

BIOEROSION OF THE PLIO-PLEISTOCENE TRANSGRESSION OF SOUTHERN ITALY

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Riassunto. Durante il Pliocene e il Pleistocene Inferiore l'unità strutturale delle Murge fu in gran parte progressivamente sommersa dal mare. L'inizio dell'ingressione, fu evidenziato da numerose tracce di bioerosione conservate su strati e ciottoli calcarei, che furono ricoperti da sedimenti carbonatici (Calcarenite di Gravina). L'ingressione avvenne con modalità diverse da luogo a luogo come conseguenza della preesistente morfologia del substrato controllata dalle condizioni strutturali. Le quattro località scelte per lo studio delle bioerosioni, rappresentano biotopi marini poco profondi, in situazioni paleogeografiche differenti. Sono state distinte quattro associazioni di tracce fossili: associazione a *Caulostrepsis*-*Maeandropolydora*, associazione a *Gastrochaenolites cor*, associazione a *G. torpedo* - *Entobia*, associazione ad alta diversità di *Entobia*. Tutte indicano ambienti marini poco profondi e sembrano essere ricorrenti in situazioni simili, dipendenti in particolare dalla morfologia a piccola scala del substrato e dall'idrodinamismo dei biotopi. Tre nuove icnospecie, *Gastrochaenolites cor*, *Maeandropolydora barocca* e *Maeandropolydora crassa* sono state istituite.

Abstract. During the Pliocene and Lower Pleistocene, the structural unit of the Murge was largely submerged by a marine transgression. As the sea advanced, the limestone basement surface was invaded by bioeroding organisms whose borings are well preserved through burial by the calcareous sediments of the Calcarenite di Gravina formation. The tilted-block topography of the submerging Murge unit produced different coastal environments ranging from protected gentle slopes to exposed vertical clifflines. Details of the bioerosion were examined at four localities that cover a range of those environments. The 35 ichnotaxa recognized (excluding microborings) are treated taxonomically where necessary, and their relative distributions and occurrences are studied. Three new ichnospecies are erected: *Gastrochaenolites cor*, *Maeandropolydora barocca* and *M. crassa*. Four recurring assemblages are recognized: *Caulostrepsis/Maeandropolydora* assemblage, *G. cor* assemblage, *G. torpedo/Entobian* assemblage and a High Diversity Entobian-Dominated assemblage. All four indicate shallow marine environments, their relative distributions being influenced by environmental factors such as the attitude of the substrate surface and the hydrodynamic energy level.

Introduction.

During the Pliocene and Lower Pleistocene, the areas of the Gargano and the Murge of southeastern Italy were gradually inundated by the sea. The lime-

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stone basement rocks of the Murge, Mesozoic in age, record this transgression clearly by the initial bioerosional attack they underwent from boring and scraping organisms before the basal calcarenitic sediment of the Tertiary/Quaternary (Calcarenite di Gravina formation) buried these surfaces. Within the transgressive carbonate sediments, horizons of limestone pebbles brought in laterally from nearby coastal areas, also provided a rich source of substrates for bioeroding organisms.

The central area of the Murge remained unsubmerged at the time of the maximum marine inundation (Lower Pleistocene) and formed two main islands (Fig. 1) (Pieri, 1980, p. 17). The gradual transgression, however, introduces stratigraphic and environmental reconstructional problems, in that the basal beds of the Calcarenite di Gravina formation have different ages at different locations; and furthermore, there is the added complication of temporally changing water depth that allows the possibility of the work of successive communities of bioeroders, characteristic of different environments, to be overprinted in the same limestone basement or pebbles. With these problems in mind, we decided to make a detailed survey of the hard substrate trace fossils, both in the Mesozoic basement and conglomeratic pebbles as well as, to a lesser extent, within larger skeletal clasts. This work was made possible by the success with which resin casts can be made of the borings (Bromley & D'Alessandro, 1983, p. 285), their filling material being largely uncemented. The assemblages are dominated by the ichnogenera *Caulostrepsis*, *Maeandropolydora*,

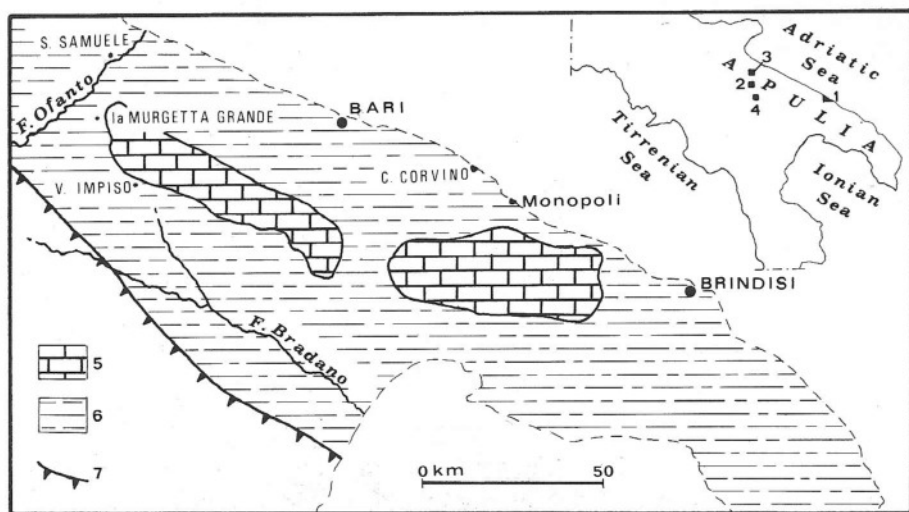


Fig. 1 — Localities mentioned in the text and an indication of Plio-Pleistocene coastline in Puglia. 1) Torre d'Orte — Cala Corvino; 2) La Murgetta grande; 3) San Samuele di Cafiero; 4) Vallone Impiso; 5) Mesozoic limestone; 6) Plio-Pleistocene sediments; 7) Thrust.

Entobia and *Gastrochaenolites* recently discussed by Bromley & D'Alessandro (1983, 1984) and by Kelly & Bromley (1984). In the present report we turn to the remaining ichnotaxa, many of which are insufficiently described in the literature, and offer some conclusions concerning the significance of the whole assemblage in regard to palaeoenvironmental reconstruction.

The localities and environmental setting.

Since Eocene times and until at least the Pleistocene, the rise of the Apennines has produced the uplift of the Murgian area, the tectonic development and erosion of which created a karstic physiography of very characteristic form. At the time of the Plio–Pleistocene transgression, as now, the area had an asymmetrical form that was produced by the asymmetrical horst structures having larger throw on the Bradanic and Ofanto margins than on the Adriatic margin (Ricchetti, 1981, pl. 1). The transgressional history of the area obviously differed according to the topographic features of the surfaces inundated (Iannone & Pieri, 1979). The steeper sides were characterized by rapid bathymetric changes but little lateral migration of coastlines as the rising sea-level progressed up slope, producing open–marine cliff–line settings. In contrast, the Adriatic margin having lower throws, was characterized by low topography, rapid lateral coastline migration during transgression, with the simultaneous establishment of protected environments involving early sediment accumulation on the gently sloping shelves.

The material on which the present report is based comes from four localities (Fig. 1) that represent contrasting situations within this frame. The localities that yielded material for the earlier studies (Torre d'Orta and Cala Corvino near Monopoli) (Bromley & D'Alessandro, 1984) lie on the gradual slope of the Adriatic margin; San Samuele di Cafiero represents the inundation of an exposed steep island on the north margin with rapidly increasing water depths; La Murgetta grande represents a shallow threshold connecting one small island to the close, northern massif; and Vallone Impiso lies on the steeply faulted, tectonically most active NW margin.

1. Torre d'Orta and Cala Corvino (Monopoli) (F° 190 I NW (1)).

The exposures of the boundary along the coast at Torre Incine and Cala Corvino are the best known among those used in this study owing to previous investigation of the sedimentology and palaeontology of the Calcarenite di Gravina formation in that area by D'Alessandro & Iannone (1984). We are concerned here not only with the base of the formation in contact with the under-

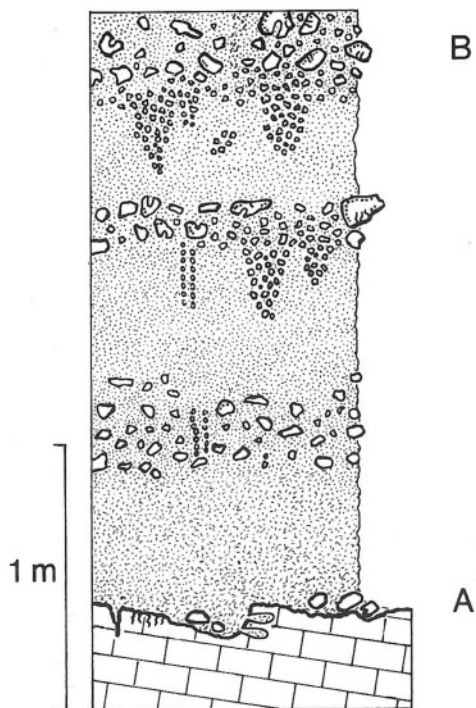


Fig. 2 — Basal Calcarenite di Gravina (stippled) and boundary features of Cala Corvino, Monopoli. Bioerosion is indicated, showing bivalve and worm borings.

lying Cretaceous limestone (Calcare di Bari), but also with horizons of limestone pebbles about 1 to 2 m above it (Fig. 2).

The topography of the basal contact is flat to gently undulating and the limestone bears a depauperated bioerosional community. The overlying carbonate sediment varies from reddened conglomeratic deposits (at Torre Incine) to, further south, grainstone of lithobioclastic sand. Body fossils are generally lacking and bioturbation (small pebble-lined shafts) and large collapse pockets derive from higher levels. Thus the basal unit corresponds to a marginal environment in a highly protected setting.

The limestone pebbles above the base have a quite different palaeontological aspect: the bioturbation of the surrounding carbonate sands becomes marked, including increased numbers of pebble-lined shafts and sinuous passages; the body fossil content also increases considerably. The pebbles of limestone, more or less untransported, are deeply bioeroded by a diverse endolithic community. A more open marine environment is indicated.

The body fossils suggest uppermost Pliocene or lowermost Pleistocene.

2. La Murgetta grande (F° 176 III NW).

This locality comprises two exposures in road cuttings about 1 km apart (I and IV), showing the limestone basement (Calcare di Bari) overlain by Calca-

LA MURGETTA GRANDE I

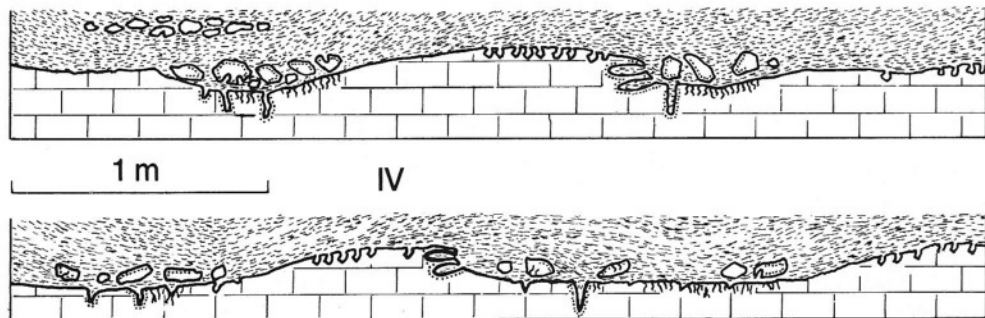


Fig. 3 – Basal Calcarenite di Gravina (stippled) and details of boundary features at exposure I and IV, La Murgetta grande. The distribution of bivalve, worm and (dots) sponge borings indicated.

renite di Gravina (Fig. 3). The two exposures are separated by a depression in the basement that is filled with carbonate sediment indicating deposition in a fully marine nearshore bar setting. Northward the widespread slope of the basement surface within a broad embayment (Iannone & Pieri, 1979) allowed direct access to open marine conditions without any initial protected phase. The contact at both localities undulates gently and is locally covered with a thin layer of boulders. Small scale topography shows that erosion of the basement was in progress and that the boulders are probably little transported. The endolithic trace fossils are well preserved and abundant, and show strong polarization according to subenvironment.

The age of the sediments has been a subject of discussion but a Pliocene age is indicated by the macrofauna (Bromley & D'Alessandro, 1984).

3. San Samuele di Cafiero (F° 176 IV NW).

An exposure in a limestone quarry of Calcare di Bari formation located along the Ofanto River in the plain at the north of the Murge limestone plateau. The locality coincides with a small horst that defined one of an archipelago of steep islands, at an early stage of the Calcarenite di Gravina transgression. In the highest levels of the quarry the bioeroded transgression surface is exposed (Fig. 4). Locally some horizontal surfaces are seen at the top of the section but chiefly it is a case of vertical fault scarp surfaces lightly bioeroded (bases of *Gastrochaenolites torpedo* are preserved). These are interrupted by littoral notches (at least two) locally deep and well developed.

The limestone is overlain by calcarenite containing bioeroded *Neopycnodonte* shells associated with rare *Crania* and *Corallium* found *in situ*, together with *Hinnites*, *Mytilus* and balanids.

4. Vallone Impiso (F° 188 IV NE).

The locality lies in a river valley on the steep western margin of the Murge plateau. The environmental pattern is complicated, as a consequence of syn-sedimentary tectonics and fluctuations in the Plio–Pleistocene transgression. Figure 5 shows the succession at the southeastern end of the locality (taking the railway bridge as landmark). The sequence, from bottom to top, is as follows:

- coarse, unbedded calcarenite, apparently non-marine, that becomes poorly bedded toward the top. Visible thickness 2 m (Unit 1);
- fine grained unbedded calcarenite about a metre thick. Contacts with both underlying and overlying intervals are abrupt (Units 2, 4). Between units 2 and 4 is a horizon (Unit 3) of limestone blocks and pebbles of all sizes up to 4 m (Fig. 6A) showing various degrees of bioerosion, the larger clasts bearing a littoral notch. Thickness is variable;

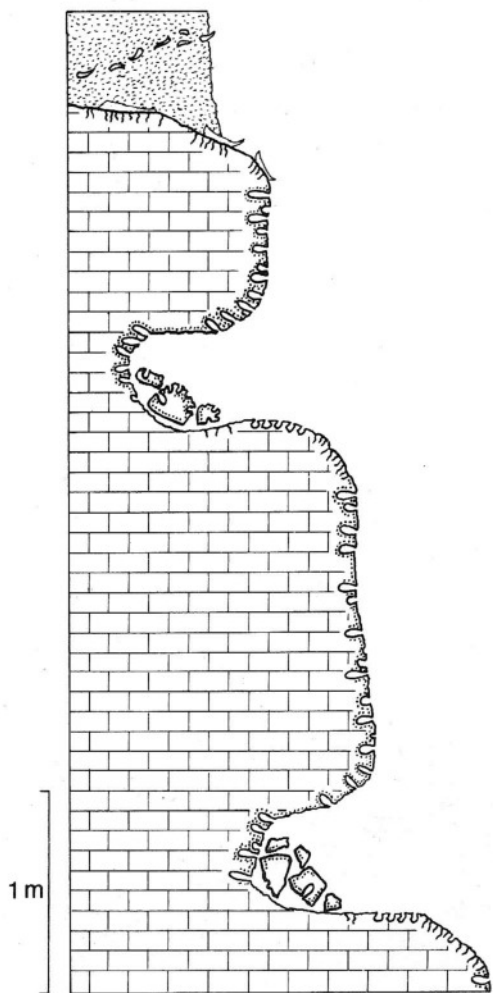


Fig. 4 – Bioerosional topography of fault scarp and upper surface of limestone (symbols as Fig. 3) at San Samuele di Cafiero. Encrusting bivalves are indicated; the overlying Calcarenite di Gravina (stippled) contains *Neopycnodonte*.

- coarse bedded calcarenite (Unit 5), festooned by about 50% bioturbation of meniscus type, probably *Scolicia* produced by echinoids (Fig. 7). Thickness 1.80 m;
- coarse and unbedded calcarenite probably fully bioturbated (Unit 6). Thickness 1 m;
- coarse calcarenite containing increasingly visible *Thalassinoides* boxworks upwards

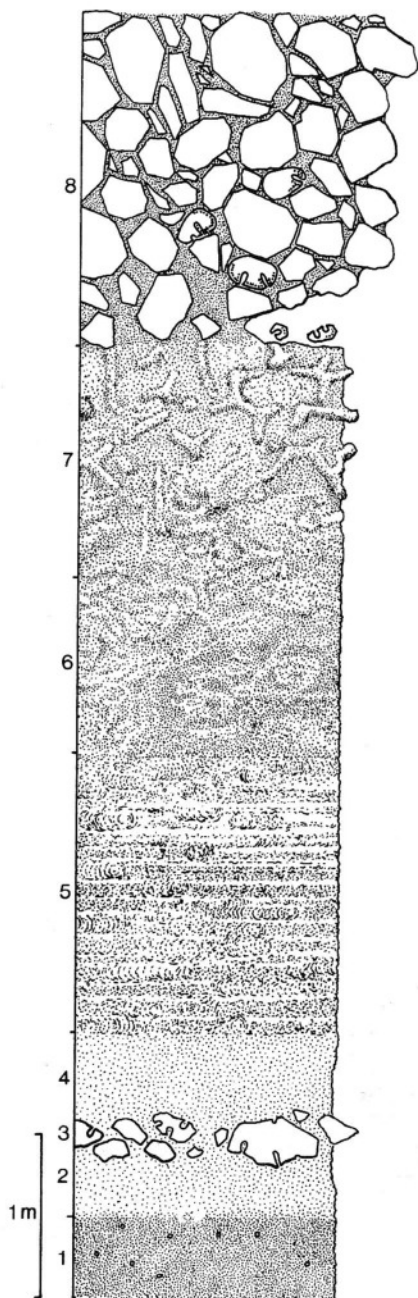


Fig. 5 – Sequence at the southeast end of the exposure at Vallone Impiso. Bioerosion and bioturbation are indicated. Beds 1 to 8 are described in the text.

