

NEW DATA ON PLANKTONIC FORAMINIFERA
BIOSTRATIGRAPHY FROM THE NEOGENE
OF THE GARGANO PENINSULA
(FOGGIA, SOUTHERN ITALY)*

GIGLIOLA VALLERI^o

Key-words: Planktonic foraminifera biostratigraphy, Neogene, Gargano, Paleogeography.

Riassunto. In questo lavoro vengono esposti i risultati di uno studio biostratigrafico di dettaglio, basato sulle associazioni a Foraminiferi planctonici, relativo ad una serie affiorante tra Apricena e Poggio Imperiale sul bordo occidentale del Gargano (FG).

Le associazioni riconosciute hanno permesso di attribuire al Pliocene Inferiore i sedimenti trasgressivi sul basamento mesozoico e di distinguere due biozone: a *Globorotalia puncticulata* (Pliocene Inferiore) e a *Globorotalia inflata* (Pliocene Superiore). E' stata riconosciuta una lacuna biostratigrafica corrispondente al Pliocene Medio.

Abstract. This paper concerns detailed analyses on planktonic foraminifera biostratigraphy of a section outcropping in the area of Poggio Imperiale, on the western side of Gargano (FG).

The sediments unconformably overlying the mesozoic carbonate platform have been assigned to *Globorotalia puncticulata* Zone (Early Pliocene) and to *Globorotalia inflata* Zone (Late Pliocene). A Middle Pliocene stratigraphic gap has been recognised.

Introduction.

Neogene formations of Gargano hold a great interest for the geologists as this peninsula is an important conjunction between Dinaric - Hellenic area and Apennines area.

The Gargano peninsula is a block of uplifted Jurassic - Cretaceous carbonate rocks. Discontinuous calcarenitic deposits of Neogene age overlie unconformably the Mesozoic basement. This calcarenite crops out along the northern side close to the Lesina and Varano lakes; in the surroundings of the Apricena and Poggio Imperiale villages to the West; close to S. Giovanni Rotondo village and close to Monte Granata to the South.

* This contribution is part of the studies of the paleontological research group of the Earth Sciences Department - University of Florence. This publication is supported by M.P.I. 60% N.090100064.

^o Dipartimento di Scienze della Terra dell'Università di Firenze, Via G. La Pira 4 - 50121 Firenze.

Various places in the surroundings of the Apricena and Poggio Imperiale villages are very interesting since in this zone it is possible to attempt to correlate marine biostratigraphy with stratigraphic units based on mammal faunas. In fact quarry works allowed findings of abundant mammal fossils in «terra rossa» deposits from karst fissures of Mesozoic limestones and caused well exposed sections of Neogene sediments.

Several studies concerning structural and paleontological aspects of the Gargano peninsula have been carried out. The reader is referred to D'Alessandro et al. (1979) for the literature about this argument.

These authors in the same paper referred to the Tortonian (Late Miocene) the calcarenitic deposits outcropping in the area we are dealing with.

Freudenthal (1971) assigned the vertebrate faunas from karst fissures in this zone to a Vallesian – Turolian age (Late Miocene).

As to the fillings of the same fissures, studies in progress (De Giuli, Masini & Torre) suggest a Middle – Early Pliocene age.

The study of the planktonic foraminifera assemblages, presented in this work, assigns to the *Globorotalia puncticulata* Zone (Early Pliocene) the sediments unconformably overlying the Mesozoic limestones.

Moreover the results of these researches point out the occurrence of a stratigraphic gap, during the Middle Pliocene, caused by a regression–rise stage followed by a second transgression depositing biocalcarenic sediments, referable to the *Globorotalia inflata* Zone (Late Pliocene). The biostratigraphic subdivision followed in this work uses the zonal scheme proposed by Colalongo et al. (1979).

Cava Dell'Erba section (Fig. 1, 2).

The present detailed biostratigraphic study concerns particularly a section located in the area of Poggio Imperiale. It was hoped to obtain here sufficient data for a detailed biostratigraphy, because of the thickness of the section, over 40 meters, and to sample at enough close intervals, because of its fairly good exposure.

The section is well exposed along a N–S cut, about 200 m long and 50 m high. An uplifted block of the Mesozoic limestones is sideways in a structural contact with the sediments of the series to the North (see Fig. 1).

Geographic location.

The section outcrops about 250 m South of the road from Poggio Imperiale to Apricena, more exactly about 4.5 km from Apricena, along the road-cut that leads to Cava Dell'Erba, at 120 m above sea level (Tav. I.G.M. 155 II NE; lat. $41^{\circ}45'10''$, long. $15^{\circ}25'35''$ E Greenwich).

Lithologic outline.

The lithostratigraphic sequence can be divided in the following five informal units from bottom to top:

1) «*Greenish clays*». This unit is composed of irregularly alternating silty clays and more or less sandy clays, ranging in colour from olive green to yellowish, gradually shading one into another. Bedding is evident only in the last few meters where there are 10 to 15 cm thick yellowish interbedded horizons, consisting of cemented fragments of balanids.

These clays unconformably overlie the Mesozoic limestones and are sharply overlain by the limestones of the following unit. The thickness of the greenish clays is about 15 meters.

2) «*Pinkish limestones*». The unit consists of a bedded limestone succession. These limestones, in layers 40 to 100 cm thick, are very fractured and are richly fossiliferous. Three members are usually present from bottom to top:

a) calcareous breccia with poor fossils content, passing upwards to biomicritic limestones containing a very high concentration of large bivalve shells;

b) biomicritic limestones consisting mostly of balanids skeletons;

c) biomicritic limestones containing abundant coral skeletons. The colour ranges from pale to bright pink. In some place these limestones are very altered and look like an unbedded sedimentary body. Two reasons could explain that observation: the first one is the lack of post-depositional diagenesis; the second is secondary dissolution. The second hypothesis is strengthened by finding of poorly preserved microfossils with dissolution of calcitic tests.

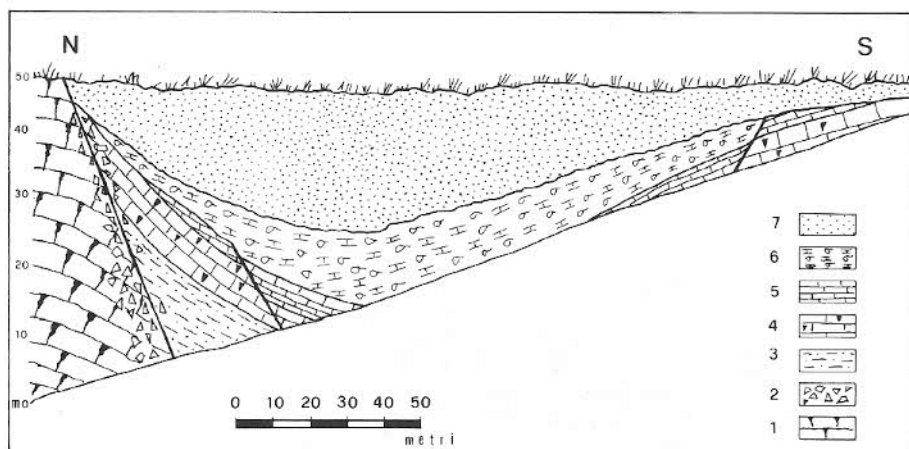


Fig. 1 — Geologic section of the Cava Dell'Erba. 1) Cryptocrystalline limestones; 2) calcareous fault-breccia; 3) silty clays and sandy clays; 4) fossiliferous limestones; 5) biomicritic limestones; 6) biostromal deposits; 7) biocalcarenic sands.

The upper limit of this unit is an erosional surface stressed by occasional occurrence of laminated clays, no more than 10 cm thick, pale green in colour. The total thickness is about 6 meters.

3) «*White–greyish limestones*». This unit consists of bedded biomicritic limestones containing small molluscs and corals. The fractured layers range from 10 to 60 cm in thickness and white to grey in colour.

These limestones come in a sharp contact with the following unit through an erosional surface. The thickness is 1.5 meter.

4) «*Coquina*». This irregular body consists of accumulation of calcareous detritus and tests: internal moulds of small bivalves are the dominant fossils causing a peculiar sponge–like aspect. A certain pseudostratification is caused by the occurrence of more or less lithified discontinuous levels consisting of encrustant organisms: bryozoans and coralline algae. Close to the fault contact with the Mesozoic limestones this «*coquina*» looks like a hard consolidated rock with massive structure. Its colour ranges from white–grey to rust–red when weathered.

The maximum thickness of this unit is 6 meters. The upper contact with the following unit is stressed by a lithified level and an abrupt change in colour.

