga-nisms.

There are various reef-types like fringing or barrier reefs, patch reefs and isolated pinnacle reefs. Patch reefs may coalescence and then cover an area of up to one km^2. Fringing reefs reach lengths of five km. Towards the sea-side, there are steep fore-reef slopes with angles from 35° to nearly vertical. The reef-flat is built mainly of laminated microbial mats. The back-reefs contain often thin clayey or marly layers which are intercalated into the reef carbonates.

As the reef-flats are controlled by the sea-level, it is possible to calculate the shore-line and the water-depth of the reef area at the time of termina-tion of reef-growth. Water-depths vary between 20 m near shore and 70 m at the seaward reefs. The various growth forms of stromatolites de-pend on the level of wave energy: plane mats grew in quiet water, columnar stromatolites in interme-diate, domal stromatolites in high levels. Oncoids and thrombolites formed on the reef-flat at the surf zone. Bryozoans, brachiopods, bivalves, gastro-pods, cephalopods, echinodermata, ostracods, en-crusting foraminifera, and calcareous algae are de-scribed from various reef localities. The extensive reef–flat, at or just below the sea level, consists of horizontal roughly bedded pack- to wackestones and bindstones consisting of laminar encrustations with a limited number of gastropods and bivalves. A distinct reef-crest separates the flat from the fore-reef front. Typical are allochthonous unround-ed and unsorted blocks of various sizes, the largest blocks have diameters of some metres. Generally, grain sizes vary between 20 cm and some mm. The lower fore-slope and talus apron consist of well sorted and about 0.2-0.5 mm large grainstones. These well sorted reef sand borders the reefs forming spits at lee sides and is found up to one km away from producing reefs. Grain-sizes of inter-reef areas depend on the distance to reefs and the topography. Some passages perpendicular to the shore acted as current channels and transported siliciclastic gravels from the hinterland to the sea.

Towards the top of the reefs crinoids, bryozoans, brachiopods and the other fauna decline progressively and finally drop out one after the other. At top, only microbial communities like stromatolitic crusts or oncoids survived. This may be the result of increasing salinity. Most likely, reef growth lasted less than 200 ka. The productivity of the buildups reached some mm/a, a size comparable with modern coral reefs.

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Present distribution of maërl beds in the Atlantic Iberian Peninsula*

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Key words: maërl, rhodolith, distribution, Atlantic Iberian Peninsula.

Deposits of living unattached calcareous algae known as maërl or rhodolith beds are widely distributed (Bosence, 1983b; Foster, 2001). They are considered an outstanding habitat along the Atlantic European coast, particularly in Scotland, Ireland, Brittany and Galicia where important beds were reported. In these regions, maërl beds are mainly distributed in areas sheltered from wave action but affected by currents (Cabioch, 1969; Bosence, 1976; Birkett *et al*, 1998; BIOMAERL, 1999; De Grave & Whitaker, 1999; Grall, 2003; Peña & Bárbara, 2008a). In the Atlantic Iberian Peninsula, maërl beds were reported from the northwest (Galicia), which were mainly developed by the non-geniculate coralline algae *Phymatolithon calcareum* (Pallas) Adey et McKibbin and *Lithothamnion corallioides* (P. et H. Crouan) P. et H. Crouan (Hamel, 1928; Miranda, 1934; Donze, 1968; Koldijk, 1968; Seoane-Camba & Campo-Sancho, 1968; Adey & McKibbin, 1970; Otero-Schmitt & Pérez-Cirera, 2002; Bárbara *et al*, 2004; Peña & Bárbara 2004). However, a recent study reported an isolated maërl area in south Portugal (Pereira *et al*, 2006). In order to improve the knowledge of this marine community in the Atlantic Iberian Peninsula and its conservation status, subtidal surveys were carried out in Galicia and the Algarve by dredging and SCUBA diving. The maërl cover, alive/dead maërl ratio and living maërl thickness were recorded for each sample, as well as the growth form and shape of the maërl (Bosence 1976, 1983a; Woelkerling *et al*, 1993, Harvey *et al*, 2005). Identification of the maërl-forming species were carried out by scanning electron microscopy (SEM). The maërl beds areas were plotted and estimated using ArcView GIS.

Our results indicate that maërl beds are distributed in two bays in the Algarve (Armação de Pera and Lagos) whereas in Galicia they are located in different rías (Ferrol, Muros-Noia, Arousa, Pontevedra and Vigo; Peña & Bárbara 2008a). It was estimated that Portuguese maërl beds occupy an area of approximately 3 km^2, whereas in Galicia the maërl beds area is greater (around 23 km^2).

In Galicia the maërl beds are recorded from the intertidal (Peña & Bárbara 2008b) to 40 m depth, whereas in the Algarve the maërl beds are restricted from 13 to 25 m. In both regions, the maërl species *Phymatolithon calcareum* is dominant. The maërl is mainly fruticose, mostly discoidal in the Algarve, whereas in Galicia different shape frequencies were observed according to the studied bed (discoidal, ellipsoidal, spheroidal). The maërl cover as well as the alive/dead maërl ratio was variable in both regions. However, the living maërl layer thickness is greater in Galicia (up to 15 cm in Ría de Arousa) than in the Algarve region (up to 5 cm in Armação de Pera). The differences observed between both regions in terms of bed structure and community dynamics are discussed in the present study.

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Coralline algae assemblages of an Upper Oligocene Ramp (Attard Member, Malta)

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Key words: **c**oralline algae, Taxonomy, Palaeoecology, Upper Oligocene, Malta.

