

Bollettino della Società Paleontologica Italiana	36 (1-2), 1997	ISSN 0375-7633	53-61	2 pls.	Parma, Dicembre 1997
--	----------------	----------------	-------	--------	----------------------

A bank of the scleractinian coral *Cladocora caespitosa* in the Pleistocene of the Crati valley (Calabria, Southern Italy): growth versus environmental conditions

Maria PIA BERNASCONI * Cesare CORSELLI ** Luigi CAROBENE ***

* Dipartimento di Scienze della Terra, Università della Calabria

** Dipartimento di Scienze della Terra, Università di Milano

*** Dipartimento di Scienze della Terra, Università di Genova

KEY WORDS - *Scleractinia, Growth, Sedimentation, Paleoecology, Pleistocene, Southern Italy*

ABSTRACT - This paper deals with a coral bank interbedded in Pleistocene silty sands which outcrop in the Crati valley (Calabria, Southern Italy). The morphometric analysis of several colonies of *Cladocora caespitosa* (Linnaeus) is based on measurements concerning both the colony and the individual corallite. The significant correlations obtained from a statistical analysis indicate that the regular and unchanged growth of the bioconstructions occurred in quite a dim environment, and a deep infralittoral allocation is also suggested by the associated molluscan fauna. The paleoenvironment suffered a sudden, strong sediment input, correlated to tectonic activity, which caused the burial of the colonies. The re-colonization of the bottom took place while the bathymetric conditions remained unchanged. The definitive burial of the coral bank is marked by a transgressive phase which yielded the deposition of circalittoral clayey sediments.

RIASSUNTO - [Analisi di un banco a *Cladocora caespitosa* nel Pleistocene della Valle del Crati (Calabria, Italia meridionale): crescita in rapporto alle condizioni ambientali] - L'analisi paleoecologica di una parte della sequenza pleistocenica affiorante in valle del Crati (Calabria) è basata sullo studio morfometrico di alcune colonie di *Cladocora caespitosa* (Linneo). Le misure effettuate riguardano sia la colonia nel suo insieme che i singoli coralliti. Le correlazioni ottenute dal confronto fra le misure hanno messo in evidenza una crescita regolare e costante nel tempo delle colonie esaminate. In particolare, lo sviluppo di un morfotipo caratterizzato da una crescita a forte componente verticale e con coralliti subparalleli indica un paleoambiente a bassa energia e scarsa illuminazione. Una collocazione batimetrica nel piano infralitorale profondo è suggerita anche dall'associazione a molluschi rinvenuti nel banco. Nel paleoambiente si alternavano periodi di stabilità, durante i quali era favorita la crescita delle colonie, a fasi di instabilità, in cui improvvisi e consistenti arrivi di sedimento più grossolano provocavano il seppellimento delle colonie. La reiterata colonizzazione del fondo da parte di *C. caespitosa* testimonia che le condizioni paleoambientali rimanevano inalterate. Lo sviluppo del banco cessa con la deposizione di argille circalitorali, trasgressive.

INTRODUCTION

The Plio-Pleistocene sequence exposed in the Crati valley (Calabria region, Southern Italy) is characterized by terrigenous sediments, for the most part deposited in a marine environment. The sediments range in size from conglomerate to clay, and the finest fractions (fine sand and mud) are fossiliferous. Fossils have been reported since the beginning of this century (Crema, 1903; Gignoux, 1909; Gignoux, 1913; Ruggieri, 1959; Vezzani, 1968; Burton, 1971; Ogniben, 1973), most of them being molluscs.

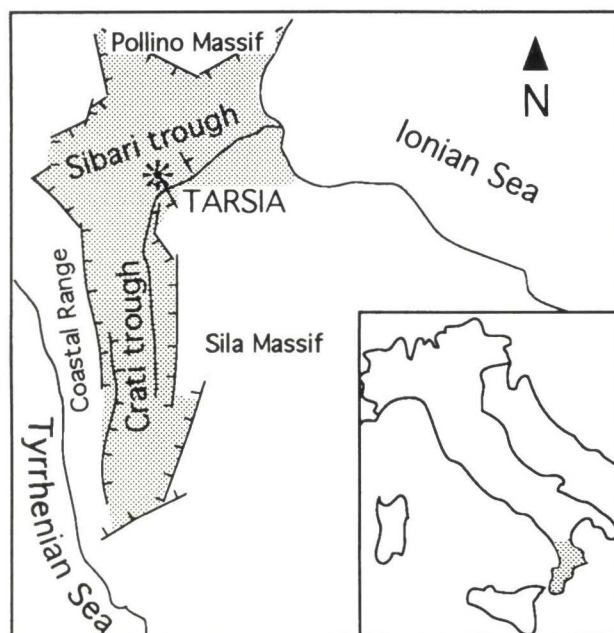
This paper deals with a coral bank interbedded in Pleistocene sandy silts which outcrops near the village of Tarsia (Text-fig.1). It represents the first record of coral in this area for that time interval. The coral bank is monospecific, composed of the

scleractinian *Cladocora caespitosa* (Linnaeus).