(Fig. 8) associated with shafts and *Skolithos*. Thickness 2.30 m (Unit 7). This continues up into the next unit as a matrix at the base;

– megabreccia, consisting of angular limestone clasts but incorporating a few rounded, bioeroded limestone pebbles, and containing on the whole little matrix (Unit 8). The contact with the underlying unit is locally erosive and in places a notch is developed that resembles a deep littoral notch and is floored by rounded, bioeroded pebbles. Seen for 2 m.

Above this sequence calcarenites return, culminating in a prograding megaset of cross-bedded, marine carbonate sands over 10 m thick, which locally tops the succession. This unit is rich in fossils including *Pecten planariae* (abundant in the Pliocene), *P. jacobaeus*, *Chlamys opercularis*, *Ostrea* sp. and several echinoids and barnacles. *Thalassinoides* and pebble-lined shafts are common, bioturbation levels being high.

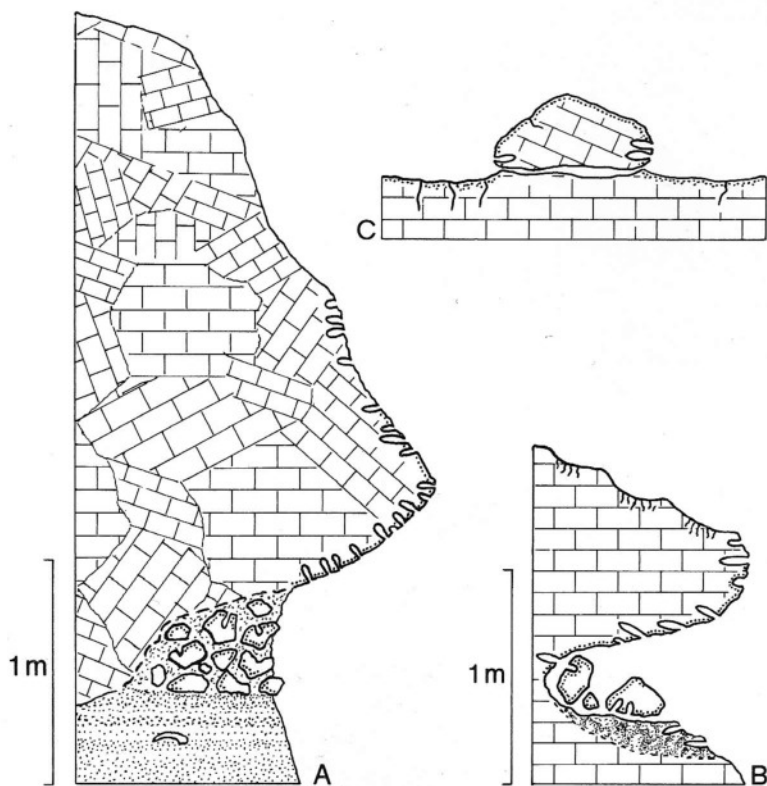


Fig. 6 – Details of bioerosion contacts at Vallone Impiso.

A) Notch in bed 3 at southeast end. B) Notch in basement limestone floored by cemented, bioturbated, bioeroded calcarenite, at northwest end. C) Basal contact on flat limestone near bridge at northwest end; boulder locally inhibiting bioerosion of the underlying limestone.

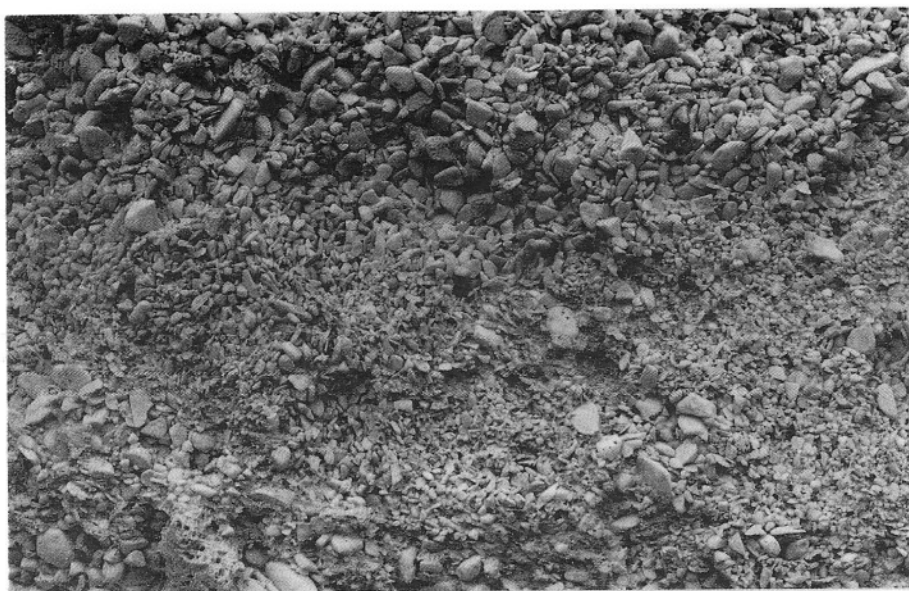


Fig. 7 – Bed 5 at Vallone Impiso (natural size). Note the festoon structure, probably produced by bioturbating echinoids.

As the lower part of the sequence (Units 1 to 8) is traced northwards, lateral variation is considerable. However, the littoral notch remains approximately at the level of the bed of limestone blocks, until this arrives in contact with the rising limestone basement. At the critical point, exposure is poor. At some places, however, the notch is flooded by cemented calcarenite, which also has been bioeroded (Fig. 6B).

Continuing north–westward to the bridge, the basement rises well above the notch level. This generally flat limestone floor also is bioeroded, as are boulders strewn over its surface, but the base of these clasts have protected the subjacent limestone floor, which has escaped colonization by endoliths (Fig. 6c; Fig. 9); the boulders clearly remained stationary on the sea floor.

Ichnotaxonomy

In the basal part of the Calcarenite di Gravina formation and its basement surface, a diversity of hard–substrate trace fossil taxa was encountered (Table 1). Many of these forms have been adequately treated taxonomically, as indicated in the list, and need no further comment here. However, a few require additional remarks and several forms are new or have not been discussed recently. These ichnotaxa are treated in the following.

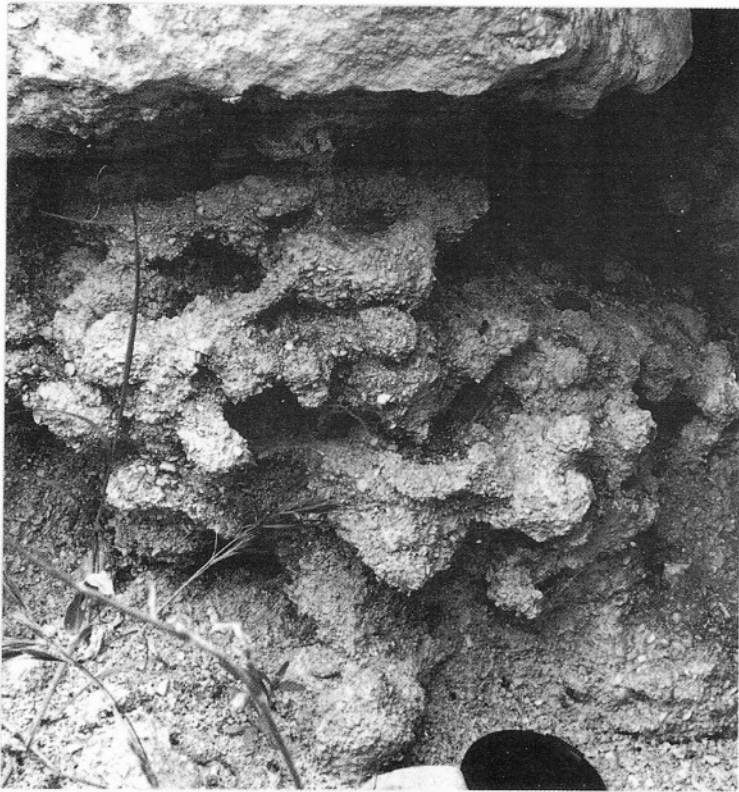


Fig. 8 — Uppermost metre of bed 7 at Vallone Impiso. *Thalassinoides* bioturbation in very coarse sand. Scale 5 cm.

Ichnogenus *Conchotrema* Teichert, 1945

1916 *Clionolithes* — Price, p. 688 (not Clarke, 1908).

1918 *Clionolithes* — Price, p. 790.

1945 *Conchotrema* Teichert, p. 203.

Diagnosis. Fine tubular boring networks in lithic substrates showing irregularly repeated branching and anastomosing in all directions. Rarely more than a few millimetres between branches, but density of ramification varies. Boring diameter ranges between approximately 0.1 and 0.25 mm. Course almost straight to sinuous contorted. Apertures numerous.

Remarks. In spite of the virtually identical definitions of *Talpina* Hagenow, 1840 and *Conchotrema* Teichert, 1945 (in Häntzschel, 1975) these igenera (1)

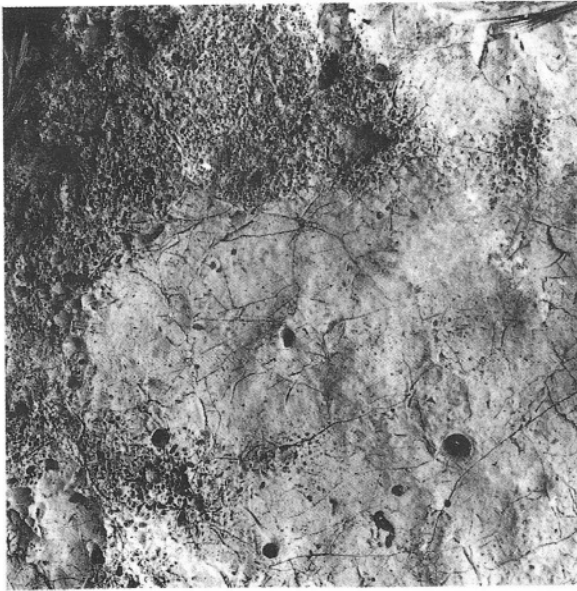


Fig. 9 – The limestone basement, at Vallone Impiso, near the bridge. The general bioerosion has locally been inhibited by the large boulders that lay on the surface. The smoother patches visible here represent resting places of boulders. Field photo; x 0.3.

cannot be considered synonymous. The branching pattern of the type species *T. ramosa* Hagenow is very characteristic in idiomorphic specimens; it is radially arranged, branching laterally to one side only, the branches are gently curved, apertures are uniformly distributed according to branching points and branching terminations, and there is no anastomosis (Bromley, 1970, fig. 1, 3; Voigt, 1975, pl. 15, fig. 1). *Talpina hirsuta* Voigt shows the same branching and aperture characteristics (Voigt, 1975, pl. 16, fig. 1, 2). On the contrary, *Conchotrema* appears much less well organized, the irregular net involving both branches and anastomoses and there are fewer apertures. Voigt (1972, 1975) suggested that both *Talpina* and *Conchotrema* are the work of endolithic phoronids.

Teichert (1945) erected *Conchotrema tubulosa* as type species, but noted that Price's species *Clionolithes canna* (1916) differed from the holotype of *C. tubulosa* only in degree of crowding and in density of branching. However, among the illustrated material, other specimens of *C. tubulosa* were as densely branched as *Clionolithes canna* (Teichert, 1945, p. 206). Price's (1916) original description of *C. canna* admirably covers the morphology of *C. tubulosa*. Thus we consider the two species as synonyms, although his igeneric attribution cannot be accepted. *Clionolithes* Clarke, 1908 includes dichotomously branched

Table 1 — Hard—substrate trace fossils of the Calcarenite di Gravina formation.

NAME		REFERENCES
<i>Caulostrepsis contorta</i>	B. & D., 1983	Bromley & D'Alessandro, 1983
<i>Caulostrepsis cretacea</i>	(Voigt, 1971)	Bromley & D'Alessandro, 1983
<i>Caulostrepsis taeniola</i>	Clarke, 1908	Bromley & D'Alessandro, 1983
<i>Caulostrepsis</i> isp. 1		Bromley & D'Alessandro, 1983
<i>Conchotrema canna</i>	(Price, 1916)	Teichert, 1945 *
<i>Entobia cateniformis</i>	B. & D., 1984	Bromley & D'Alessandro, 1984
<i>Entobia geometrica</i>	B. & D., 1984	Bromley & D'Alessandro, 1984
<i>Entobia laquea</i>	B. & D., 1984	Bromley & D'Alessandro, 1984
<i>Entobia mammillata</i>	B. & D., 1984	Bromley & D'Alessandro, 1984
<i>Entobia megastoma</i>	(Fischer, 1868)	Bromley & D'Alessandro, 1984
<i>Entobia retiformis</i>	(Stephenson, 1952)	*
<i>Entobia ovula</i>	B. & D., 1984	Bromley & D'Alessandro, 1984
<i>Entobia paradoxa</i>	(Fischer, 1868)	Bromley & D'Alessandro, 1984
<i>Entobia volzi</i>	B. & D., 1984	Bromley & D'Alessandro, 1984
<i>Entobia</i> isp. A		*
<i>Entobia</i> isp. B		*
<i>Gastrochaenolites cor</i>	nov. isp.	*
<i>Gastrochaenolites dijugus</i>	Kelly & Bromley, 1984	Kelly & Bromley, 1984
<i>Gastrochaenolites lapidicus</i>	Kelly & Bromley, 1984	Kelly & Bromley, 1984
<i>Gastrochaenolites torpedo</i>	Kelly & Bromley, 1984	Kelly & Bromley, 1984
<i>Gastrochaenolites</i> cf. <i>turbinatus</i>	Kelly & Bromley, 1984	Kelly & Bromley, 1984
<i>Gnathichnus pentax</i>	Bromley, 1975	Bromley, 1975
? <i>Lapispecus</i> isp.		*
<i>Maeandropolydora barocca</i>	nov. isp.	*
<i>Maeandropolydora crassa</i>	nov. isp.	*
<i>Maeandropolydora decipiens</i>	Voigt, 1965	Bromley & D'Alessandro, 1983
<i>Maeandropolydora elegans</i>	B. & D., 1983	Bromley & D'Alessandro, 1983
<i>Maeandropolydora sulcans</i>	Voigt, 1965	Bromley & D'Alessandro, 1983*
<i>Radulichnus inopinatus</i>	Voigt, 1977	Voigt, 1977
<i>Rogerella pattei</i>	(Saint-Seine, 1954)	Codez & Saint-Seine, 1958*
<i>Rogerella</i> isp.		*
<i>Trypanites fimbriatus</i>	(Stephenson, 1952)	*
<i>Trypanites solitarius</i>	(Hagenow, 1840)	*
Sponge-bored pits associated with <i>Conchotrema crassa</i> —like form.		*
Spiral etching traces		Radwansky, 1977
Microborings (bryozoans, thallophytes)		

* Itaxa discussed in this paper.

B. & D. = Bromley & D'Alessandro.

galleries radiating from a single central cavity. In agreement with Teichert (1945, p. 203) we regard Price's species as *Conchotrema* and consequently we refer our material to *Conchotrema canna*.

Conchotrema differs from *Maeandropolydora* in its small size, repeat ramifications as well as in lacking pouches. In particular *M. sulcans*, the closest species, is larger and far less frequently branched than *Conchotrema*.

Conchotrema canna (Price, 1916)

Pl. 39, fig. 2; Pl. 40, fig. 2, 6; Pl. 41, fig. 4; Pl. 43, fig. 2; Pl. 44, fig. 3; Pl. 47, fig. 4

1916 *Clionolithes canna* Price, p. 688, pl. 30, fig. 1.

1918 *Clionolithes canna* - Price, p. 790.

1921 *Clionolithes canna* - Clarke, fig. 91.

1945 *Conchotrema tubulosa* Teichert, p. 204, pl. 1, fig. 1, 2; pl. 2, fig. 1, 2; pl. 3, fig. 2-4.

1952 *Graysonia bergquisti* Stephenson, p. 53 (*partim*), pl. 9, fig. 4, paratype, U.S.N.M. 105086.

Diagnosis. Fine tubules, freely branching and anastomosing, so as to form in dense development an irregular mat of several strands' thickness; borings vary slightly in diameter, rarely more than 0.2 mm; seldom unbranched for as much as 2 mm between nodes; branches straight, more or less curved, to highly sinuous. Apertures numerous.

Description. This itaxon is characteristic through its relatively small size, constant diameter and frequent irregular branching. The boring usually occurs as a tangle of open loops within the outermost 5-6 mm of the substrate. Size is constant within individual networks, most ranging around 0.15 to less than 0.3 mm. Apertures are rarely visible in crowded substrates but are clearly numerous; in young individuals, beginning as a series of branched loops, apertures occur frequently (Pl. 39, fig. 2).

Occurrence. In oyster shell and limestone; numerous specimens from all localities.

Ichnogenus *Entobia* Bronn, 1838

Entobia retiformis (Stephenson, 1952)

Pl. 42, fig. 1, 3; Pl. 46, fig. 2, 3; Pl. 49, fig. 1-3; Text-fig. 10

1952 *Cliona retiformis* Stephenson, p. 51, pl. 8, fig. 1, 2, ? fig. 3.

