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The Upper Eocene crustose coralline algal pavement in the Colli Berici, north-eastern Italy

Davide Bassi

Dipartimento delle Risorse Naturali e Culturali, University of Ferrara, C.so Ercole I d'Este 32, 44100 Ferrara, Italy
bsd@unife.it

Abstract

A crustose coralline algal pavement, identified in Upper Eocene (Priabonian) shallow water, middle-ramp carbonates in north-eastern Italy (Colli Berici, Southern Alps), represents a rare example of this facies. The crustose pavement consists of a coralline crust bindstone with a wackestone-packstone matrix, and is characterised by the dominance of crustose coralline thalli composed primarily of melobesioids (*Lithothamnion* and *Mesophyllum*) and mastophoroids (*Spongites*, *Lithoporella*, *Neogoniolithon*). In places the coralline bindstone can be seen to develop from isolated encrusting-to-foliose thalli which bifurcate and join to form an open framework interbedded with matrix debris from crusts. Various forms of rhodoliths occur commonly within this facies. The largest discoidal rhodoliths (up to 12 cm of large diameter) show an inner arrangement consisting of loosely packed laminar (encrusting-to-foliose) coralline thalli with a high percentage of constructional voids (50-63%). Accessory components are represented by larger hyaline perforated foraminifera such as nummulitids and orthophragminids. This facies formed in a ramp palaeoenvironment characterised by relatively low hydrodynamic energy and low rates of sedimentation. Channelised structures present within the facies were formed by return currents which swept the middle ramp creating such distal structures. Further toward the distal middle-ramp the return currents decreased in energy and discharged nutrients allowing the mesotrophic crustose coralline algal pavement to develop.

Keywords: Crustose coralline algal pavement, storm influenced carbonate ramp, palaeoecology, Late Eocene, north-eastern Italy.

Introduction

Coralline algae (Corallinales, Rhodophyta) were important carbonate sediment producers during the Cenozoic and, in particular, during the Eocene they constitute together with the larger foraminifera thick sedimentary successions representing Tethyan shallow-water, carbonate platform tropical systems. Free-living, non-geniculate (i.e. lacking uncalcified joints) coralline algae can occur at high concentrations over large areas. Sediments formed by unattached corallines include rhodolith pavements, which are accumulations of rhodoliths, as well as maerl composed of rhodoliths, coralline branches, and their detritus (Bosellini and Ginsburg 1971; Bosence 1983a; Adey 1986; Scoffin 1988; Freiwald 1994; Freiwald et al. 1991). Such observations were not oddities (Foster 2001): in terms of area covered, maerl or rhodolith beds may be one of the Earth's "Big Four" benthic communities that are dominated by marine macrophytes, ranking with kelp beds and forests, seagrass meadows, and crustose coralline reefs. Moreover, rhodolith beds provide habitat for numerous associated macroalgae and invertebrates (e.g. Littler and Littler 1997; Foster Attached coralline algae can form simple or complex encrusting frameworks on most hard substrates. Several authors emphasized the role of crustose coralline algae in binding coral frameworks (for review see Macintyre and Aronson 1997;

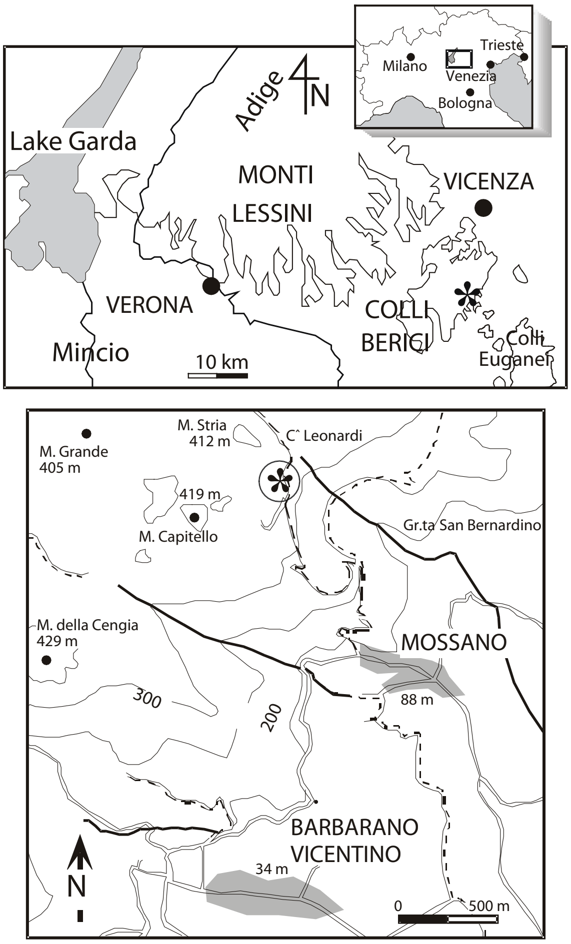

Fig. 1. Geographic map and location of the studied outcrop.