The coralline algae assemblages of the Attard Member (Chattian, Malta) have been analized. The Attard Member of the Lower Coralline Limestone Formation was deposited on a carbonate ramp. Red algal lithofacies are represented by rhodolith floatstone-rudstone and red algae foraminiferal floatstone to packstone. These facies are ascribed respectively to inner ramp and middle ramp environments on the basis of facies and biota analysis of Attard Member (Brandano *et al*, in press a,b).

The inner ramp algal assemblage shows a dominance of sporolithaceans (31.61%), followed by melobesioids (30.74%), subordinate mastophoroids (19.92%) and peyssonneliaceans (17.73%); the middle ramp assemblage is characterized by an increase of sporolithaceans (50.25%) and decrease of melobesioids (27.56%), mastophoroids (12.16%) and peyssonneliaceans (10.03%).

The occurrence of *Lithoporella* and the abundance of *Sporolithon* in the red algal assemblages suggest carbonate sedimentation took place in tropical waters (Adey, 1986; Bosence, 1983b; Braga & Aguirre, 2001; Piller, 2003).

The rhodoliths of the inner ramp generally are characterized by laminar concentric structure and columnar-branching structure with branching density of III or rarely IV group (following Bosence, 1983a) passing outward to laminar structure. The co-occurence (mostly exclusive in some samples) of I and II group free living branches suggest the presence of complex mosaic of facies represent sedimentation in patches of sea grass adjcent to erosional blow-outs and therefore high hydrodynamic sectors where rhodoliths grew and moderate hydrodynamic sectors where I and II group free living branches proliferated.

In the middle ramp the dominance of rhodoliths with laminar-columnar structure suggest a moderate to moderate-high hydrodynamism. Activity of bottom-dwelling organisms rolling the rhodoliths is not documented in the investigated lithofacies.

The coralline algal assemblage of the inner ramp indicates light conditions comparable to bathymetries below 20 m, where genus *Sporolithon* proliferates in clear tropical waters (Aguirre *et al*, 2000). The middle ramp assemblage suggests light conditions comparable to bathymetries below 30 m in clear waters (Bosence, 1991). These paleobathymetric reconstructions partially disagree with the results of sedimentological characters, depositional geometries as well as faunal association of Attard Member (Brandano *et al*, in press a,b). Paleoenvironmental reconstructions suggest bathymetric interval between 8.8 and 22 m for inner ramp lithofacies, whereas the middle ramp paleodepth ranges between 22 and 30 m.

These discrepancies may be reconduced to the depositional environment settings. The inner ramp environment was colonized by seagrasses (Brandano *et al*, in press a, b). Seagrass can form sciaphylic microenvironments (Verheij & Erftemeijer, 1993). The middle ramp environment is above storm wave base, where the fine sediment is washed away by currents and deposited in the outer ramp environments. This processes may contribute to reduction of water transparency in the middle ramp.

Therefore caution is necessary in using proposed schemes for bathymetric hypothesys (e.g. Adey, 1986; Bosence, 1991; Aguirre *et al*, 2000) elaborated in euphotic and/or oligotrophic tropical waters.

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Two new Dasycladales from the Jamal formation, Permian of Iran *Tabasoporella* nov. gen., and *Pseudotabasoporella* nov. gen.

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Key words: algae, Dasycladales, *Tabasoporella*, *Pseudotabasoporella*, Permian, Jamal Formation, Iran.

Calcareous algae of the Permian Jamal Formation were studied in three sections of the Shotori Mountains located in the northeast of Iran. In this paper - our investigation – two new genera including, *Tabasoporella* nov. gen., and *Pseudotabasoporella* nov. gen. are described. The section containing these genera is exposed about 2 km northeast of the type section of Jamal Formation in Mount Jamal. This locality is referred to as Howz-e Dorah. (Stöklin e*t al,* 1965)

Tabasoporella nov. gen. is characterized by metaspondyl arrangement of phloiophore and wine-glass-shaped laterals with a stalk grouped to tufts. The individual tufts are separated by a ring-like cavity appearing as triangular, oval or trapezoid in longitudinally dissected section. The arrangement and shape of the laterals in *Pseudotabasoporella* nov. gen. is similar to *Tabasoporella*, but there are no cavities between the tufts.(Rashidi & Senowbari-Daryan, in press)

Two new genera's and other dasycldales are highly developed and limited to the Permian period. They disappear at the end of Permian and are not found in the Triassic deposits.

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Maërl facies distribution offshore Cilento Peninsula (Tyrrhenian Sea, Italy)

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Key words: Marine soft bottom environments, chirp sonar, ecotypes, present-day shelf carbonate production, Tyrrhenian Sea.

In our study we attempt to estimate the contribution of algal components provided by Maerl facies in shallow marine soft bottom environments located offshore of Cilento peninsula (south-western Italy). In the Mediterranean and particularly in the Tyrrhenian Sea, shallow marine soft bottom environments are mainly formed by terrigeneous sediments, supplied by fluvial system and coastal erosional processes (Tortora, 1996), although various skeletal assemblage can provide an important contribution to the present-day shelf carbonate production (Pérès & Picard, 1964). Indeed, in non-tropical shallow-marine environments, the contemporary presence of terrigeneous and skeletal carbonate sediments has been established (Tortora, 1996), but the interaction between the two has not been well documented yet.