Emended diagnosis. A camerate entobian composed in phase A of long, much branched exploratory threads. In phase B small, irregularly round chambers emerge from the expanding much branched intercameral canals. Phase C is characterized by pustulose, small rounded chambers evaginating from relatively

thick, cylindrical intercameral canals. The chambers may cover the canals entirely or, more usually, are scattered along them in rings or groups owing to cameral fusion. Apophyses sparse. In some examples, phase D occurs, showing crowding of camerate branches in interspaces. Apertures circular, of two sizes, small.

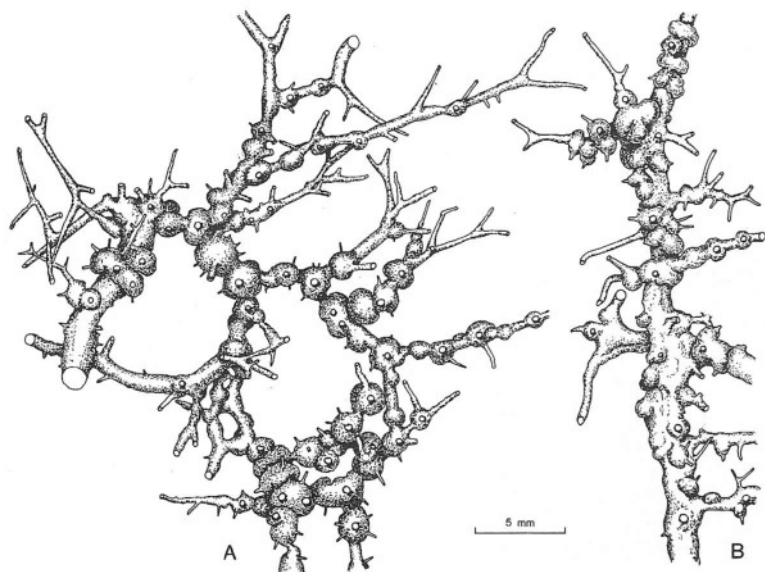


Fig. 10 — *Entobia retiformis* (Stephenson). Sketched from two specimens from La Murgetta grande. A) MGUH 17482, showing well developed growth phases A and B but poor C. B) MGUH 17499, a fragment demonstrating more typical growth form of phase C.

Description. Phase A is well developed in this entobian. Long exploratory canals, slightly palmate at nodal points, advance into the substrate and produce a linear to sinuous open front to the boring. During phase B, small irregularly round chambers emerge from the linear or sinuous intercameral canals, at first annulations resembling beads on a thick string. This phase may extend for a centimetre or more, the intercameral canal expanding until, in phase C, it is wider than the initial chambers. These now are fused irregularly in groups and arranged like subspherical pustules and incomplete rings along all sides of the canal, sometimes covering it completely and giving a somewhat irregular appearance to the sinuous network of branches. Apophyses are not common but even in phase C, long exploratory threads may emerge from the chambers. Extra side branches are also produced so that in some cases phase D is reached, where intercameral spaces become occupied by groups of fused chambers and the sinuous pattern becomes less marked. Crowding, however, has only been observed in stenomorphs. Chambers 0.9 to 2.4 mm in diameter.

A two-tier system may develop, and branches may delve some millimetres below the substrate surface. Where at the surface, each fused chamber may bear an aperture on a long apertural canal, but the deeper chambers largely lack direct connection with the surface. Apertures are of two sizes, small ones averaging 0.3 mm, connecting with chambers, sparser large ones, averaging 0.6 mm at the termination of the intercameral canal system. The characteristic entobian wall ornament is present as usual.

Remarks. The morphological features of our material correspond closely to those of the holotype of *Cliona retiformis* Stephenson together with one of the paratypes (Pl. 49, fig. 1-3), showing the same arrangement of pustulose chambers and reticulate development. The type material is housed in the United States National Museum of Natural History, Smithsonian Institution, Washington, D.C., where we have studied and photographed it. Stephenson (1952) supplied no strict diagnosis and his description is in very general terms, so we have given here an emended diagnosis for *Entobia retiformis* on the basis of the type material and our idiomorphic examples in limestone. The features of Stephenson's entobians are on a somewhat smaller scale than ours, being slightly stenomorphic in shells, although the holotype includes growth phase C and the paratype has reached phase D.

In some respects this entobian resembles *E. volzi* Bromley & D'Alessandro (Pl. 43, fig. 5) i.e. in shape and development of chambers as well as in the possession of very wide intercameral canals. However, the overall form of the two borings is entirely different. *E. volzi* is built on a finer scale, having smaller chambers, and advances with closed front, having short exploratory threads and highly compact form. Another similar species is *E. ovula* Bromley & D'Alessandro. However, the manner in which the rounded chambers fuse together so as to obliterate any canal between them, distinguishes *E. retiformis* from *E. ovula*, although the sizes of the two are similar.

Occurrence. Numerous casts from La Murgetta grande, Cala Corvino (Monopoli), a few from Vallone Impiso.

Entobia ichnosp. A

Pl. 43, fig. 6; Pl. 48, fig. 1, 2

Remarks. A hitherto undescribed entobian occurs in four samples, three limestone boulders from Vallone Impiso and an oyster from La Murgetta grande. The limestone boulders contain six borings by gerontic individuals and the oyster contains three much smaller structures but apparently of the same form. The borings have a somewhat stellate outline, several branches radiating from the centre. These branches are non-camerate and taper rapidly in short

cylindrical distal exploratory canals. Elsewhere on the boring, both exploratory canals and apophyses are greatly reduced and the ontogenetic phases A to E are telescoped into a very short distance. The three juvenile borings show similarly contracted development, the branches being almost conical; they show some resemblance to the juvenile clionid boring illustrated by Bromley (1970, fig. 2d). Where the roof of the «gerontic» borings is intact, crowded, large apertures are seen, from 1.2 to 20 mm in diameter, 2 to 4 mm apart.

Occurrence. Three specimens from La Murgetta grande, four from Vallone Impiso.

Entobia ichnosp. B

Pl. 46, fig. 1

Remarks. In a limestone boulder from Cala Corvino, a characteristic and distinct, unnamed entobian is present. It is the largest chambered entobian in the present material, is strongly camerate, and resembles a gigantic *E. geometrica* Bromley & D'Alessandro (Pl. 43, fig. 1; Pl. 45, fig. 1). The two measurable chambers are 10 mm long \times 13 mm and 14 \times 14 mm respectively. They are irregularly rounded, having grown to interfit but not fuse. The opposed surfaces of adjacent chambers are interconnected by many fine intercameral canals. Apertural details unknown (the specimen has lost its roof) but wall microornament of normal sponge-type is preserved. Apophyses probably numerous but have not survived the casting technique.

Owing to the sparseness of the material the entobian is not formally named here. Even if the morphology of the chambers corresponds closely to the boring of *Cliona rhodensis* Ruetzler & Bromley, we have not enough material to know if all phases of the boring system have similar development.

Occurrence. One cast from Cala Corvino.

Ichnogenus *Gastrochaenolites* Leymerie, 1842

Gastrochaenolites cor ichnosp. nov.

Pl. 39, fig. 8; Pl. 40, fig. 5; Pl. 41, fig. 1; Pl. 42, fig. 2, 4, 6; Text-fig. 11

Derivation of name. *Cor*, Latin = heart.

Type series. Holotype MGUH 17466 (Pl. 42, fig. 2, 4, 6); paratypes MGUH 17467 (Pl. 40, fig. 5), MGUH 17468-9.

Type horizon. Calcarenite di Gravina.

Geological age. Pliocene.

Type locality. La Murgetta grande, Barletta (Bari).

Collocation. Geological Museum, University of Copenhagen, Denmark.

Diagnosis. Smooth *Gastrochaenolites*, the somewhat discoid main chamber having a heart-shaped cross-section that is emphasized by a weak furrow running along both edges. The furrow fades out in the neck region; neck short and aperture round to oval, rarely reniform.

Remarks. The heart form of the cross-section easily distinguishes *G. cor* from *G. cluniformis* Kelly & Bromley; furthermore, the furrow (in the cast, ridge in the original) lies within the longer axis of the cross-section in *G. cor* (Fig. 11) and the shorter in *G. cluniformis*. There is no visible lining.

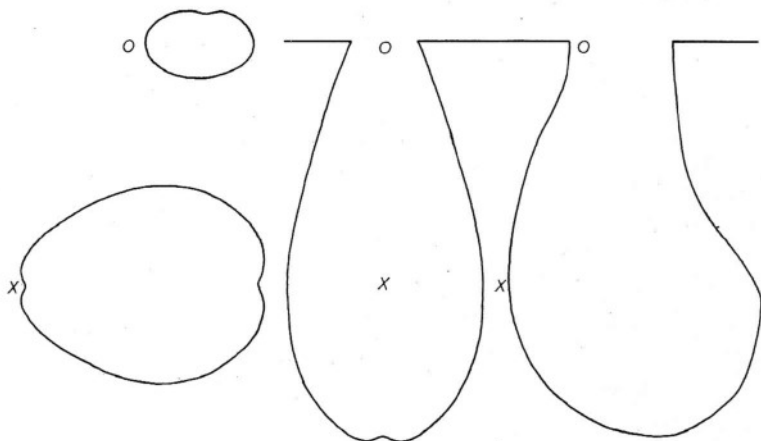


Fig. 11 — *Gastrochaenolites cor* isp. nov. Idealized section based on the holotype.

Shell casts are commonly preserved in the borings. Some of these belong to *Petricola lithophaga* (Retzius) that could be considered the original borer; numerous examples belong to the nestler *Irus irus* (Linnaeus), while other shells (e.g. *Spisula subtruncata*) accumulated passively in the borings. *G. cor* has been found mainly on the upper surface of limestone together with small *G. torpedo*.

Occurrence. Very abundant at La Murgetta grande (14 casts in addition to type material), Cala Corvino (one cast), Vallone Impiso (one cast). Abundant at San Samuele.

Maeandropolydora Group

We have placed the following itaxa within the *Maeandropolydora* Group, on the basis of the presence of both pouches and branches interconnecting cylindrical galleries. *M. sulcans* and ?*Lapispecus* isp. lack pouches but are tentatively placed here on the basis of their close similarity in morphology and size to the interconnecting galleries of the pouched ispecies. *M. crassa* has very few,

poorly developed, rather cylindrical pouches; it may thus be considered transitional between the pouched ispp. on the one hand and *M. sulcans* and ?*Lapispecus* on the other.

<i>M. barocca</i>	isp. nov.	lateral vane and twisted pouches
<i>M. elegans</i>	Bromley & D'Alessandro	limited pouches
<i>M. decipiens</i>	Voigt	pouches
<i>M. crassa</i>	isp. nov.	few, poorly developed pouches
<i>M. sulcans</i>	Voigt	no pouches or vane
? <i>Lapispecus</i>	isp.	lateral vane

Isolated fragments of canals of the *Maeandropolydora* Group are common, as are also borings of juvenile individuals, but they cannot be referred to ispp. with certainty.

Ichnogenus *Maeandropolydora* Voigt, 1965

Maeandropolydora barocca ichnosp. nov.

Pl. 40, fig. 1, 2, 3; Pl. 43, fig. 3; Pl. 44, fig. 1, 2, 5; Pl. 47, fig. 1; Pl. 48, fig. 4;

Text—fig. 12, 13, 14

Derivation of name. Word artificially created from the Portuguese *barroco* by the Scholastics to indicate a complex process of logic involving alternation of

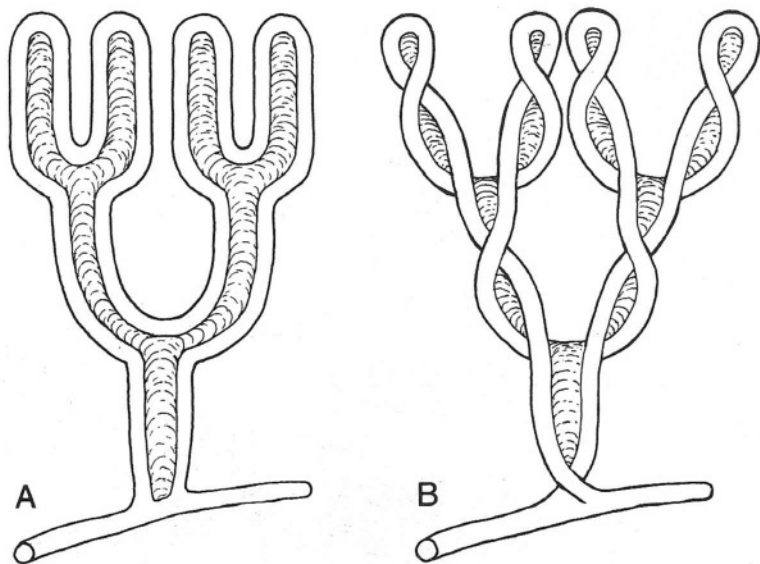


Fig. 12 — *Maeandropolydora barocca* isp. nov. Idealized sketches showing mode of branching. A) Simplified by the removal of the spiral twist; B) rendered in a single plane.

affirmatives and negatives, in reference to the paired dextral and sinistral twists of the boring. Moreover, the morphology is reminiscent of baroque ornament.

Type series. Holotype MGUH 17471 (Pl. 40, fig. 1; Text—fig. 13); paratypes MGUH 17472–6 (Pl. 47, fig. 1; Pl. 48, fig. 4; Text—fig. 13, 14; Pl. 40, fig. 3; Pl. 44, fig. 1).

Type horizon. Calcarenite di Gravina.

Geological age. Pliocene.

Type locality. La Murgetta grande, Barletta, Bari.

Collocation. Geological Museum, University of Copenhagen, Denmark.

Diagnosis. *Maeandropolydora* showing extreme development of pouches, each having a spiral course and tending to arise by bifurcation of other pouches. These structures are interconnected by branched cylindrical galleries locally possessing small, lateral vanes.

Description. The species is characterized by extreme development of very long, spirally twisted pouches. These have a clearly visible marginal gallery around a spreite-like vane, showing growth sculpture (cf. Bromley & D'Alessandro, 1983, fig. 7C). The pouches characteristically originate in pairs in a twisted manner from an original pouch, a third generation arising in some cases from each of these (Fig. 12). In idiomorphic examples these pouches tend to run parallel (Fig. 13). In most individuals, however, crowding by other borings causes stenomorphy (Fig. 14) and prevents full pouch development, and allows

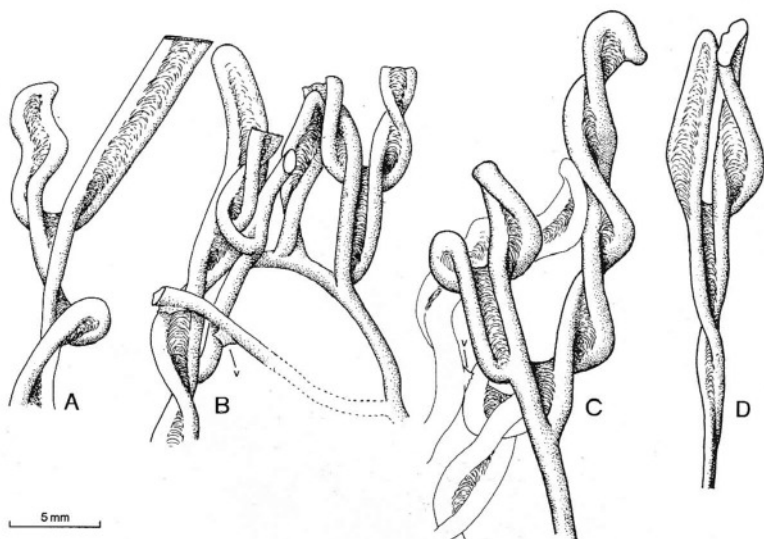


Fig. 13 — *Maeandropolydora barocca* isp. nov. La Murgetta grande. Camera lucida sketches of relatively idiomorphic specimens. A and B (Holotype), MGUH 17471; C (Paratype), MGUH 17475; D (Paratype), MGUH 17473; v) vane.

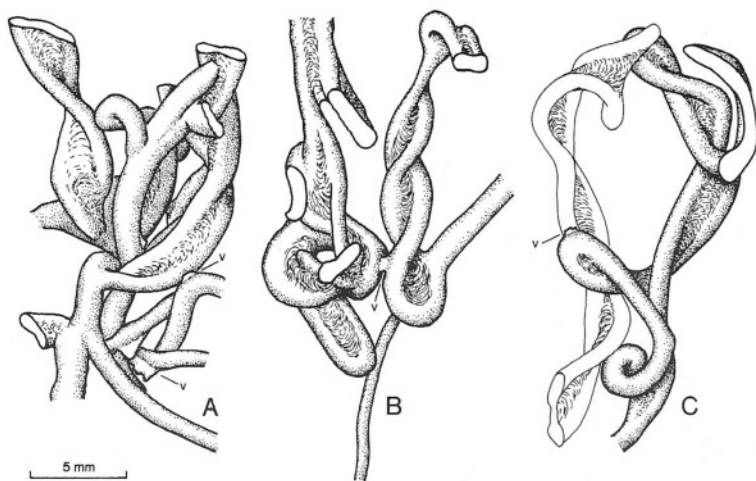


Fig. 14 — *Maeandropolydora barocca* isp. nov. Paratype. Camera lucida sketches of stenomorphic (A and B, MGUH 17473) and a relatively idiomorphic example (C, MGUH 17474). The example C represents two lobes (probably of one individual) which slightly interfere with each others' growth; v) vane.

ontogenetic stages to be seen. Pouches never intersect; they may just touch each other or more usually narrowly avoid contact. These structures are interconnected by winding, branching, cylindrical borings. A lateral vane may develop on the cylindrical borings for a very restricted distance where these come into the close vicinity of borings, other cavities or the rock surface (Fig. 13, 14) (in this way the vanes suggest some behavioural similarity to exploratory threads of the *Entobia* maker). Diameter of galleries varies from about 0.5 to 1.5 mm. Pouches can reach a length of 3 cm.

