

# PRELIMINARY DATA ON THE HOLOCENE FORAMINIFERA OF THE CILENTO CONTINENTAL SHELF (TYRRHENIAN SEA)

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## ABSTRACT

The present paper supplies the first data on the foraminiferal assemblages and ecology in Holocene surface sediments of the Campanian continental shelf, in the area off the Cilento promontory.

Different types of assemblages have been distinguished and they have been related with parameters as depth, type of sediment and presence of algal and plant remains.

Our study has pointed out the strong prevalence of benthic species both in infralittoral and circalittoral samples and the absence of species that are extinct or indicative of particular paleoclimatic episodes. The age of the assemblages is therefore Holocene, with the exception of a group of foraminifers, presumably reworked, similar to microfaunas of Tyrrhenian age.

The composition of the assemblages, in relation with the known chemical-physical parameters (type of sediment, algal and plant remains, fluvial input and water-depth) has put in evidence that:

- there is an almost perfect agreement, both in the infralittoral and in the circalittoral zone, between type of sediment and the characteristic foraminiferal assemblages;

- as to the algal and plant remains, present in all the samples, in the infralittoral zone the abundance of epiphytic species is in agreement with the presence of *P. oceanica* and of crusty and branching Melobesioideae;

- on the contrary in the circalittoral zone the presence of epiphytic species, along with algal remains, is probably due to phenomena of transport from shallower levels.

- the fluvial input, given by the rivers Solofrone and Alento, causes a sensible increase of euryhaline species, even if it has not a decisive effect on their global frequency.

Finally some remarks are made on the ecological meaning of some species, that, for some of them, is not in agreement with what reported in previous papers.

**Keywords:** Foraminifera, Ecology, Holocene, Cilento, Tyrrhenian Sea, Italy.

## RIASSUNTO

Nel presente lavoro vengono forniti i primi dati sulle associazioni e sull'ecologia dei foraminiferi presenti nei sedimenti superficiali di età olocenica nella piattaforma continentale campana, nell'area prospiciente la porzione settentrionale del Cilento.

Sono stati individuati vari tipi di associazione e sono stati messi in rapporto ai parametri noti, quali la profondità, il tipo di sedimento e la presenza di popolamenti vegetali.

Lo studio effettuato ha messo in evidenza la forte prevalenza delle specie bentoniche nei campioni sia infralittorali che circalittorali e l'assenza di specie estinte o comunque significative di particolari episodi paleoclimatici.

L'età delle associazioni è dunque olocenica, fatta eccezione per un gruppo di foraminiferi, presumibilmente rimaneggiati, simili a microfaune di età tirreniana.

La composizione delle associazioni, in relazione con i parametri chimico-fisici noti (tipi di sedimento, popolamenti vegetali, apporti fluviali e profondità) ha evidenziato una corrispondenza pressoché totale delle associazioni caratteristiche, riguardo ai tipi di sedimento presenti e non sempre invece nei confronti dei popolamenti vegetali e degli apporti fluviali.

Vengono inoltre fornite osservazioni sui significati ecologici di alcune specie, non corrispondenti, per alcune di esse, a quelli noti in letteratura.

**Parole-chiave:** Foraminiferi, Ecologia, Olocene, Cilento, Mar Tirreno, Italia.

## RESUMEN

En este trabajo se dan los primeros datos sobre las asociaciones de foraminíferos y su ecología en los sedimentos holocenos superficiales de la plataforma continental de Campania, en el área al norte de Cilento.

Se han caracterizado varias asociaciones y se las ha relacionado con la profundidad, tipo de sedimento y praderas de algas.

El estudio ha puesto de manifiesto el predominio de las especies bentónicas, tanto en las muestras infra- como circalitorales, y la ausencia de especies extintas o indicativas de episodios paleoclimáticos particulares. La edad de las asociaciones es holocena, salvo un grupo probablemente retrabajado, similar a las faunas tirrenienses.

La composición de las asociaciones en relación con los parámetros físico-químicos conocidos (sedimento, vegetación, influencia fluvial y profundidad) puso en evidencia que, respecto al tipo de sedimento, hay una correspondencia casi total con las asociaciones características. Por el contrario, no siempre la hay respecto de la vegetación ni de los aportes fluviales.

Por otra parte, se han realizado observaciones sobre el significado ecológico de algunas especies, que no se corresponden con lo referido en la literatura.

**Palabras clave:** Foraminíferos, Ecología, Holoceno, Cilento, Mar Tirreno, Italia.

## INTRODUCTION

The present paper supplies the first data on the foraminiferal assemblages and ecology in Holocene surface sediments of the Campanian continental shelf, in the area off Cilento; this area, lying between the Gulf of Salerno and the Gulf of Policastro, is delimited to the north by the mouth of the river Solofrone and to the south by the mouth of the river Alento.

The assemblages studied come from 10 bottom samples, more or less regularly distributed along the coast from north to south, collected partly in the Gulf of Salerno (B.110-B.113) and partly off the Cilento promontory (B.125-130) (Fig.1).

The distribution of the sampling sites holds a certain interest because the samples come from two areas with a different geomorphological and sedimentological history (Bartole *et al.*, 1983). The Gulf of Salerno and the Sele Plain, lying behind the former, were affected during the Plio-Quaternary by strong subsidence which led to the accumulation of more than 1000 m of sediments (Ippolito *et al.*, 1973; Agip, 1977). The Cilento shelf, on the contrary, represents a structural high with modest Plio-Quaternary sedimentation. In particular, in the northern part of the Gulf of Salerno and off the river Alento it is possible to recognize a zone of normal sedimentation and in the Cilento shelf a zone of low sedimentation-rate and/or erosion. In this second zone there are more or less wide areas where the substrate is exposed. Moreover, sandy sediments, probably representing relict deposits, have been observed off Punta Licosa, and "coralligene"(?) banks off Capo Palinuro. (Coppa *et al.*, 1992).

Data on the distribution of foraminifers in the Gulf of Salerno and in the Gulf of Policastro, bordering the area studied in the present paper, have been supplied by Sgarrella and Barra (1985) and Sgarrella *et al.* (1985) respectively.