The study area was investigated during an oceanographic cruise carried out by the R/V Universitatis in 2004. A detailed acoustic seafloor mapping was performed by the collection of multibeam echosounder bathymetric data and chirp sonar profiles. Sediment samples were also collected by grab and gravity core. The biogenic components and carbonate phases of the investigated marine sediments were described from grab samples. The collected chirp sonar profiles were studied and described following the scheme of Damuth (1980), with the support of the sediment samples results. We thus recognized seven main classes of echo-types along the investigated area. Their relative abundance and distribution were calculated along all the investigated seafloor. The composition of the sediment sampled within the ecotype defined I_b, was interpreted to belong to the *Maërl* facies of the coastal Detritic Biocoenosis (DC) (Pérès & Picard, 1964). Since beds of unattached, protuberant rhodoliths proved to have specific acoustic response (Birkett *et al*, 1998; Hetzinger *et al*, 2006) we then turned the data provided by the acoustic systems to assist in mapping the spatial extent of the sampled *Maërl* facies. These sediments were further investigated by grab sampling, allowing for sedimentological analysis and identification of the algal component by thin sections. The result of these combined analyses (the mapping of the different ecotypes representing the acoustic properties of the seafloor and the laboratory analysis of the *Maërl*) provides the first assessment of the algal carbonate contribution in the whole study area. Over a total of 196 km^2 survey area, the *Maërl* facies occurs over at least 15 km^2 of the investigated seafloor. Consequently, an estimate of the algal carbonate presently occurring at the seafloor was assessed on the basis of the mapped spatial distribution of the *Maërl* facies.

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Carpathoporella occidentalis Dragastan 1995: skeletal elements of octocorals (branches/internodes, sclerites, holdfasts)

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Key words: *Carpathoporella*, Octocorallia, calcareous algae, Taxonomy, Lower Cretaceous, Albania.

Carpathoporella occidentalis Dragastan 1995 (designation of a lectotype!), non 1967, non 1989 (synonym *Coptocampylodon fontis* Patrulius 1967 nom. nud.) is interpreted up to now as a problematic alga (?Dasycladale, ?Charophyt). It represents a widespread taxon in Early Cretaceous shallow-water carbonates predominantly of the Tethyan domain (Austria, Bulgaria, Croatia, Greece, Romania, S-France, S-Germany, S-Italy, Spain, Serbia and Venezuela). New material from the Aptian of Albania allows a new taxonomic interpretation. The various shaped specimens can be assigned to the skeletal elements of octocorals, namely sclerites (e.g. tuberculated sphaeroids), occasionally branching internodes (or branches) exhibiting longitudinal grooves and lateral calices, and basal holdfasts. The coarse-grained calcitic preser-vation suggests a primary aragonitic skeletal structure of these elements.

Interestingly, *Coptocampylodon lineolatus* Elliott 1963 (type-species, Early Cretaceous of Iraq) was originally interpreted as remains of octocorals. Most likely, however, this taxon was established on mixed material deriving from different lithologies: isolated specimens including the holotype were interpreted as crustacean coprolites (Živkovic & Bogner, 2006), paratypes from thin-sections are of uncertain origin (?algal debris). Therefore, the later described *Coptocampylodon* species *C. elliotti* Radoičić, *C.*? *rhaeticus* Schlagintweit et al. and *C. pantici* Ljubović & Radoičić all together do not show any features indicating a coprolite nature and must belong to another genus (or other genera). Comparing *Carpathoporella occidentalis* Dragastan with these species, the most obvious similarities exist with *C. elliotti* Radoičić from the Albian of the Dinarides pointing to a possible octocoral origin, too.

Phylogenetic radiation of the Octocorallia started in the Upper Cretaceous of the boreal realm surpassing the K/T boundary without significant change (Bernecker & Weidlich, 2005). From the Early Cretaceous only shallow-water representatives of the order Helioporacea (with aragonitic skeletons) are reliably reported; no deeper-water octocoral taxa are known from the Early Cretaceous. The deeper-water Upper Cretaceous azooxanthellate taxa could therefore possibly derive from Early Cretaceous shallow-water Tethyan ancestors in an onshore-offshore evolutionary pattern. Morphologically, *Carpathoporella* shows the most similarities to both genera *Epiphaxum* Lonsdale (order Helioporacea) and *Moltkia* Steenstrup (order Alcyonaria). The former is so far known from the Turonian to Recent, the latter from the Cenomanian to Oligocene (Voigt, 1958; Lozouet & Molodtsova, 2008).

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The Cretaceous record of *Neomeris* Lamouroux 1816 subgenus *Larvaria* (Defrance 1822) Génot 1980 (Dasycladales): an overview

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Key words: Dasycladalean algae, *Neomeris* (*Larvaria*), Taxonomy, Lower Cretaceous, Tethyan realm.

The systematic inventories of Cretaceous Dasycladales (Granier & Deloffre, 1993; Barattolo, 2002) didn´t list any representative of *Neomeris* subgenus *Larvaria*. *Neomeris* (*L.*) *koradae* Dieni, Massari & Radoičić (Paleocene of Sardinia) was found in the Upper Maastrichtian of Italy and transferred to *Jodotella* Morellet & Morellet (Parente, 1997). The first two Cretaceous species were described by Radoičić (2002) with *N.* (*L.*) *conradi* and *N.* (*L.*) *decapoaae* (Barremian-Aptian of Macedonia). Sokač (2004) noted comparable dimensions and included both into synonymy of *Neomeris cretacea* Steinmann. A final decision, however, must decipher the position of the secondary laterals either laterally on both sides of the fertile ampulla or in a plane beneath the latter. *Acroporella assurbanipali* Elliott (Valangi-nian-Hauterivian of Iran) was revised by Barattolo & Romano (2001) showing that it belongs to *Neomeris* (*Larvaria*). Summarizing, there is one definite and two uncertain records of *Neomeris* (*Larvaria*) in the Lower Cretaceous and none from the Upper Cretaceous. This lack may be just an effect of missing discoveries. For instance, only recently *Neomeris* (*Larvaria*) was reported from the Latest Albian-Early Cenomanian of Brazil (Granier *et al*, 2008).