Remarks. *M. barocca* differs from *M. decipiens* Voigt in having considerably larger, spirally twisted pouches, and a tendency for a symmetrical mode of growth of these. The presence of lateral vanes has not been noted in *M. decipiens*. The twisted pouches in stenomorphic material may closely resemble *Caulostrepsis contorta* Bromley & D'Alessandro (Pl. 39, fig. 7). However, the more compact form of the latter, the manner in which its pouches lie in different planes, and the lack of connecting galleries, clearly distinguish these forms.

Occurrence. Numerous specimens in the transgressed limestone surface, but also in limestone boulders resting on this. Known only from the type locality.

***Maeandropolydora crassa* ichnosp. nov.**

Pl. 44, fig. 4; Pl. 45, fig. 2–5; Text—fig. 15

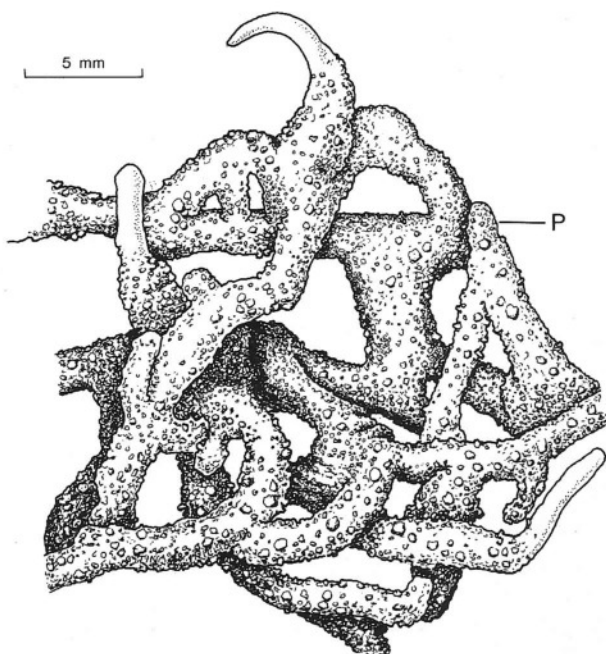


Fig. 15 – *Maeandropolydora crassa* isp. nov. Holotype. Sketch of part of boring showing coarse surface ornament and smooth blind terminations. A single reduced pouch (P) is visible.

Derivation of name. *Crassus*, Latin = large and fat.

Type series. Holotype, MGUH 17477 (Pl. 45, fig. 2–5; Text–fig. 15); paratype, MGUH 17479 (Pl. 44, fig. 4); unfigured paratype, MGUH 17478.

Type horizon. Calcarenite di Gravina.

Geological age. Pliocene.

Type locality. La Murgetta grande, Barletta, Bari.

Collocation. Geological Museum, University of Copenhagen, Denmark.

Diagnosis. Abundantly branched, large, cylindrical boring system in lithic substrates, the internodes straight, curved or sharply bent. At some sharp bends, a cylindrical continuation flattens out to become a small pouch. Many short, curved side branches end blindly. The wall of the boring is granular, scattered with minute protuberances (in cast), except in the slender terminations of blind branches, which normally are smooth. Boring diameter varies somewhat in individual networks. Apertures circular and numerous.

Description. Networks of coarse borings basically organized around loops perpendicular to surface, masked later by abundant side branches. Side branches numerous, tending to be a little narrower than the parent branch; many of these end blindly and taper somewhat before doing so. Internodes (more than 1.0 mm in diameter and ranging to 2.8 mm) may be straight, but generally

curve, commonly looping down from apertures at the surface. Very tight loops occur, some extending via a cylindrical branch into flattened but small pouches. Gently undulating elements perpendicular to the surface as well as short side branches ending blindly and normally tapering somewhat distally, are common in some material. The surface is uniformly irregular, sparsely covered with rounded minute protuberances (as seen in cast) except at the distal parts of blind branches, which tend to be smooth.

Remarks. The repetitive branching, numerous apertures and rare pouches indicate affinity of this species to *M. decipiens* (Pl. 39, fig. 5, 9; Text—fig. 16 E). However, the large size and the many, curved blind branches distinguish it from that species. The extreme rarity of the development of pouches in this form may suggest an intermediate position between *M. decipiens* and *M. sulcans*.

The granular wall in particular renders this form conspicuous in crowded assemblages. *M. crassa* tends to be idiomorphic and thus appears to represent an early, rapid colonization of the substrate, preceding entobians, which are emplaced stenomorphically in the remaining spaces around it.

In dolomitic substrates, where diversity of endoliths is greatly reduced, there are commonly some borings present that resemble *M. crassa*, although branching frequency there is much lower.

Occurrence. Limestone from La Murgetta grande and San Samuele di Cafiero; dubious at Vallone Impiso (see combination of borings).

***Maeandropolydora sulcans* Voigt, 1965**

Pl. 41, fig. 3; Pl. 42, fig. 3; Text—fig. 16 B—D

1983 *Maeandropolydora sulcans* Bromley & D'Alessandro, p. 294, pl. 21, fig. 4, 6; pl. 24, fig. 2; text—fig. 5 (*cum syn.*).

Remarks. This species was erected by Voigt (1965) for *Maeandropolydora* preserved chiefly as grooves on carbonate substrate surfaces. Bromley & D'Alessandro (1983) slightly emended the diagnosis by excluding forms containing pouches (placing those in *M. decipiens* Voigt) and emphasizing the full-boring preservation of the form. Half-borings are easily produced taphonomically by construction of whole borings along cracks in limestone, at cementation surfaces of oysters, along aragonite/calcite interfaces within shells and between *Gastrochaena* boring linings and their substrate. However, we are assured (E. Voigt, pers. comm., 1985) that original groove production over substrate surfaces, especially where these are buried superficially in sediment, also occurs frequently in this species.

The present excellently preserved material allows us to confirm the

branched nature of this species previously only tentatively suggested (Bromley & D'Alessandro, 1983, p. 295). Branching is not frequent, and long passages wind without showing ramification.

Included in this species also are arcuate borings formed in a wide U between two apertures (Fig. 16 B–D). All gradations of complication occur between these, via winding U–borings and branched U–borings to complex winding networks. In its simplest U form this species is comparable to *Pseudopolydorites radwanskii* Glazek, Marcinowsky & Wierzbowski (1971). However, in that form the scale is larger, the limbs more parallel and further development unknown.

M. sulcans is the only species in *Maeandropolydora* that lacks a vane or pouches. It is therefore intermediate in morphology between that genus and *Conchotrema* to which it may possibly show a closer affinity.

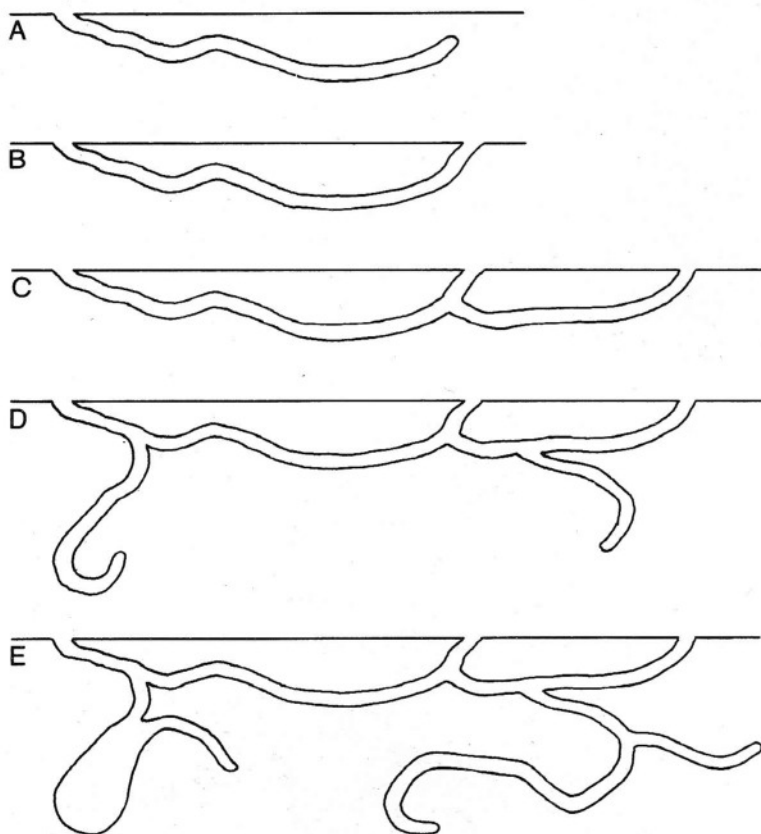


Fig. 16 – Morphology of different ichnotaxa shown as an ontogenetic series. A) *Trypanites solitarius*. B–D) *Maeandropolydora sulcans*. E) *M. decipiens*. See text for additional explanation.

Ichnogenus *Lapispecus* Voigt, 1970? *Lapispecus* ichnosp.

Pl. 43, fig. 3; Pl. 44, fig. 5

Remarks. In our material there are uncommon, incomplete lengths of cylindrical galleries possessing a lateral vane resembling that of *Lapispecus cuniculus* Voigt. The vane is narrower than in the type species and the boring further differs in being almost straight; it should be noted, however, that Voigt's material was highly stenomorphic and contorted.

Ichnogenus *Rogerella* Saint-Seine, 1951

The borings of acrothoracic cirripedes are easily identified as such, and occur from the Upper Palaeozoic to Recent (Seilacher, 1969). Many igeneric names have been applied, most of which are monospecific, although this group of trace fossils is extremely uniform and clearly requires but one or very few igenera. We select, therefore, the oldest available igenus to cover the present material.

1937 *Nygmites* Mägdefrau (non Häntzschel, 1962), p. 57 (*partim*), pl. 5, fig. 3, 4. *Nomen nudum*.

1951 *Rogerella* Saint-Seine, p. 1053.

1953 *Seminolithes* Hyde, p. 125.

1954 *Zapfella* Saint-Seine, pp. 448–449, pl. 18, fig. 1–3; pl. 19, fig. 1–5.

1958 *Simonizapfes* Codez & Saint-Seine, p. 704, pl. 37, fig. 2–4.

1958 *Brachyzapfes* Codez & Saint-Seine, p. 706, pl. 38, fig. 1, 2.

1980 *Seminolithes* – Rodriguez & Gutschick, p. 1356, text-fig. 1.

1984 *Bascomella* – Sando, p. 190, fig. 1 F, G.

Probably also *Bascomella* Morningstar, 1922 and *Graysonia* Stephenson, 1952 should be regarded as synonyms of this group. However, owing to the compound nature of these itaxa (Elias, 1957; Bromley, 1970) they are of dubious status.

***Rogerella pattei* (Saint-Seine, 1954)**

Pl. 39, fig. 3, 6

1954 *Zapfella pattei* Saint-Seine, pp. 448–449, pl. 18, fig. 1–3; pl. 19, fig. 1–5.

1958 *Zapfella pattei* – Codez & Saint-Seine, p. 707, pl. 39, fig. 1–6; text-fig. 4z.

Remarks. Our material possesses the features described by Saint-Seine (1954) and Codez & Saint-Seine (1958) as diagnostic for this species.

Occurrence. Rare, occurring in patches, at only two localities: at La Murgetta grande in limestone and oysters, and at San Samuele in limestone.

Rogerella ichnosp. A

Pl. 39, fig. 4; Pl. 40, fig. 7

Remarks. Limestone pebbles from Vallone Impiso contain eight specimens of *Rogerella* that deviate from *R. pattei*. They are both larger and more perpendicularly orientated (in the anterior—posterior plane) than that species. Lengths from 4 to 5 mm, greatest width 1.8 to 2.5 mm and the deepest is preserved to 5 mm depth. The anterior end is swollen as in *Rogerella pattei*. Four specimens are connected to *Maeandropolydora crassa* juveniles (Pl. 40, fig. 7), having been used by their makers as access points to the substrate.

Ichnogenus *Trypanites* Mägdefrau, 1932

- 1840 *Talpina* Hagenow (*partim*), (not species type), p. 671.
 1908 *Clionolithes* Clarke, p. 168 (*partim*), pl 8, fig. 2–5, 7, 8 (not species type).
 1921 *Palaeosabella* Clarke, fig. 78, 79, 81–83, 95, 99, 101–103 (non 100).
 1932 *Trypanites* Mägdefrau, p. 151.
 1952 *Specus* Stephenson, p. 51, pl. 8, fig. 4–6.
 1962 *Nygmites* Häntzschel, p. W230.
 1968 *Conchifora* G. Müller, pp. 68 (*partim*), 70, text—fig. 5, pl. 1, fig. 2; p. 72, text—fig. 5, pl. 1, fig. 9; pl. 5 fig. 1.
 1969b *Vermiforichnus* Cameron, p. 190, fig. 72.
 1971 «*Potamilla*» – Glazek et al., pp. 439–441 (*partim*), text—fig. 2a–g.
 1972 *Trypanites* – Bromley, p. 95 (*partim*), fig. 1 H, G, F.
 1979 *Trypanites* – Hofmann, p. 52, pl. 21 B–E.
 1979 *Vermiforichnus* – Hofmann, p. 54, pl. 22 A–F.
 1980 *Trypanites* – Pemberton et al., pp. 1258–65 (*partim*), pl. 1.
 1984 *Vermiforichnus* – Sando, p. 190, fig. 1D, 2A,D.

Calciroda Mayer, 1952 is dubious (Müller, 1956); it appears to be branched, thereby distinguishing itself from *Trypanites*.

Cameron (1969b, p. 692) suggested that *Gitonia* Clarke, 1908 was a synonym of *Vermiforichnus*. However, the type species of *Gitonia*, *G. corallophila*, clearly has two apertures (Clarke, 1908, p. 154) and in part is lined with a calcareous tube (Cameron, 1969b, p. 692). Therefore we doubt that this igenus may be considered a synonym of *Trypanites*. Clarke's second species, *G. siphon*, appears to be a simple cylindrical boring and may be considered a synonym of *T. solitarius*, but we have not examined the type material.

Diagnosis. Single—entrance, cylindrical or sub—cylindrical, unbranched borings in lithic substrates, having circular cross—section throughout length. The axes of the borings may be straight, curved or irregular.

Our understanding of the igenus *Trypanites* is more restricted than that of Bromley (1972) where non—cylindrical itaxa and xylic itaxa (see Kelly & Bromley, 1984) also were included. The igenus now comprises three species:

- Type species *Trypanites weisei* Mägdefrau, 1932
 Other species *Trypanites solitarius* (Hagenow, 1840)
Trypanites fimbriatus (Stephenson, 1952)

Remarks. The poorly characterized species of *Trypanites* are distinguished on the basis of unsatisfactory characteristics. *T. solitarius* and *T. weisei* are distinguished by their attitudes in the substrate, *T. solitarius* running closely beneath the surface, in contrast to *T. weisei*, which is considered to be perpendicular to the surface. However in the present material and in many other occurrences throughout the geological column from Cambrian to Recent, there is clearly a gradational series between two extremes, and the two taxa are not clearly distinguished on this basis. In his original description of *T. weisei*, Mägdefrau (1932, fig. 1) himself indicated an example at about 45° to the surface. (In 1937, however, Mägdefrau founded a new genus – *Nygmites* – on the basis of obliquity of such borings to the surface).

Another diagnostic character has been considered the straightness (*T. weisei*) as opposed to winding course (*T. solitarius*) of the boring (Bromley, 1972). This feature also appears to be an unsuitable taxobase. Deviations of a boring from a straight course can be caused by many factors: minor variations in the quality of the lithic substrate; avoidance of neighbouring borings; restricted size of the substrate, etc. *Trypanites weisei* was erected on the basis of idiomorphic borings in hardgrounds whereas *T. solitarius* was based on stenomorphic borings within the restricted material on belemnite rostra.

Trypanites weisei is considered the type species through monotypy. However, if, owing to their extremely weak diagnostic features and considerable overlap, *Trypanites weisei* Mägdefrau, 1932 were to be considered a junior synonym of the Hagenow species, *Trypanites* is invalid (igenus without species) and the species would be named *Talpina solitaria*. Unfortunately the name *Talpina* is not available for this form, as *T. ramosa*, the type species, is a branched boring quite unlike the discussed form. «*Talpina solitaria*» thus belongs elsewhere, as was noted by Mägdefrau himself (1937). This author indeed did not place it within his earlier igenus *Trypanites*, but included it in his new igenus, *Nygmites*. However, Häntzschel (1962), observed that *Nygmites* was a «*nomen nudum*, established without designation of the type species», and re-erected *Nygmites* on the basis of *Talpina solitaria* Hagenow, the first species described by Mägdefrau (1937) for *Nygmites*.

To sum up, if this course were followed, the validity of the igenus *Trypanites* could come into question: formally, if *Trypanites weisei* were considered junior synonym of *Talpina solitaria*, its designation as type species of *Nygmites* Häntzschel, 1962, would entail replacing the name *Trypanites* by *Nygmites*, being the oldest valid name.

It should be noted that, as shown in *Entobia* ispp. (Bromley & D'Alessandro, 1984), ontogeny plays an important rôle in the classification of borings. Thus it is obvious that every *Maeandropolydora sulcans* (cf. Fig. 16) must pass through a phase having but one aperture, where it will be classified as *T. solitarius*. This emphasizes a difference between *T. weisei* and *T. solitarius*, in that *T. solitarius* may be regarded as an insipient *M. sulcans*, whereas *T. weisei* may not.