Rasser and Riegl 2002) and some interpret them to be the main binding agents in coral reefs (Littler and Littler 1997). Crustose coralline algae can form in fact considerable parts of coral reefs, known as algal ridges (e.g. Adey 1978; Steneck et al. 1997; Macintyre et al. 2001), and can even build entire reef structures (algal cup reefs, boilers, breakers) (e.g. Bosence 1983a, b), trottoirs (e.g. Adey 1986; Betzler et al. 1997; Rust and Kershaw 2000), or coralligene de plateau (e.g. Bosence 1985a; Betzler et al. 1997). These oligo-mesotrophic benthic communities thrived within the euphotic zone. Although these growth-forms are well known and documented from present-day occurrences, the knowledge on fossil crustose coralline frameworks is little (e.g. Bassi 1995; Rasser and Piller 2004).

Bassi (1995) described a Priabonian (Late Eocene) crustose coralline algal pavement from Le Scudellette, Colli Berici (north-eastern Italy). In this study a coeval crustose coralline algal pavement is described from the famous Mossano section (Fig. 1). Both outcrops belong to the Marne di Priabona formation. The pavement thrived under a storm dominated environment and is formed primarily by an unusual encrusting coralline framework with sub-discoidal rhodoliths. The palaeoecological model suggests that the significant changes of the middle-ramp benthic communities with depth could have originated by offshore return currents which played an important role both in controlling substrates and in supplying nutrients (Bassi 2005).

Stratigraphical setting

The study shallow water platform carbonates outcrop in the eastern Colli Berici (north-eastern Italy) (Fig. 1). The Colli Berici area is geologically related to the Monti Lessini as showing stratigraphic analogies to the Cenozoic formations of the Lessini Shelf (Corsi and Gatto 1967; Conedera et al. 1972; Mietto et al. 1981; Bosellini 1989; Papazzoni 1994).

The Meso-Cenozoic sedimentary sequences of the Colli Berici range from the Late Cretaceous to Early Miocene (Antonelli et al. 1990). The herein studied coralline facies belong to the Upper Eocene Marne di Priabona formation which widely outcrops in the study Mossano area reaching a thickness of about 170 m (Ungaro 1969; Papazzoni and Sirotti 1995; Bassi and Loriga Broglio 1999; Bassi et al. 2000).

The Marne di Priabona overlie the Middle Eocene Nummulitic Limestones ("Calcari Nummulitici"; Fabiani 1911; Malaroda 1967; Ungaro and Bosellini 1965) and are overlain by the Lower Oligocene Calcareniti di Castelgomberto formation. These Rupelian calcarenites, ranging from 80 to 200 m in thickness, are characterised by massive limestones and irregularly bedded biogenic calcarenites with corals and coralline red algae (Geister and Ungaro 1977; Ungaro 1978; Frost 1981).

Material and methods

The studied section is located just above the village of Mossano, along the road from Mossano to Cá Leonardi and Monte Stria (Fig. 1). The stratigra phy of the study succession has been described in Schweighauser (1953), Ungaro (1969, as "unit E"), and Bassi et al. (2000, "Stop 4"). This study is based on field observations, a microfacies analysis of thin sections (4.5 x 6.0 cm), and the study of isolated larger foraminifera and rhodoliths. The textural classification follows Embry and Klovan (1972). Semi-quantitative data on the component distribution of thin sections was carried out according to Baccelle and Bosellini (1965) and Flügel (1982). Component estimates were made using at 25x magnification under a binocular microscope.

Larger foraminifera present in the studied profile are listed in Bassi et al. (2000). Taxonomic uncertainties concerning fossil coralline taxonomy as discussed by Braga and Aguirre (1995), Rasser and Piller (1999), and Bassi and Nebelsick (2000) are avoided by using genera names only. Family, subfamily, and genus circumscriptions follow Woelkerling (1988), Verheiji (1993), Braga et al. (1993), Bassi (1998b), Aguirre and Braga (1998). Rasser and Piller (1999), Braga et al. (1993). Coralline algal growth-form terminology follows Woelkerling et al. (1993). All the study samples are stored in the Museo di Paleontologia e Preistoria "*P. Leonardi*", Dipartimento delle Risorse Naturali e Culturali, University of Ferrara, Italy.

Results

The facies succession

The Priabonian shallow water carbonates that formed along the eastern margin of the Colli Berici represent a middle-ramp setting (Bassi et al. 2000). The stratigraphical section along with a general facies pattern is provided in Fig. 2. The studied carbonates consist of wackestones, packstones, rudstones, and bindstones dominated by coralline red algae and larger foraminifera.

Calcareous algae are the frequent-to-dominant components of the study material and are represented by the members of the subfamilies Mastophoroideae, Melobesioideae, and Sporolithoideae (Rhodophyta, Corallinales), and by the peyssonneliacean *Polystrata alba* (Pfender) Denizot (Peyssonneliaceae).