Neomeris (*L.*) *velici* (Sokač & Nikler) nov. comb. from the Lower Cretaceous of the Nikšić area, Montenegro, and originally assigned to the genus *Cymopolia* is reported from Valanginian peri-reefal carbonates of Albania. Noteworthy, that another species from this locality, *Cymopolia longistilla* Sokač & Nikler was newly combined as *Neomeris* (*Drimella*) *longistilla* by Radoičić (2002). *N.* (*L.*) *velici* (Sokač & Nikler) nov. comb. isdistinguished from *N.* (*L.*) *assurbanipali* (Elliott) by larger dimensions and the shape of the laterals, but more data are needed as the latter species was based on one single section. Both *N.* (*L.*) *velici* and *N.* (*L.*) *assurbanipali* are the oldest known representatives of the subgenus *Larvaria*. A possible third representative is described as *Neomeris* (*Larvaria*) sp. also from the Valanginian of Albania.

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Coralline algal-coral assemblages from a turbid-water environment: an example from the Oligocene of the Tertiary Piedmont Basin (NW Italy)

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Key words: coralline algae, corals, turbid-water environment, Oligocene, Italy.

In the geological record, but also at the present time, coral assemblages thriving in permanently or episodically turbid waters as a result of terrigenous input are much more common than what is expected, thinking to the conventional optimal conditions for coral reef growth (*i.e.* warm, well-illuminated, oligotrophic shallow waters of the tropics and subtropics). In fact, despite relatively high turbidity conditions, restricted light penetration, presence of often mobile substrates, active coral growth is well developed and many coral bioconstructions in the past are actually associated with marly and mixed carbonate-siliciclastic sediments (for the Cenozoic: Wilson, 2005).

Within this picture, we present an interesting case study from a succession cropping out near Cascine (AL) in the paleo-geographic domain of the Tertiary Piedmont Basin (TPB) (northern Italy). In the TPB, is recorded an E-W time-transgressive phase characterized by the deposition of deltaic siliciclastic conglomerates and sandstones, marine shallow-water sediments and reef limestones. These reefs developed during the Oligocene under terrigenous sedimentation within prodelta and delta fan systems (Pfister, 1980; Quaranta *et al,* 2007). In the middle part of the studied succession corals coexist with abundant coralline algal assemblages represented by Melobesioideae (40.1%) among which the most abundant species are *Lithothamnion ishigakiense*, *Lithothamnion moretii* and many thalli of *Lithothamnion/Phymatolithon* spp., Mastophoroideae (26.3%) with abundant *Lithoporella melobesioides* and *Spongites* cf. *albanensis,* Sporolithaceae (19.7%) among which occurr *Sporolithon* cf. *praeerythraeum* and abundant thalli of *Sporolithon* sp.1, Lithophylloideae (9.5%) among which occurs *Lithophyllum* cf. *intumescens* and Peyssonneliaceae (4.4%) represented only by genus *Polystrata*. Very Rare geniculate algae referred to tribe Corallineae.

The coralline algae mostly occur as small ellipsoidal (major axes generally ranging between 1.0 - 3.4cm and minor axes measuring 0.5 - 1.5cm) generally monospecific and rarely multispecific rhodoliths usually composed of encrusting-warty, locally lumpy thalli, mostly grown around fragments of branching coral. Rhodoliths have laminar, laminar-columnar internal structure (Bosellini & Ginsburg, 1971; Bosence, 1983a). It is of note that the thin coating sequence is made by one to three thalli (so they could be called "coatings" *sensu* Steneck 1986 instead of rhodoliths).

The paleoenvironmental conditions inferred for this succession by the coral biofacies represent a typically turbid-water association. The coral biofacies are in fact dominated by fragmented fine-branching corals (*Stylophora thirsiformis* and *Acropora haidingeri*), which suggest a low energy environment dominated by fast-growing forms able to oppose a passive resistance to sedimentation (Larcombe *et al,* 2001).

These paleoenvironmental conditions are confirmed by the algal assemblage. The predominant laminar internal structure of the rhodoliths usually indicates frequent turning in high energy conditions but the small size and the nearly cilindrical shape of nuclei, the poorly developed thalli together with the locally occurrence of lumpy algal growth form suggest rare rolling periods (i.e. moderate or low energy).
The analysed algal assemblage is typical of subtropical warm water environments as suggested by *Lithoporella* and *Sporolithon.* The predominance of melobesioids and mastophoroids and the occurrence of lithophylloids together with abundant *Sporolithon* suggest depths below 20 m (Aguirre *et al*, 2000; Bosence, 1983b) in clear waters, however considering the turbidity condition inferred by coral facies the studied algal assemblage could be shallower.

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Siliciclastic components from the metamorphic rocks of the basement often occur in the sediment associated to corals. Generally speaking, coral clasts highlight a low incidence of transport and sometimes seem to be deposited almost *in situ*.

Corals in growth position also occur in the succession and consist of a suite of phaceloid and massive colonies of prevailing *Caulastrea pseudoflabellum, Goniopora nummulitica* and *Favia subdenticulata,* and other less common species (*Astreopora meneghiniana, Diploria crebriformis, Favia subdenticulata, Antiguastrea lucasiana*) (Pfister, 1980). These corals show morphological characters typical of sediment-resistant corals (Sanders & Baron-Szabo, 2005). Moreover from the low coral biodiversity it is possible to infer an environment where particular ecological factors (*e.g.* sediment input and restricted light penetration) exerted major controls on carbonate production (Silvestri *et al*, 2008).