5) «*Yellow calcareous sands*». This lithologic unit consists of coarse sands, fragments of calcareous tests, chest–nut yellow in colour. A stratified structure is caused by the occurrence of consolidated lenses and layers up to 20 cm thick. The upper two meters are homogeneous finer sands without an evident stratification.

An erosional surface limits upwards this sands from the actual soil, brown to black in colour. The total thickness of the unit is 15 meters.

Tectonic outline.

The first three lithological units of the section have been disturbed by postdepositional tectonics: they have been faulted and folded in a asymmetrical syncline. Northwards the strata dip very strongly: from 40° to nearly vertical; southwards they dip gently: from 10° to horizontal. The sediments of the upper lithological units, little disturbed by synsedimentary tectonics, filled this depression, showing a maximum thickness in the middle part and marginal pinch–outs (see Fig. 1).

Planktonic foraminifera biostratigraphy.

The detailed study on microfossil assemblages has been done with the aid of light and scanning electron microscope on 52 samples, from the Cava Dell'Erba section, in which the fossils are quite abundant and well diversified.

The zones to which the planktonic foraminifera associations can be assigned are *Globorotalia puncticulata* Zone of the Early Pliocene and *Globorotalia inflata* Zone of the Late Pliocene. A stratigraphic gap corresponding to the Middle Pliocene has been documented by planktonic foraminifera content.

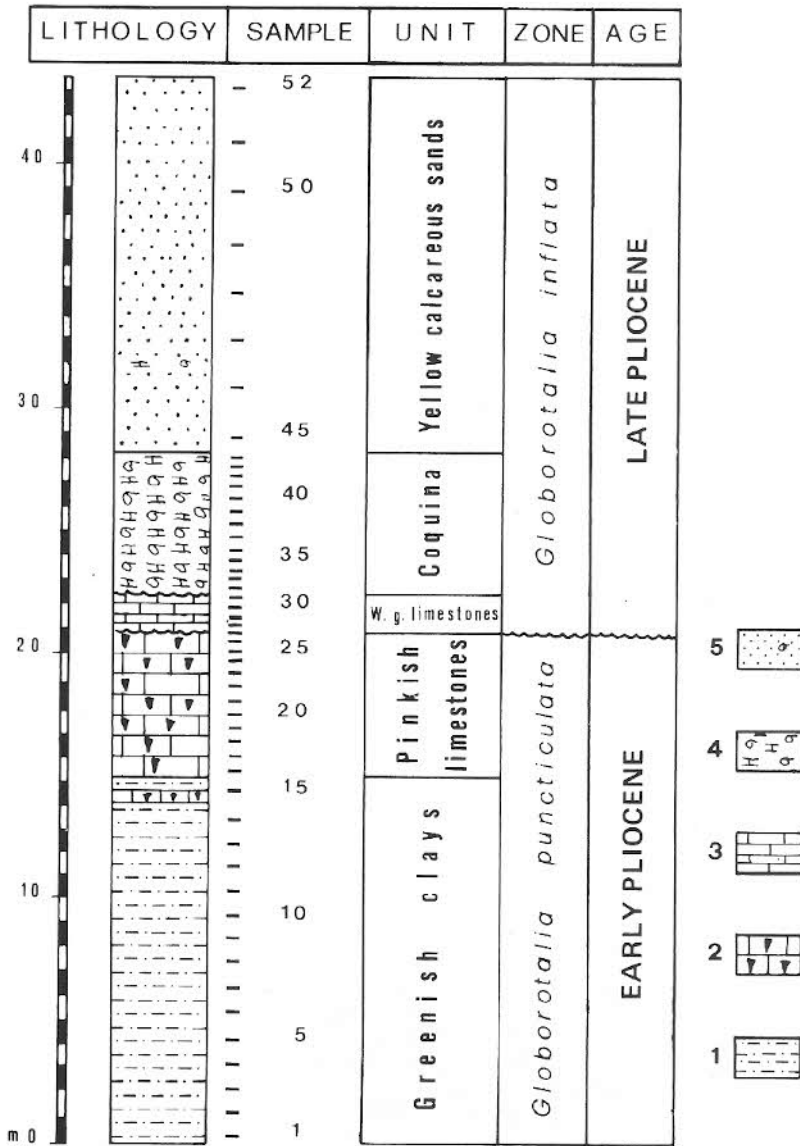


Fig. 2 – Lithologic column and biostratigraphy of the Cava Dell'Erba section. 1) Silty-sandy clays; 2) fossiliferous limestones; 3) biomicritic limestones; 4) biostromal deposits; 5) biocalcareous sands.

Figure 2 shows the stratigraphic column of Cava Dell'Erba section with the position of the investigated samples and the biostratigraphic scheme based on the planktonic foraminifera zones.

Discussion on fossil content.

The distribution of planktonic and benthonic foraminifera in the investigated samples results from Tables 1, 2 and 3.

Unit 1. Samples from «greenish clays» are characterized by a rich foraminiferal assemblage, both in term of specimens and species. Planktonic foraminifera are usually more abundant than benthonic. *Globorotalia puncticulata* occurs more frequently than the other planktonic foraminifera throughout the unit. In addition the occurrence of other Early Pliocene species (*Uvigerina rutila*, *U. longistriata*, *Siphonina planoconvexa*, *Planularia auris*, *Bolivina antiqua*) allow to refer the unit to the *Globorotalia puncticulata* Zone. The specimens are always well preserved.

Unit 2. A change in foraminifera assemblage is recorded within the «pinkish limestones». An abrupt fall in fossil frequencies occurs at the base of this unit: an oligotypic assemblage, with *Elphidium* sp. and *Lenticulina* sp., is noticed. Upwards the samples are again characterized by an abundant and diversified assemblage. Benthonic foraminifera, dominated by shallow water species, are more frequent than planktonic. The occurrence of *Globorotalia puncticulata* throughout the unit indicates it can be always referred to the Early Pliocene. Moreover *G. bononiensis* and *G. puncticulata padana* occur, even if rarely, in a few samples. Usually the tests are not well preserved.

This unit is characterized also by a macrofossil content. Member a) contains amassed shells of bivalves, genus *Perna* (valve length: 16–17 cm). Member b) consists mostly of cemented skeletons of large balanids: *Balanus tintinnabulum tintinnabulum* Linneo has been recognized (height: 6–8 cm). Member c) is characterized by the occurrence of abundant solitary corals (width: 6–7 cm, height: 11–12 cm) and coralline algae, *Melobesiae*.

Sample 27 from laminated clays, overlying unit 2, is unfossiliferous.

Unit 3. A remarkable change in the foraminifera assemblage from the «white – greyish limestones» occurs. All the Early Pliocene typical species abruptly disappear. *Globorotalia inflata* is present from the base and *G. crassaformis* is very rare.

Macrofossils occur with lower frequency than in the former unit. Skeletons of small corals are the dominant rests together with gastropods, echinoderms and coralline algae.

EARLY PLIOCENE		LATE PLIOCENE										A G E						
<i>Globorotalia puncticulata</i>		<i>Globorotalia inflata</i>										Z O N E						
1		2			3			4				5		U N I T				
A		B			C			D				E		S A M P L E				
SPECIES												S A M P L E						
	1																	<i>Globorotalia borionensis</i>
	2																	<i>G. crassaformis</i>
	3																	<i>G. inflata</i>
	4																	<i>G. puncticulata</i>
	5																	<i>G. puncticulata p.</i>
	6																	<i>Globigerina apertura</i>
	7																	<i>G. bulloides</i>
	8																	<i>G. calida praecalida</i>
	9																	<i>G. cf. nepenthes</i>
	10																	<i>G. quinqueloba</i>
	11																	<i>Globigerinoides obliquus</i>
	12																	<i>G. ruber</i>
	13																	<i>G. sacculifer</i>
	14																	<i>G. trilobus</i>
	15																	<i>Neogloboquadrina dutertrei</i>
	16																	<i>N. pachiderma</i>
	17																	<i>Globigerinella aequilateralis</i>
	18																	<i>Orbulina universa</i>
	19																	
	20																	
	21																	
	22																	
	23																	
	24																	
	25																	
	26																	
	28																	
	29																	
	30																	
	31																	
	32																	
	33																	
	34																	
	35																	
	36																	
	37																	
	38																	
	39																	
	40																	
	41																	
	42																	
	43																	
	44																	
	45																	
	46																	
	47																	
	48																	
	49																	
	50																	
	51																	
	52																	

Table 1 - Distribution of selected planktonic foraminifera in the Cava Dell'Erba section.
 * Rare; o common; • abundant.