Larger foraminifera are present with different proportions in all the facies. They are represented by nummulitids, such as *Nummulites*, *Assilina*, *Heterostegina*, *Spiroclypeus*, and *Pellatispira*, and by orthophragminids such as *Discocyclina*, *Nemkovella*, and *Asterocyclina*. Accessory components consist of small benthic foraminifera (textularids, rotaliids, miliolids), encrusting foraminifera (acervulinids), fragments of bryozoans, bivalves, echinoderms,

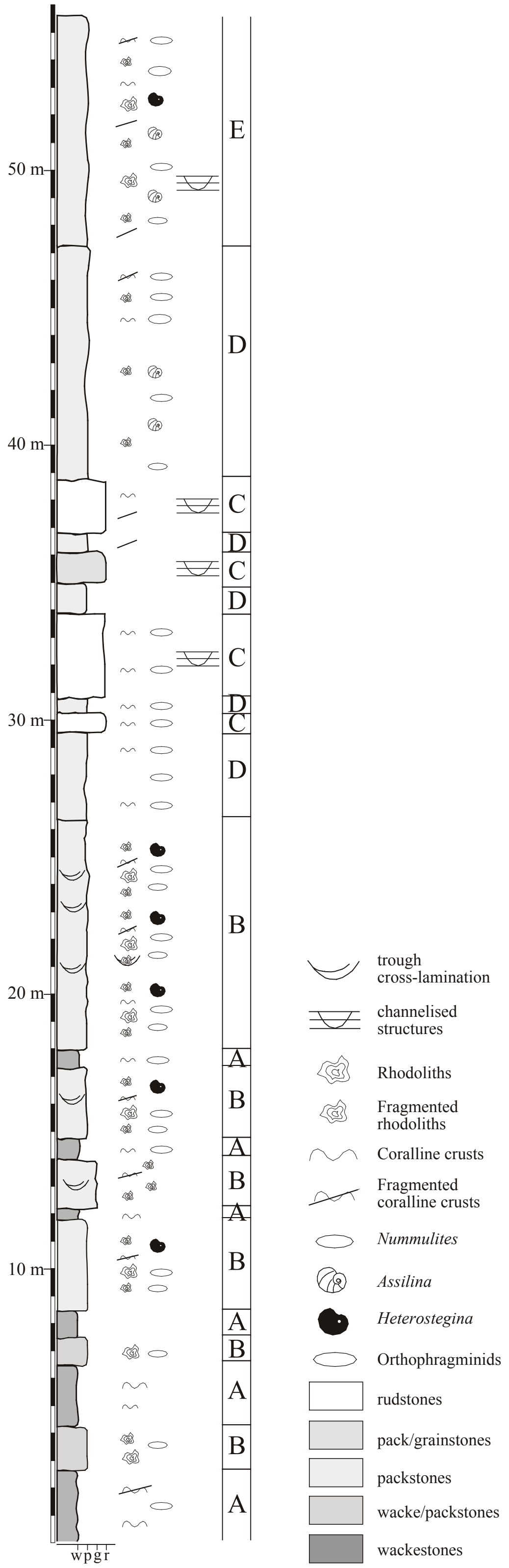

Fig. 2. Stratigraphic column and facies (A-E) distribution along the studied Priabonian Mossano section (Bassi 2005). **A** Coralline crust wackestone facies. **B** Small *Nummulites* and rhodolith packstone facies. **C** Orthophragminid rudstone facies. **D** Orthophragminid packstone facies. **E** Crustose coralline algal pavement facies.

rare solitary corals, and serpulids. Detailed studies on some of these groups has been published (e.g. Fabiani 1908, 1915; Accorsi Benini et al. 1988, 1992).

Five facies (A-E) were distinguished on the base of component distribution and fabric analysis (Bassi 2005).

Coralline crust wackestone (Facies A): This facies, which forms decimetre beds with ondulated surfaces, is characterised by grey-blue coralline algal wackestones in which thin coralline crusts float (Fig. 3). The coralline growth-forms are represented by encrusting thalli of about 1 mm in thickness. Three non-geniculate genera have been recognised: *Lithothamnion* (42%), *Mesophyllum* (28%), *Neogoniolithon* (18%) and *Lithoporella melobesioides* (Foslie) Foslie (12%); *Sporolithon* can also be present. The benthic foraminiferal assemblage consists of small *Nummulites*, disc-shaped orthophragminids, *Pellatispira madaraszi*, *Heterostegina* sp., encrusting foraminifera (such as *Acervulina linearis*), and miliolids. Bryozoans, echinoderms, and bivalve fragments as well as spicules of calcareous sponges are also present. No planktonic foraminifera were found. The Facies A alternates with the Facies B at the base of the study section (Fig. 2).