SAMPLES	LATITUDE	LONGITUDE	DEPTH	SEDIMENT	WD	WWR
B.110	40°22'76"N	14°57'65"E	-23	saS	100	6
B.125	40°13'98"N	14°53'27"E	-34	bG	81	60,86
B.126	40°12'60"N	14°56'01"E	-37	bGsaS	72	64,30
B.127	40°11'16"N	14°59'36"E	-48	sM	91	1,20
B.129	40°08'42"N	15°05'51"E	-49	M	52,50	0,76
B.112	40°17'87"N	14°54'91"E	-51	mS	54,50	10,09
B.128	40°09'31"N	15°01'47"E	-52	saM	59	21,18
B.111	40°20'20"N	14°54'81"E	-53	M	50	1
B.113	40°16'00"N	14°52'60"E	-69	gsaM	63,50	34,96
B.130	40°07'27"N	15°08'39"E	-72	M	110	0,18

**Table 1.** In the table it is given for each sample the code, geographical co-ordinates (**latitude** and **longitude**), water-depth (in m), type of sediment (**bG**= bioclastic gravel; **bGsaS**= bioclastic gravel and sandy silt; **gsaM**= gravelly sandy mud; **saS**= sandy silt; **mS**= muddy silt; **saM**= sandy mud; **sM**= silty mud; **M**= mud), weight (in g) of dried sediment (**WD**) and weight of washing residue for 100 g of dried sediment (**WWR**).

## SAMPLING METHODS

The samples were collected by means of a Shipek grab during two scientific cruises of the N/O Bannock (1984, 1985). They have been dried in oven at 30°C, then weighted and a washed on sieves with 88 micron openings; the residue obtained has been dried again in oven at 30°C, weighted and splitted so to obtain fractions allowing to collect at least 300 specimens, the minimum number necessary for a correct statistical analysis (Blanc-Vernet, 1969). Sample codes, geographic co-ordinates, water-depth, type of sediment, weight of dried sediment and weight of washed residue per 100 g of dried sediment are given in Table 1.

Nearly all the samples come from the area of low sedimentation-rate; the sediments consist of bioclastic gravel, bioclastic gravel mixed with sandy silt, gravelly sandy mud, sandy mud, muddy silt, silty mud and mud. In particular three samples collected in the vicinity of the mouths of the rivers Solofrone (B.110, B.111 - zone of low sedimentation-rate) and Alento (B.129 - zone of normal sedimentation) are represented by sandy silt and mud respectively.

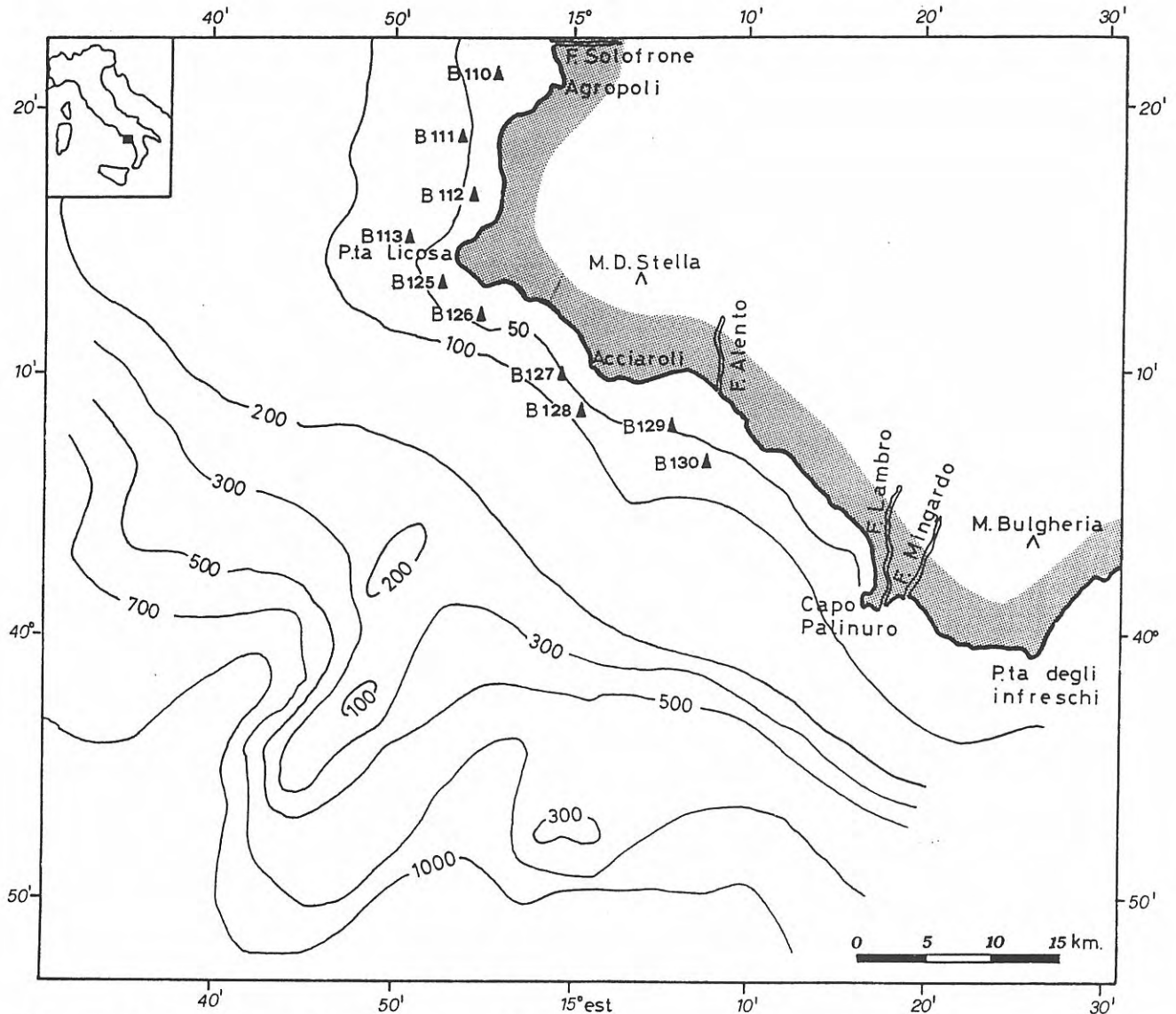


Figure 1. Bathymetric map of Cilento, with location of the samples.

The biogenic fraction of the samples is conspicuous and mainly made of foraminiferal tests; small gastropods, fragments of cheilostome and cyclostome bryozoan colonies and ostracods occur subordinately; small bivalves are even more subordinate. Sponge spicules, little anellids, scaphopods, pteropods, fragments of branchiurid chelae and echinoids are present quite occasionally.

Plant remains are represented in almost all the samples by phanerogam frustules and lumps of broken fibres. Small branches and/or crusts of calcified *Melobesioideae* are also abundant but only in few samples; numerous brown Algae frustules (*Cystoseira*) have been found only in B.126.