EARLY PIOCENE		LATE PIOCENE		A G E	
<i>Globorotalia puncticulata</i>		<i>Globorotalia inflata</i>		Z O N E	
1		4		5	
A		D		E	
SAMPLE	SPECIES	SAMPLE	SPECIES	SAMPLE	SPECIES
52	Ammonia beccarii	52	Ammonia beccarii	52	Ammonia beccarii
51	Bolivina antiqua	51	Bolivina antiqua	51	Bolivina antiqua
50	B. leonardii	50	B. leonardii	50	B. leonardii
49	Bulimina inflata	49	Bulimina inflata	49	Bulimina inflata
48	B. marginata	48	B. marginata	48	B. marginata
47	Cibicides lobatulus	47	Cibicides lobatulus	47	Cibicides lobatulus
46	Cibicides ungerianus	46	Cibicides ungerianus	46	Cibicides ungerianus
45	Elphidium crispum	45	Elphidium crispum	45	Elphidium crispum
44	Marginulina costata	44	Marginulina costata	44	Marginulina costata
43	M. crebricosta	43	M. crebricosta	43	M. crebricosta
42	Orthomorphina bassanii	42	Orthomorphina bassanii	42	Orthomorphina bassanii
41	O. stainforthi	41	O. stainforthi	41	O. stainforthi
40	Planularia auris	40	Planularia auris	40	Planularia auris
39	Siphonina planoconvexa	39	Siphonina planoconvexa	39	Siphonina planoconvexa
38	Stilostomella hispida	38	Stilostomella hispida	38	Stilostomella hispida
37	Uvigerina longistriata	37	Uvigerina longistriata	37	Uvigerina longistriata
36	U. paragrana	36	U. paragrana	36	U. paragrana
35	U. rutula	35	U. rutula	35	U. rutula
34		34		34	
33		33		33	
32		32		32	
31		31		31	
30		30		30	
29		29		29	
28		28		28	
26		26		26	
25		25		25	
24		24		24	
23		23		23	
22		22		22	
21		21		21	
20		20		20	
19		19		19	
18		18		18	
17		17		17	
16		16		16	
15		15		15	
14		14		14	
13		13		13	
12		12		12	
11		11		11	
10		10		10	
9		9		9	
8		8		8	
7		7		7	
6		6		6	
5		5		5	
4		4		4	
3		3		3	
2		2		2	
1		1		1	

Table 2 - Distribution of selected benthic foraminifera in the Cava Dell'Erba section.
 • Rare; o common; ● abundant.

EARLY PIOCENE		LATE PIOCENE		A G E
<i>Globorotalia puncticulata</i>		<i>Globorotalia inflata</i>		Z O N E
1	2	3	4	5
A		B		C
UNIT		UNIT		SAMPLE
1	16	28	32	45
2	17	29	33	46
3	18	30	34	47
4	19	31	35	48
5	20	32	36	49
6	21	33	37	50
7	22	34	38	51
8	23	35	39	52
9	24	36	40	
10	25	37	41	
11	26	38	42	
12	27	39	43	
13	28	40	44	
14	29	41	45	
15	30	42	46	
16	31	43	47	
17	32	44	48	
18	33	45	49	
19	34	46	50	
20	35	47	51	
21	36	48	52	
22	37	49		
23	38	50		
24	39	51		
25	40	52		
26	41			
27	42			
28	43			
29	44			
30	45			
31	46			
32	47			
33	48			
34	49			
35	50			
36	51			
37	52			
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				

<p>GLOBIGERINA CFR NEPENTHES</p> <p>UVIGERINA RUTILA</p> <p>UVIGERINA LONGISTRATA</p> <p>SIPHONINA PLANCONVEXA</p> <p>GLOBOROTALIA PUNCTICULATA</p>	<p>GLOBOROTALIA INFLATA</p> <p>GLOBOROTALIA CRASSIFORMIS</p> <p>BULIMINA MARGINATA</p> <p>ORTHOMORPHINA STAINFORTHII</p>
---	--

Table 3 – Distribution of selected foraminifera in the Cava Dell’Erba section.

Unit 4. A change in faunal assemblage in this unit marks a further evolution in the environmental conditions. The benthonic species are dominant in the foraminifera association. *Globorotalia inflata* occurs in almost every sample and *G. crassaformis* is usually very rare. The specimens from this unit are well preserved.

The content in macrofossils is very abundant: echinoderms, gastropods and encrustant organisms, bryozoans and coralline algae, constitute about 80% of the rock.

Unit 5. The unit «yellow calcareous sands» is characterized by a foraminifera assemblage dominated by benthonic species, most of them suggesting shallow water. Planktonic foraminifera are rare, however *Globorotalia inflata* is present in almost every sample. The specimens are broken and show evident phenomena of corrosion caused by agitated water.

As to the period to which refer these three units, our data allow to exclude an age older than Late Pliocene: in fact *Globorotalia inflata* is present from the base of the «white – greyish limestones». Moreover because of the lack of significant species of younger periods, throughout these units, we think the sediments of these units may be assigned to the *Globorotalia inflata* Zone of the Late Pliocene.

Discussion on paleoenvironmental evolution.

At the beginning of the Pliocene (*Sphaeroidinellopsis* spp. Zone – *Globorotalia margaritae* Zone) the Mesozoic carbonate platforms were emergent. Later a rapid ingression occurs (*Globorotalia puncticulata* Zone). Open marine conditions persist during the deposition of «greenish clays» with dominant planktonic microfauna. A regressive stage starts during the latest part of the *Globorotalia puncticulata* Zone. The environment evolves towards reef facies conditions with warm, shallow and well oxygenated water favouring building-up organisms (balanids, corals, coralline algae). «Pinkish limestones» with dominant benthonic microfauna are laid down during this stage (*G. puncticulata* Zone).

Later the sea level falls. The lack of specimens of «*Globorotalia crassaformis* group», with the exception of rare individuals co-occurring with *Globorotalia inflata*, allow us to define a stratigraphic gap during the Middle Pliocene at least. Supra-tidal conditions occur: discontinuous small marshes probably develop in which the thinly laminated barren clays deposit.

During the Late Pliocene (*Globorotalia inflata* Zone) a second ingressive phase occurs. An open quieter environment develops with deeper sea bottom, in which «white – greyish limestones» deposit with abundance of planktonic microfauna.

After tectonic activity, during the Latest Pliocene, a low energy lagoonal basin develops with a certain connection with the sea as testified by the high faunal diversity and density of «coquina» deposits. The biostromal body consists of shell beds accumulated by periodical streams. During alternating quieter periods encrusting organisms grow, forming interbedded biostromal lenses. In this shallow water little basin, from time to time, planktonic foraminifera in high frequency have been carried floating in tide waves.

The lagoonal basin, on the way to fill, rapidly evolves towards a higher energy littoral environment, in which «yellow calcareous sands» deposit.

Conclusions.

The results above exposed confirm the occurrence of a transgression depositing pelagic sediments during the Early Pliocene period. Because of a general rising, faults – already outlining the horst structure of the Gargano peninsula – start to work again and emergent platform conditions occur throughout the Middle Pliocene period. A second ingressive cycle deposits calcarenitic sediments during the Late Pliocene.

In various sites of the investigated area calcarenitic deposits overlie the Mesozoic basement. They seem to constitute a continuous transgressive layer on the Mesozoic limestones and on the karst fissures.

At the present time it is impossible to discriminate which of the two sedimentary cycles (Early or Late Pliocene) deposited this calcarenitic cover on the karst fissures. Moreover these sediments, unfossiliferous or with stratigraphically meaningless fauna when directly overlying fissures, cannot be used to date the continental fauna in the fissures.

Only on the base of further analyses it will be possible to establish well-founded correlations between marine and continental data and to confirm hypotheses on paleoenvironmental evolution of the Gargano.

Systematics of the planktonic foraminifera

Examinations on planktonic foraminifera have been carried out by transmitted light microscope, on thin sections, and especially by stereoscopic light microscope and scanning electron microscope, on residual sieved materials.

All the illustrations of the tables are stereoscan photographs made with the scanning electron Jeol SM3 microscope of the Earth Science Department of Florence, except for Fig. 1 and 2 (transmitted light photographs) of Pl. 43.

In this chapter only the most significant species are described and systematically classified according to Loeblich & Tappan (1964) and further modifications and taxonomic revisions (Loeblich & Tappan, 1974).