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Sedimentary setting and rhodolith deposits in channelized carbonate margins: case histories from the Early Miocene of the peri-Mediterranean area

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Key words: Sedimentology, rhodolith assemblages, temperate-type carbonates, channelized margins, Early Miocene, Mediterranean area.

Bioclastic sediments characterized by foramol biological assemblages (Lees, 1975) rich in coralline red algae (as rhodoliths) and bryozoans (rhodalgal assemblage *sensu* Carannante *et al*., 1988) are largely spread in open shelves from atypical tropical areas to cool-water regions. The foramol/rhodalgal carbonate shelves in temperate settings largely differ from the tropical ones: main differences are in grain composition, geometry of the depositional bodies, and response to the sea level oscillations (see Carannante *et al*, 2008 and references therein). These shelves, devoid of rims or limiting bars, are prone to supply large amount of sediment to the neighbouring deeper areas by gravitative flows (Carannante *et a*., 1996; 1999; Passlow, 1997). Significant re-sedimentation episodes normally occur via sediment pathways along more or less dissected margins. They result in complex channel-related sedimentary bodies whose nature was for a long time misinterpreted in ancient rhodolith-dominated sedimentary sequences. These latter were, in fact, frequently considered as *in situ/near situ* deposits.

Detailed sedimentological analyses of ancient rhodolitic limestones, previously interpreted as *in situ* bioclastic sediment (rhodalgal carbonate factories), proved the re-sedimented nature of the related deposits (Carannante, 1982; Carannante & Vigorito, 2001; Cherchi *et al*, 2000; Bassi *et al*, 2006; Vigorito *et al*, 2005, 2006). The analyses performed allowed to reconstruct the 3D geometry of the channel-related sedimentary bodies and to assess the role of the rhodolith assemblages in making up channel-fill packages. Shallower water rhodoliths, which thrived on the upper parts of the channel sides or on the main carbonate factory, were re-mobilized down the channel and constituted the infilling deposits with a basin-ward progradation. Other rhodolith deposits were, presumably, removed down-slope from the high-energy factory area by storms and accumulated below storm wave base. Two case histories from Early Miocene carbonate systems of the Mediterranean Region (Sardinia and southern Apennines) are here discussed. There, increasing amounts of rhodalgal skeletal debris were removed from the productive areas (only locally preserved), mainly during sea level falls. The sediments removed were funnelled towards the basin through complex submarine channel networks in which they built channel-fill deposits.

To map the different facies, in terms of biogenic assemblages and taphonomic characterization, coupling palaeo-biological analyses (i.e. rhodolith characteristics, bryozoan growth-forms, taphonomic features) to the physical (sedimentological and geometrical) ones, contributed significantly to the palaeo-environmental reconstruction of the studied rhodoliths-rich carbonate systems.

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Secular variation in composition of shallow-water carbonates in the northwestern Pacific Ocean during the past 100 million years

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Key words: Cenozoic, Cretaceous, coral reef, northwestern Pacific Ocean, seamount, shallow-water carbonate.

Sedimentological analysis was conducted on shallow-water carbonates collected from 34 sites on 28 submerged seamounts in seven areas of the northwestern Pacific Ocean using the Deep-sea Boring Machine System. These samples provide continuous records of biotic and abiotic composition of reefs/carbonate platforms for the last 100 million years.

The carbonate deposits can be divided into three types: Cretaceous, Eocene, and Oligocene to Pleistocene types. The Cretaceous shallow-water carbonates are characterized by abundance of molluscs (including rudists), non-skeletal grains (e.g. ooids, peloids, cortoids, and intraclasts), and microbial sediments. It is noteworthy that most components have been micritized to possess thick micrite envelopes. The Eocene shallow-water carbonates are delineated by dominance of larger foraminifers, *Halimeda*, and dasycladacean algae. Scleractinian corals and nongeniculate coralline algae still constitute very minor components. Rhodoliths are common, but non-skeletal grains become minor constituents. The Oligocene to Pleistocene shallow-water carbonates are similar in composition to the Eocene type, but differs from the latter by abundant occurrence of scleractinian corals and nongeniculate coralline algae, both of which have been widespread since the Oligocene. These indicate that carbonate factories comparable with modern coral reefs were initiated in the Oligocene, which corresponds to the timing of 1) the transition from Calcite II to Aragonite III, 2) the atmospheric CO2 concentration progressively was declined, and 3) the extensive built-up of ice sheets in the Antarctica and onset of the glacial mode.

Initiation of modern coral reefs, therefore, was closely related to changes in seawater chemistry (= increased Mg/Ca ratio), oceanic conditions, such as an increase in the latitudinal and bathymetric thermal gradients (= more stratified ocean), and nutrient availability (= lowered nutrient level) in tropical seas from the Oligocene onwards.

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Revision and re-documentation of M.Airoldi's species of *Lithothamnion* from the Tertiary Piedmont Basin

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Key words: Systematic palaeontology, Corallinales, Airoldi type-collection, *Lithothamnion*.

During the last fifteen years, palaeophycologists gave a strong impulse to the revision of the fossil Corallinales, using, whenever possible, the same diagnostic criteria currently accepted by botanists (among others: Braga *et al* 2006, Vannucci *et al*, 2008).

This paper is the fourth contribution to the revision of M.Airoldi type collection of Corallinales from the Oligocene of the Tertiary Piedmont Basin (BTP, NW Italy), located at the Dip.Te.Ris. of the Genova University.