The purpose of the study is twofold: 1) to extrapolate the paleoenvironment on the basis of a morphometric analysis of several coral colonies and 2) to provide new information on the tectono-sedimentary evolution of the Crati basin.

GEOLOGICAL SETTING

The Crati basin is located in an L-shaped tectonic depression, which is bordered by the Coastal Range in the west and south, by the Sila Massif in the east and by the Pollino Massif in the north (Text-fig. 1). Two main structural sectors can be recognized, i.e., the Crati trough, oriented S-N, and the Sibari trough, oriented WSW-ENE. Despite the complexity of the geodynamic history of this northern portion of the Calabrian Arc, the



Text-fig. 1. Map of the area studied. Asterisk indicates the coral bank outcrop, close to the village of Tarsia.

authors (Lanzafame & Zuffa, 1976; Lanzafame & Tortorici, 1981; Tortorici, 1981; Carobene & Damiani, 1985; Tortorici *et al.*, 1995) agree in summarizing its tectonic evolution as follows:

- the opening of the basin in the Late Pliocene, when the Sila and the Pollino massifs had already emerged
- an increase in its subsidence up to the Early Pleistocene accompanied by the migration of the basin depocenter from west to east
- the uplift of the Coastal Range from the Early Pleistocene
- the general uplift of the area, the Crati basin included, from the Middle Pleistocene up to the emersion.

As a result, the Crati basin is filled with a thick sedimentary cover (about 1500-1600 m), ranging in age from Tortonian to Holocene (Burton, 1971).

The Pleistocene sediments are widely distributed in the basin, mostly related to fluvial depositio-

nal systems (Colella, 1988). In the area studied they unconformably overlie sediments attributed to the Tortonian (Romeo & Tortorici, 1980), reaching a total thickness of about 200 m (Text-fig. 2). Five (I to V) depositional sequences (transgressive-regressive), separated by erosional surfaces have been recognized (Carobene *et al.*, 1997); the second (II) is the thickest and includes the coral bank under examination. In particular, the base of sequence II includes, from bottom to top, continental breccias overlaid by marine sediments with abundant remains of *Ostrea edulis* Linnaeus, *Chama gryphoides* Linnaeus and *Cerithium vulgatum* (Bruguière), and by silty sands with *Cladocora caespitosa* (cb in Text-fig. 2; Pl. 1, figs. 1-3).

The coral bank represents a lens about 200 m long, which attains a maximum thickness of 5 m. The exposure of the coral colonies is excellent because they extensively outcrop on the walls of three caves artificially dug inside the lens (Pl. 1, fig. 1); two of them, connected by a short tunnel, are about 5 m long and 3 m wide, with a curved ceiling 2 m high in the middle; the third cave is smaller, about 1 m x 1.5 m x 1 m. The colonies are fairly well preserved in their general morphology, but a decalcification process probably acted to some extent. This implies that a simple touch causes the corallites to detach. The colonies occur in four superposed layers (Pl. 1, figs. 4, 5), separated by a decimetric horizon of sediment with abundant fragments of *C. caespitosa* which are parallel to the sedimentation surface.

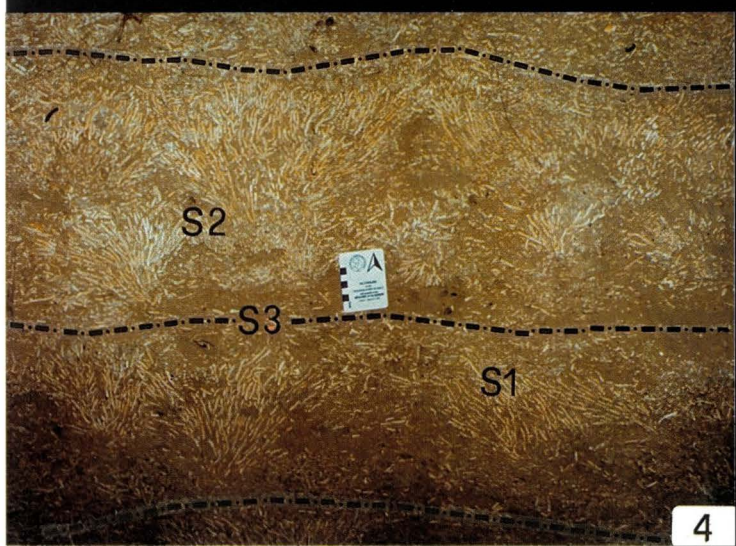
As regards the age, the appearance of *Gephyrocapsa* sp. 3 (*sensu* Castradori, 1993) in sequence II and its disappearance in sequence III indicate that sediments of sequence II were possibly deposited during the Sicilian (Carobene *et al.*, 1997).