Order Foraminifera Eichwald, 1830

Superfamily *Globigerinacea* Carpenter, Parker & Jones, 1862

Family *Globigerinidae* Carpenter, Parker & Jones, 1862

Genus *Globigerina* d'Orbigny, 1826

***Globigerina apertura* Cushman, 1918**

Pl. 44, fig. 1-4; Pl. 45, fig. 4-6

1918 *Globigerina apertura* Cushman, p. 57, pl. 12, fig. 8 a-c.

1969 *Globigerina bulloides apertura* - Blow, p. 317, pl. 12, fig. 8.

1972 *Globigerina bulloides apertura* - Akers, p. 47, pl. 21, fig. 3 a-c; pl. 37, fig. 1 a-c; pl. 47, fig. 3 a, b.

1978 *Globigerina apertura* - Zachariasse et al., p. 215, pl. 1, fig. 3-7; pl. 2, fig. 8 a-d.

1983 *Globigerina apertura* - Spaak, p. 119, pl. 1, fig. 8-11.

Remarks. This species can be easily recognized by the highly arched aperture and the rather strongly raised fore portion of the test. The four quite globose chambers making the last whorl rapidly increase in size. The aperture in the central umbilical cavity is bordered by a faint imperforate rim. The test-surface structure is regularly reticulate with a coarse porosity; some times the primary structure is concealed by a later overlapping plate of crystals causing a smoothed structure.

Diameter. *Globigerina apertura* specimens range from 0.38 to 0.45 mm in maximum diameter.

Occurrence. This species occurs in almost all the samples of the «greenish clays» and of the «pinkish limestones» units.

Range. According to Blow (1969) *G. apertura* ranges from Zone N 16 (Tortonian) to Zone N 19 (Early Pliocene) and questionably to the early part of Zone N 20 (Middle Pliocene); according to Parker (1973) *G. apertura* became extinct in the Late Pliocene-Early Pleistocene.

***Globigerina bulloides* d'Orbigny, 1826**

Pl. 45, fig. 1-3

1826 *Globigerina bulloides* d'Orbigny, p. 227, mod. 17, 76.

1960 *Globigerina bulloides* - Banner & Blow, pp. 3-4, pl. 1, fig. 1 a-c.

1962 *Globigerina bulloides* - Parker, p. 221, pl. 1, fig. 1-8.

1969 *Globigerina bulloides bulloides* - Blow, pp. 316-317, pl. 14, fig. 1, 2.

1972 *Globigerina bulloides bulloides* - Akers, p. 48, pl. 31, fig. 1 a, b.

Remarks. The trochospire is low; the chambers, four in the final whorl, are uniformly inflated. A large umbilical opening is usually present with a nearly absent lip. The specimens of the assemblages have the test-wall quite thick and

the original fine hispidity and dense porosity are concealed by the growth of a calcite crystals crust causing a coarsely rugose surface.

Diameter. Specimens of *G. bulloides* range from 0.30 to 0.66 mm in diameter.

Occurrence. Specimens of *G. bulloides* occur, frequent to rare, in almost all the samples of the section.

Range. According to Blow (1969) *G. bulloides* takes rise from *G. praebulloides* within Zone N 16 (Tortonian) and it ranges until Zone N 23 (Holocene).

***Globigerina calida praecalida* Blow, 1969**

Pl. 44, fig. 5–7; Pl. 45, fig. 7–9

1962 *Globigerina calida* Parker, p. 221, pl. 1, fig. 9.

1969 *Globigerina calida praecalida* Blow, pp. 317, 380, pl. 13, fig. 6, 7; pl. 14, fig. 3.

Remarks. Test trochoid with a very low spire; the globular chambers, four in the final whorl, rapidly increase in size. The aperture is a moderately high arch in an interio–marginal position, not quite visible from the umbilical side. The test surface is distinctly hispid with fine not densely scattered pores.

Diameter. Specimens of *G. calida praecalida* have been found in 250 μ m sieve residues, maximum diameter ranging from 0.41 to 0.86 mm.

Occurrence. Frequent to rare *G. calida praecalida* occurs discontinuously from the sample A 1 of «greenish clays» to the sample B 24 of «pinkish limestones».

Range. According to Blow (1969) *G. calida praecalida* appears around the middle part of Zone N 17 (Messinian) and ranges to Zone N 23.

***Globigerina cf. nepenthes* Todd, 1957**

1957 *Globigerina nepenthes* Todd, p. 301, pl. 78, fig. 7.

1972 *Globigerina nepenthes* – Akers, p. 52, pl. 14, fig. 1 a, b.

1983 *Globigerina nepenthes* – Spaak, p. 119, pl. 1, fig. 7.

Remarks. The specimens are low spired and compactly coiled; the final whorl is formed by four inflated chambers, the last one is protruding, an apertural rim borders the arched aperture. Wall surface is coarsely perforated and reticulate, generally with a strong secondary thickening.

Diameter. Specimens of *G. cf. nepenthes* occur only in 125 μ m sieve residues: maximum diameter is not larger than 0.25 mm.

Occurrence. *G. cf. nepenthes* occurs very rarely only in samples A1, A6 and A14 from «greenish clays».

Range. *Globigerina nepenthes* is known to occur from Zone N 14 to near the Zone N 20 / Zone N 19 boundary (Blow, 1969), according to Parker (1967) till the lower part of Zone N 19. According to Colalongo & Sartoni (1979) *G. nepenthes* disappears before the *Globorotalia margaritae* Zone / *G. puncticulata* Zone boundary. Borsetti et al. (1979) point out the disappearance of *G. nepenthes* within the *Globorotalia puncticulata* Zone.

Family *Globorotaliidae* Cushman, 1927

Genus *Globorotalia* Cushman, 1927

***Globorotalia bononiensis* Dondi, 1962**

- 1962 *Globorotalia bononiensis* Dondi, p. 162, fig. 41–45.
 1968 *Globorotalia bononiensis* – Dondi & Papetti, pl. 5, fig. 1 a–c.
 1975 *Globorotalia bononiensis* – Zachariasse, p. 115, pl. 4, fig. 1 a–c.

Remarks. This species is characterized by subglobular chambers, four in the final whorl rapidly increasing in size and by a broadly rounded periphery. The dorsal side is slightly convex. The aperture is a large and high arch in a extra-umbilical position, bordered by a distinct lip. The test-wall is thin and finely perforate.

Diameter. Specimens of this species have been found in 125 and 250 μm sieve residues, diameter is 0.20 – 0.30 mm.

Occurrence. *G. bononiensis* is very rare: it occurs in the last sample from «greenish clays» A 15 and in the samples B 21 and B 24 from «pinkish limestones».

Range. The distribution of *G. bononiensis* is limited to the upper part of the Early Pliocene and to the lowermost Middle Pliocene.

***Globorotalia crassaformis* (Galloway & Wissler, 1927)**

Pl. 47, fig. 1, 2

- 1927 *Globigerina crassaformis* Galloway & Wissler, p. 41, pl. 7, fig. 12.
 1962 *Globorotalia crassaformis* – Parker, p. 235, pl. 4, fig. 17, 18, 20, 21.
 1967 *Globorotalia hirsuta aemiliana* Colalongo & Sartoni, pp. 267–270, pl. 30, fig. 2 a–c; pl. 31, fig. 3.
 1967 *Globorotalia crotonensis* Conato & Follador, pp. 556–557, fig. 1 a–c, 41, 42.
 1983 *Globorotalia crassaformis* – Spaak, p. 235, pl. 17, fig. 1–13.

Remarks. The test is biconvex, left coiled with three and half–four slightly inflated chambers in the last whorl. Wall–surface is coarsely rugose; test–structure is usually concealed by secondary calcite crystals thick crust. The aperture, in a umbilical–extraumbilical position, is a narrow arched fissure with not

distinct lip. The specimens of the assemblages show variations in the character of periphery, ranging from keeled to rounded, and in the convexity of the umbilical and dorsal side.

Diameter. Specimens have a 0.4 mm maximum diameter.

Occurrence. *G. crassaformis* occurs very rarely. Few small individuals have been found only in a few samples from the «white–greyish limestones», the «coquina» and the «yellow calcareous sands».

Range. *G. crassaformis* is known from within Zone N16 to Zone N23, according to Blow (1969). According to Colalongo & Sartoni (1967) *G. aemiliana* is limited to the uppermost Early Pliocene till the early part of Middle Pliocene; *G. crotonensis* is limited to the Middle Pliocene (Conato & Follador, 1967).

Globorotalia inflata (d'Orbigny, 1839)

Pl. 46, fig. 6–11; Pl. 47, fig. 3–5

1839 *Globigerina inflata* d'Orbigny, p. 134, pl. 2, fig. 7–9.

1967 *Globorotalia inflata* – Banner & Blow, pp. 144–146, pl. 4, fig. 1–11.