The present material is insufficient in any case for taking a decision regarding the validity of the two ispecies. Borings of this type are sparsely represented, and chiefly in restricted pebble substrate, so that stenomorphy leads to an identification as *T. solitarius*.

Vermiforichnus clarkei Cameron 1969a (type ispecies by monotypy) has been used chiefly by American authors for borings having the same morphology as *Trypanites* (as defined herein) occurring in skeletal substrates of Palaeozoic age. We find, however, that *V. clarkei* comprises borings that are referable either to *Trypanites solitarius* (i.e. pl. 8, 3, 5, in Clarke, 1908; fig. 97, 101 in Clarke, 1921) or to *T. fimbriatus* (pl. 8, fig. 8 in Clarke, 1908; fig. 81, 82, 103 in Clarke, 1921). We see no reason for considering this itaxon as valid.

Cameron (1969a) did not give a diagnosis, either for his igenus or ispecies. Later Fillion & Pickerill (1984) supplied a diagnosis of *Vermiforichnus* on the basis of Cameron's description (1969a,b) corresponding to that of *Trypanites*. On the basis of their description and figures we cannot attribute their material with certainty to ispecies.

Trypanites differs from *Caulostrepsis* in being circular in cross-section. The lack of a constriction in the apertural/neck region and lower ratio diameter/length distinguishes it from *Gastrochaenolites*.

***Trypanites fimbriatus* (Stephenson, 1952)**

Pl. 42, fig. 5

- 1908 *Clionolithes (Vioa) priscus* Clarke (non McCoy, 1852), p. 168, pl. 8, fig. 8, ? 4; ? pl. 9, fig. 1.
 1921 *Palaeosabella prisca* Clarke, fig. 81, 82, 96, 102, 103.
 1952 *Specus fimbriatus* Stephenson, p. 51, pl. 8, fig. 4, 6.
 1968 *Conchifora cylindrififormis claviformis* Müller, p. 72, pl. 1, fig. 9; pl. 5, fig. 1; text—fig. 5.
 1969a *Vermiforichnus clarkei* Cameron, p. 190 (partim).
 1975 *Specus fimbriatus* — Häntzschel, p. W133, fig. 82.3.
 1976 *Talpina annullata* — Robbia & Ostinelli, p. 541, pl. 73, fig. 6, 7; pl. 74, fig. 1–5.
 1977 *Trypanites weisei* — Kobluk et al., fig. 17.
 1979 *Vermiforichnus* sp. Hofmann, p. 54, pl. 22, A–F.
 1980 *Trypanites* Pemberton et al., pp. 1259–1265 (partim), pl. 1.

Description. Single, slightly club-shaped borings having the distal portion a little swollen; axes are straight or gently curved, generally perpendicular to the surface from which the borings originate, but in thin substrates they are forced to run parallel to it (stenomorphs; cf. Stephenson, 1952, pl. 8, fig. 4, 6). They neither cross each other nor interpenetrate, but show avoidance growth strategies.

Remarks. The specimens from Calcarenite di Gravina differ from Stephenson's *S. fimbriatus* in having a generally larger size. However, this difference could be related to the kind of substrate; the type specimens were found in molluscan shells, ours in limestone pebbles. Robba & Ostinelli's specimens from *Dentalium* shells also have reduced size (average length 1.1 mm); they are unbranched, clavate shaped, which excludes their attribution to the genus *Talpina*. The annulated ornamentation is an enoglyph (imparted by the ultrastructure of the substrate) as Robba & Ostinelli themselves suggested.

Occurrence. Numerous, crowded specimens in three samples from La Murgetta grande; two specimens from Vallone Impiso.

***Trypanites solitarius* (Hagenow, 1840)**

Pl. 40, fig. 4; Pl. 41, fig. 1, 2; Pl. 46, fig. 4; Pl. 47, fig. 2; Text—fig. 16A

1840 *Talpina solitaria* Hagenow, p. 671.

1908 *Clionolithes priscus* — Clarke (non McCoy, 1852), pl. 8, fig. 5.

1921 *Palaeosabella prisca* — Clarke, fig. ? 78, 97, 101.

1969 *Vermiforichnus clarkei* Cameron, p. 190 (*partim*).

1971 «*Potamilla*» type A and type B — Glazek et al., pp. 440–441, text—fig. 2a–g.

1972 *Trypanites solitarius* — Bromley, p. 96, fig. 1H (*cum syn.*).

1976 Tracce di Polichetti—Robba & Ostinelli, p. 545, pl. 75, fig. 1, 2; pl. 74, fig. 6.

?1984 *Vermiforichnus clarkei* — Fillion & Pickerill, p. 32, fig. 11a,d.

Description. *Trypanites* having in each specimen an almost constant diameter; in our material, the course is irregular from weakly bent to contorted. Diameter ranging from about 1 mm to 8 mm.

Remarks. We have placed all cylindrical *Trypanites* present in our material in *T. solitarius* and subdivide this in informal subtaxonomic «forms», viz.: forms A, B and C. Absolute size of trace fossils is generally not considered a functional ichnotaxobase; thus, although three general size classes of cylindrical *Trypanites* have been observed, it is not considered advisable here to introduce new species for these.

Trypanites solitarius form A (Pl. 40, fig. 4; Pl. 41, fig. 1, 2; Pl. 47, fig. 2) comprises slender borings having a diameter of about 1 mm but less than 2 mm. Maximum length over 4 cm. Rounded termination. *T. solitarius* form B (Pl. 41, fig. 2; Pl. 46, fig. 4) is typically about 3 mm in diameter and may reach 5 cm in length. The termination is hemispherical. *T. solitarius* form C is uncommon and

very large, having a diameter from 6 to 8 mm and a preserved maximum length of 5.5 cm (incomplete, distal end unknown). Form C is uncontorted and relatively straight.

Occurrence. *T. solitarius* form A is abundant at every locality sampled (except San Samuele di Cafiero where our samples of limestone are limited). Form B is present at all localities, whereas form C was found only at Vallone Impiso and at La Murgetta grande. All forms occur in limestone, but form A alone is represented in oyster shells as well.

Problematica or combinations of borings

Pl. 39, fig. 1, 8; Pl. 40, fig. 7; Pl. 47, fig. 3; Pl. 48, fig. 3

The basal surface beneath the Calcarene di Gravina at Vallone Impiso, in the metre scale, is topographically generally flat but contains a 10 cm-scale small relief. Within this relief occur shallow, rounded pits (Pl. 39, fig. 1, 8; Pl. 47, fig. 3; Pl. 48, fig. 3); five pits are preserved in two cast samples. The pits, 2–2.5 cm wide and more or less circular, have short, radiating borings penetrating from their surfaces. These borings have a stunted appearance, their morphology ranging between two types. The one type is reminiscent of *Maeandropolydora crassa*, being cylindrical with a slightly pointed round termination, but unlike *M. crassa* these are very short (5 mm long, 0.5 mm or so wide), lack the characteristic ornament and occur in minute clusters or bouquets that originate by branching. The other type is clearly entobian, emerging from the sides of the *M. crassa*-like borings (Pl. 40, fig. 7) or standing freely, having similar lengths. All these radiating borings increase in diameter in a flaring fashion towards the aperture into the pit.

Traces of sponge microsculpture are preserved on pit surface and flared apertures. The entobian projections resemble *Entobia* isp. A.

We speculate, therefore, that the sponge responsible for *Entobia* isp. A also produced these pits. A normal radiating specimen of *Entobia* isp. A occurs immediately adjacent to one of them. The *M. crassa*-like borings may be juvenile, having been produced by the *M. crassa*-maker at a later date in the abandoned entobian. The same behaviour is seen in association with *Rogerella* isp. A (Pl. 40, fig. 7), which also acted as an entrance point into the substrate for organisms producing *M. crassa*-like borings.

Results

Over 1000 rock and shell samples have been examined in this study as epoxy casts. It was hoped at the outset that, with such an extensive material,

the itaxa could be found to be grouped in recurring assemblages. A detailed pattern has not emerged, although several broad assemblages have been identified.

Owing to the crowded nature of borings within the substrates, it is rarely possible to count individual entities. It is not even clear how to correlate these entities in different taxa: «higher» taxa such as bivalves present no problem in this respect, but sponges possibly may be considered colonies, and if *Conchotrema canna* is a phoronid boring (Voigt, 1975) this represents a pseudocolony of many individuals.

Thus, a simple presence/absence matrix was constructed for itaxa per sample. This revealed several trends as well as differences between localities, and highlighted the abundance or absence of forms in particular situations. The heterogeneous nature of the material and extremely random distribution of many itaxa also become apparent. The data available give no clear picture of the distribution of individual itaxa relative to major environments. Nevertheless, some general assemblages can be recognized that are sufficiently broad that they recur in similar situations, particularly with reference to substrate surface orientation.

Distribution of some individual itaxa.

Gastrochaenolites torpedo and other bivalve borings. *G. torpedo* occurs almost exclusively on steeply inclined to vertical or slightly overhanging surfaces, owing to the more or less horizontal orientation of the boring. In such situations it reaches full size (over 10 cm long) and is commonly accompanied by entobians. Pebbles more than 10 cm in length may contain such numerous *G. torpedo* and entobians as to be rendered friable by them (horizon B at Cala Corvino; La Murgetta grande I). On upward facing horizontal surfaces, other ispp. of *Gastrochaenolites* occur, in particular *G. cor.* It is surprising, therefore, that at La Murgetta grande (I and IV) very small, vertically oriented *G. torpedo* have gained a footing in competition with the more usual occupants of this niche. This occurrence is interesting, since *G. torpedo* can only occur on horizon surfaces where there is a complete absence of sedimentation. In pebbles and boulders, small (stenomorphic) *G. torpedo* occur on sides and subsurfaces.

G. dijugus dominates locally in pebbles of horizon B outcropping in a narrow inlet a few hundred metres north of Cala Corvino. *G. torpedo* is rare here, while *Caulostrepsis* isp. and entobians occur in all pebbles, their surface ornamented by *Gnathichnus pentax*.

Maeandropolydora barocca and *M. crassa*. These two ispecies have distribution patterns that show several features in common. Both ispecies tend to be very abundant when they occur. This is particularly true of *M. barocca*, which in

some specimens occurs alone. Both species characteristically have idiomorphic development, other forms accompanying them in crowded situation showing stenomorphy. *M. barocca* can become so crowded in some specimens that it causes stenomorphy in itself. The two species are mutually exclusive; no specimen contains both at La Murgetta grande, *M. barocca* being abundant at I and almost missing at IV; *M. crassa* common at IV and absent at I. *M. barocca* also tends to occur separately from *Gastrochaenolites torpedo*, and the entobians in its presence are very poorly developed, consisting chiefly of exploratory threads and growth phase B.

Our interpretation of these facts is that both species are the work of opportunists, colonizing the substrate early and boring rapidly, and occupying large portions of it before other colonists can arrive. One species generally is able to be present together with *M. barocca*: the small, branched *Conchotrema canna*. A reason for this may be found in the different tiers occupied by the two trace fossils. *C. canna* develops a dense network very close beneath the substrate surface whereas *M. barocca* penetrates perpendicularly and deeply into the limestone. There is therefore little direct competition for space between these forms. Furthermore, the trace fossils are probably the work of very different animals (polychaete and phoronid) and competition in other life areas probably also is limited.

M. crassa also belongs to a considerably deeper tier than *C. canna* (though shallower than *M. barocca*). *M. crassa* is a large boring and would interfere with *M. barocca* growth. The exclusion of *M. crassa* from boulders infested by *M. barocca* may thus be due in part to tier competition, and may also involve the close similarity of the trace makers, both in this case probably polychaete annelids.

?*Lapispecus* isp. and *M. barocca*. The fact that ?*Lapispecus* isp. occurs at one locality only (La Murgetta grande I), and there exclusively in the company of *M. barocca* which also is very nearly restricted to that locality, requires comment. It should be remembered that *M. barocca* alone among the ispp. of *Maeandropolydora* produces a small but distinct lateral vane where it passes close to other borings. However, in no case was a ?*Lapispecus* gallery, with narrow, more or less continuous vane, seen in direct connection with *M. barocca*. In the original material, *L. cuniculus* Voigt (1970), associated with *Caulostrep-sis cretacea*, was highly stenomorphic, wound round tightly within small pebbles, and thus always in close proximity with other parts of itself. This is the situation in which a strong vane might be most likely to develop. The pouches of *M. barocca*, however, do not resemble *C. cretacea*, but more closely approach *C. taeniola* morphology. Voigt considered that *C. cretacea* and *L. cuniculus* in his material were not necessarily genetically related, and the problem

of the close association of *M. barocca* and ?*Lapispecus* isp. in our material also remains unresolved.

General assemblages.

Caulostrepsis/Maeandropolydora assemblage. At each of the four localities, upward-facing, more or less horizontal limestone surfaces situated in slight depressions have been colonized by endolithic worms, almost to the exclusion of other macroborings. Probably this represents a highly stressful habitat, exposed to the turbulence and turbidity associated with shallow marine rock pavements and yet, because of the minor depression topography, also the site of most variable sediment accumulation. Burial in sediment is a major inhibiting factor for the endolithion and the different organism groups are not equally capable of coping with it. The active worms, especially the annelids, are among the best adapted in this respect; some spionids such a *Polydora* are able to extend their boring up through the sediment cover as a burrow (e.g. Hertweck, 1971). Sponges, in contrast, are generally unable to withstand even minor amounts of silting and it is not surprising, therefore, that entobians are missing or poorly developed in this worm-dominated community. At San Samuele and Monopoli, the itaxa dominating this assemblage are *C. contorta* and fewer *C. cretacea*. At La Murgetta grande I, however, the niche is occupied almost exclusively by *M. barocca*.

Gastrochaenolites cor assemblage. Associated with the previous assemblage, but occupying relatively high places on a horizontal limestone surface, is a characteristic bivalve assemblage dominated by *G. cor*, and generally poor in other itaxa. The bivalve borings can occur with different entobians (*E. paradoxa*, *E. mammillata*, *E. cateniformis*, *E. laquea*, *E. retiformis*). *Caulostrepsis contorta* and *Maeandropolydora sulcans* may be present, but usually obvious worm borings are lacking or are rare. This assemblage has been found in similar situations at San Samuele and at La Murgetta grande IV, where it is particularly well developed.

Gastrochaenolites torpedo / Entobian assemblage. (Fig. 17). On steep to vertical overhanging limestone surfaces a very characteristic assemblage occurs, dominated by large *G. torpedo*. A superficial tier of entobians always accompanies the *G. torpedo*, together with less obvious *M. sulcans*, *M. decipiens* and *C. cretacea*. The assemblage can be recognized even after karstic degradation of exposures, owing to the considerable depth of penetration and the characteristic form of *G. torpedo*, which survives long after the entobians have weathered away. *G. torpedo* corresponds precisely to the work of *Lithophaga lithophaga*, body fossils of which occur in the borings at Monopoli; this species has re-

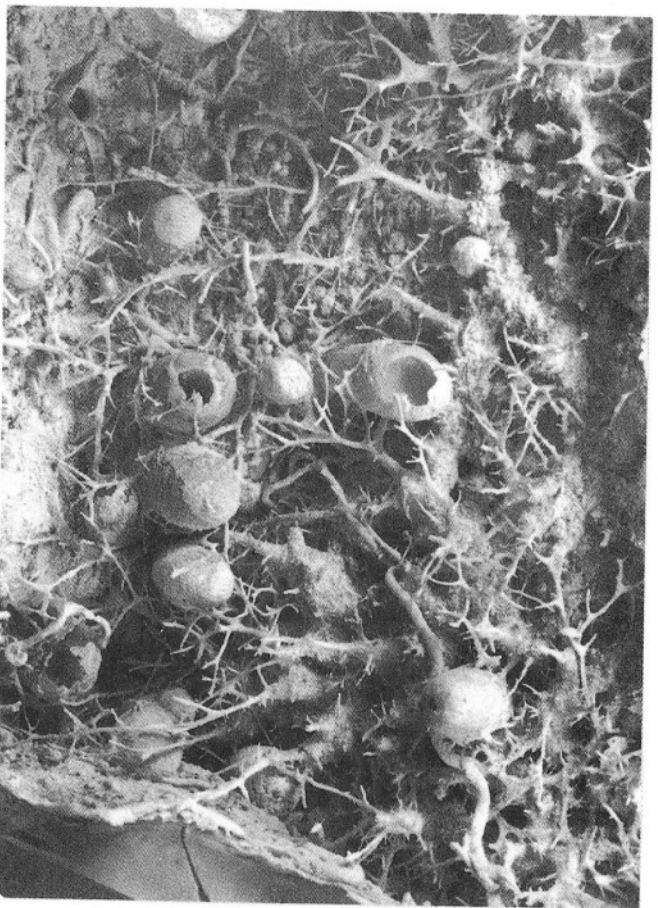


Fig. 17 — *Gastrochaenolites torpedo*/Entobian assemblage, in a vertical fracture surface within the limestone basement at La Murgetta grande I. Artificial cast, MGUH 17491; x 1.3.

stricted bathymetric distribution in the Mediterranean today. Virtually confined to a depth range of 0–10 m, its activity increases upward and culminates in the first metre of water (Kleemann, 1973, 1974). Thus this assemblage is a good indicator of earlier sealevels, as has long been recognized (e.g., Lyell, 1830, pp. 449–456). The common occurrence of this assemblage together with a littoral notch confirms this interpretation.