Airoldi published his contributions during the early thirties. At that time, it was not usual to explicitly designate the holotype, nor to provide photographs of the material, though a detailed description and some schematic hand drawings were included in the protologue of the new species.

We revised here the *Lithothamnion* species described by Airoldi in 1932: *L. roveretoi, L. obstrusum* and *L. stefaninii.*

The studied material consists of thin sections of original Airoldi collection, macroscopic rock samples associated respectively to *L. roveretoi* and *L. stefaninii* and of two thin sections (already studied by Fravega 1984) obtained from the original collection of rock samples containing *L. stefaninii*. Scanning Electron Microscope (SEM) preparations for further information were obtained from fragments thought to be used by Airoldi for his sections of *L. roveretoi* and *L. stefaninii.* Each species has been critically analized on the basis of its microscopical anatomy and biometry.

After this revision, we confirm that *L. roveretoi* belong to the genus *Lithothamnion* for the flat and flared epithallial cells. We also confirm that *L.obstrusum* belong to the genus *Lithothamnion* for the subepithallial initials that are longer than their immediate inward derivatives. *L. stefaninii* is here attribuited to the genus *Sporolithon* under the new comb. *Sporolithon airoldii*, since one of the thin sections prepared from the original rock sample revealed a sporangial plant with the vegetative anatomy of *L. stefaninii* and buried sori. The combination *Sporolithon stefaninii* was unavailable, since this combination applies to a Raineri’s different species of living *Sporolithon* from the Red Sea.

Therefore, the thalli of *L. stefaninii* originally described by Airoldi are here considered as the gametangial plant of *Sporolithon airoldii*.

A critical list of references is given for each species, retaining only the unequivocal citations from adequately illustrated literature, in order to provide the geographic and stratigraphic distribution of the species.

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The type collections of fossil crustose coralline algae housed in the Dip.Te.Ris (Genova University, Italy)

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Key words: Taxonomy, type collections, Corallinales.

Revision and re-documentation of type collections of fossil crustose coralline algae using, whenever possible, the same diagnostic criteria currently accepted by botanists is a crucial need of paleophycologists. The Department for the study of the territory and its resources (Dip.Te.Ris) of the University of Genova presently hosts some historical collections of fossil crustose coralline algae including the type material of several new species described by M. Airoldi, S. Conti and V.I.Mastrorilli between the thirties and the seventies. The examination of these collections revealed that the type material of 95 species out of the 120 described by Airoldi (1930; 1931a-b; 1932; 1933; 1935), Conti (1943; 1946a-e; 1950) and Mastrorilli (1955; 1958; 1966; 1967; 1968; 1973) are actually located at the Dip.Te.Ris., (among them, 19 have been already re-documented and revised). The type material of 24 species could not be located or identified and is considered lost.

The type material that is presently under revision (77 species) is critically listed, and when needed, a short comment concerning the validity of its original generic disposition is provided.

The result is the identification of three categories of type material (a, b, c), that we describe as follows:

a) the type material of 39 species is well preserved and shows all the needed anatomical details for the taxonomic disposition at the genus rank. Among these specimens, we are able to confirm the original generic disposition for 33 species; the type material of 6 species do not belong to the genus of the basionym. All the species of *Archaeolithothamnium* belonging to this group are placed in *Sporolithon* Heydrich 1897 because of nomenclatural priority;

b) the type material of 24 species, though well preserved, does not contain the diagnostic features for an unequivocal generic disposition, and only the relevant subfamily could be identified. Further studies on this material could lead to significant improvement on its identification;

c) the type material of 14 species resulted inadequate for species identification, because of poor preservation or lack of anatomical details.

Moreover, other three collections containing the type material of 14 species, supposed to be housed at the Dip.Te.Ris. (Conti, 1949; Mastrorilli, 1950; Bellini & Mastrorilli, 1975) could not be located and are also considered lost.

We present here the critical checklist of the new species described by Airoldi, Conti and Mastrorilli presently conserved at the Genova Dip.Te.Ris., with the indication of the type specimen and a short systematic comment.

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A Messinian micrite-vermetid association indicating a microbial induced biomineralization (Salento Peninsula, southern Italy)

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Key words: Vermetids, organomicrite, biomineralization, Messinian, Italy.

A carbonate facies, made up mainly of micrite and vermetid shells has been recognized in the early Messinian coral reef complex of the Novaglie Formation (Salento Peninsula, southern Italy) (Bosellini *et al*., 2002). The micrite-vermetid association crops out at the base of the coral reef complex and shows completely different features in comparison with the overlying reefal sediments. The aim of the present study is to give an account of the origin of this facies and to describe the conditions which led to its formation. For this purpose we carried out an interdisciplinary approach using field and microfacies observations, geochemical, EDS, and epifluorescence analyses.

Micrite-vermetid association shows a thickness from 30 cm up to 2,5 m, grading upward into biocalcarenite sediments of the coral reef slope. The lower part of this facies is represented by discontinuous layers, up to 10 cm thick, containing vermetids and barnacles in life position, directly encrusting the pre-Miocene substrate. Vermetids are represented by a monogeneric association of *Petaloconchus*, with individuals sparsely distributed, sometimes forming small aggregates with prevailing upright growth. Most of the shells show the presence of unwound “feeding tubes”, which can be destroyed and rebuilt with different orientation, in order to cope with environmental changes, such as variations in the water flow direction or in the sedimentation rate. Vermetids are incorporated in a fine grained, micritic wackestone–packstone with planktonic foraminifera, peloids, fragments of barnacles, bryozoans, serpulids, bivalves and coralline algae.