1972 *Globorotalia inflata* – Akers, p. 112, pl. 52, fig. 3; pl. 57, fig. 2.

Remarks. The specimens of *Globorotalia inflata* in the assemblages are sinistrally coiled with three and half–four chambers in the final whorl. The shape is plano–convex. The test–wall is thick uniformly perforate with marked surface tubercles, both dorsally and ventrally; some times a thick crust, occluding the pores, is caused by calcite crystals growth. The aperture is a broad, high arch interiomarginal in position and possesses a distinct imperforate lip.

Diameter. The greatest diameter ranges from 0.25 to 0.4 mm.

Occurrence. *G. inflata* occurs, even if discontinuously from the lowermost sample of the «white–greyish limestones» unit, D 28, to the last sample of the «yellow calcareous sands» unit, E52.

Range. In the Mediterranean sea the first occurrence of *G. inflata* marks the Middle Pliocene – Late Pliocene boundary. According to Banner & Blow this species ranges from the base of Zone N17 (Messinian) to the Recent.

Globorotalia puncticulata (Deshayes, 1832)

Pl. 42, fig. 1–9; Pl. 43, fig. 1, 2; Pl. 46, fig. 1–5

1826 *Globigerina punctulata* d'Orbigny, p. 277, list. n. 8.

1832 *Globigerina puncticulata* Deshayes, p. 170.

1960 *Globigerina puncticulata* – Banner & Blow, pp. 15–17, pl. 5, fig. 7 a–c.

1975 *Globorotalia puncticulata* – Zachariasse, p. 114, pl. 14, fig. 2 a–c.

Remarks. The test is tightly coiled in a low trochospire with a moderately convex dorsal side. The chambers are slightly inflated, four in the last whorl.

The aperture is an umbilical – extra–umbilical large arch with a more or less distinct rim. The wall is thick, finely and uniformly perforated with a marked surface granularity, dorsally on the surface of the early whorl, and with tubercles, ventrally in the area around the umbilicus. The wall of the last chamber is smooth, except on the apertural face. In some cases secondary calcite crystals crust conceal the original wall–structure.

Diameter. Specimens of *G. puncticulata* have been found in 250 and 125 μm sieve residues; the maximum diameter ranges from 0.25 to 0.60 mm.

Occurrence. *G. puncticulata* is an abundant constituent in the assemblage of every sample of «greenish clays», A1 – A15, and it occurs till the last sample of «pinkish limestones», B 26.

Range. In the Mediterranean basin *G. puncticulata* is a zonal marker, limited to the Early Pliocene. According to Blow (1969) it occurs, in sediment of the oceans, within Zone N19 (Early Pliocene) to Zone N23.

***Globorotalia puncticulata padana* Dondi & Papetti, 1968**

1968 *Globorotalia puncticulata padana* Dondi & Papetti, pp. 86–88, pl. 3, fig. 1–4.

Remarks. The sub–globular chambers are three and half–four in the final whorl, the last two have about the same size. The test is coiled in a low trochospire with a flat dorsal side. The aperture is an interior marginal – extra–umbilical small arch bordered by a thin lip. The smooth test–surface is finely perforate.

Diameter. The specimens of this sub–species are smaller than *G. puncticulata* ones; maximum diameter is 0.35 mm.

Occurrence. *G. puncticulata padana* occurs rarely only in sample B 24 from «pinkish limestones».

Range. This species ranges from the uppermost part of Early Pliocene to the *G. crassaformis* Zone (Middle Pliocene) in the Mediterranean basin.

Acknowledgements.

The author is grateful to Prof. D. Torre, Director of Earth Sciences Department of Florence, and to Prof. C. De Giuli, Earth Sciences Department of Florence, for the useful criticisms during the preparation of the work.

Special thanks are extended to Prof. C. Pirini Radrizzani, Institute of Geology – University of Genova, for discussion on microfauna content and to Prof. M. B. Cita, Earth Sciences Department of Milano, for critically reviewing the manuscript. Prof. E. Menesini, Earth Sciences Department of Pisà, classified *Cirripedia*.

Thanks are due to Mr. F. Dell'Erba, owner of the site, who facilitated the sampling work.

The author thanks also M. Ulivi, Earth Sciences Department – University of Florence, for his technical assistance at the Scanning Electron Microscope and F. Cozzini, Museum of Paleontology of Florence, who took care of the photographic work.

REFERENCES

- Agip Mineraria (1982) - Foraminiferi padani (Terziario e Quaternario). Agip Mineraria, (2 Ed.), 52 pl., S. Donato Milanese.
- Akers W. H. (1972) - Planktonic foraminifera and biostratigraphy of some Neogene formations, Northern Florida and Atlantic coastal plain. *Tulane Studies Geol. Paleontol.*, v. 9, n. 1-4, pp. 1-139, 60 pl., New Orleans.
- Balduzzi A., Casnedi R., Crescenti U. & Tonna M. (1983) - Il Plio-Pleistocene del sottosuolo del bacino Pugliese (Avanfossa Appenninica). *Geol. Romana*, (in press), Roma.
- Banner F. T. & Blow W. H. (1960) - Some primary types of species belonging to the superfamily *Globigerinacea*. *Contr. Cushman Found. Foramin. Res.*, v. 11, n. 1, pp. 1-41, 8 pl., Ithaca.
- Banner F. T. & Blow W. H. (1967) - The origin, evolution and taxonomy of the foraminiferal genus *Pulleniatina* Cushman 1927. *Micropaleont.*, v. 13, n. 2, pp. 133-162, 4 pl., 14 fig., New York.
- Blow W. H. (1969) - Late Middle Eocene to Recent Planktonic Foraminiferal biostratigraphy. *Proc. First Internat. Conf. Plank. Microf.*, Geneva 1967, v. 1, pp. 199-421, 54 pl., 43 fig., Geneva.
- Borsetti A. M., Cati F., Colalongo M. L. & Sartoni S. (1979) - Biostratigraphy and absolute age of the Italian Neogene. *VIIth Intern. Congr. Mediterranean Neogene*, Ann. Géol. Pays Hellén., t. hors série, n. 1, pp. 183-197, Athènes.
- Ciaranfi N. & Rapisardi L. (1979) - Dati preliminari sulla neotettonica dei Fogli 155 «S. Severo» e 163 «Lucera». *Contr. Prel. Realizz. Carta Neot. Italia, P. F. Geodinamica Pubbl.*, n. 251, pp. 39-45, Napoli.
- Ciaranfi N. & Ricchetti G. (1979) - Considerazioni sulla neotettonica del Gargano (Foglio 156 «S. Marco in Lamis» e Foglio 157 «Monte S. Angelo»). *Contr. Prel. Realizz. Carta Neot. Italia, P. F. Geodinamica Pubbl.*, n. 251, pp. 53-66, Napoli.
- Colalongo M. L. & Sartoni S. (1967) - *Globorotalia hirsuta aemiliana* nuova sottospecie cronologica del Pliocene in Italia. *Giorn. Geol.*, s. 2, v. 35, pp. 265-284, 2 pl., 2 fig., Bologna.
- Colalongo M. L. & Sartoni S. (1979) - Schema biostratigrafico per il Pliocene e il basso Pleistocene in Italia. *Contr. Prel. Realizz. Carta Neot. Italia, P. F. Geodinamica Pubbl.*, n. 251, pp. 645-654, Napoli.
- Conato V. & Follador U. (1967) - *Globorotalia crotonensis* e *Globorotalia crassacrotonensis* nuove specie del Pliocene italiano. *Boll. Soc. Geol. It.*, v. 86, pp. 555-563, 6 fig., Roma.
- Cushman J. A. (1918) - Pliocene Foraminifera of the coastal plain of the United States. *U. S. Geol. Surv. Bull.*, n. 676, pp. 1-100, 31 pl., Washington.
- D'Alessandro A., Laviano A., Ricchetti G. & Sardella A. (1979) - Il Neogene del Monte Gargano. *Boll. Soc. Paleont. It.*, v. 18, n. 1, pp. 9-116, 19 pl., 32 fig., Modena.
- De Giuli C. & Torre D. (1983 a) - A microfauna with *Allophaiomys pliocaenicus* from Gargano (Southern Italy). *Palaeont. Ital.*, (in press), Pisa.
- De Giuli C. & Torre D. (1983 b) - Species interrelationships and evolution in the Pliocene endemic faunas of Apricena (Gargano Peninsula - Italy). *Actes I Congr. Int. Paléoécologie, Lyon 1983*, (in press), Lyon.
- Deshayes G. P. (1832) - Encyclopédie Méthodique; Histoire Naturelle des vers, Mme. V. Agasse, v. 2, pt. 2, pp. 1-594; v. 3, pp. 595-1152.