## THE ASSEMBLAGES: COMPOSITION AND INTERPRETATION

In all the samples the foraminifers are present with numerous, normal size and well preserved tests; 218 species have been recognized, 207 of them are benthic (Table 2).

In the following pages the typical assemblages found in the sediments of the infralittoral and circalittoral zone (*sensu* Peres and Picard, 1964) are schematically reported. The assemblages were individuated taking into consideration all the species

**Table 2.** In this table the samples are listed with reference to the marine zones (infralittoral and circalittoral) in order of increasing water-depth. For each sample it is given the frequency of each benthic species as a percentage of the total number of benthic foraminifers (**X** = percentage lower than 0,5%); the presence (+) of planktic species; water-depth at sampling site; type of sediment (**bG**= bioclastic gravel; **bGsaS**= bioclastic gravel and sandy silt; **gsaM**= gravelly sandy mud; **saS**= sandy silt; **mS**= muddy silt; **saM**= sandy mud; **sM**= silty mud; **M**= mud); type of vegetation (**C**=*Cystoseira*; **bM**= branching *Melobesioideae*; **cM**= crustose *Melobesioideae*; **P**=*P. oceanica*); percentage of benthos on the total of foraminiferal fauna.





present with percentages higher than 3%, listed in decreasing frequency order.

The ecological significance of the various species is given with reference to the literature (Blanc-Vernet, 1969; Haake, 1977; Blanc-Vernet *et al.*, 1979; Venec Peyre, 1984; Sgarrella and Barra, 1985; Sgarrella *et al.*, 1985; Coppa, 1987, 1988; Jorissen, 1988).

#### *Infralittoral zone* (B.110, B.125, B.126)

Benthic foraminifers exceeds the 98%; planktic foraminifers are quite occasional and represented by 9 species, never occurring all together in each sample.

##### Sandy silt

B.110 (-23 m).

**Assemblage:** *Ammonia beccarii*, *Criboelphidium granosum*, *Cribrononion cuvillieri*, *Hyperammina elongata*, *Haynesina depressula*, *Ammoglobigerina globigeriniformis*, *Ammonia parkinsoniana* and *Textularia candeiana*.

##### Bioclastic gravel

B.125 (-34 m).

**Assemblage:** *Planorbulina mediterraneensis*, *Cibicides lobatulus*, *Asterigerinata mamilla* and *Elphidium crispum*.

##### Bioclastic gravel and sandy silt

B.126 (-37 m).

**Assemblage:** *Asterigerinata mamilla*, *Rosalina bradyi*, *Rosalina concinna*, *Rosalina globularis*, *Cibicides refulgens*, *Rosalina obtusa*, *Quinqueloculina* aff. *parvula* and *Discorbinella bertheloti*.

At -23m, where the influence of fluvial input is strong (Coppa, 1991, B.110 = CO.565), the euryhaline species *Ammonia parkinsoniana*, *Criboelphidium granosum*, *Cribrononion cuvillieri* and *Haynesina depressula* are dominant (Fig. 2b) together with *Ammonia beccarii* (Fig. 2d). Among the agglutinated species (18.7%), some are very fragile (*Eggerelloides scabrus*, *Siphonaperta aspera*

*dilatata*) and have been recorded on low energy bottoms (Blanc-Vernet *et al.*, 1979). The epiphytic and muddy species are absent (Fig. 3).

At -34m and at -37m the sediments are characterized, in agreement with the presence of *P.oceanica* and of crusty and branching Melobesioideae, by epiphytic species (*Planorbulina mediterraneensis* and *Cibicides lobatulus* at -34m, *Rosalina bradyi*, *Rosalina globularis*, *Rosalina obtusa* and *Cibicides refulgens* at -37m) (Fig. 2a) and by *Asterigerinata mamilla*. This species (Fig. 2d) is associated with *Elphidium crispum* in the bioclastic gravel and with *Discorbinella bertheloti* in the bioclastic gravel mixed with sandy silt. In these two samples the euryhaline and muddy species are absent (Fig. 3).

#### *Circalittoral zone*

(B.128, B.113, 127, B.112, B.129, B.111 and B.130).

Also in this zone the benthic foraminifers prevail (90.6% - 99%); planktic foraminifers are represented by 9 species, not present in all the samples.

##### Sandy mud

B.128 (-52 m).

**Assemblage:** *Melonis barleeaanum*, *Valvulineria bradyana*, *Ammonia beccarii*, *Neoconorbina terquemi*, *Cribrononion cuvillieri*, *Buccella granulata*, *Rosalina bradyi* and *Asterigerinata mamilla*.

##### Gravelly sandy mud

B.113 (-69 m).

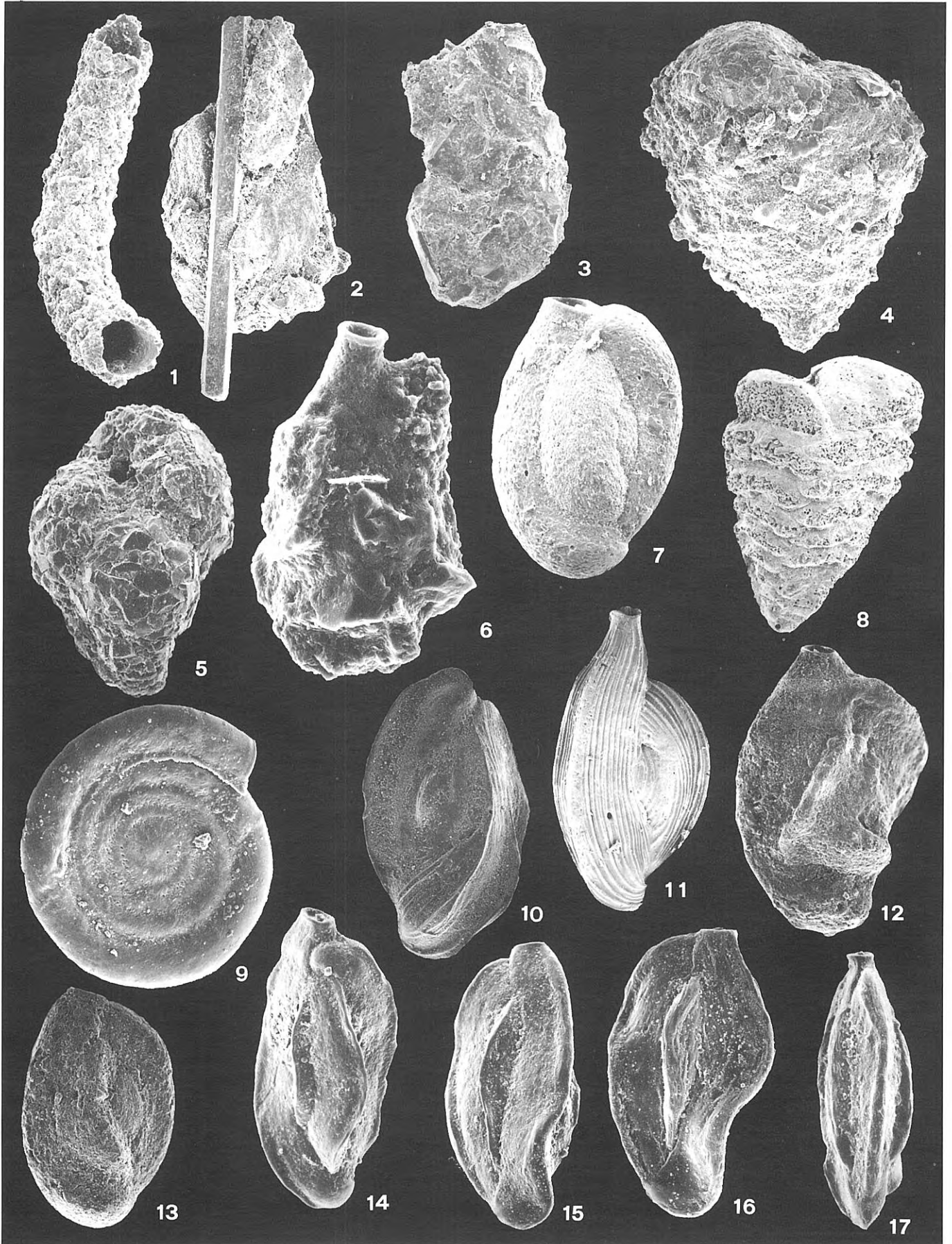
**Assemblage:** *Melonis barleeaanum*, *Ammonia beccarii*, *Valvulineria bradyana*, *Neoconorbina terquemi*, *Gavelinopsis praegeri*, *Rosalina bradyi* and *Cassidulina carinata*.