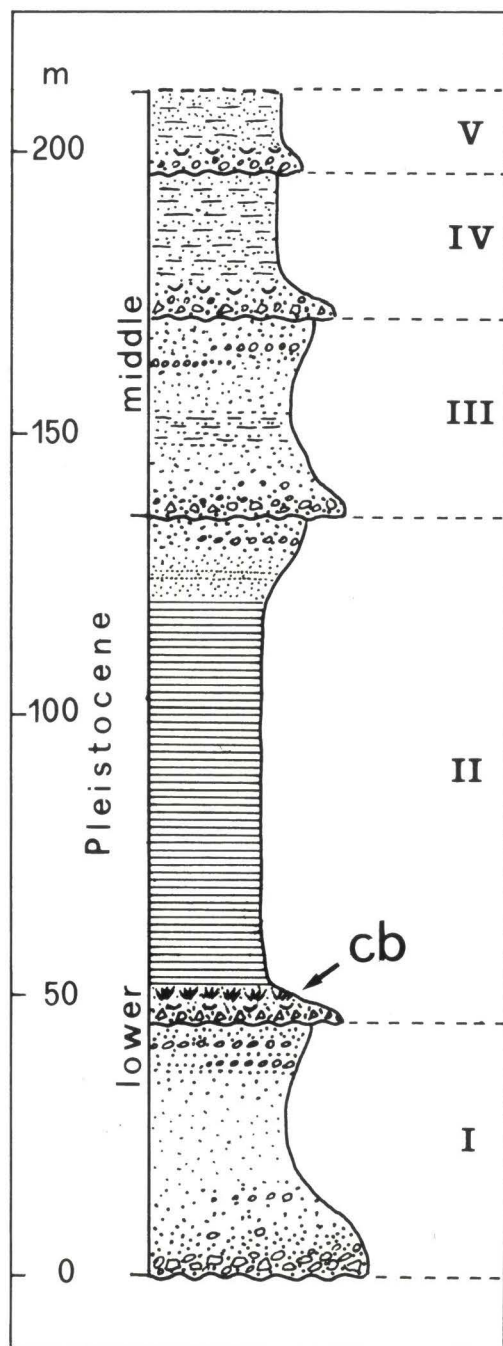
METHODS

Morphometric analysis was carried out on 14 colonies of *C. caespitosa*, those best preserved with bottom and top exposed. Measurements were made both on the colony as a whole and on

EXPLANATION OF PLATE 1

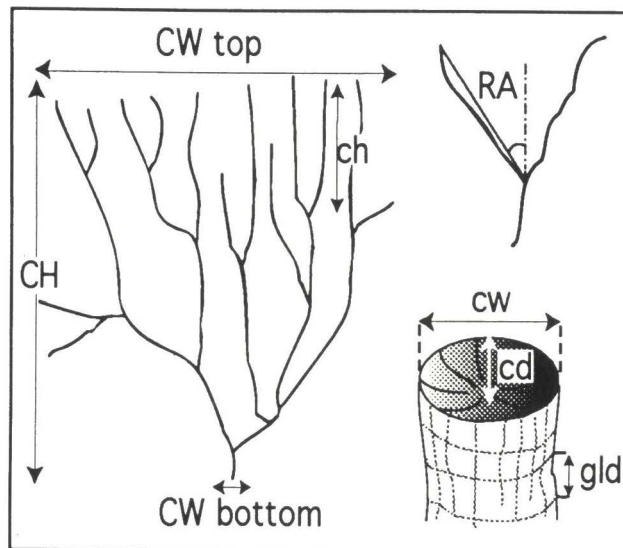
- Fig. 1 - View of the coral bank inside the cave. The transition from the continental sediments to the overlying coral bank is denoted by the change in colour from dark to light yellow.
- Fig. 2 - Detail of the base of the coral bank with the transition to the underlying continental sediments.
- Fig. 3 - Molluscs at the base of the coral bank. White arrows indicate, from left to right, valves of *Chama gryphoides* and *Ostrea edulis*. Scale = 5 cm.
- Fig. 4 - View of the coral colonies occurring in superposed layers, as denoted by the dotted line. Labels S1-S3 indicate sampling points for grain size analyses. Scale = 5 cm.
- Fig. 5 - Enlargement of Fig. 4 showing the decimetric horizon between the coral layers. Scale = 5 cm.





Text-fig. 2 - Stratigraphic sequence of the Pleistocene sediments outcropping in the Crati valley. Roman numerals (I to V) indicate the transgressive-regressive sequences. cb: *Cladocora caespitosa* coral bank.

the individual corallite (Text-fig. 3), using meter, calliper and goniometer. The colonies were characterized by linear and angular measurements (height, width, ramification angle etc.) and by ratios (slenderness ratio, ramification density). The data are summarized in Tab. 1.