This *in situ* assemblage passes upward into clinostratified deposits, which constitute the largest part of the micrite-vermetid facies. Most of the sediments are represented by fine bioclastic wackestones with the same types of grains. Some areas are characterized by peloidal mudstones. The clinostratified micrite-vermetid facies is constituted by a large amount of broken vermetid feeding tubes, forming isooriented accumulations parallel to the stratification. *Petaloconchus* feeding tubes usually show a quite remarkable length (up to 8 cm) in comparison with their average diameter (2 mm).

Three types of micrite-rich facies were recognized: (a) not/low fluorescent detritic micrite with a few fine bioclastic grains, sometimes showing gravitative fabric; (b) fluorescent mudstones/ wackestone, rich in fine bioclastic grains; (c) fluorescent thrombolitic peloidal organomicrite.

Basal layers with vermetids and barnacles in life position show the dominance of the first type of micrite. Its detritic nature is supported by the occurrence of gradated geopetal fillings of several vermetid shells, indicating a gravitative deposition. This account is also corroborated by the low autofluorescence, implying a low organic matter content. Clinostratified vermetid deposits are characterized by the occurrence of type (b) and (c) micrite-rich facies. In this case the autofluorescence can be explained by two different types of organic matter. The former probably deriving from decaying metazoan and planktonic organisms, the latter linked to metabolic activity of microorganism that induced biomineralization of thrombolites.

On the basis of these data it is possible to hypothesize the processes which led to the formation of the micrite-vermetid carbonate facies. Particularly, two different depositional phases can be distinguished:

- *Vermetids colonization and accumulation of detritic micrite*. This phase starts with the colonization by the vermetid community of the pre-Miocene substrate. Subsequently, periodical inputs of detritic micrite occurred, which forced vermetids to produce remarkably long, upward oriented, feeding tubes in order to avoid to be buried by sedimentation.
- *Deposition of isooriented vermetid facies and accumulation of mudstones/ wackestone and organomicrite*. The isooriented setting of vermetid

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conchs is interpreted as the result of a slight redeposition of the previous assemblage, due to overloading or to other destabilizing processes. Actually, vermetid ecological demands do not support a way of life within a muddy substrate. Therefore the organomicrite deposition, which happened after the death of the vermetid community, can be correlated to the occurrence of large amount of decaying organic matter (Reitner & Neuweiler, 1995). The source of this organic matter can be linked to the death of a great number of *Petaloconchus* individuals.

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Charophyte-Rich Microfacies in the Maastrichtian of the Eastern Pyrenees (Catalonia, Spain)

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Key words: Charales, carbonate microfacies, coal-bearing sequences, Late Cretaceous, Pyrenees, Iberia.

Microfacies rich in charophyte remains are generally considered a monotonous type of facies characteristic of lacustrine environments and were poorly studied until now. In the Lower Maastrichtian of the Eastern Pyrenees freshwater lacustrine limestone intercalated with brackish lignite occur and show diverse fabrics and skeletal assemblages of freshwater charophytes, cyanobacteria and invertebrates. This allows us to characterise a number of previously unknown microfacies from this extremely particular sedimentary setting.

The Upper Cretaceous of the Vallcebre Basin represents the infilling of a Pyrenean piggy-back basin related to the Lower Pedraforca thrust-sheet. Santonian to Thanetian sequences range from turbidites, deltaic sandstone, marl and coal to non-marine limestone and fluvial red beds. During the Maastrichtian to Thanetian ("Garumnian"), the basin displays a gradual regression. Transitional facies show low-order cycles formed, from base to top, by brackish marl, brackish sub-bituminous coal and freshwater lacustrine limestone, which is the object of our study. The palaeoenvironmental reconstruction, resulting from sedimentological and taphonomic analysis, suggests that alkaline lakes bordered by a dense conifer vegetation of Cheirolepidiaceae passed seawards to a large brackish mud-flat or lagoon, in the proximal part of which the conifer remains were deposited to form thick peat layers.

The lacustrine limestones studied show a range of charophyte-rich microfacies, which are in downslope direction:

(1) Packstone-wackestone composed by small fragments of haplostichous thalli (e.g. sample FI-3). This facies is related to the deposition of freshwater bioclasts in lakeshores affected by wave action.

(2) Packstone-grainstone with large, well-preserved, in part articulated thalli (*Clavatoraxis* sp.) and gyrogonites of characean charophytes, probably *Microchara* sp. (e.g. sample FI-6). This facies is attributed to deposition in charophyte meadows below lacustrine wave action.

(3) Laminated organic wackestone-mudstone with charophytes and small fragments of amber (e.g. sample FI-16). Some laminae are rich in large haplostichous *Charaxis* sp. thalli, only calcified in the intercellular area between the internode and the cortical cells. These thalli are collapsed leading to the accumulation of intercellular fragments. In the same laminae there are gyrogonites of *Peckichara* sp. unfortunately without anatomical connection. Other intercalated horizons show larger tubes of sparry calcite without internal structures. They are tentatively attributed to ecorticate thalli. This facies may represent deposition of parautochthonous remains of a *Peckichara* sp. meadow in relatively deep areas of the lake.

(4) Wackestone-mudstone of charophyte haplostichous thalli and cyanobacteria (e.g. sample CH-3). Two kinds of thalli are distinguished. The most common type may be attributed to *Clavatoraxis* sp. since it bears spine-cell rosettes. Characean gyrogonites have been found with anatomical connection, suggesting that *Clavatoraxis* is not exclusive of clavatoraceans as previously thought. The second type is similar to the *Charaxis* sp. thalli of facies (1) but they are generally fragmented. In the finer grained parts of the rock calcified filaments attributed to cyanobacteria (aff. to *Girvanella* type) are abundant and may represent poorly developed microbial mats. This facies represents deposition of transported charophytes thalli in the deeper and poorly illuminated zones of the lake.