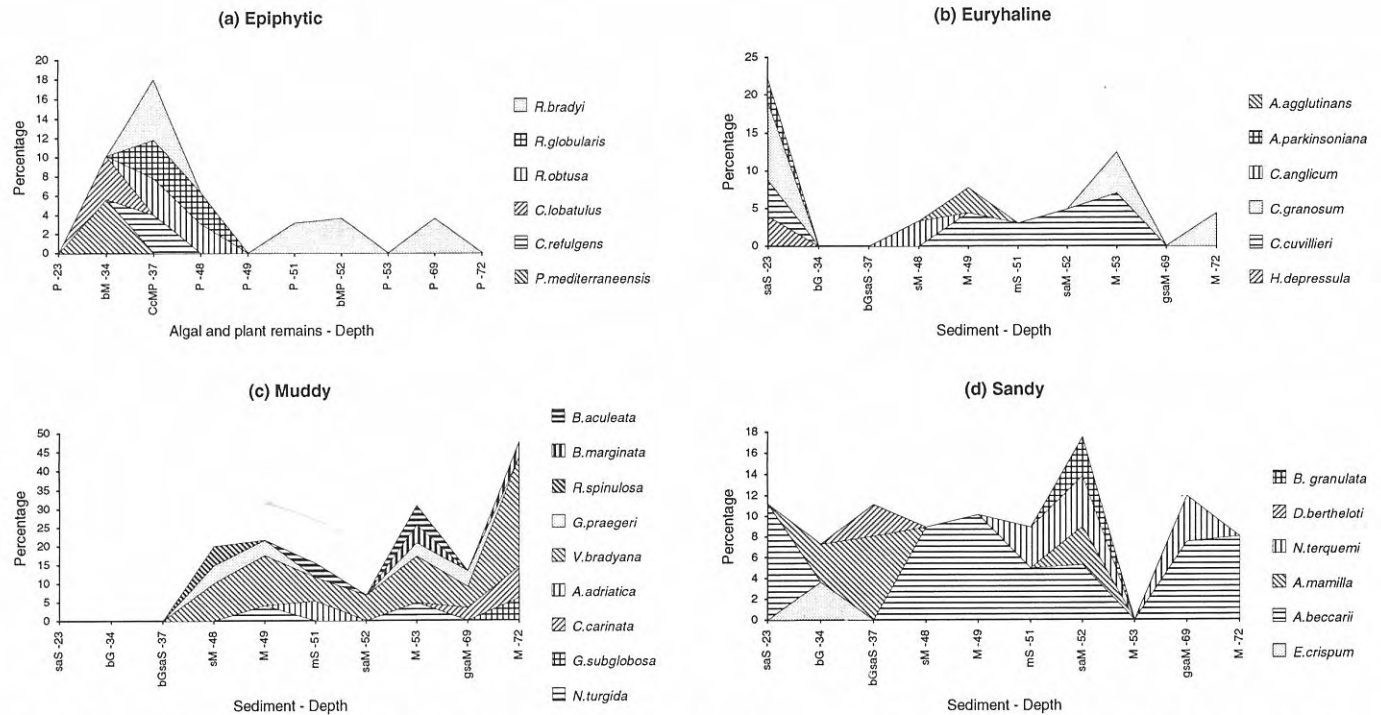
In the sandy-muddy sediments *Melonis barleeaanum* prevail. This ubiquitous species is associated with the muddy species *Valvulineria bradyana* and with the sandy species *Buccella granulata*, (only at -52m), *Neoconorbina terquemi*, *Asterigerinata mamilla* and *Ammonia beccarii* (Fig. 2d). *Gavelinopsis praegeri* and *Cassidulina*

## Plate I

- 1 *Hyperammina elongata* Brady. Side view. B.110. x85.
- 2 *Reophax atlanticus* (Cushman). Side view. B.110. x110.
- 3 *Ammobaculites agglutinans* (d'Orbigny). Side view. B.129. x156.
- 4 *Textularia candeiana* d'Orbigny. Side view. B.112. x147.
- 5 *Eggerelloides scabrus* (Williamson). Side view. B.129. x128.
- 6 *Sardamina cherchiai* Coppa. Side view. B.110. x314.
- 7 *Siphonaperta aspera dilatata* (Y et J. Le Calvez). Side view. B.110. x94.
- 8 *Textularia pseudorugosa* Lacroix. Side view. B.125. x30.
- 9 *Cyclogira involvens* (Reuss). Side view. B.112. x156.
- 10 *Triloculina* sp. Side view. B.112. x45.