Text-fig. 3 - Measurements carried out on colonies and corallites. CW: colony width (bottom and top); CH: colony height; RA: ramification angle; ch: corallite height; cw: corallite width; cd: calical depth; gld: distance between growth lines.

The slenderness ratio (SR), defined as the ratio of colony height and lower width (Abelson *et al.*, 1993), provides information on the feeding habit. The degree of closeness of the bioconstruction is expressed by the ramification density (RD = mean distance between corallites in a colony), i.e., the ratio of maximum width (CW_{top}) and the number of corallites (CN) counted on CW_{top}. The regularity in growth is shown by the budding number (BN), i.e., the number of buddings counted along the corallite. In Tab. 1, values concerning corallites are mean values, each of them based on at least four measurements (the complete set of measurements is available from the authors).

Qualitative observations cover the presence of epibionts and/or endoliths, their position with respect to colony growth, and evidence of growth stasis and of calical contractions.

A statistical analysis, based on the data of Table 1, helped in the definition of the prevalent coral morphology. In particular, correlations were used, and only those with a coefficient (r) of 95% significance (cf. Table 32.1 in Cavalli-Sforza, 1987) were considered. Statistical analysis was performed on a Power Macintosh 7100 using CA-Cricket Graph III software.

Grain size analysis was carried out on samples collected from two coral layers (S1, S2) and from the decimetric horizon between them (Pl. 1, fig. 4). Data were obtained using the sieve analyses and are reported in Tab. 2.

The molluscan species associated with the coral bank were collected and identified. Their ecological meaning was investigated in order to complete the set of paleoenvironmental information derived from the biogenic content.

OBSERVATIONS

Some general remarks can be made taking into account the data reported in Tab.1.

The 14 colonies measured are concentrated in only three layers; the top part of the fourth is not exposed. The colonies are irregularly spaced, the distance between their bottom parts ranging from 8 to 40 cm. However, most of them (10 out of the 14) tend to become coalescent towards their top parts. The height (CH) varies from 17 to 34 cm and the maximum width (CW_{top}) from 14 to 57 cm, their mean values being 25.5 and 32.8 cm, respectively. The slenderness ratio (SR) exceeds 1.5, and the ramification density (RD) varies from 0.5 to 1.78.

The mean corallite height (ch) ranges from 3.5 to 10 cm and their mean width (cw) from 4.5 to 6 mm. The distance between growth lines (gld) varies from 3.2 to 6 mm. Data on the ramification angle (RA) and the calical depth (cd) are less easily available; the mean values do not exceed 10° for the former and 1.5 mm for the latter.

Three significant correlations result from the comparison of the measurements (Text-fig. 4). In

samples	S1	S2	S3
% sand			
2 - 0.125 mm	3.31	4.65	33.8
0.125-0.0625 mm	51.34	73.39	37.11
% total sand	54.18	78.04	71.54
% silt + clay	45.82	21.95	28.45

Tab. 2 - Grain size analyses carried out on samples 1 to 3. Sample collecting points are reported in Pl. 1, fig. 4.

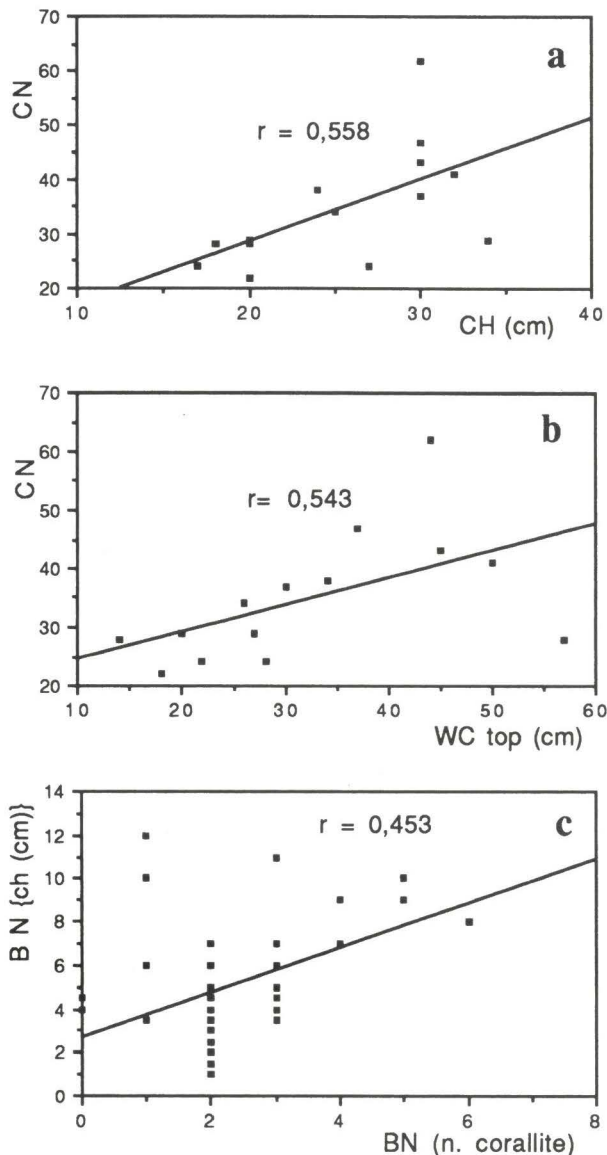
particular, the number of corallites (CN) is correlated (at 95% level of significance) to both height ($r=0.558$) (Text-fig. 4a) and maximum width ($r=0.543$) (Text-fig. 4b) of the colonies. A strong relation ($r=0.453$; at 99% of significance) also exists between the number of buddings counted along the corallite and its height (Text-fig. 4c).