Small *Nummulites* and rhodolith packstone (Facies B): This facies consists of coarse grained packstones dominated by large benthic foraminifera and corallines. These bioclastic calcarenites locally exhibit small-to-medium scale trough cross-bedding.

The larger foraminiferal assemblage consists of small-lense shaped *Nummulites*. Large disc-shaped orthophragminids, *Heterostegina* sp., *Assilina* cf. *alpina*, *Pellatispira madaraszi*, and *Spiroclypeus granulosus* are also present. Small benthic foraminifera are represented by rare rotaliids, common-to-rare textulariids, and rare *Sphaerogypsina*, *Eorupertia*, *Fabiania,* and *Chapmanina*. Encrusting foraminifera (acervulinids) can be common.

Three non-geniculate corallines and one peyssonneliacean have been identified: *Lithothamnion* (24%), *Mesophyllum* (18%), *Lithoporella melobesioides* (Foslie) Foslie (18%), *Spongites* (6%), *Sporolithon* (15%), and *Polystrata alba* (Pfender) Denizot (19%). Rhodoliths are multispecific; several rhodoliths are made up only of *Polistrata alba*. The rhodoliths, approximately 0.5-2.0 cm in mean diameter, are dispersed in the packstone matrix and do not form any particular accumulation (Fig. 3). Fragments of fruticose thalli are also present. The most common rhodolith morphologies are laminar sub-spheroidal, with two distinctive growth-phases: a delicate, laminar inner one, and a successive warty sticking out from the laminar thalli. Nuclei can consist of massive coralline thalli, matrix and bryozoans. Their outer surface is often characterised by eroded and abraded warty protuberances.

Orthophragminid rudstone (Facies C): The rudstones are made up of densely-packed, poorly sorted, stacked larger foraminiferal tests (Fig. 4). Locally small-to-medium scale trough cross-bedding is present. The abundant interskeletal shelter cavities and the intraskeletal ones were rarely and partially filled by micrite. The remaining voids were fringed by spar and filled by blocky calcite. The benthic foraminiferal assemblage is dominated by large orthophragminids such as *Discocyclina* spp., *Nemkovella strophiolata*, *Asterocyclina alticostata*. A-forms were found only. Small *Nummulites*, *Heterostegina reticulata*, *Assilina alpina*, *Spirocly peus granulosus*, and *Pellatispira madaraszi* are also present. Saddle-shape orthophragminid shells are approximately 1 mm in thickness. Shell fragments of largest specimens at the contact with smaller disc-shaped ones (or with small disc-shaped *Nummulites*) are adapted to the latter which are more resistant to compaction. Macrofossils include fragments of bryozoans, pectinids, echinoderms, and fragments of solitary branching corals. The corallines are represented by thin encrusting thalli of *Lithothamnion* and *Mesophyllum*, up to 200 µm in thickness. The corallines encrust the ortho-phragminid tests only in their outer surface. Owing to the rarity and thickness of the coralline crusts, it was not possible to quantify the taxonomic abundance.

Within the Facies C canalised structures varying in thickness and unconformable within the general bedding are present (Fig. 5).

Orthophragminid packstone (Facies D): This facies consists of densely-packed, well-sorted orthophragminid tests, nummulitids, and small benthic foraminifera in calcareous marly pack stones (Fig. 4). Skeletal particles account for at least 75% of rock volume. The orthophragminid packstones occur as beds 20-50 cm thick within orthophragminid rudstones, may overlain the infilling sediments of the canalised structures or form laterally to these