- Dondi L. (1962) - Nota paleontologico-stratigrafica sul pede—Appennino Padano. *Boll. Soc. Geol. It.*, v. 81, n. 4, pp. 113–245, 13 fig., Roma.
- Dondi L. & Papetti I. (1968) - Biostratigraphical zones of Po Valley Pliocene. *Giorn. Geol.*, s. 2, v. 35, n. 3, pp. 63–98, 3 pl., 3 fig., Bologna.
- D'Orbigny A. (1826) - Tableau Méthodique de la classe des Céphalopodes. *Ann. Sc. Nat.*, s. 1, v. 7, pp. 96–314, Paris.
- D'Orbigny A. (1839) - Foraminifères des Iles Canaries. In *Histoire Naturelle des Iles Canaries*, v. 2, pt. 2, Zool., pp. 119–146, 3 pl., Paris.
- Follador U. (1967) - Il Pliocene e il Pleistocene dell'Italia centro-meridionale, versante adriatico. *Biostratigrafia. Boll. Soc. Geol. It.*, v. 86, n. 3, pp. 565–584, 1 pl., 2 fig., Roma.
- Follador U. (1973) - Paleogeografia del Pliocene e del Pleistocene dell'Italia centro-meridionale, versante adriatico. *Boll. Soc. Geol. It.*, v. 92, n. 1, pp. 141–159, 7 fig., Roma.
- Freudenthal M. (1971) - Neogene vertebrates from the Gargano Peninsula, Italy. *Scripta Geologica*, v. 83, pp. 1–10, Leiden.
- Galloway J. J. & Wissler S. G. (1927) - Pleistocene Foraminifera from the Lomita Quarry, Palos Verdes Hills, California. *Journ. Paleont.*, v. 1, pp. 35–87, 12 pl., Lawrence.
- Gradstein F. M. (1974) - Mediterranean Pliocene *Globorotalia*. A biometrical approach. *Utrecht Micropaleont. Bull.*, v. 7, pp. 1–128, 8 pl., 44 fig., Utrecht.
- Hansen H. J. & Reiss Z. (1972) - Scanning electron microscopy of wall structures in some benthic and planktonic foraminifera. *Rev. Esp. Micropaleont.*, v. 4, n. 2, pp. 169–179, 5 pl., Madrid.
- Hofker J. jr (1969) - On the internal structure of recent planktonic foraminifera. *Proc. First Internat. Conf. Plank. Microf.*, Geneva 1967, v. 2, pp. 273–278, 4 pl., Geneva.
- Hofker J. sr (1971) - Wall-structure of Globigerine and Globorotaliid Foraminifera. *Rev. Esp. Micropaleont.*, v. 3, n. 1, pp. 35–60, 10 pl., Madrid.
- Loeblich A. R. & Tappan H. (1964) - Protista 2. In Moore R. C. (Ed.) - *Treatise on Invertebrate paleontology. Geol. Soc. Am., Univ. Kansas Press*, v. 2, pp. 1–900, 653 fig., Lawrence.
- Loeblich A. R. & Tappan H. (1974) - Recent advances in the classification of the foraminifera. In Hedley R. H. & Adams C. G. (Eds.) - *Foraminifera. Academic Press London and New York*, v. 2, pp. 1–53, Bath.
- Parker F. L. (1962) - Planktonic foraminiferal species in Pacific sediments. *Micropaleont.*, v. 8, n. 2, pp. 219–254, 10 pl., New York.
- Parker F. L. (1967) - Late Tertiary biostratigraphy (Planktonic Foraminifera) of tropical Indo-Pacific deep-sea cores. *Bull. Amer. Paleont.*, v. 52, n. 235, pp. 115–208, 16 pl., 5 fig., New York.
- Parker F. L. (1973) - Late Cenozoic biostratigraphy (Planktonic Foraminifera) of tropical Atlantic deep-sea sections. *Rev. Esp. Micropaleont.*, v. 5, n. 2, pp. 253–289, 10 pl., 4 fig., Madrid.
- Postuma J. A. (1971) - *Manual of Planktonic Foraminifera. Els. Publ. Company*, pp. 1–420, Amsterdam.
- Sellwood B. W. (1978) - Shallow-water carbonate environments. In Reading H. G. (Ed.) - *Sedimentary Environments and Facies. Blackwell Scientific Publ.*, pp. 259–313, 50 fig., London.
- Spaak P. (1983) - Accuracy in correlation and ecological aspects of the planktonic foraminiferal zonation of the Mediterranean Pliocene. *Utrecht Micropaleont. Bull.*, v. 28, pp. 1–160, 10 pl., 51 fig., Utrecht.
- Todd R. (1957) - Geology of Saipan, Mariana Islands. Small Foraminifera. *U. S. Geol. Surv. Prof. Paper*, n. 280–H, pp. 265–320, 29 pl., 4 fig., Washington.

- Zachariasse W. J. (1975) - Planktonic foraminiferal biostratigraphy of the Late Neogene of Crete (Greece). *Utrecht Micropaleont. Bull.*, v. 11, pp. 1-171, 17 pl., 23 fig., Utrecht.
- Zachariasse W. J., Riedel W. R., Sanfilippo A., Schmidt R. R., Brolsma M. J., Schrader H. J., Gersonde R., Drooger M. M. & Broekman J. A. (1978) - Micropaleontological counting methods and techniques. An exercise on an eight meters section of the Lower Pliocene of Capo Rossello., Sicily. *Utrecht Micropaleont. Bull.*, v. 17, pp. 1-265, 23 pl., 95 fig., Utrecht.

PLATE 42

Globorotalia puncticulata (Deshayes) from «greenish clays», *Globorotalia puncticulata* Zone, Early Pliocene.

Fig. 1 - 3 — A large specimen from sample A 9.

1) Spiral view; 2) side view; 3) umbilical view; x 75.

Fig. 4 - 6 — Specimen from sample A 4 showing a distinct rim.

3) Spiral view; 4) side view; 5) umbilical view; x 100.

Fig. 7 - 9 — Specimen from sample A 1.

7) Spiral view; 8) side view; 9) umbilical view; x 100.