Encrusting epibionts were observed at different levels on several colonies: mostly serpulids, vermetids and subordinate bryozoans. Only one endolith (a bivalve) was recorded.

The sediment of the coral bank can be defined as a silty sand, the percentage of sand ($0.0625 < \varphi < 2$ mm) in the three samples exceeding 54% (Tab. 2). The two coral layers (S1, S2) differ from the intercalated horizon (S3) by the amount of medium to coarse sand ($0.125 < \varphi < 2$ mm), which is less than 5% in the first two and greater than 33% in the third.

Layer	Distance between colonies (cm) bottom top		CH (cm)	CW (cm) bottom top		SR	CN	RD	mean values					BN n. corallites/ch
									ch (cm)	cw (mm)	RA (°)	cd (mm)	gld (mm)	
3	40	0	32	16	50	2	41	1.21	7.3	5.7	-	-	5.3	1/10 3/5 0/4.5 0/4 2/3
3	23	0	30	-	30	-	37	0.81	7	4.8	6	-	5.5	4/7 5/9 2/1.5 2/3
3	24l 33r	0	30	12	37	2.5	47	0.78	-	6	10	-	4.5	6/8 3/5 2/4 3/4.5
2	20l 30r	0	30	9	45	3.33	43	1.04	8.2	5.2	-	-	5.8	1/12 2/5 4/9 3/7
2	40l 18r	0	25	7	26	3.57	34	0.76	9.5	5	-	-	5.2	3/11 2/6 2/3 2/3
2	36	7	17	-	22	-	24	0.91	3.5	5.4	-	-	5.4	2/3.5 1/6 2/2.5 2/2
2	8l 30r	7	18	-	14	-	28	0.5	6.7	4.5	-	1.2	4.7	1/6 2/3
2	12	28	20	7	18	2.85	22	0.81	10	5.5	-	-	4.7	5/10 2/3 2/2 2/1
2	54	0	34	7	20	4.85	29	0.69	4.4	5.4	-	-	5.5	3/6 2/3 2/5 1/3.5
2	40l 40r	0	20	13	57	1.53	28/50CW	1.78	8.2	5.7	-	1	6.2	5/10 5/10 3/7 3/6
2	13	0	20	7	27	2.85	29	0.93	5.7	6	10	-	3.2	2/7 2/5 2/4.5 3/7
1	20	0	30	10	44	3	62	0.7	5	6	-	-	4.5	3/6 2/3 3/5 1/6
1	20	0	24	8	34	3	38	0.89	-	4.5	5	-	6	2/1 2/1
1	40	10	27	11	28	2.45	24	1.16	3.6	5.8	7	1.5	6.7	3/5 2/2 3/3.5 3/4

Tab. 1 - Data concerning the morphometric analysis carried out on 14 colonies. l: left; r:right; SR: slenderness ratio (CH/CW_{bottom}); CN: number of corallites counted on maximum colony width (CW_{top}); RD: ramification density (CW_{top}/CN); BN: budding number. Other abbreviations as in Text-fig. 3.



Text-fig.4 - Plot of the significant correlations obtained from the morphometric analysis. a: colony height (CH) versus number of corallites counted on maximum colony width (CN); b: colony width (CW) versus number of corallites counted on maximum colony width (CN); c: number of corallites versus corallite height (BN).