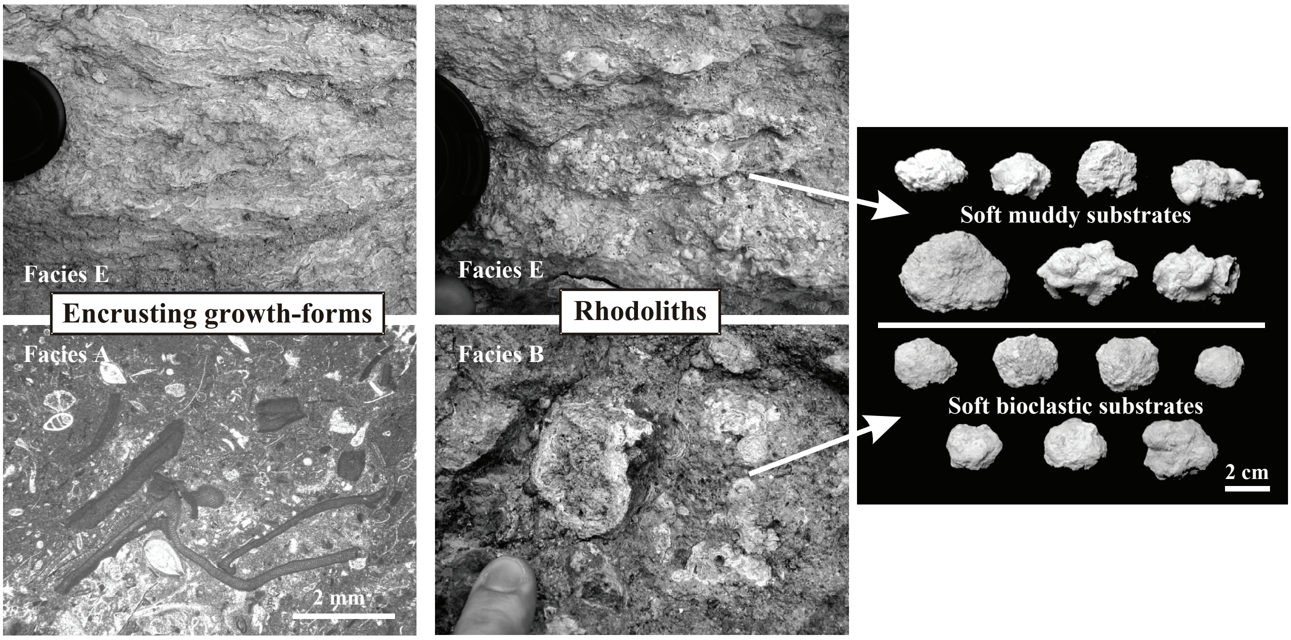

Fig. 3. Encrusting growth-forms characterise the coralline bindstone of the crustose coralline algal pavement (Facies E) and the coralline crust wackestones facies (Facies A). Sub-discoidal and sub-spheroidal rhodoliths are respectively present in the Facies E and A. Note that the rhodoliths show similar warty growth-forms both on soft muddy and bioclastic substrates. Substrate definition after Reiss and Hottinger (1984).

latter "decimetre-scale" lenses.

The benthic foraminiferal assemblage is represented by *Asterocyclina stellata*, *Nemkovella strophiolata*, *Discocyclina* spp. The orthophragminid tests show the same typical saddle-shape of the specimens occurring in the rudstone facies. Small *Nummulites*, *Assilina alpina*, and rare *Heterostegina reticulata* were recognised. Small benthic foraminifera have been listed by Ungaro (1969). The corallines are represented by fragments of thin encrusting thalli of *Lithothamnion*, *Mesophyllum*, and rare *Lithoporella melobesioides* (Foslie) Foslie. Owing to the rarity and thickness of the coralline crusts, it was not possible to quantify the taxonomic abundance. Echinoderms, bryozoans, and pectinids are also present.

Crustose coralline algal pavement facies (Facies E): The crustose coralline algal pavement is restricted to the upper part of the section corresponding to the uppermost Priabonian and shows a thickness from 3 to about 8 m; it occurs at the top of the facies succession (Fig. 2), just above the orthophragminid rudstones and the orthophragminid packstones. The pavement can laterally grade into the orthophragminid rudstone facies.

The facies consists of a coralline crust bindstone with a wackestone-packstone matrix, and is characterised by the dominance of crustose coralline thalli (Fig. 3).

In places the coralline bindstone can be seen to develop from isolated encrusting-to-foliose thalli which bifurcate and join to form an open framework interbedded with matrix debris from crusts.

Lumpy to fruticose branches frequently arise from the crustose coralline algal pavement; these have a relatively constant diameter of 3 mm and a height of up to 15 mm. Fragments of fruticose branches are present within the matrix.

Rhodoliths occur commonly within this facies and are characteristically discoidal in shape (Fig. 3). Three types of rhodoliths were differentiated: 1) small massive, sub-spherical rhodoliths, 1-3 cm in diameter; 2) small sub-spheroidal rhodoliths with a loose inner arrangement and 3) large discoidal rhodoliths (up to 10 cm in diameter) with an inner arrangement consisting of loosely packed laminar coralline thalli with a high percentage of constructional voids (50-63%) (Fig. 5). Occasionally, smaller sub-spheroidal laminar rhodoliths serve as the nuclei of the larger ones. The corallines are represented by *Lithothamnion* (46%), *Mesophyllum* (35%), and *Sporolithon* (19%); *Spongites* and *Lithoporella melobesioides* (Foslie) Foslie are also present. Coralline growth-forms are dominated by encrusting morphologies (Fig. 3); rhodoliths are mainly constituted by encrusting and foliose growth-