High diversity entobian-dominated assemblage. This is probably a complex of many discrete assemblages. Certainly the taxa involved are extremely variable. The majority of limestone clasts, especially the larger ones, contain a highly diverse endolithic assemblage dominated by *Entobia* spp. (e.g. at Cala Corvino), in contrast to the first two assemblages which have restricted diversity and occur on the basement surface. This assemblage also occurs in the basement in protected cracks, (as at La Murgetta grande I, IV) and within the notch boulders (Vallone Impiso). It may even be present on the open surface of the basement itself in protected situations, as for example at Vallone Impiso: in a large, open depression strewn with boulders (Pl. 43, fig. 1).

Dolomite. At San Samuele and Vallone Impiso some carbonate clasts proved to be dolomite. The endolithic assemblage in these was considerably reduced. Entobians are largely absent and where they occur are unidentifiable, small exploratory threads or *E. megastoma*-like borings. *Maeandropolydora crassa*, however, is not uncommon in dolomite clasts, showing less branching than usual and a tendency to produce sinuous perpendicular galleries.

Conclusion

Environmental significance.

The bioerosion described here has occurred in lithic-grounds of extremely shallow marine environments. The four assemblages distinguishable show great variation and reflect the complex microenvironments that occur in a coastal rockground setting. The organisms responsible for the individual trace fossils are largely unidentified and direct comparison with recent environments is thus limited. Biological taxonomy of the bivalve borings, however, is fairly certain and yields valuable environmental information. *G. torpedo* contains fossil shells of *Lithophaga lithophaga* and *G. cor* encloses *Petricola lithophaga*. Both these species occur today in the shallowest water and *L. lithophaga* in particular is indicative of sea level bioerosion.

With the help of the evidence supplied by bioerosion, the following remarks can be made on the palaeoenvironments represented by the transgressive base of the Calcarene di Gravina formation at the four localities.

1) Monopoli. Bioerosion of the basal surface here is variable along the coast. At Torre Incine there is no bioerosion of the limestone surface, and the overlying basal sediments of the Calcarene di Gravina for one metre are red stained, and have no indication of marine influence. Deposition no doubt took place here in a terrestrial-fluviatile environment before the ingress of marine conditions with the pebble beds at horizon B.

The pebbles are heavily bioeroded, showing the High Diversity Entobian-Dominated assemblage and indicate fully marine shallow water conditions.

500 m southwards, near Cala Corvino, a littoral notch has been produced in a minor fault scarp in the basement limestone. The notch is bioeroded as usual with the *Gastrochaenolites torpedo*/Entobian assemblage and clearly represents the sea level during a pause in the advancing marine transgression.

At Cala Corvino itself, the basal limestone at horizon A is heavily bioeroded, containing the *Caulostrepsis/Maeandropolydora* assemblage, indicating shallow water, turbid marine conditions. In sloping steps in the surface, *G. torpedo* is developed.

The lateral variation at horizon A from non–marine to shallow marine over this short distance presents no problems, as the limestone surface can be seen to undulate and contains some minor fault scarps.

Horizon B at Cala Corvino is as at Torre Incine.

2) *La Murgetta grande*. The undulating limestone surfaces at both sublocalities here contain fully marine bioerosional assemblages. Stressful conditions are indicated by the presence of the *G. cor* assemblage on relatively high places and the *Caulostrepis/Maeandropolydora* assemblage in depressions. Steeply inclined and vertical steps in the surface contain the *Gastrochaenolites torpedo*/Entobian assemblage and walls of fissures within the surface are attacked by the High Diversity Entobian–Dominated assemblage. The same assemblage is found in the boulders lying on the basal surface. Thus, non–horizontal substrate surfaces tend to be attacked by sponges, a distribution that may indicate turbidity of the water and a tendency for temporary, minor sediment accumulation during the bioerosion phase. The unique local development of *M. barocca* at *La Murgetta grande* I and its virtual absence at IV, may be explained when the distribution of *G. torpedo* is examined. *G. torpedo* is much more common at I, occurring there even on upward facing surfaces. This attitude may indicate high turbulence and complete freedom from sedimentation on the substrate. Its rarity at IV may indicate deeper, more turbid water there, allowing domination of *G. cor*; locality IV lies toward the centre of the canal and thus would naturally be a deeper water site than locality I. Thus the ichnological evidence suggests that the limestone surface was bioeroded at locality IV in about 10 m water while that at I was bored in shallower water. The *G. torpedo* are well preserved at I, indicating that this surface was eventually buried by calcarenite, halting the bioerosion process, already at this shallow depth.

3) *San Samuele di Cafiero*. The succession of bioerosional notches cut into the fault scarp at this locality is associated with the *G. torpedo*/Entobian assemblage and the notches clearly represent successive pauses in sea level advance. Bioerosion is well preserved, which would not be expected if the sequence were regressive; there is no evidence to suggest that the higher notches were degraded by karstic processes while the lower ones were being produced. Thus a transgressive sequence is indicated, the lowest notch being the oldest and being drowned as sea level rose to pause and produce the next notch above. The *G. torpedo*/Entobian assemblage is not restricted to the notches, however, but is present continuously up the vertical limestone surface over several metres. A gradual rise of sea level may be indicated by this or, alternatively, sea level may have sprung relatively rapidly from notch to notch, the intermediate bioerosion having been initiated during the rise and continued within the 10 m or so of water beneath the upper notch.

The top of the limestone platform here is encrusted with *Hinnites crispus* and *Ostrea lamellosa*, further supporting the shallow water indications. The overlying calcarenite contains *Neopycnodonte cochlear* which today is characteristic of circalittoral biocoenoses, occurring in some tens of metres depth, in conditions of reduced lighting. Field relationships do not indicate locally shaded habitats that could support deep water faunal enclaves in shallow water settings. The presence of this oyster might indicate rapid deepening of the sea by some tens of metres. However, the rich bioerosion of these shells, which occurred when the oysters were living, continues to have a shallow water aspect (High Diversity Entobian-Dominated assemblage) and suggests that the *N. cochlear* lived in shallower water than today. This latter assumption is supported by the observation that a few molluscan taxa show a deepening trend in the Mediterranean Sea from the Late Tertiary. Examples include *Venus multilamella* Lamarck (Caldara, D'Alessandro & Loiacono, in press), *Cardium hians* Brocchi and *Amyclina semistriata* (Brocchi) (Caldara, Colella & D'Alessandro, 1979). The bioerosion of the oyster shell shows differences from the limestone assemblage (especially the lack of bivalve borings) which may be accounted for in part at least by the difference in substrate quality. A similar endolithic assemblage in the same species of substrate shell (and others) was reported in infralittoral settings by Barrier & D'Alessandro (1985).

4) Vallone Impiso. The complicated depositional history of this locality is not immediately apparent. Two distinct horizons of bioerosion are clearly represented: the basement surface on which the calcarenite deposition was initiated, and the notch horizon, lying within the calcarenite sequence but overlapping onto the rising basement towards the north. The basement surface is bioeroded deeply and the trace fossil assemblages clearly indicate a marine environment (Pl. 43, fig. 1). Further south-east the base is not exposed and the lowest units of the calcarenite have a non-marine aspect. However, where the basement is visible, from the level of the notch and upwards, a fully marine environment prevailed. The notch corresponds to the level of limestone blocks in an apparently coincidental manner, and also runs parallel to the stream bed in a way that suggests the possibility that the notch resulted from fluvial erosion. However, the bioerosion associated with the notch clearly indicates that it was produced in a marine environment and represents an earlier sea level.

Two explanations may now be offered to account for the existence of the notch (Fig. 18). The first, and possibly more obvious explanation, is that it is a phenomenon related to the final marine regression from the area (Fig. 18A). Its extremely good preservation speaks for this, and the fact that it resembles a surface cut into the present outcrop surface. This explanation is unlikely, however, on the basis of regional geology and in particular for two reasons. It does not explain the remarkable coincidence that the notch follows

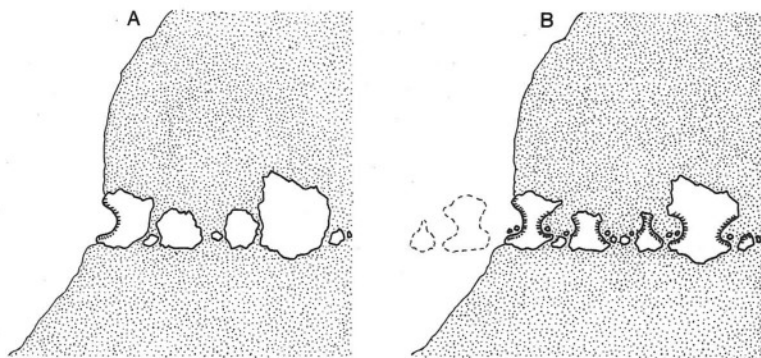


Fig. 18 — Alternative models for the bioerosional notch in the breccia horizon 3 at Vallone Impiso.

precisely a horizon of giant limestone blocks within the calcarenite. Nor is it clear why subsequent erosion of this brecciated horizon, in terrestrial conditions within an active stream valley, has not obliterated the notch: its condition is very fresh.

The second explanation is that the notch is syndepositional and developed on the blocks immediately after their deposition. Recent erosion in the river valley merely exposes the next notched block (Fig. 18B). This second explanation is certainly the more satisfactory of the two and suggests the depositional model sketched in Fig. 19.

Thus the lowest part of the calcarenite deposition took place in marginal marine conditions. Then movement along the nearby fault brought a massive influx of limestone debris into the basin and simultaneously brought this part of the basin into the sea level setting. In this shallow sea, the boulders were bioeroded and the littoral notch was produced on the larger, stable blocks. The situation is more complicated, because the notch may be floored or immediately overlie a cemented, marine–bioturbated calcarenite that also has

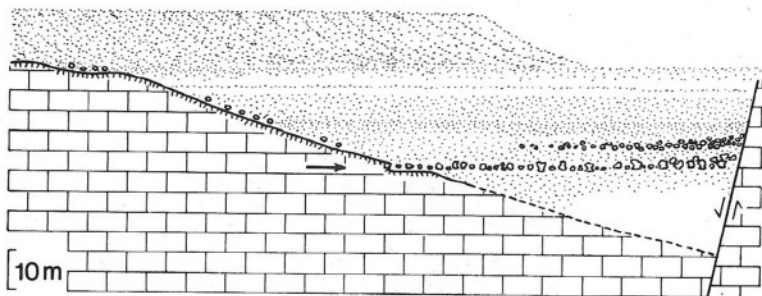


Fig. 19 — Depositional model for the Vallone Impiso locality.

been bioeroded (Fig. 6B). This may indicate an earlier brief marine ingression and emergence in order to lithify the sediment prior to the bioerosional event. In any case, further subsidence then buried the boulder horizon in carbonate sand, initially deposited in upper sublittoral conditions, but gradually building up into the marginal environment again as indicated by the trace fossil sequence (*Scolicia*, *Thalassinoides*, *Skolithos*) (Fig. 4). The next limestone breccia influx possibly also involved the development of a littoral notch, but the conglomerate incorporated a few boulders bioeroded on a nearby beach, again as demonstrated by trace fossils and extreme rounding. Subsequent deposition occurred in a shallow marine environment as shown by the bioerosion of the basement shoal further north. The remaining sequence above this is entirely marine, representing a prograding bar in shallow water.

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PLATE 39

- Fig. 1, 8 — Problematic borings in a rounded pit in limestone. In 8) the borings emerge from a *Gastrochaenolites cor*. MGUH 17506; x 3. All samples from Vallone Impiso.
- Fig. 2 — *Conchotrema canna* (Price). «Juvenile» stage in limestone from Cala Corvino (Monopoli). MGUH 16056; x 5.5.
- Fig. 3, 6 — *Rogerella pattei* (Saint-Seine). Artificial casts of borings preserved in *Neopycnodonte* shell. La Murgetta grande. MGUH 17503. Fig. 6, x 3.5; fig. 3, detail of the same sample, x 6.
- Fig. 4 — *Rogerella* ichnosp. A. Vallone Impiso, MGUH 17504; x 4.
- Fig. 5, 9 — *Maeandropolydora decipiens* Voigt. In limestone from La Murgetta grande, MGUH 17480; x 5.
- Fig. 7 — *Caulostrepsis contorta* Bromley & D'Alessandro. In limestone from La Murgetta grande, MGUH 17489; x 4.

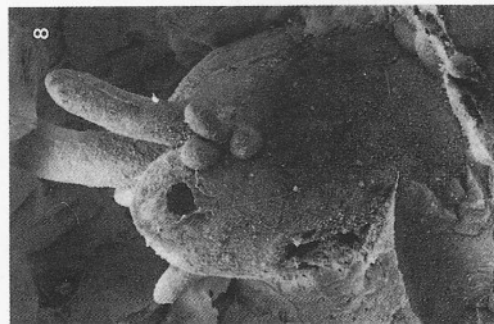
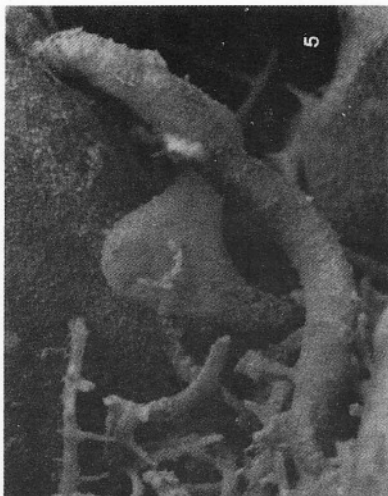
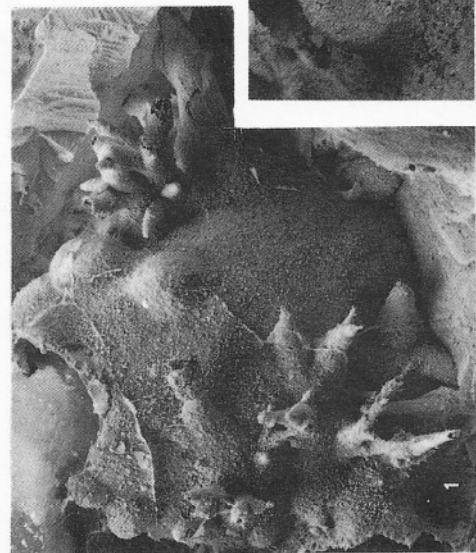
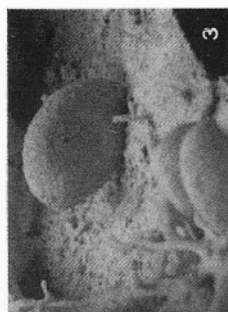


PLATE 40

- Fig. 1 – *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande. Holotype, photographed before preparation: see Pl. 44, fig. 2. MGUH 17471; x 2.
- Fig. 2 – *Conchotrema canna* (Price) and *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande, MGUH 17485; x 3.5.
- Fig. 3 – *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande. Paratype, MGUH 17475; x 2.5.
- Fig. 4 – *Trypanites solitarius* (Hagenow) form A. In limestone from La Murgetta grande, MGUH 17493; x 3.5.
- Fig. 5 – *Gastrochaenolites cor* ichnosp. nov. Paratype, natural cast in limestone from La Murgetta grande, MGUH 17467; x 2.
- Fig. 6 – The course of slender *Conchotrema canna* galleries is influenced by an earlier Entobian boring limestone from La Murgetta grande, MGUH 17487; x 5.
- Fig. 7 – Combination of borings: *Rogerella* ichnosp. A and ?*Maeandropolydora crassa* ichnosp. nov. Limestone from Vallone Impiso, MGUH 17507; x 4.5.

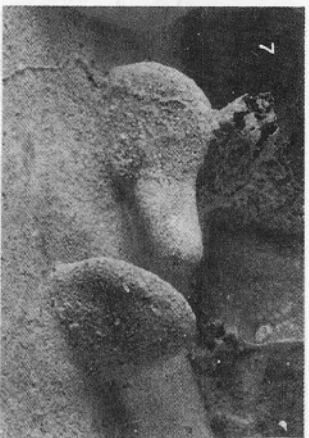
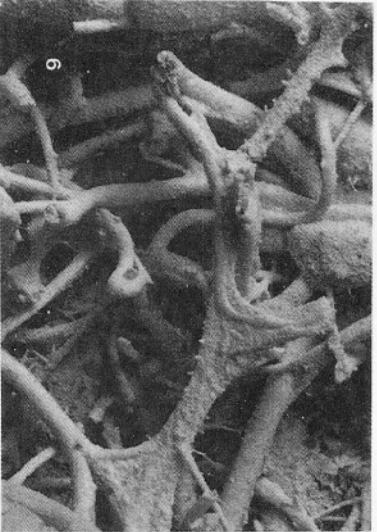
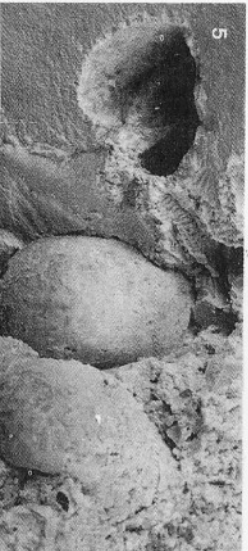


PLATE 41

- Fig. 1 – *Trypanites solitarius* (Hagenow) form A, *Entobia megastoma* (Fischer, 1868) and *Gastrochaenolites cor* ichnosp. nov. In limestone from La Murgetta grande, MGUH 17497; x 1.9. At the right the conical end of the boring is marked B; the aperture at left, A.
- Fig. 2 – *Trypanites solitarius* (Hagenow) form A (A, left) and form B (B, low, right). In limestone from Vallone Impiso, MGUH 17492; x 3.
- Fig. 3 – *Maeandropolydora sulcans* Voigt and entobian exploratory threads in limestone from Vallone Impiso, MGUH 17481; x 3.5.
- Fig. 4 – Extremely slender *Conchotrema canna* (Price) net among entobian exploratory threads. In limestone from La Murgetta grande, MGUH 17488; x 2.