The molluscan fauna associated with the coral bank includes 14 species, 5 bivalves and 9 gastropods:

Nucula nucleus (Linnaeus)
Chlamys sp.
Mimachlamys varia (Linnaeus)
Chama gryphoides (Linnaeus)
Venus casina (Linnaeus)
Gibbula magus (Linnaeus)
Cantharidus exasperatus (Pennant)
Turbona cimex (Linnaeus)
Rissoina bruguieri (Payraudeau)
Cerithium vulgatum (Bruguère)
Mitrella sp.
Cantharus dorbigny (Payraudeau)
Nassarius incrassatus (Müller)
Fasciolaria lignaria (Linnaeus)

DISCUSSION AND CONCLUSIONS

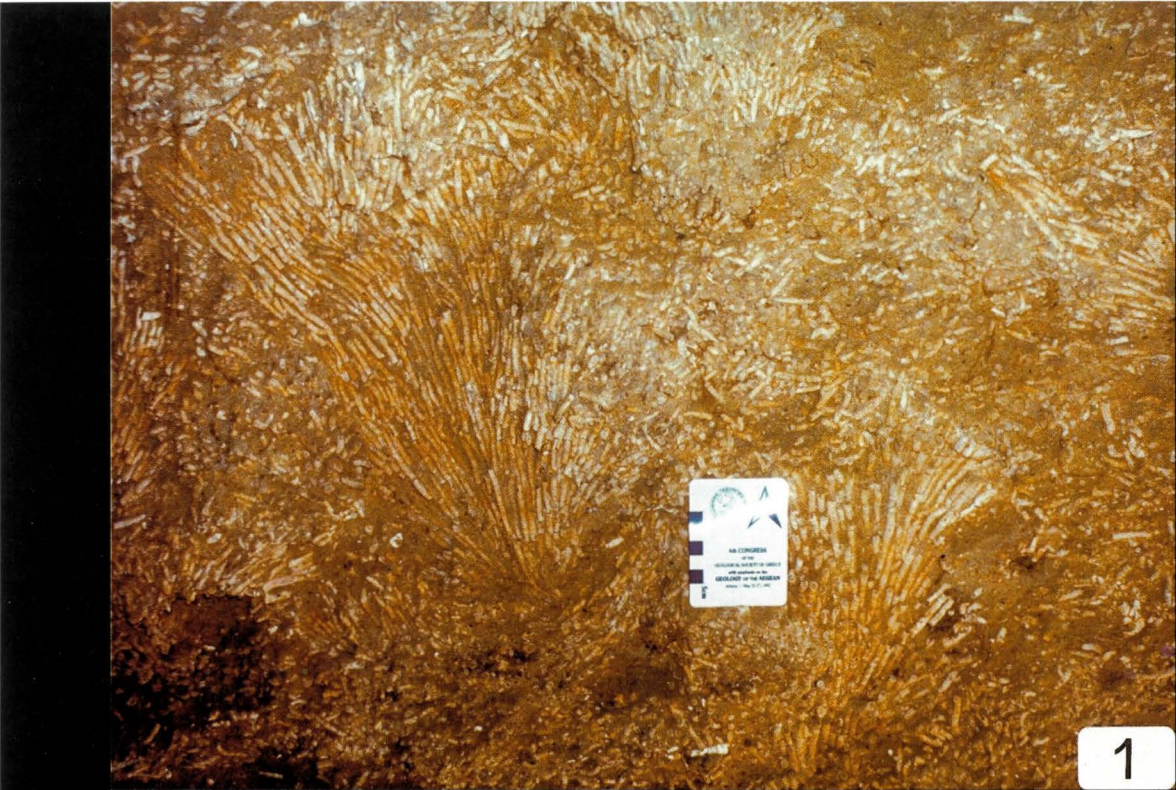
The colonies of *Cladocora caespitosa* recorded in the Pleistocene silty sands of the Crati valley can be ascribed to a single morphotype. The significant correlations obtained from the morphometric analyses (Text-fig. 4) testify that their growth system did not change with time. Regularly spaced budding phases (Text-fig.4c) produced a high-SR body morphology (Abelson *et al.*, 1993) (Pl. 2, figs. 1, 2). The relatively short mean distance between corallites (mean RD = 0.92 cm) and the ramification angle values (never exceeding 10°) concur in defining a morphotype close to the forma *typica* of this species, as characterized by Abel (1959; Fig. 16). This morphotype indicates a very quiet paleoenvironment, with low to absent water movement and low light intensity. Such physical marine conditions may occur in the deeper infralittoral zone, where the light intensity is reduced but still supports the photosynthesis of the zooxanthellae, a typical symbiont of *Cladocora caespitosa* (Zibrowius, 1980). The occurrence of encrusting epibionts at different levels on the colonies could indicate that they were sediment-free during growth. It can be concluded that the sedimentation ratio was low, and the coral bank rather far from the sediment source. Geological evidence points towards a relatively stable environment, with less subsidence in this area than in the surroundings.

EXPLANATION OF PLATE 2

Fig. 1 - Example of the prevalent morphotype of *Cladocora caespitosa* colonies.

Fig. 2 - Small colonies on the wall of the cave.

Scale = 5 cm.