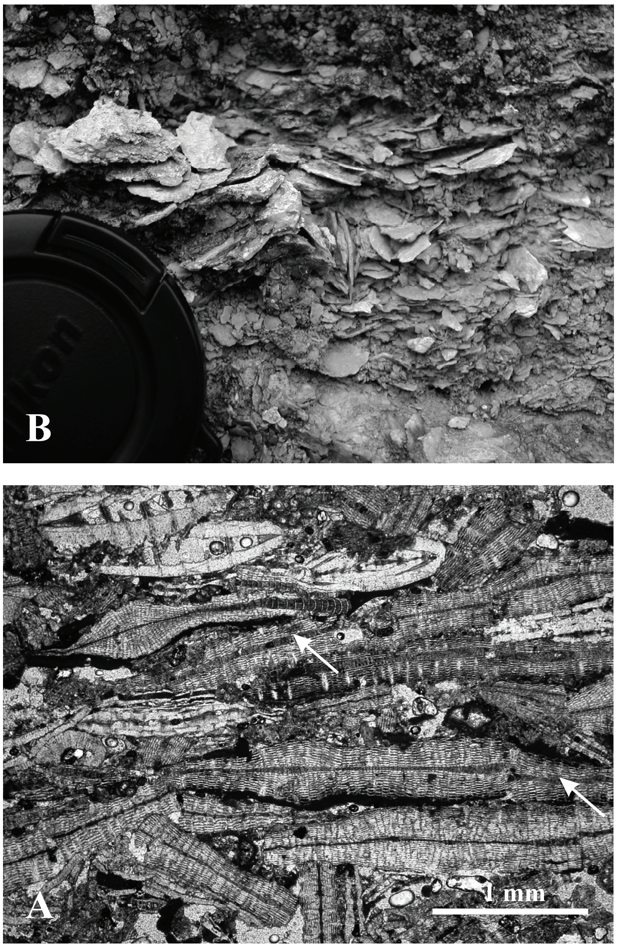

Fig. 4: A. microfacies of Facies C, note the thin delicate coralline thalli (arrows) encrusting the foraminiferal tests. B, field aspect of Facies C; camera cap is 4.5 cm in diameter.

forms; warty protuberances can be recognised on the outer surface.

Accessory components are represented by larger hyaline perforated foraminifera such as small *Nummulites* spp., *Assilina alpina*, *Pellatispira madaraszi*, *Biplanispira* sp., *Spiroclypeus granulosus*, and orthophragminids.

Small textulariids, small rotaliids, encrusting acervulinids, and rare planktonic foraminifera are also present. Bryozoans are present as branched and massive cyclostomes; bivalves (pectinids), irregular echinoids, sponge spiculas, serpulids, and rare fragments of solitary corals were also identified.

Within the facies, cut-and-fill channels similar in shape to those of Facies C are present (Fig. 5). The sediments within the channels are the same of the surrounding pre-erosional beds. These structures are less frequent than in the Facies C and are smaller in size. These latter beds have been described as "dünnbankige Kalke und Kalkmergel" (Schweighauser 1953), as erosional sedimentary structures (Bosellini 1964), and as "calcaires marneux en couches minces, …alternant avec quelques bancs massif, discordant" (Ungaro 1968). The erosional surfaces show wide concavity forms, sometime asymmetric with one of these having lower angle incision. The sediments within the channel structures are the same of the surrounding prae-erosional beds.

Discussion and conclusions

The facies succession in this Priabonian shallow water carbonate deposits shows a depth gradient with increasing water depth from a proximal to a distal middle-ramp environment. In the middle-ramp areas (below the fair-weather wave base), calcareous algal deposits (Facies A) and small *Nummulites* and rhodolith calcarenites (Facies B) deposited in the same depth range laterally adjacent to one another. Toward deeper water, they grade into the distal middle ramp facies with the orthophragminid rudstone and packstone facies (Facies C and D) as well as the crustose coralline algal pavement facies (Facies E) which both characterised the distal middle-ramp.

Close to the storm-wave base (distal middle-ramp) corallines developed extensively making up the crustose coralline algal pavement which possibly extended down to the proximal outer ramp settings (Bassi 2005).

Such a gradient scheme (Fig. 2) can be interpreted by an increasing water depth from proximal to distal middle-ramp environment represented respectively by the Facies A-B and Facies C-D-E.

In the middle-ramp small *Nummulites* and rhodolith packstone, trough cross-bedding deposits formed laterally to coralline crust wackestones. These rhodoliths exhibit two well-differentiated growth-phases which point to a first active growth during low-water energy periods, followed by high-energy events during which they were reworked and partially destroyed. A further palaeoenvironmental gradient can be followed from these facies to the orthophragminid rudstone and orthophragminid packstone facies which are characterised by orthophragminid shell concentrations and canalised structures. The latter were formed by return currents which swept the middle ramp creating distal middle-ramp canalised structures cutting through the ramp.