- 11 *Quinqueloculina* sp. Side view. B.111. x73.
- 12 *Quinqueloculina bradyana* Cushman. Side view. B.126. x97.
- 13 *Quinqueloculina polygona* d'Orbigny. Side view. B.110. x99.
- 14 *Quinqueloculina* aff. *Q. stelligera* Schlumberger. Side view. B.126. x160.
- 15 *Quinqueloculina* aff. *Q. stelligera* Schlumberger. Side view. B.126. x177.
- 16 *Quinqueloculina* aff. *Q. stelligera* Schlumberger. Side view. B.126. x177.
- 17 *Quinqueloculina* aff. *Q. stelligera* Schlumberger. Side view. B.126. x124.





**Figure 2 a-d.** Frequency of the characteristic species in function of sediment type (**bG**= bioclastic gravel; **bGsaS**= bioclastic gravel and sandy silt; **gsaM**= gravelly sandy mud; **saS**= sandy silt; **mS**= muddy silt; **saM**= sandy mud; **sM**= silty mud; **M**= mud), water-depth and the algal and plant remains (**C**=*Cystoseira*; **bM**= branching Melobesioideae; **cM**= crustose Melobesioideae; **P**=*P. oceanica*).

*carinata* are present only at -69m with low percentages (Fig. 2c).

In these two samples *Rosalina bradyi* is the only epiphytic species: the euryhaline species are occasionally represented only at -52m by *Cribrononion cuvillieri* (Fig. 2b).

#### Silty mud

B.127 (-48 m).

**Assemblage:** *Valvulineria bradyana*, *Ammonia beccarii*, *Reussella spinulosa*, *Gavelinopsis praegeri*, *Rosalina globularis*, *Cribrononion anglicum* and *Rosalina obtusa*.

#### Muddy silt

B.112 (-51 m).

**Assemblage:** *Valvulineria bradyana*, *Textularia candeiana*, *Asterigerinata adriatica*, *Ammonia beccarii*,

*Neoconorbina terquemi*, *Bulimina aculeata*, *Melonis barleeianum*, *Rosalina bradyi* and *Cribrononion cuvillieri*.

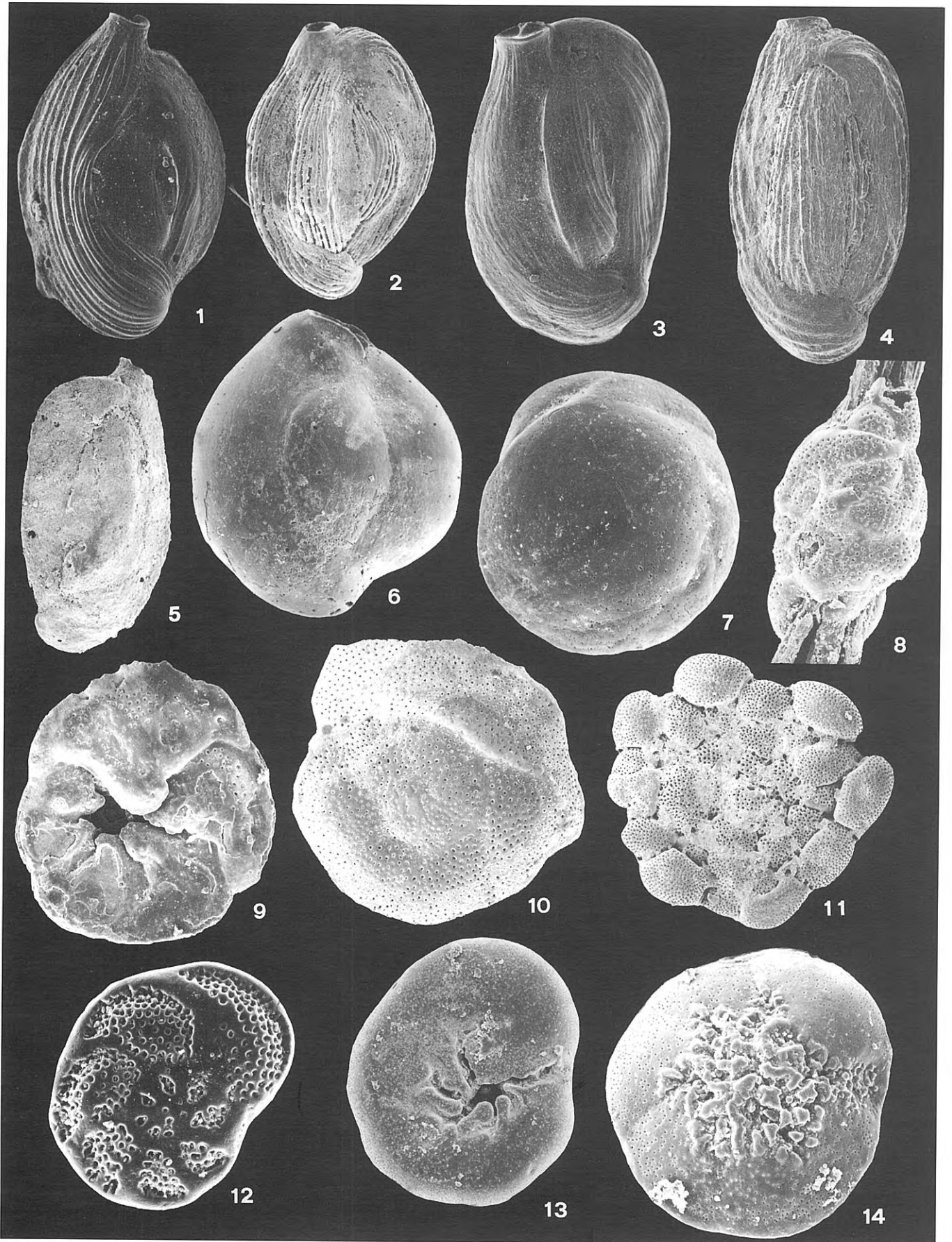
In the silty-muddy sediments the species *Valvulineria bradyana* is dominant, associated with the muddy species *Reussella spinulosa*, *Gavelinopsis praegeri* at -48m, *Bulimina aculeata* and *Asterigerinata adriatica* at -51m (Fig. 2c). Also *Ammonia beccarii* (Fig. 2d) is dominant in these samples, associated at -51m with *Neoconorbina terquemi* and with the ubiquitous species *Textularia candeiana* and *Melonis barleeianum*. The euryhaline species *Cribrononion anglicum* and *Cribrononion cuvillieri* are occasionally represented (Fig. 2b), as well as the epiphytic species *Rosalina bradyi*, *Rosalina globularis*, *Rosalina obtusa* (Fig. 2a), this probably in connection with phenomena of transport from more shallow levels.