The inferred depth is also confirmed by the associated molluscan fauna. All the determined species are known from shelf biocoenoses. In particular, taxa restricted to the infralittoral zone are represented only by gastropods (*Turbona cimex*, *Rissoina bruguieri*, *Cerithium vulgatum*, *Cantharus dorbigny*, *Fasciolaria lignaria*) living on hard substrates and are not exclusive of any specific biocoenosis; rather, they are generally associated with the *Posidonia* seagrass (HP) and/or with the Photophyllous Algae (AP) biocoenoses. Species with a wider bathymetric range (infralittoral to circalittoral) require either soft mixed sediments (*Nucula nucleus*, *Venus casina*, *Gibbula magus*) or hard substrates (*Mimachlamys varia*, *Chama gryphoides*, *Cantharidus exasperatus*). The infaunal species (*Nucula nucleus*, *Venus casina*, *Gibbula magus*) are usually recorded from circalittoral biocoenoses [Muddy Detritic Bottoms (DE) and Coastal Detritic Bottoms (DC) biocoenoses] or from the Coarse Sands under Bottom Currents (SGCF) biocoenosis, independent of the bathymetric zonation. As a whole, the autecological characteristics of the molluscan species are consistent with a deep infralittoral allocation of the coral bank.

Our interpretation of the colony distribution in overlying layers takes into account information about the polyp's efficiency in rejecting particles and about the grain size analyses of the three samples. The colonies of *C. caespitosa* examined belong to the sessile benthic fauna characterized by a high-SR body morphology ($SR > 1.5$). This implies that they were suspension feeders, encountering higher fluxes of fine suspended particles (Abelson *et al.*, 1993). However, the geometry of their calices indicates a general inefficiency in sediment rejection. Particle rejection efficiency depends on the polyp's distensional capacity: the greater the distension, the more efficient the sediment rejection. In turn, the distensional capacity is related to skeletal features, such as number and ornamentation of septa, calical depth and morphology of the calical floor (Hubbard & Pocock, 1972). In the genus *Cladocora*, the relatively low number of septa and their comparative smoothness, the low calical relief and the flat calical floor testify a low efficiency in fulfilling this function. Although quantitative data from *Cladocora caespitosa* is not available, experiments carried out on a closely-related Atlantic species, *Cladocora arbuscula* (Lesueur), have shown that its low sediment rejection capacity ceases when the particle diame-

ter exceeds 125 μ (Hubbard & Pocock, 1972). As regards the sediment texture of the coral bank, the sand fraction is prevalent in all the samples examined (Tab. 2); however, in sample S3, from the decimetric horizon intercalated between the coral layers, the quantity of particles larger than 125 μ is comparatively greater (33.8%) than in samples S1 and S2 (3.31% and 4.65% respectively). This suggests that i) the burial of the colonies is the consequence of an increased input of coarser sediment fractions, and ii) *C. caespitosa* is possibly unable to reject particles $> 125 \mu$ in diameter.

A sudden, strong sediment input can be reasonably related to tectonic activity rather than to ordinary hydrodynamic events such as bottom currents and/or sea-storms. This hypothesis is also supported by geological and structural data testifying to widespread tectonic activity in the Crati valley during this time span (Carobene & Damiani, 1985; Tortorici *et al.*, 1995).

In conclusion, morphometric analysis of the colonies of *Cladocora caespitosa* embedded in the Pleistocene silty sands of the Crati valley provides a new approach to the interpretation and description of the paleoenvironment and to the definition of the sedimentation basin's evolution.

Towards the end of Early Pleistocene a transgressive phase affected the sedimentation basin and deposited marine sediments onto continental breccias. Deep infralittoral conditions were established. The paleoenvironment was characterized by a low energy level and low light intensity. *C. caespitosa* colonized the soft bottoms, represented by silts and fine sands, settling on small hard substrates, such as *Ostrea edulis* and *Chama gryphoides* valves. In that quiet and stable environment, the growth of the colonies produced a morphotype close to the forma *typica*. The usually low sedimentation ratio occasionally increased suddenly, probably as a response to tectonic events. These stronger and coarser sediment inputs caused the burial of the colonies. However, after these events *C. caespitosa* was able to re-colonize the bottom, producing the same morphotype again. This suggests that, with the exception of the special sediment inputs, the environmental conditions did not change during the formation of the coral bank. Another transgressive phase produced a circalittoral environment. The resulting decrease in light made symbiosis with the zooxanthellae impossible and altered the coral metabolism. The growth ratio decreased and the colonies were buried.

ACKNOWLEDGMENTS

We wish to thank H. Zibrowius and an anonymous reviewer for the perspective and useful suggestions which improved the manuscript. Financial support for the investigation was provided by Italian MURST (to M.P.B. and C.C.) and CNR funds (n. 94.01661.PF54 to L.C.).