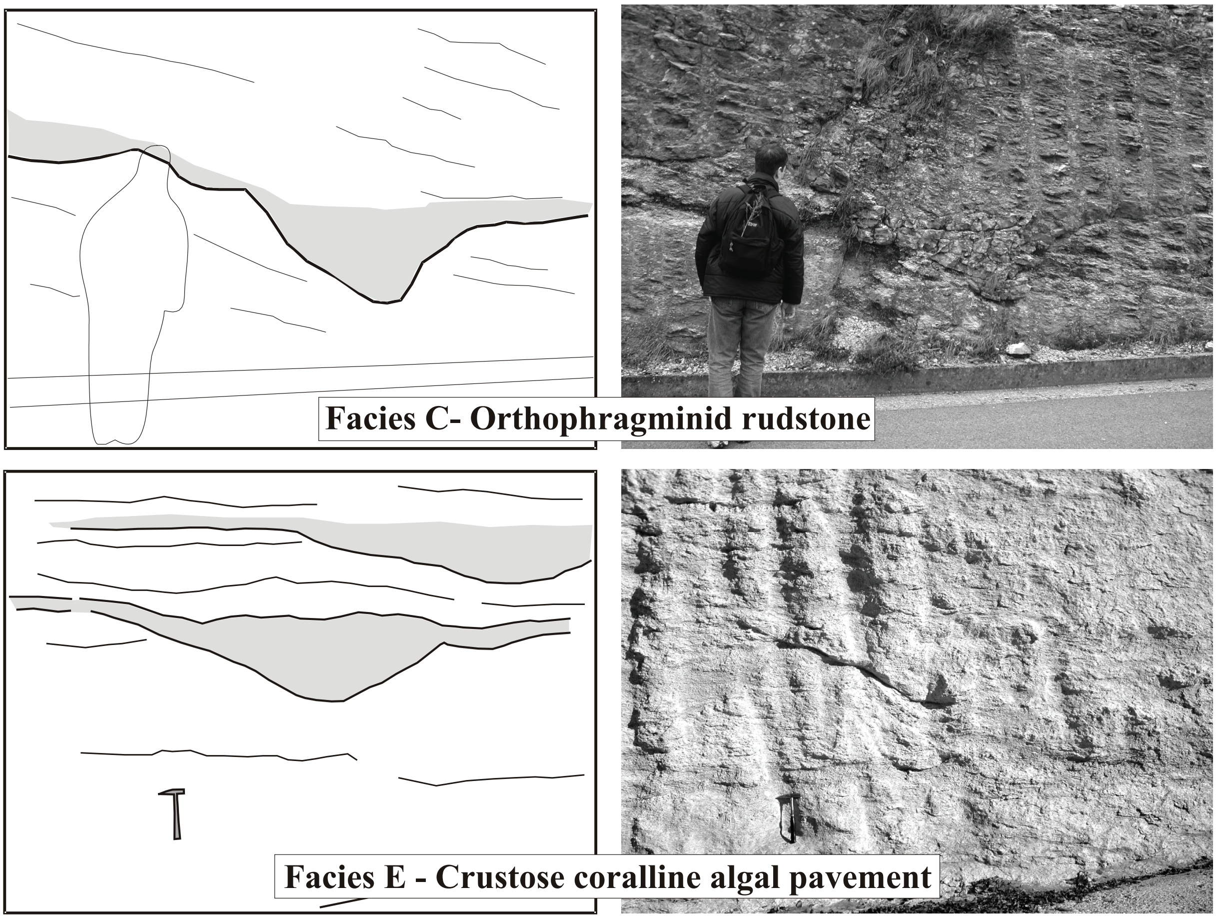

Fig. 5. Outcrop photographs and interpretation of the channel structures present in the Facies C and Facies E. Bedding surfaces are indicated. Note the asymmetrical flanks of the channels.

A similar system consisting, however, of submarine lobes and feeder channels of re-deposited, temperate carbonate and mixed siliciclastic-carbonate platform deposits, has been described in detail in the Upper Tortonian from southern Spain (Braga et al. 2001). Further toward the distal middle-ramp the return currents decreased in energy and possibly discharged nutrients allowing the mesotrophic coralline crustose pavement to develop.

The shallow-water marine areas of the eastern Colli Berici carbonate ramp were, therefore, affected by sporadic storms. These major storms would create storm surges that would eventually result in a bottom return flow (return current) capable of transporting shallow water sediments directly seaward, rather than parallel to isobaths (see e.g. Walker, 1984).

The analysis of the coralline crustose bindstone and the rhodolith internal arrangement of the Facies E point to variable turbulence conditions due to occasional influence of storms (Bassi 1995). Moderate turbulence conditions are represented by the small rhodoliths with loose internal arrangements, while lower turbulence is evidenced by the larger sub-discoidal foliose rhodoliths with a high percentage of constructional voids. Irregularly shaped rhodoliths with low branch densities, as those described in the Facies E, are more abundant in the deeper areas of wave beds and in the deep current beds where transport by water motion is infrequent and may caused by water motion including surges generated by large episodic storms such as hurricanes (Marrack 1999; Hottinger 1983; Bourrouilh-Le Jan and Hottinger 1988; Ballantine et al. 2000). Similarities between the crustose coralline algal pavement and the rhodoliths described above suggests that the rhodoliths develop from eroded fragments of the crustose pavement. The undisturbed growth of the crustose pavement took place during fair weather conditions occasionally interrupted by storms which were responsible for the different concentration of the rhodoliths as well as for the formation of the small rhodoliths (Bassi 2005).