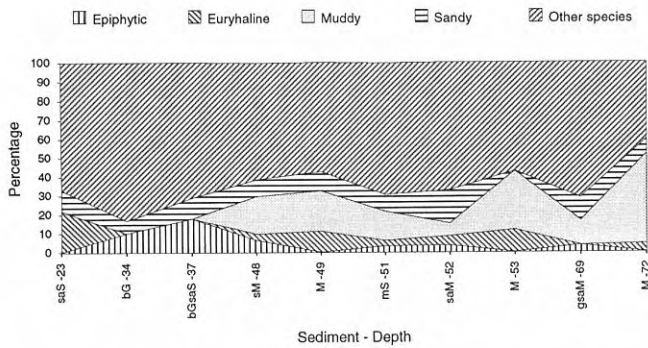
## Plate II

- 1 *Quinqueloculina duthiersi* Schlumberger. Side view. B.127. x106.
- 2 *Quinqueloculina disparilis* d'Orbigny. Side view. B.126. x44.
- 3 *Quinqueloculina* sp. Side view. B.110. x89.
- 4 *Quinqueloculina jugosa* Cushman. Side view. B.126. x90.
- 5 *Quinqueloculina rugosa* d'Orbigny. Side view. B.126. x77.
- 6 *Quinqueloculina viennensis* Y. et J. Le Calvez. Side view. B.125. x59.
- 7 *Buccella granulata* Di Napoli. Spiral side. B.128. x133.

- 8 *Planorbulina mediterraneensis*. d'Orbigny. Umbilical side. The photograph shows the specimen in life position, epiphytic on a *P. oceanica* frustule. B.126. x106.
- 9 *Rosalina* sp. Umbilical side. B.113. x64.
- 10 *Rosalina* sp. Spiral side. B.110. x61.
- 11 *Planorbulina mediterraneensis* d'Orbigny. Umbilical side. B.126. x41.
- 12 *Rosalina bradyi* (Cushman). Spiral side. B.126. x85.
- 13 *Rosalina bradyi* (Cushman). Umbilical side. B.126. x106.
- 14 *Buccella granulata* Di Napoli. Umbilical side. B.111. x185.







**Figure 3.** Relation between epiphytic species, euryhaline species, species typical of sandy and muddy bottoms in function of sediment type (**bG**= bioclastic gravel; **bGsaS**= bioclastic gravel and sandy silt; **gsaM**= gravelly sandy mud; **saS**= sandy silt; **mS**= muddy silt; **saM**= sandy mud; **sM**= silty mud; **M**= mud) and water-depth.

#### Mud

B.129 (-49 m).

**Assemblage:** *Valvulineria bradyana*, *Ammonia beccarii*, *Cribrononion cuvillieri*, *Gavelinopsis praegeri*, *Nonionella turgida*, *Melonis barleeianum*, *Ammobaculites agglutinans* and *Cribroelphidium granosum*.

B.111 (-53 m).

**Assemblage:** *Valvulineria bradyana*, *Cribrononion cuvillieri*, *Bulimina aculeata*, *Cribroelphidium granosum*, *Bulimina marginata*, *Nonionella turgida*, *Gavelinopsis praegeri* and *Bulimina elongata subulata*.

B.130 (-72 m).

**Assemblage:** *Valvulineria bradyana*, *Cassidulina carinata*, *Ammonia beccarii*, *Globocassidulina subglobosa*, *Cribroelphidium granosum* and *Bulimina marginata*.

In the sediments *Valvulineria bradyana* is dominant, associated with other muddy species (*Bulimina* spp., *Gavelinopsis praegeri*, *Cassidulina carinata*, *Globocassidulina subglobosa* and *Nonionella turgida*) (Fig. 2c). The sandy species are absent; only at -49m and at -72m they are represented by *Ammonia beccarii*

(Fig. 2d). The influence of two rivers Alento and Solofrone determines (at -49m and at -53m) the high frequency of the euryhaline forms (*Ammobaculites agglutinans*, *Cribroelphidium granosum* and *Cribrononion cuvillieri*) (Fig. 2b) and of species with an agglutinated test, among which *Eggerelloides scabrus*. The epiphytic species are absent, in accordance with the water -depth (Fig. 2a).

The composition of the benthic assemblages, in relation with the known chemical-physical parameters (type of sediment, algal and plant remains, fluvial input and water-depth) shows that:

- there is an almost perfect agreement, both in the infralittoral and in the circalittoral zone, between type of sediment and the characteristic foraminiferal assemblages.

As shown in Fig. 3, going from more or less coarse sandy sediments to silty and muddy sediments there is on one side a sharp increase of species characteristic of muddy substrates, whose frequency fluctuates in relation with the grain size. On the other side there is a decrease, even if less evident, of the species characteristic of sandy sediments. As to the algal and plant remains, present in all the samples, in the infralittoral zone the abundance of epiphytic species is in agreement with the presence of *P. oceanica* and of crusty and branching Melobesioideae, whereas in the circalittoral zone, their frequency drops dramatically. Finally, the fluvial input, given by the rivers Solofrone and Alento, seems to cause strong increases of euryhaline species, even if they are present also in other zones far from the fluvial mouths.