REFERENCES

- ABEL, E.F., 1959, Zur Kenntnis der marinen Höhlenfauna unter besonderer Berücksichtigung der Anthozoen: *Pubbl. Staz. Zool. Napoli*, 30 suppl.: 1-94.
- ABELSON, A., MILOH, T. & LOYA, Y., 1993, Flow patterns induced by substrata and body morphologies of benthic organisms, and their roles in determining availability of food particles: *Limnol. Oceanogr.*, 38 (6): 1116-1124.
- BURTON, A.N., 1971, Carta Geologica della Calabria alla scala 1:25.000. Relazione Generale: Cassa per il Mezzogiorno, Serv. Bonifiche: 1-120.
- CAROBENE, L., COLALONGO, M.L., PASINI, G. & RAFFI, I., 1997, Sequenze deposizionali del Pleistocene inferiore nella valle del fiume Crati presso Tarsia (Calabria): *Giorn. Geol.*, in press.
- & DAMIANI, A.V., 1985, Tettonica e sedimentazione pleistocenica nella media valle del F. Crati. Area tra il T. Pescara ed il F. Mucone (Calabria): *Boll. Soc. Geol. It.*, 104: 93-114.
- CASTRADORI, D., 1993, Calcareous nannofossil biostratigraphy and bio chronology in Eastern mediterranean deep-sea cores: *Riv. Ital. Paleont. Strat.*, 99 (1): 107-126.
- CAVALLI-SFORZA, L., 1987, Analisi statistica per medici e biologi: 209 pp., Bollati Boringhieri.
- COLELLA, A., 1988, Pliocene-Holocene fan deltas and braid deltas in the Crati basin, Southern Italy: a consequence of varying tectonic conditions. *In* Nemec, W. & Steel, R.J. (eds), *Fan deltas*: Blackie: 50-75.
- CREMA, C., 1903, Sul piano Siciliano nella valle del Crati (Calabria): *Boll. R. Comit. Geol.*, 4 (3): 245-271.
- GIGNOUX, M., 1909, La Calabre: *Ann. Géogr.*, 18 (98): 141-160.
- , 1913, Les formations marine pliocènes et quaternaires de l'Italie du Sud et de la Sicile: *Ann. Univ. Lyon*, 36: 1-369.
- HUBBARD, J.A.E.B. & POCKOCK, Y.P., 1972, Sediment rejection by recent scleractinian corals: a key to paleo-environmental reconstruction: *Geol. Rundsch.*, 61: 598-626.
- LANZAFAME, G. & TORTORICI, L., 1981, La tettonica recente della valle del Fiume Crati (Calabria): *Geogr. Fis. Dinam. Quat.*, 4: 11-21.
- & ZUFFA, G.G., 1976, Geologia e petrografia del Foglio Bisignano (Bacino del Crati, Calabria) con carta geologica alla scala 1:50.000: *Geol. Rom.*, 15: 233-270.
- OGNIBEN, L., 1973, Schema geologico della Calabria in base ai dati odierni: *Geol. Rom.*, 12: 243-585.
- ROMEO, M. & TORTORICI, L., 1980, Stratigrafia dei depositi miocenici della Catena Costiera calabra meridionale e della media Valle del F. Crati (Calabria): *Boll. Soc. Geol. It.*, 99: 303-318.
- RUGGIERI, G., 1959, La fauna Calabrian di Cosenza: *Giorn. Geol.*, 22 (2): 118-127.
- TORTORICI, L., 1981, Analisi delle deformazioni fragili dei sedimenti postorogeni della Calabria settentrionale: *Boll. Soc. Geol. It.*, 100: 291-308.
- , MONACO, C., TANSI, C. & COCINA, O., 1995, Recent and active tectonics in the Calabrian arc (Southern Italy): *Tectonophysics*, 243: 37-55.
- VEZZANI, L., 1968, I terreni plio-pleistocenici del basso Crati (Cosenza): *Atti Acc. Gioenia Catania*, 20: 28-84.
- ZIBROWIUS, H., 1980, Les Scléractiniaires de la Méditerranée et de l'Atlantique nord-orientale: *Mém. Inst. océanogr. Monaco*, 11: 1-284.

(manuscript received November 30, 1996
accepted June 30, 1997)

Maria Pia BERNASCONI
Dipartimento di Scienze della Terra
87036 Arcavacata di Rende (CS), Italy
e-mail: bernasconi@unical.it

Cesare CORSELLI
Dipartimento di Scienze della Terra
Via Mangiagalli 34, 20133 Milano, Italy
e-mail: ccor@hp715.gp.terra.unimi.it

Luigi CAROBENE
Dipartimento di Scienze della Terra
Corso Europa 26, 16132 Genova, Italy
e-mail: carobene@dister.unige.it