Rasser and Piller (2004), analysing Priabonian red algal limestones from boreholes of the Alpine-Carpathian Foreland Basin, discussed the requirements for coralline framework formation which are represented by the occurrence of appropriate species, sediment input, and substrate stability/hydrodynamic energy. In the Eocene coralline algal framework of the Alpine Foreland, *Lithothamnion* sp. seems to be able to form thick crustose successions as well as to stabilize coarse substrates. Although sediment influx does not affect coralline framework formation remarkably, a suitable substrate for the formation of such a framework has been pointed in setting with mobile exposed ridges and protected troughs. In the Rasser and Piller's (2004) study the crustose framework develops from maerl facies.

In the herein case study, the crustose coralline algal pavement grows in a distal middle-ramp where orthophragminid rudstones-to-packstones deposited. The pavement represents therefore areas not suitable for the dominance of the larger foraminifera (even present in large amount) but where coralline algae thrived. In these areas the environmental constraints for crustose corallines were the substrate and the water turbulence. Delicate coralline crusts on soft muddy substrates (Fig. 3) may play a role of stabilising the sea bottom. The crustose coralline algal pavement grown mainly during the fair-weather periods. Occasional major storms together with the return currents (testified by the channelised structures) caused a high current activity which involved rhodoliths and swept the pavement.

In the fossil record, *Neogoniolithon* has been found forming encrusting thalli directly on the fine-grained (muddy) carbonate substrates (e.g., Fravega and Vannucci 1987 as "*Lithophyllum contii*"; Bassi 1995 as *Mesophyllum* sp. 2; Nebelsick and Bassi 2000 as "encrusting type 1"; Rasser and Piller 2004 as *Neogoniolithon* sp.). Although most present-day corallines cannot survive in sediment-dominated environments, *Neogo-niolithon strictum* is commonly found there (e.g., Bosence 1985b). This species has unusually abundant multiple cell fusions throughout its thallus (particularly in the hypothallus and medullary region of branches), which may act as conduits for photosynthates (Steneck 1986; Steneck et al. 1997).

The Priabonian crustose coralline algal pavement shows, therefore, characters that make it peculiar. It survived, and even flourished, in environments of lower wave energy occasionally subjected to major storms and return currents. Among the present-day algal frameworks (see Introduction), algal ridges and algal cup reefs develop in tropical areas. Fossil coralline frameworks have been reported from the Middle Eocene of northern Spain (Taberner and Bosence 1985), from the Late Eocene of north-eastern Italy (Bassi 1995), from the Late Eocene of Alpine Foreland (Rasser and Piller 2004), from the Middle Miocene of south-eastern Poland (Pisera 1985), from the Miocene of Malta (Bosence 1983c; Bosence and Pedley 1982), and from the Quaternary from dredging off Queensland (Australia; Marshall et al. 1998).

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Riassunto
[Il pavimento crostoso ad alghe rosse corallinacee dell'Eocene Superiore dei Colli Berici, Italia nord-orientale]

Le alghe rosse corallinacee (Corallinales, Rhodophyta) sono state importanti produttori di sedimenti carbonatici durante il Cenozoico e, assieme ai macroforaminiferi, hanno costituito potenti successioni sedimentarie durante l'Eocene.

Il pavimento crostoso a corallinacee (*crustose coralline algal pavement*), identificato in carbonati di piattaforma carbonatica nell'Eocene Superiore (Priaboniano) dei Colli Berici (Italia settentrionale), rappresenta un raro esempio di questa facies. Il pavimento consiste in un *bindstone* a corallinacee incrostanti con matrice *wackestone-packstone*. È caratterizzato dalla dominanza di talli composti principalmente da Melobesioideae (*Lithothamnion* and *Mesophyllum*) e Mastophoroideae (*Spongites*, *Lithoporella*, *Neogoniolithon*). Il *bindstone* a corallinacee, sviluppatosi *in situ*, deriva da talli isolati incrostanti e *foliose* che si biforcano e si fondono assieme per costituire una struttura complessa. I rodoliti presenti sono di forma varia: quelli di maggiori dimensioni (fino a circa 12 cm di diametro) mostrano un'organizzazione interna costituita da talli laminari (incrostanti e *foliose*) con un'alta percentuale di vuoti costruzionali. Componenti accessori dell'associazione sono rappresentati da macroforaminfieri ialini perforati quali nummulitidi ed ortofragminidi. Questa facies si formò in una rampa mediana caratterizzata da energia idrodinamica relativamente bassa e bassi tassi di sedimentazione. Sono inoltre presenti strutture canalizzate che si formarono a causa di correnti di ritorno che spazzavano la rampa mediana. Verso la parte più distale della rampa queste correnti diminuivano d'intensità e depositavano nutrienti facilitando lo sviluppo del pavimento a corallinacee.

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