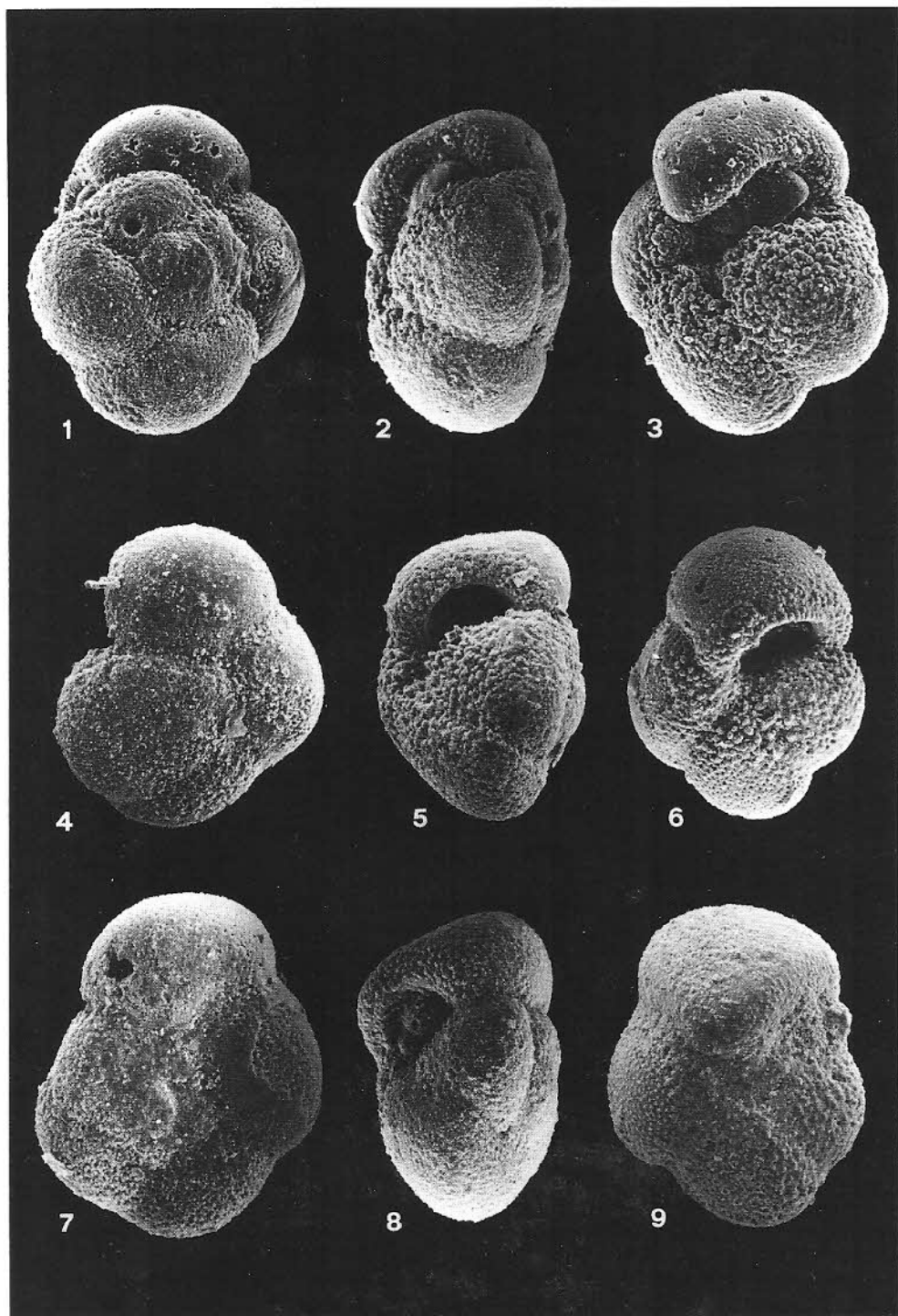


PLATE 43

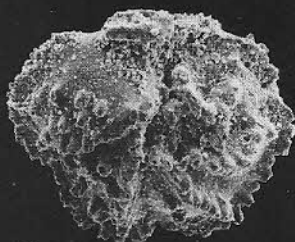
- Fig. 1, 2 — *Globorotalia puncticulata* (Deshayes). Transmitted light photo.
1) Axial section; from sample A 9; x 100; 2) axial section; from sample B 23;
x 100.
- Fig. 3 - 5 — *Siphonina planoconvexa* Silvestri, from sample A 9.
3) Dorsal view; 4) apertural view; 5) ventral view; x 75.
- Fig. 6, 7 — *Uvigerina rutila* Cushman & Todd, from sample A 1; x 100.
- Fig. 8 — *Uvigerina longirostra* Perconig, from sample A 1; x 100.



1



2



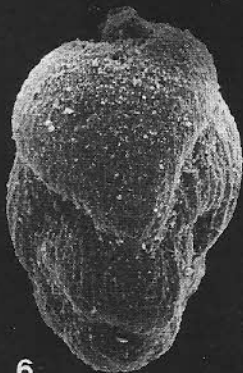
3



4



5



6



7



8

PLATE 44

Specimens from «greenish clays», *Globorotalia puncticulata* Zone, Early Pliocene.

- Fig. 1 - 4 - *Globigerina apertura* Cushman. Specimens showing reticulate test-structure. 1) Spiral view; from sample A 3; x 100; 2) umbilical view; from sample A 3; x 100; 3) side view, slightly oblique; from sample A 9; x 100; 4) a detail of fig. 3 showing the aperture; x 200.
- Fig. 5 - 7 - *Globigerina calida praecalida* Blow. Specimen from sample A 9 showing distinctly hispid test-surface. 1) Spiral view; 2) side view; 3) umbilical view; x 100.

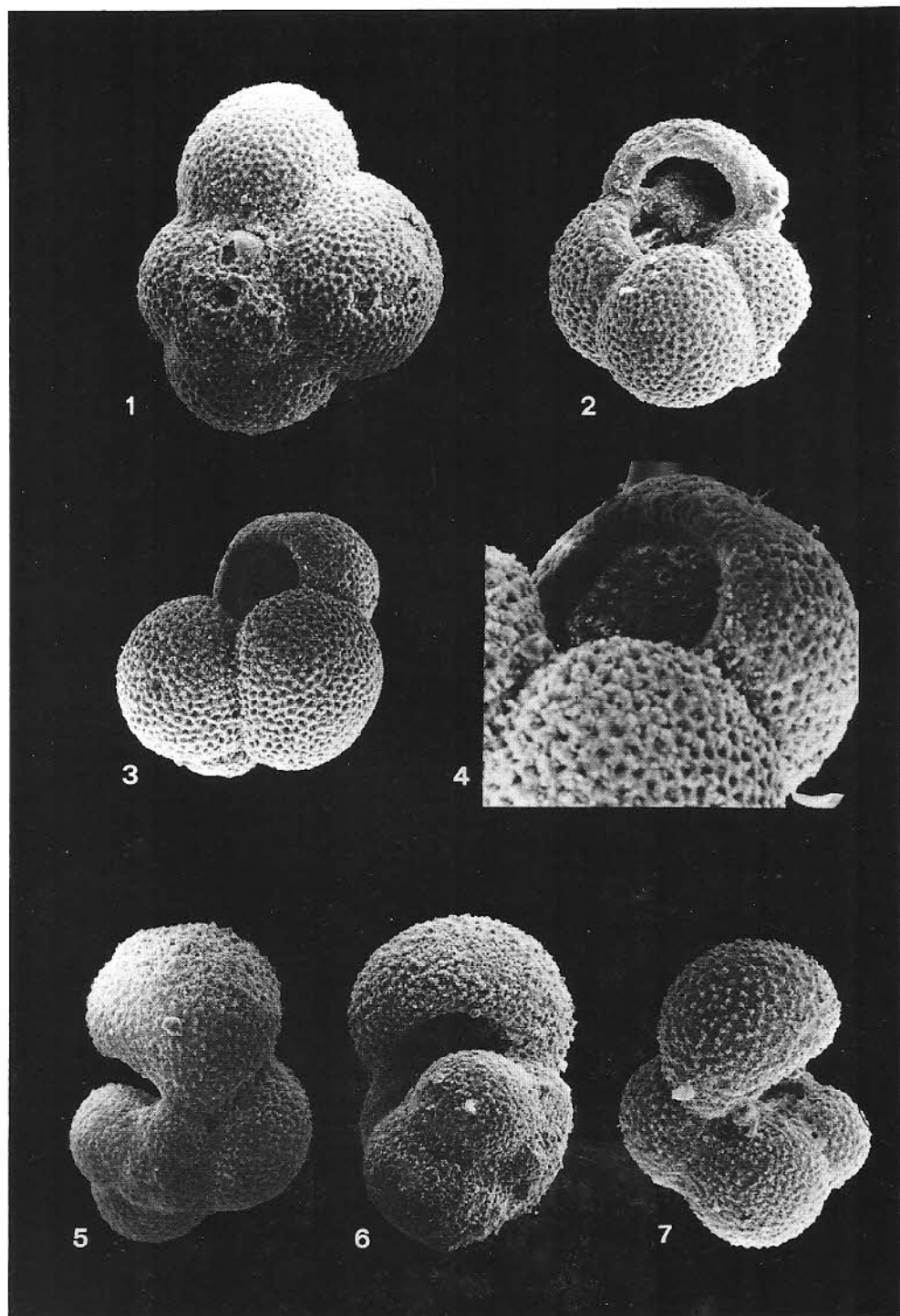


PLATE 45

Specimens from «pinkish limestones», *Globorotalia puncticulata* Zone, Early Pliocene.

Fig. 1 - 3 — *Globigerina bulloides* d'Orbigny; from sample B 21.

1) Spiral view; x 150; 2) umbilical view; x 150; 3) a detail of fig. 2 showing a thick heavily calcified wall and phenomena of test dissolution; x 500.

Fig. 4 - 6 — *Globigerina apertura* Cushman. 4) Umbilical view; from sample B 21; x 75; 5) umbilical view; from sample B 24; x 75; 6) umbilical view; from sample B 24; x 100.

Fig. 7 - 9 — *Globigerina calida praecalida* Blow. 7) Umbilical view; from sample B 24; x 75. 8) spiral view; from sample B 24; x 75. 9) spiral view; from sample B 21; x 50.