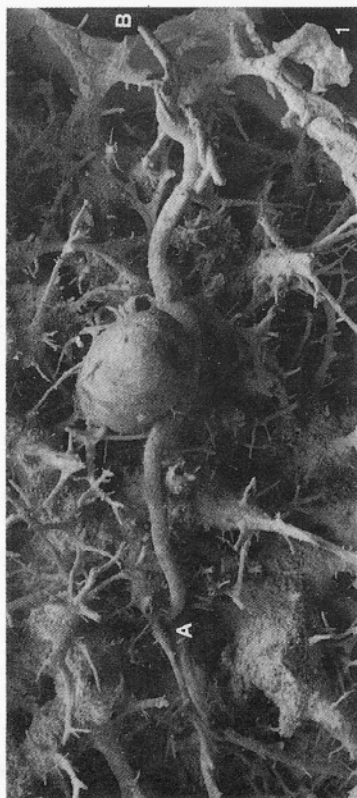
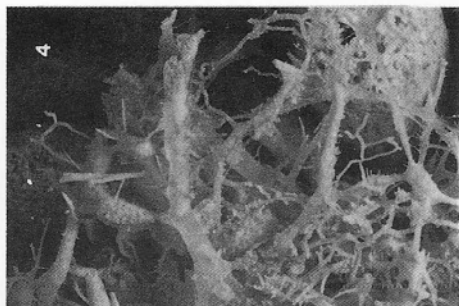
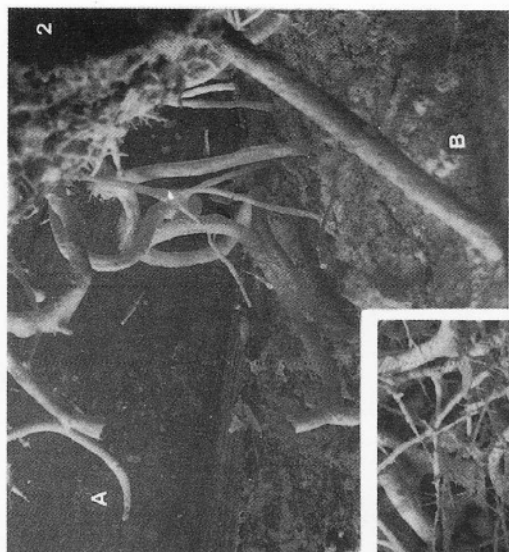


PLATE 42

- Fig. 1 — *Entobia retiformis* (Stephenson). In limestone, MGUH 17499; x 2.5.
- Fig. 2, 6 — *Gastrochaenolites cor* ichnosp. nov. Holotype, in limestone, MGUH 17466; x 2.5.
- Fig. 3 — Three arches of *Maeandropolydora sulcans* Voigt and exploratory threads of *Entobia retiformis*. In limestone, MGUH 17482; x 3.
- Fig. 4 — *Gastrochaenolites cor* ichnosp. nov. In limestone, MGUH 17470; x 2.5.
- Fig. 5 — *Trypanites fimbriatus* (Stephenson). In limestone, MGUH 17494; x 3.5.

All the specimens from La Murgetta grande.

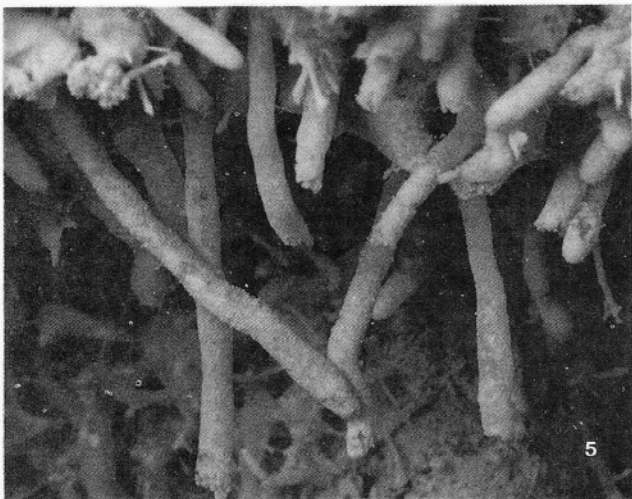
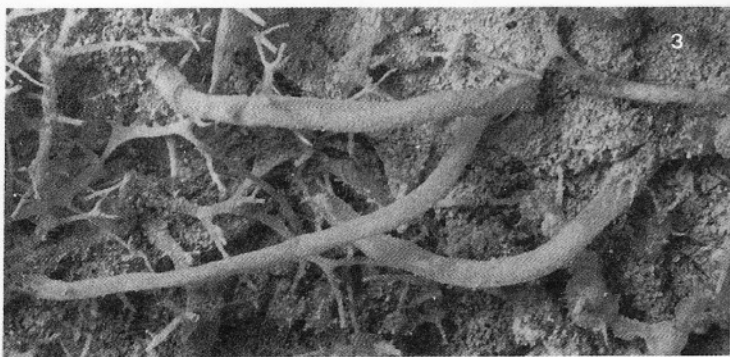


PLATE 43

- Fig. 1 – High diversity entobian-dominated assemblage. Field photo at Vallone Impiso. Transgressed limestone surface. *Entobia geometrica* Bromley & D'Alessandro (upper centre) and *E. mammillata* Bromley & D'Alessandro (right) are conspicuous. About natural size.
- Fig. 2 – *Conchotrema canna* (Price). In limestone from Vallone Impiso, MGUH 17483; x 5.
- Fig. 3 – ? *Lapispecus* ichnosp. Gallery showing an evident lateral vane, associated with *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande, MGUH 17496; x 5.
- Fig. 4 – Natural surface of a limestone pebble, from Vallone Impiso, showing *Gnathichnus* and a spiral etching pattern, MGUH 17509; x 4.
- Fig. 5 – *Entobia volzi* Bromley & D'Alessandro. In limestone from Vallone Impiso, MGUH 17498; x 4.
- Fig. 6 – A very small example of *Entobia* ichnosp. A in limestone from La Murgetta grande, MGUH 17500; x 5.

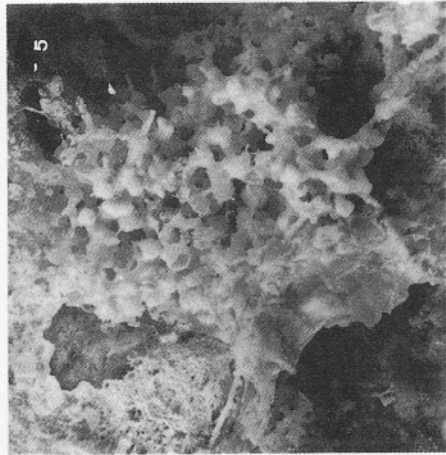
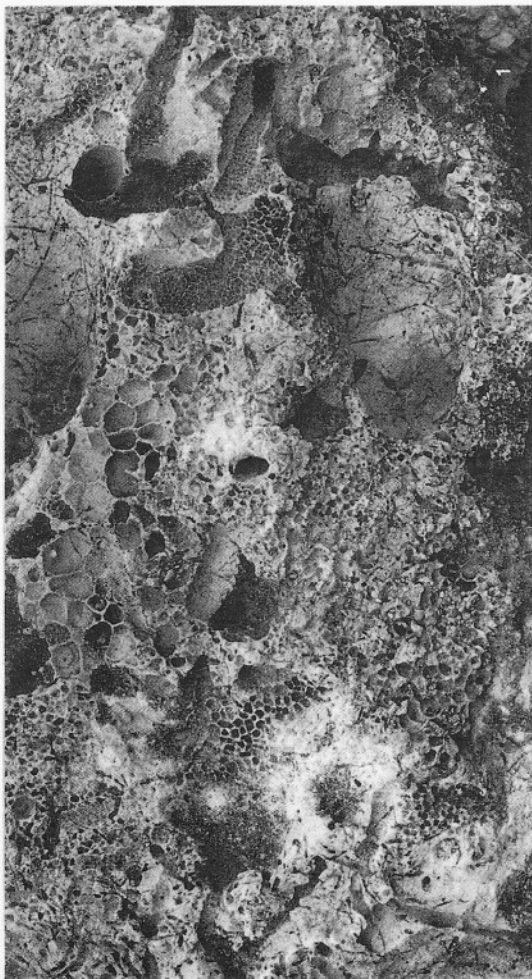
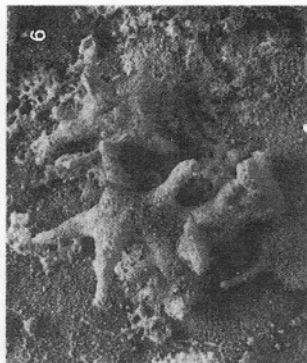
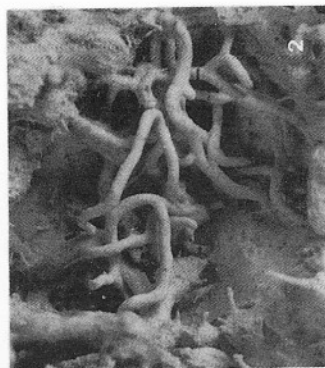


PLATE 44

- Fig. 1 – *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande. Paratype, MGUH 17476; x 2.
- Fig. 2 – *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande. Holotype, MGUH 17471; x 4.
- Fig. 3 – *Conchotrema canna* (Price). In limestone from Vallone Impiso, MGUH 17484; x 5.
- Fig. 4 – *Maeandropolydora crassa* ichnosp. nov. In limestone from La Murgetta grande. Paratype, MGUH 17479; a characteristic diminutive pouch; x 5.
- Fig. 5 – *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande associated with ?*Lapispecus* ichnosp., MGUH 17495; x 3.

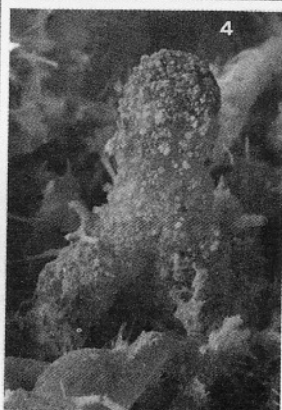
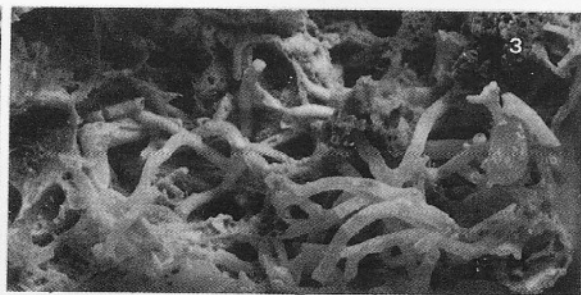


PLATE 45

- Fig. 1 — A spiral etching trace and the apertures of *Entobia geometrica* Bromley & D'Alessandro, on the natural surface of a limestone pebble from Cala Corvino. MGUH 17508; x 3.
- Fig. 2, 4, 5 — *Maeandropolydora crassa* ichnosp. nov. Details of the holotype. Note the granular surface, but smooth terminations (2,4) and characteristic diminutive pouches (5); x 5.
- Fig. 3 — *Maeandropolydora crassa* ichnosp. nov. In limestone from La Murgetta grande. Holotype, MGUH 17477; natural size.

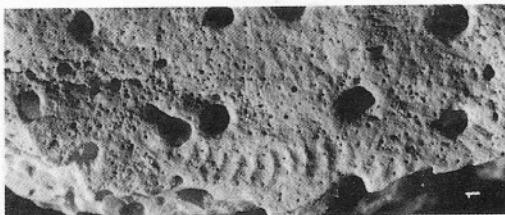
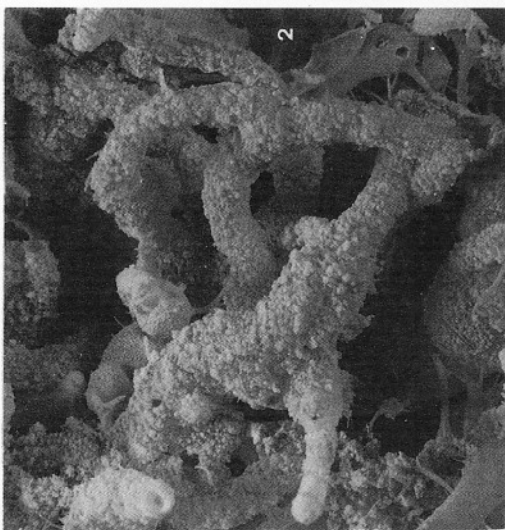
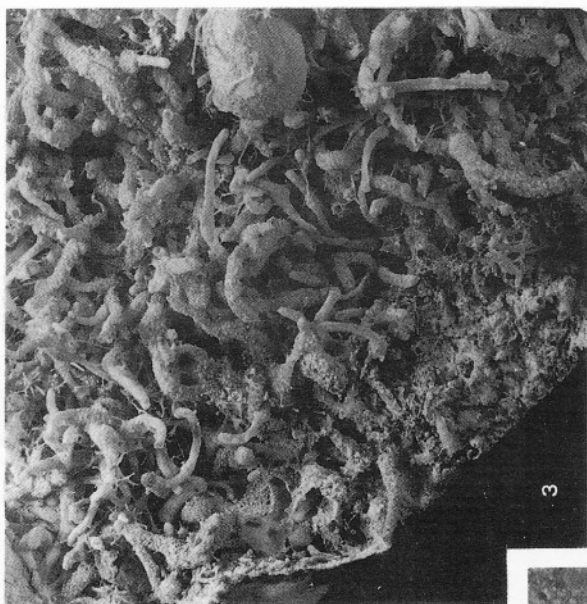


PLATE 46

- Fig. 1 – *Entobia* ichnosp. B. In limestone from Cala Corvino, MGUH 17502; x 2.5.
- Fig. 2 – *Entobia retiformis* (Stephenson). System completely enveloping a *Gastrochaenolites* ichnosp. in limestone from La Murgetta grande, MGUH 17499; x 3.5.
- Fig. 3 – *Entobia retiformis* (Stephenson). Same sample as fig. 2; x 2.5.
- Fig. 4 – *Trypanites solitarius* (Hagenow) form B. Two separate borings in limestone, the one arching over the other. Blind terminations uppermost. Vallone Impiso, MGUH 17490; x 2.

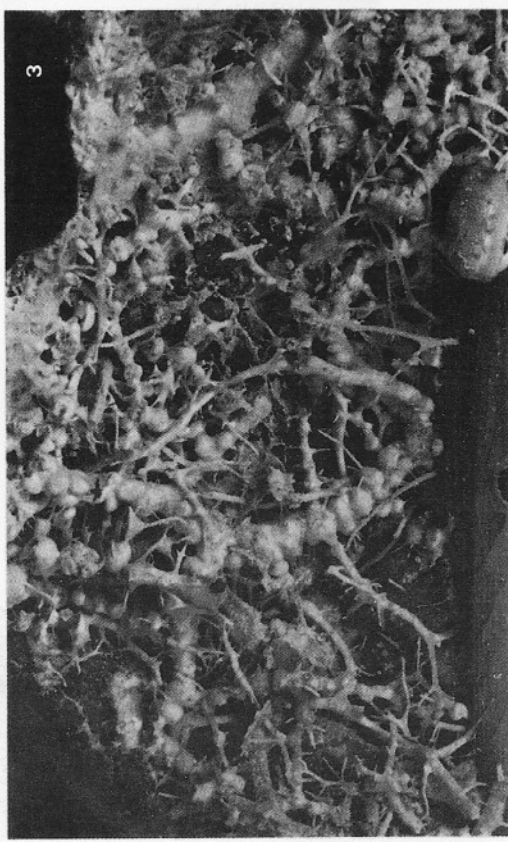
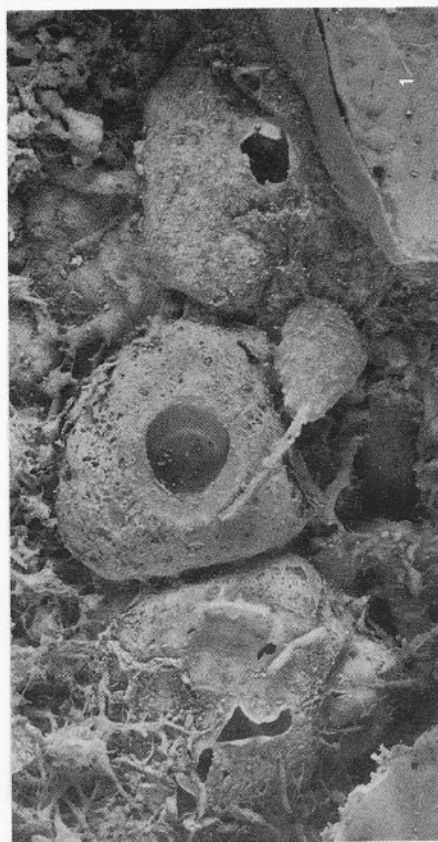
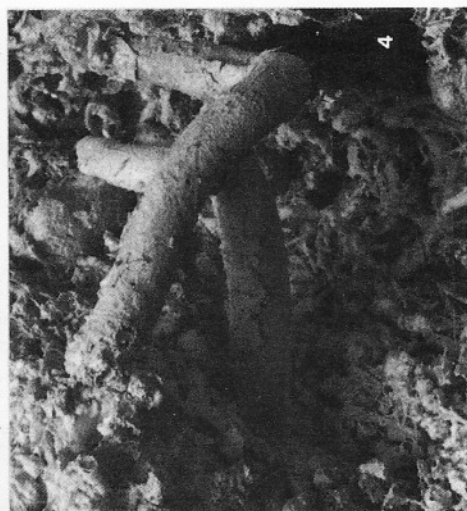
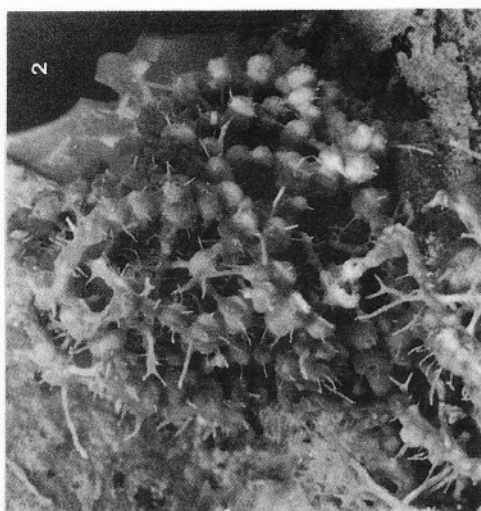


PLATE 47

- Fig. 1 – *Maeandropolydora barocca* ichnosp. nov. In limestone from La Murgetta grande, natural vertical fracture surface. Paratype, MGUH 17472; x 1.5.
- Fig. 2 – *Trypanites solitarius* (Hagenow) form A. La Murgetta grande, MGUH 17491; scale in millimetres. Two specimens are present, the one having aperture at A terminating at A', the other opening at B and ending at B'.
- Fig. 3 – Problematic borings radiating from a pit in the limestone surface. Vallone Impiso, MGUH 17505; x 2.5.
- Fig. 4 – *Conchotrema canna* (Price). Artificial cast in *Neopycnodonte* shell. San Samuele di Cafiero, MGUH 17486; x 4.5.