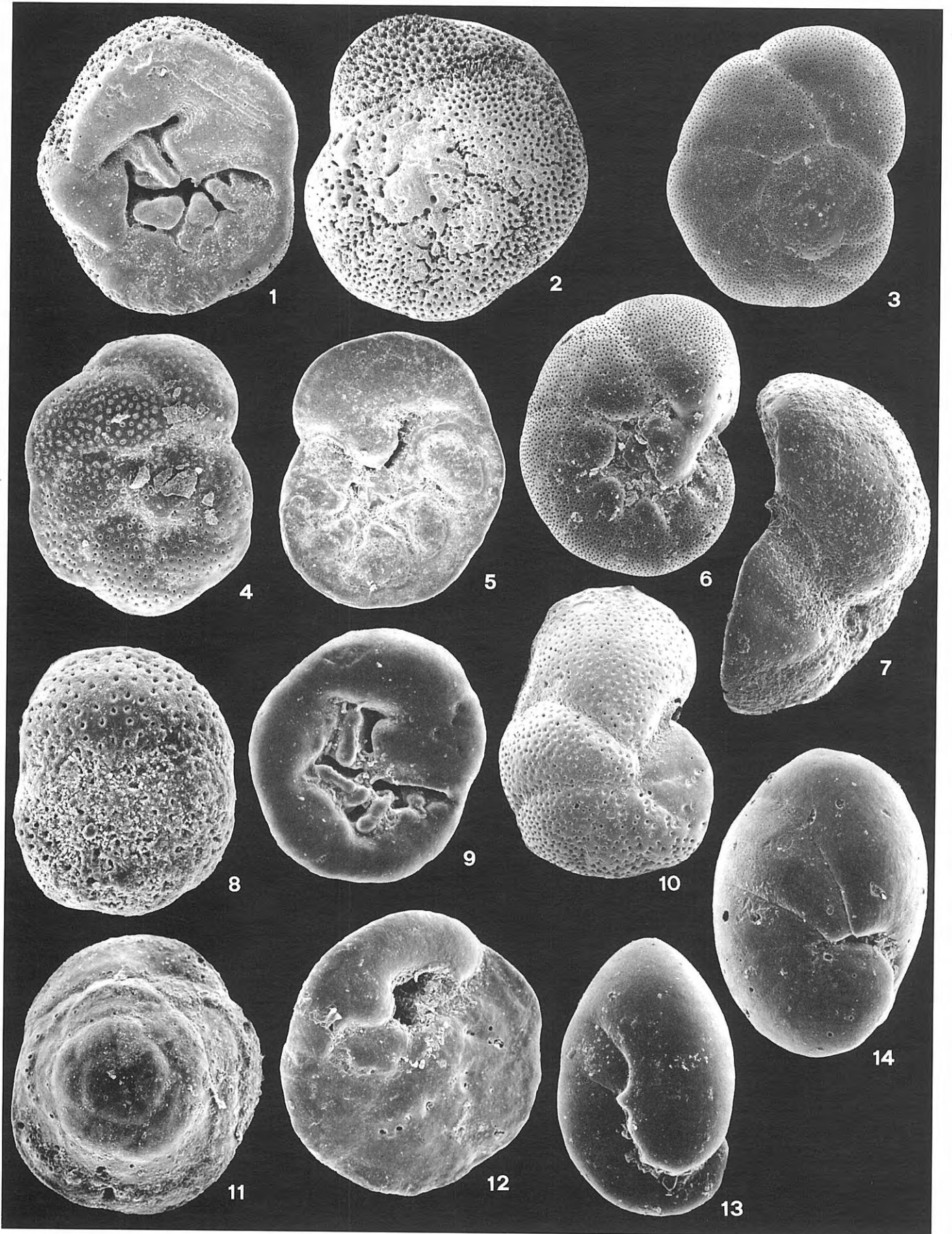
## OBSERVATIONS ON THE ECOLOGY OF SOME SPECIES

An analysis of the assemblages composition in our samples shows that a complete agreement is not always found between the ecological meanings attributed in literature to the species (Blanc-Vernet, 1969; Blanc-Vernet *et al.*, 1979; Venec Peyre, 1984; Jorissen, 1988; etc.) and the environmental parameters directly observed at sampling sites (grain-size of sediment, vegetation, water-depth and proximity of river mouths).

In particular the following remarks can be made:

### Plate III

- 1 *Rosalina obtusa* d'Orbigny. Umbilical side. B.112. x105.
- 2 *Rosalina obtusa* d'Orbigny. Spiral side. B.112. x101.
- 3 *Valvulineria bradyana* (Fornasini). Spiral side. B.129. x92.
- 4 *Rosalina floridana* (Cushman). Spiral side. B.126. x105.
- 5 *Rosalina floridana* (Cushman). Umbilical side. B.126. x85.
- 6 *Valvulineria bradyana* (Fornasini). Umbilical side. B.129. x92.
- 7 *Cibicides lobatulus* (Walker and Jacob). Side view. B.110. x142.
- 8 *Rosalina globularis* d'Orbigny. Spiral side. B.126. x206.
- 9 *Rosalina globularis* d'Orbigny. Umbilical side. B.126. x206.
- 10 *Cibicides lobatulus* (Walker and Jacob). Umbilical side. B.110. x142.
- 11 *Asterigerinata mamilla* (Williamson). Spiral side. B.128. x163.
- 12 *Asterigerinata mamilla* (Williamson). Umbilical side. B.128. x177.
- 13 *Nonionella turgida* (Williamson). Umbilical side. B.129. x284.
- 14 *Nonionella turgida* (Williamson). Umbilical side. B.129. x248.



- Among the species characteristic of sandy sediments (Fig. 2d), *A. beccarii* is abundant also on circalittoral muddy and muddy-sandy bottoms;

- similarly *N. terquemi*, present in almost all the samples increases in the muddy sediments of the circalittoral zone;

- the epiphytic species (*R. bradyi*, *R. globularis* and *R. obtusa*) are found also at depths below 40 m, probably in connection with phenomena of transport from more shallow levels (Fig. 2a);

- the species with agglutinated fragile test (*E. scabrus* and *S. aspera dilatata*) (Pl. I, Figs. 5, 7), indicative of mobile low energy bottoms, are present with appreciable percentages only in proximity of river mouths (rivers Solofrone and Alento);

- *C. granosum* and *C. cuvillieri* (Pl. IV, Figs. 2, 6), sensitive to salinity changes, are present, as well as in the zones influenced by the two rivers, also in others, where there is no evidence of deviations from normal salinity (Fig. 2b);

- *C. anglicum*, euryhaline species, is present only at -48m, far from the river mouths (Fig. 2b).

On the contrary, as regards the species indicative of sandy sediments (Fig. 2d), the following species have been found in conditions confirming their ecologic meanings:

- *A. mamilla* (Pl. III, Figs. 11, 12) is typical of poorly sorted sands at water-depth of -37m and where the sandy fraction prevails;

- *B. granulata* (Pl. II, Figs. 7, 14), found also on muddy substrates, is frequent only where a sandy fraction is present.

To the same extent the species typical of muddy bottoms (*B. aculeata*, *B. marginata*, *G. praegeri*, *V. bradyana* and *N. turgida*) characterize the circalittoral terrigenous muds (Fig. 2c), confirming once again their relation with the substrate grain-size.

Moreover *A. parkinsoniana*, is found only at -23m, in proximity of the river Solofrone mouth, this confirming its significance of euryhaline infralittoral species (Fig. 2b).