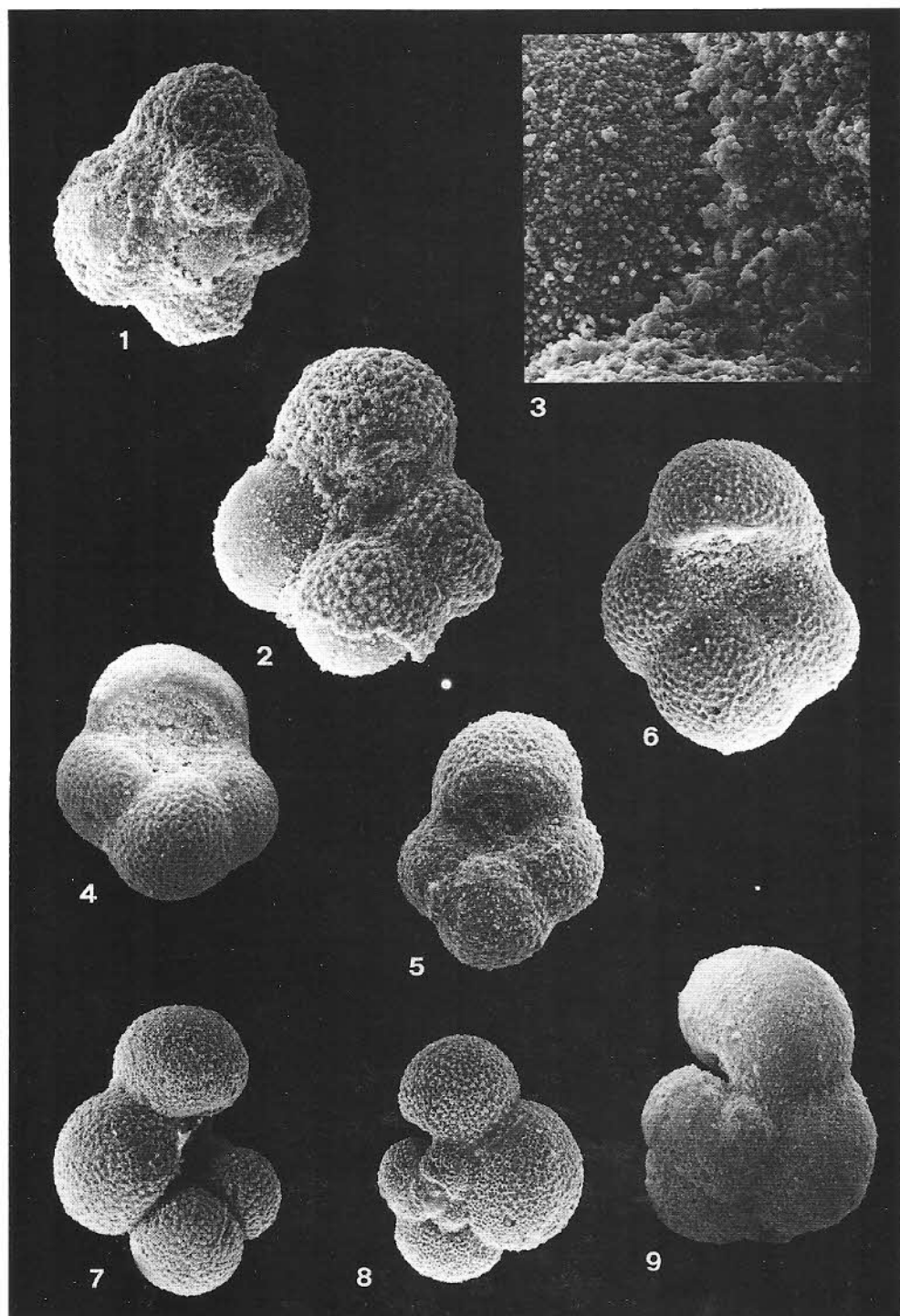


PLATE 46

Fig. 1 - 5 — *Globorotalia puncticulata* (Deshayes) from «pinkish limestones», *G. puncticulata* Zone, Early Pliocene. All figures x 100.

1) Spiral view; from sample B 21; 2) side view; from sample B 21; 3) umbilical view, slightly oblique; from sample B 21; 4) spiral view; from sample B 24; 5) oblique view; from sample B 24.

Fig. 6-11 — *Globorotalia inflata* (d'Orbigny) from «Coquina», *G. inflata* Zone, Late Pliocene.

Fig. 6 - 10, x 100; fig. 11, x 400. 6) Spiral view; from sample D 33; 7) side view; from sample D 33; 8) umbilical view; from sample D 33; 9) spiral view; from sample D 40; 10) side view; from sample D 40; 11) a detailed of fig. 10 showing the aperture bordered by a rim and tubercles on wall-surface.

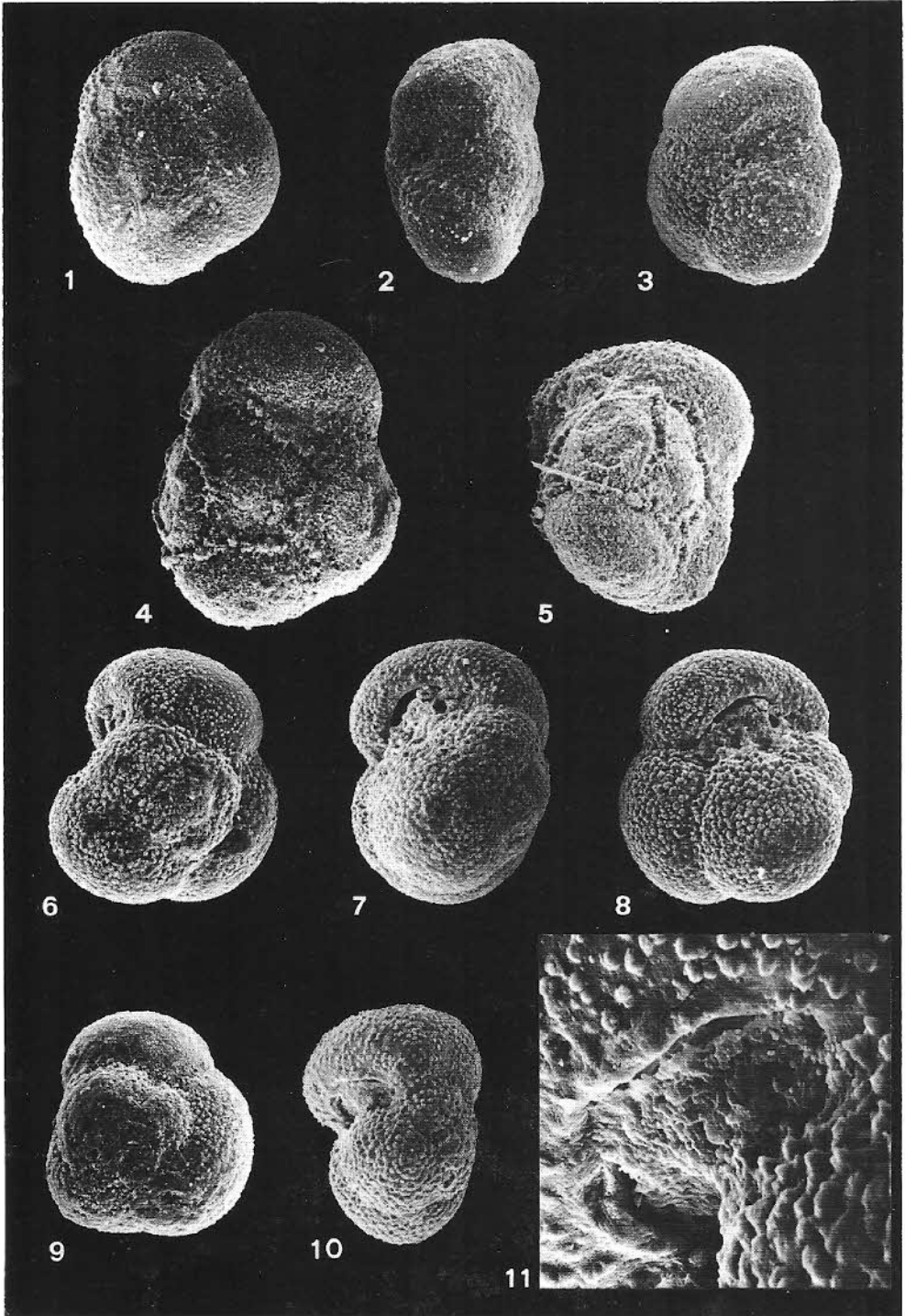


PLATE 47

Specimens from «yellow calcareous sands», *Globorotalia inflata* Zone, Late Pliocene.

Fig. 1, 2 – *Globorotalia crassaformis* (Galloway & Wissler). Specimen from sample E 50; x 150. 1) Umbilical view; 2) side view.

Fig. 3 - 5 – *Globorotalia inflata* (d'Orbigny). Specimen from sample E 48, showing a thick wall caused by secondary crystal; x 100.

Fig. 6, 7 – *Bulimina marginata* d'Orbigny. from sample E 47; x 100.

Fig. 8 – *Globigerinoides ruber* (d'Orbigny). from sample E 48; oblique view; x 100.