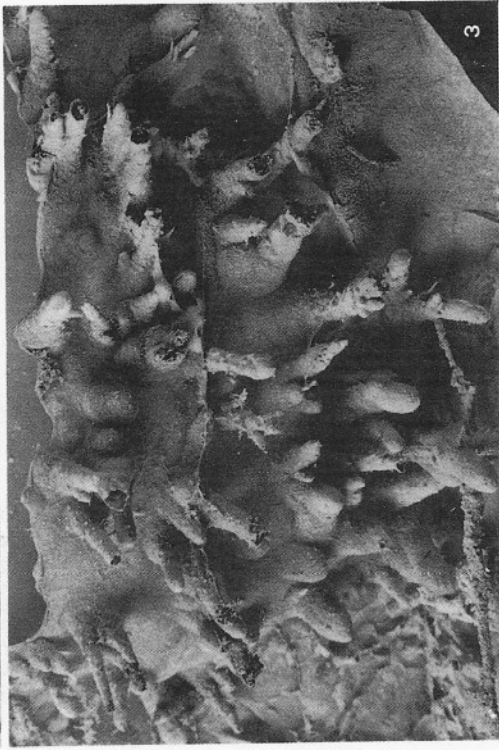
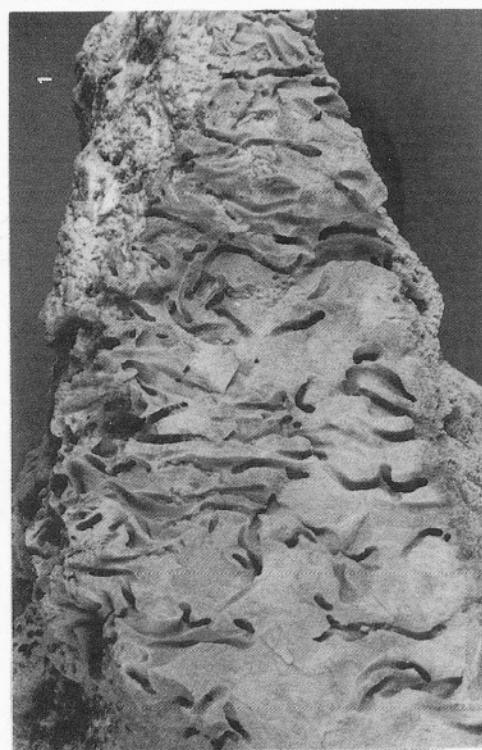
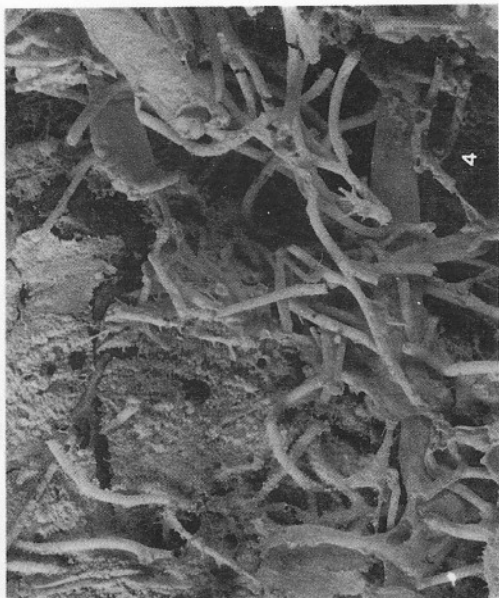
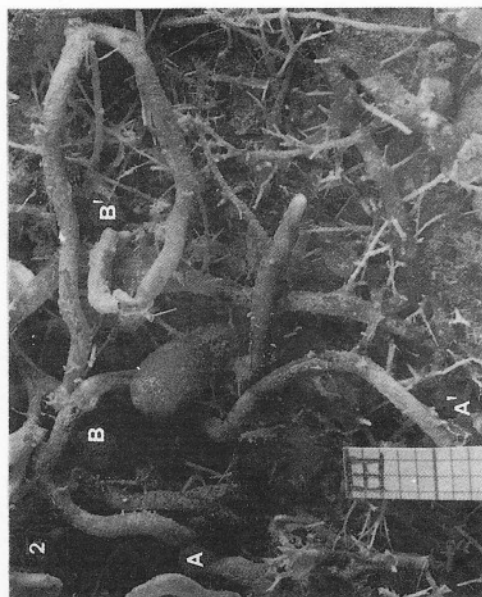


PLATE 48

- Fig. 1, 2 – *Entobia* ichnosp. A. In limestone from Vallone Impiso, MGUH 17501; x 1.6.
- Fig. 3 – Problematic borings radiating from a pit in the limestone surface from Vallone Impiso. MGUH 17506; x 3.
- Fig. 4 – *Maeandropolydora barocca* ichnosp. nov. Sectional view seen from above in a natural fracture plane parallel with and close beneath the limestone basement surface. La Murgetta grande. Paratype, MGUH 17472; x 1.5.

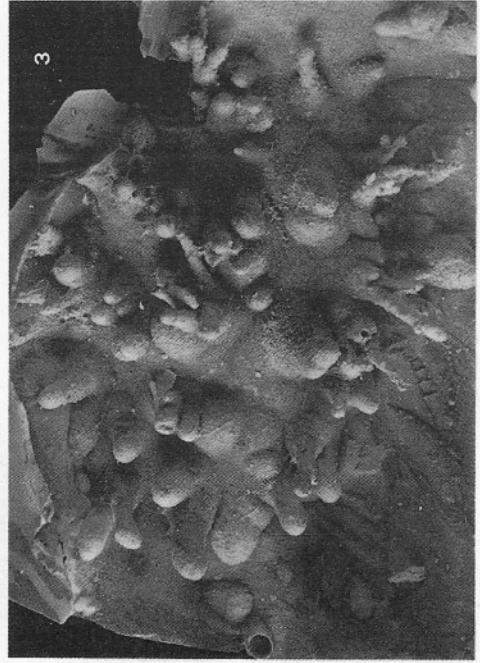
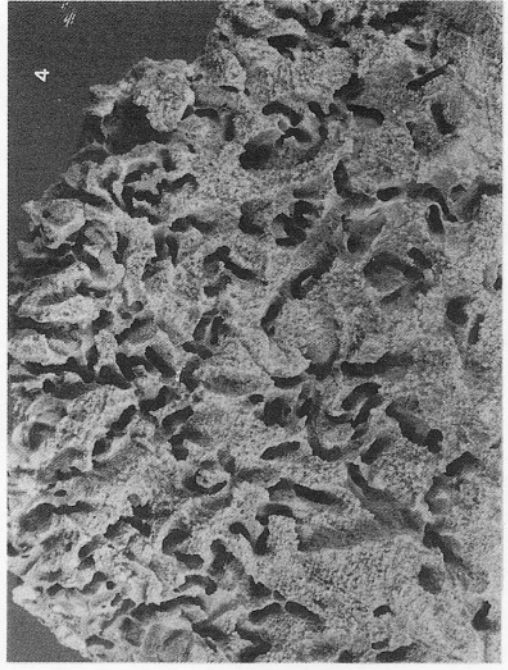
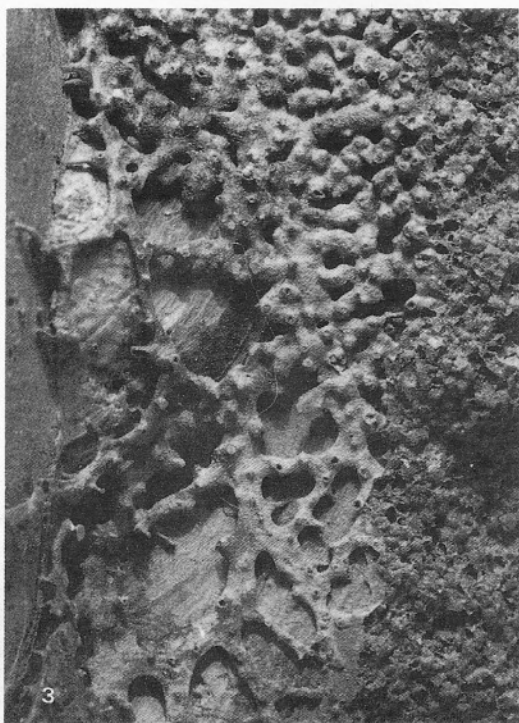
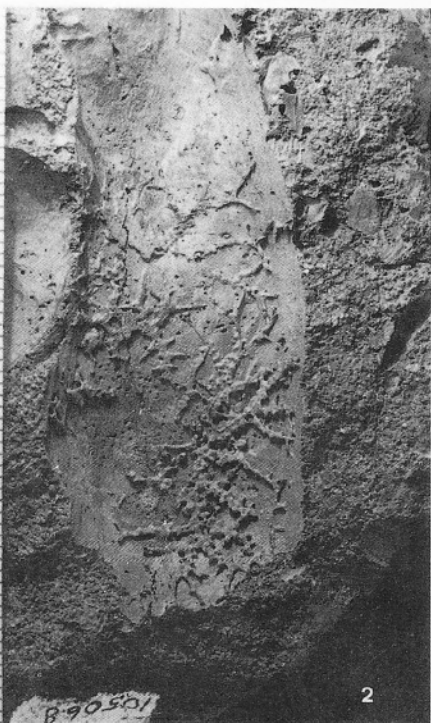
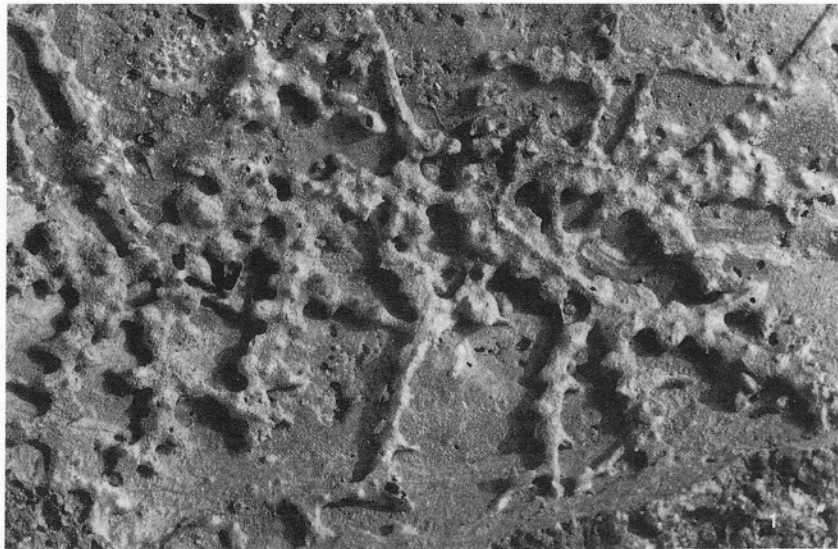


PLATE 49

- Fig. 1, 2 – *Entobia retiformis* (Stephenson). Natural cast in aragonitic shell substrates, slightly stenomorphic. Holotype, Tarrant County–Texas, USNM 105068; 1), x 4.5; 2), x 1.5.
- Fig. 3 – *Entobia retiformis* (Stephenson), showing growth phases C below, D above. Paratype, Tarrant County–Texas, USNM 105069; x 4.



Recensioni

PUBBLICAZIONI DI CARATTERE GENERALE

Stradner H. & Perch-Nielsen K. (Ed.) (1987) — **International Nannoplankton Association, Vienna Meeting 1985: Proceedings.** *Abhandl. Geol. Bundesanst.*, v. 39, 315 pp., AS 900, Wien.

Il volume costituisce gli atti dell'«International Nannoplankton Association» Meeting, svoltosi a Vienna dal 19 al 22 settembre 1985. In quell'occasione, per la prima volta, si erano riuniti più di 50 specialisti in nannofossili calcarei che presentarono 32 comunicazioni orali e 20 posters. Herbert Stradner e Katharina Perch-Nielsen, organizzatori del Meeting, sono gli editori di questa raccolta comprendente 19 contributi, di cui uno riguarda le silicoflagellate e 18 i nannofossili calcarei. I lavori, tutti in inglese e preceduti da un riassunto in tedesco e talora anche in francese, si susseguono secondo l'ordine alfabetico degli Autori. Gli argomenti trattati sono molto diversificati, i metodi di studio comprendono investigazioni sia al microscopio ottico polarizzatore che al microscopio elettronico a scansione, le analisi sono di tipo qualitativo, semi- e quantitativo. Nove contributi sono di carattere prettamente biostratigrafico e comprendono nuove biozonazioni basate sui nannofossili calcarei, talora integrate con la biostratigrafia a foraminiferi planctonici o con la magnetostratigrafia. In cinque lavori viene presentata la tassonomia e l'evoluzione di vari gruppi, mentre la paleoceanografia è trattata in tre contributi. Argomenti peculiari sono presentati in tre lavori che approfondiscono rispettivamente il problema, sino ad ora irrisolto, del dimorfismo delle coccolitoforidi, lo studio biometrico dei coccoliti e la paleobiologia dedotta dalla morfologia funzionale. L'intervallo di tempo che risulta essere più trattato è il Cretacico (5 lavori); Paleocene, Miocene e Pleistocene sono discussi in 2 contributi, mentre 1 lavoro è dedicato a Triassico, Giurassico, Oligocene e Recente. Per quanto riguarda i limiti cronostatigrafici, un contributo focalizza il passaggio Eocene/Oligocene ed un altro il limite Triassico/Giurassico.

La veste grafica del volume è eccellente: il testo è molto curato, le illustrazioni, di grande formato, hanno un'ottima risoluzione e le tavole fotografiche sono di buona qualità.

A buon diritto il volume costituisce il «punto della situazione» nello studio dei nannofossili calcarei che si dimostrano ottimi strumenti di lavoro non solo nell'analisi biostratigrafica ma anche in applicazioni meno tradizionali, quali sedimentologia, biometria e paleobiologia. La raccolta è comunque destinata allo specialista che potrà usufruire di un esauriente aggiornamento sulle tecniche di investigazione e sui temi di ricerca.

E. ERBA

Huntley B. & Birks H.J.B. (1983) — **An Atlas of Past and Present Pollen Maps for Europe: 0–13000 years ago.** Vol. di 667 pp., 474 fig., 34 tav. fuori testo. Cambridge University Press, £ 90, \$ 174, Cambridge (ISBN 0521 23735.1).

Lo scopo principale del volume è di rappresentare la variazione spaziale dei dati palinologici di 843 località europee, comprese l'Islanda e la Groenlandia. Vengono perciò riportate le carte isopolliniche (in cui le isolinee rappresentano la percentuale dello stesso polline o spora di un dato taxon ad un dato tempo) dell'Europa per i periodi tardo- e postglaciale ad intervalli di 500 anni ¹⁴C. Le carte di ogni taxon sono completate dall'analisi statistica

dei dati (analisi delle componenti principali) e da un commento sulla validità della carta stessa. In base ai risultati ottenuti gli autori propongono varie ipotesi sulle ricostruzioni vegetazionali, le variazioni delle distribuzioni areali e le località rifugio. Le applicazioni di un simile lavoro perciò non sono solo botaniche, ma coinvolgono variazioni culturali e ambientali a larga scala come il clima, i suoli e la domesticazione di piante ed animali.

Poichè gli autori non hanno utilizzato tutte le località europee con analisi palinologiche, la scelta dei siti può essere valutata differentemente, specialmente da noi italiani gravemente penalizzati dall'atlante (meno di 10 siti per tutta la penisola). Si può però osservare che questo fatto riflette in parte anche l'arretratezza degli studi palinologici italiani. Gli autori comunque non specificano il loro criterio di scelta dei siti.

Altre critiche possono essere mosse ai criteri di aggregazione dei taxa, all'utilità stessa di simili ricostruzioni a piccola scala e alla propensione degli autori a spiegare tutti gli andamenti isopollinici con cambiamenti climatici non sempre ben giustificati.

Tutto ciò però non inficia la validità dell'atlante che, se ben usato, offre ad ogni sito palinologico un contesto generale utile per valutare i dati e dovrebbe spingere i palinologi europei a confrontarsi con gli andamenti della vegetazione a scala continentale.