## REWORKED FAUNAS

Analysis of the assemblages has shown that all the foraminifers present belong to living species. Extinct

species and species indicative of particular climatic episodes occurred during the Quaternary are lacking: all the microfaunas are of Holocene age. An exception to this could perhaps be represented by a group of large size foraminifers, with worn tests of yellowish colour, belonging to the genera *Quinqueloculina* (*Q. disparilis* and *Q. viennensis*) and *Textularia* (*T. pseudorugosa*) found at -34m (B.125 - 37.8%) in bioclastic gravels. Similar occurrences have been reported in recent sediments along the coast of Lebanon (Moncharmont-Zei, 1968) and at the Cheradi Islands (Taranto) in sands of probable Tyrrhenian age. Therefore it can not be excluded that, at least in a narrow zone of the shelf off Punta Licosa, marine sediments of older age could be present. It must be taken into account to this regard that in this zone, where the substrate is exposed, sandy sediments, probably representing relict deposits, have been identified by means of Mini Sparker profiles (Coppa *et al.*, 1992).

## CONCLUSIONS

The present study has evidenced the following points:

- the strong prevalence of benthic foraminifers that never drop below 90.6%; the very low frequency of the plankton does not allow any remark on type of climate;

- the absence of extinct and palaeoclimatically significant species: the assemblages are of Holocene age;

- the presence in the bioclastic gravels of large size foraminifers with worn tests of yellowish colour, belonging to the genera *Quinqueloculina* and *Textularia*, that are reported both in warm areas and in sediments of probable tyrrhenian age;

- there is an almost perfect agreement, both in the infralittoral and in the circalittoral zone, between type of sediment and the characteristic foraminiferal assemblages;

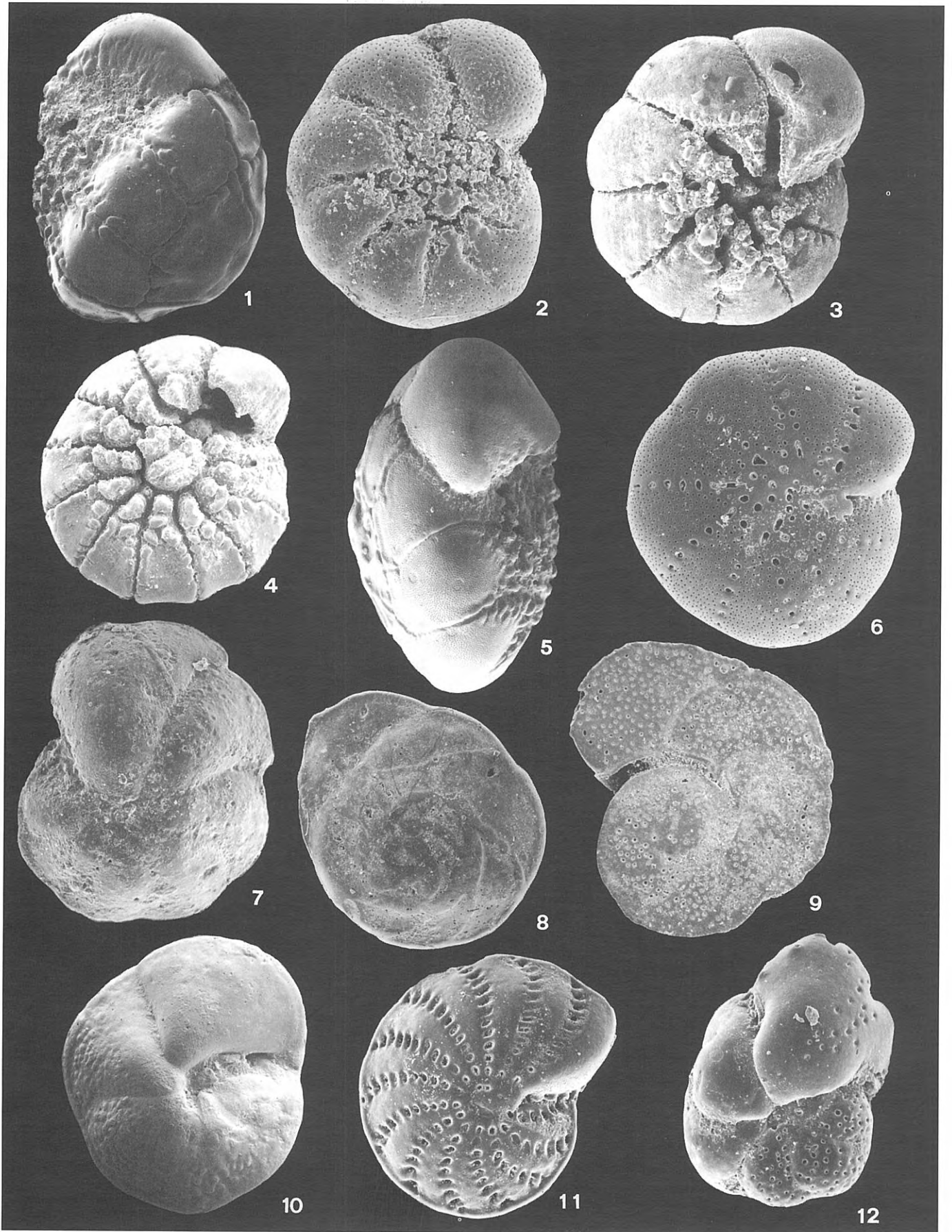
- as to the algal and plant remains, present in all the samples, in the infralittoral zone the abundance of epiphytic species is in agreement with the presence of *P. oceanica* and of crusty and branching Melobesioideae;

- on the contrary in the circalittoral zone the presence of epiphytic species, along with algal and plant remains, is probably due to phenomena of transport from shallower levels;

### Plate IV

- 1 *Ammonia beccarii* (Linneo). Side view. B.127. x89.
- 2 *Cribrorhynchium granosum*. (d'Orbigny). Side view. B.110. x156.
- 3 *Ammonia beccarii* (Linneo). Umbilical side. B.110. x127.
- 4 *Ammonia beccarii* (Linneo). Umbilical side. B.113. x72.
- 5 *Ammonia beccarii* (Linneo). Side view. B.128. x94.
- 6 *Cribrononion cuvillieri* (Levy). Side view. B.126. x177.
- 7 *Cibicides lobatulus* (Walker and Jacob). Umbilical side. B.126. x105.

- 8 *Eponides repandus*. (Fichtel and Moll). Spiral side. B.125. x48.
- 9 *Cibicides pseudolobatulus*. Perelis and Reiss. Spiral side. B.126. x105.
- 10 *Eponides repandus* (Fichtel and Moll). Umbilical side. B.128. x109.
- 11 *Elphidium advenum*. (Cushman). Side view. B.110. x109.
- 12 *Cibicidella variabilis* d'Orbigny. Umbilical side. B.126. x143.



- finally the fluvial input, given by the rivers Solofrone and Alento, seems to cause strong increases of euryhaline species, that however are present also in other zones, far from fluvial mouths.

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