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Danian dasycladales (green algae) from the Western Pyrenees, Spain

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Key words: Dasycladales, Paleocene, Spain.

Paleocene represents one of the most important period for dasycladalean diversification. A great blooming occurred after the K/P crisis with the appearance of new genera and species.

Biostatigraphy of Paleocene green algae and their relative facies characterization is usually difficult because the outcrops are rare, spotted and with gaps. The facies transition is not usually preserved so that whatever paleoenvironmental reconstruction sounds speculative.

In Western Pyrenees there is an extraordinary example of an entire carbonate system preserved (Baceta *et al* 2005). Different environmental contexts are present in the original continuity (lagoon, reef, slope) and this situation is of great interest for palaeoecology of dasycladaleans.

Thanks to this study also the systematic of dasycladaleans algae have a good increase, not only for the good variability of genera here observed but also for the

Ten outcrops were sampled: Lizarraga, Cave of Lizarraga, Peña Blanca, Urbasa Pass (lower part), Urbasa Pass (upper part), Oroz-Betelu, Santa Marina, Mintxate, Isaba and Zuriza; most of them are from upper Danian.

The first three outcrops are spectacular examples of reef facies. As sketched by Barattolo (2002), the taxonomic variability is very high and the main genera recorded are: *Uglasiella, Barattoloporella, Cymopolia, Broeckella, Jodotella, Terquemella, Triploporella, Zittelina, Uteria, Microsporangiella, Orioporella.* Noteworty is the presence of *Barattoloporella salentina* Parente (1997), a Maastrichtian species first known in Paleocene beds.

The two section of Urbasa Pass represent lagoonal environments. The genera found are rather different from those of the previous three sections. Here a great abundance of *Cymopolia, Microsporangiella, Orioporella, Neomeris, Decastroporella, Trinocladus, Clypeina* and *Indopolia* is recorded.

The Oroz-Betelu and Santa Marina sections are referred to lower Danian; the former in lagoon facies, the latter in reef one. Although interesting, the two sections show a low diversity at genus level. The genera *Terquemella, Triploporella* and *Uglasiella* occur in the Oroz-Betelu section, while *Broeckella, Clypeina, Orioporella, Terquemella, Uteria* and *Zittelina* are present in the Santa Marina section.

The last three outcrops, Zuriza, Isaba and Mintxate belong to the Ezkaurre-Alano Ridge. These sections represent inner platform, inner platform/margin transition, front reef environments respectively. Dasycladaleans are relatively uncommon. The richest samples were collected from Isaba section where the genera *Clypeina, Terquemella, Uglasiella, Zittelina, Triploporella,* and *Broeckella* occur. In Zuriza section only *Neomeris* and *Terquemella* are present. Samples from Mintxate are very poor in dasycladaleans and only *Neomeris* is recognizable.

Finally a first attempt of algal assemblages according to environmental placement within the lagoon-reef complex is supplied.

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Green algae Dasycladales from the Upper Maastrichtian-Paleocene of Qalhat (NE Oman)

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Key words: Dasycladales, Maastrichtian-Paleocene, Oman.

The Qalhat region (NE Oman) is seemingly one of the few places in the world where shallow-water carbonate platform sections are preserved that cover the K/P boundary with no evidence of significant gaps. A 148 m-thick section has been recently described in detail by Schlüter *et al* (2008). The section was subdivided into four units. Unit 1 (0-55m) is characterized by abundant Maastrichtian larger foraminifers and rudists. Unit 2 (55-65 m) is dolomitized; echinoderm and gastropod remains are the only common fossils. The occurrence of *Kolchidina paleocenica* (Cushman) at 61.6 m suggests a Danian age for the upper part of this interval. Green algae appears in interval 3 (65-136) and are represented by dasycladaleans and codiaceans. Codiacean and red algae (corallinaceans and peyssonneliaceans) are abundant in interval 4 (136-158) whereas dasycladaleans decline towards the top. A Danian-Selandian age (SBZ1-SBZ2) is attributed by Schlüter *et al* (2008) to intervals 3-4.

The occurrence of dasycladaleans across the K-P boundary in the Qalhat region had been already cited by Roger *et al* (1998). In this paper we give further information on the taxonomic composition of the algal assemblages.

The Maastrichtian Unit 1 is characterized by a low diversity association dominated by *Cymopolia eochoristosporica* Elliott. Small specimens referable to the genus *Trinocladus* are common at the top of this interval. Palaeocene algae first occur a few metres above the K/P boundary, at the base of unit 3. This unit is characterized by rich and high diversity assemblages composed of *Cymopolia*, *Trinocladus*, *Neomeris*, *Indopolia*, *Jodotella*, *Clypeina*, *Orioporella*, *Terquemella* and *Acicularia*. High diversity dasycladalean assemblages composed of *Uteria*, *Orioporella*, *Trinocladus*, *Indopolia* and *Decastroporella* are still present at the base of Unit 4, whereas in the upper part of this unit algal assemblages are dominated by red algae.

Our data suggests that at Qalhat dasycladalean diversity had already recovered, and that many of the typical Paleocene genera were already present, in the early Danian. This earlier recovery with respect to other areas, where high diversity is attained only in the upper Danian-Selandian (Barattolo, 2002), may be explained by the occurrence of more open marine facies in the Qahlat region.

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