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The Plio-Pleistocene of the Anzio coast (Rome)*

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ABSTRACT - *The topic of this paper is part of a wider biostratigraphic and paleoecologic research on Neogene-Quaternary sequences of the Tyrrhenian coast South of Rome. The work regards the foraminiferal assemblages of Plio-Pleistocene sediments outcropping along the coast extending from Tor Caldara to Anzio. Previous geological-structural studies had shown a structural high corresponding to an anticline with its axis in Tor Caldara.*

All the samples collected from North (Tor Caldara) to South (Anzio) were analysed qualitatively, but those having a low degree of reworking and a significant microfaunal amount were also analysed quantitatively. The more ancient sediments (predominantly clayey) constitute the nucleus of the anticline (Tor Caldara) and are subhorizontal. These sediments are attributed to the Globorotalia margaritae Zone (MPL2, Zanclean), and to the upper epibathyal environment. A stratigraphic hiatus due to absence of the Globorotalia margaritae/Globorotalia punctulata Zone (MPL3) occurs. Southwards, in Tor Materno, Lido delle Sirene and Lido di Marechiaro, exposures of weakly inclined, clayey and clayey-sandy deposits are found, belonging to the Globorotalia punctulata Zone (MPL4, Zanclean). Their foraminiferal assemblages suggest a poorly oxygenated circalittoral environment with local more anaerobic episodes. In Tor Materno, Lido di Marechiaro, Anzio Colonia and Villa di Nerone the sediments are assigned to the Globorotalia aemiliana Zone (MPL5), characterized by an increasing coarseness of lithologies: from clayey-sandy terms and silty sands to more or less cemented sands and biocalcarenes, with dipping towards ESE of about 5° to 20°. The boundary with the sediments attributed to the Globorotalia punctulata Zone, was not identified, owing to the lack of data on this portion of the coast. The lower part of the Globorotalia aemiliana Zone, where the marker is associated with Globorotalia bononiensis, was ascribed to the Piacenzian stage, while the upper part with the same marker associated with Bulimina marginata can be attributed to the Gelasian stage. The Piacenzian/Gelasian boundary was thought to correspond to the disappearance of Globorotalia bononiensis. The depositional environment ranges from circalittoral (finer sediments) to infralittoral (sands and "Macco" biocalcarenes) closing the marine Pliocene sequence.

The Lower Pleistocene sediments (Globigerina cariacensis Zone) transgressively overlie the Pliocene ones (Globorotalia margaritae and Globorotalia punctulata Zones); they are subhorizontal and consist of clayey-sandy lithologies and more or less cemented sands. The foraminiferal assemblages have typical Early Pleistocene species, such as Bulimina etnea and Globigerinoides tenellus. The Pleistocene sequence base shows a level with Arctica islandica and Terebratulina ampulla.

RIASSUNTO - [Il Plio-Pleistocene della costa di Anzio (Roma)] - *Questo lavoro rappresenta la fase iniziale di una ricerca più ampia riguardante la biostratigrafia e la ricostruzione paleoambientale delle successioni neogenico-quaternarie del litorale tirrenico a Sud di Roma fino a Torre Astura. Sono state studiate le associazioni a foraminiferi dei sedimenti plio-pleistocenici affioranti lungo il tratto di costa compreso tra Tor Caldara ed Anzio. Studi geologico-strutturali precedenti hanno evidenziato in questo settore un alto strutturale interessato da un'anticlinale il cui asse è localizzato in corrispondenza della punta di Tor Caldara. La campionatura, effettuata da Nord (Tor Caldara) verso Sud (Anzio), ha presentato notevoli difficoltà a causa dell'esposizione verticale dei terreni e della forte antropizzazione della costa. Sono state quindi misurate alcune sezioni (Tor Caldara, Lido di Marechiaro e Villa di Nerone) e raccolti numerosi campioni puntuali. I sedimenti esaminati coprono l'intervallo temporale Pliocene inferiore /Pleistocene basale.*

Su tutti i campioni è stata condotta un'analisi di tipo qualitativo; l'analisi quantitativa è invece stata effettuata solo su campioni con sufficiente contenuto microfaunistico e basso grado di rimaneggiamento. Sono stati inoltre considerati il rapporto P/P+B, le abbondanze dell'epifauna, dell'infauna e del genere Globigerinoides. I terreni più antichi, prevalentemente argillosi, affiorano nel nucleo dell'anticlinale (punta di Tor Caldara) e presentano giaciture suborizzontali. Tali depositi sono attribuibili alla Zona a Globorotalia margaritae (MPL2, Zancleano) e contengono associazioni ad elevata frazione planctonica (ca.80%) e benthos molto diversificato; l'ambiente deposizionale è profondo, riferibile all'epibatale superiore.

Procedendo verso Sud, in località Tor Materno, Lido delle Sirene e Lido di Marechiaro, affiorano depositi argillosi ed argillo-sabbiosi debolmente inclinati, appartenenti alla Zona a Globorotalia punctulata (MPL4, Zancleano) le cui associazioni indicano un ambiente circalitorale poco ossigenato, con locali episodi di maggiore anossicità testimoniati da concentrazioni di Trifarina fornasinii e Globobulimina spp. In livelli centimetrici si osservano elevate frequenze di Dentoglobigerina altispira altispira. Seguono (Tor Materno, Lido di Marechiaro) depositi attribuibili alla Zona a Globorotalia aemiliana (MPL5) caratterizzati da litologie via via sempre più grossolane: da termini argillo-sabbiosi e sabbie siltose a sabbie più o meno cementate e biocalcareni, con pendenze variabili da 5° a 20° ca. verso ESE. Si è distinta una porzione inferiore della Zona a Globorotalia aemiliana, attribuibile al piano Piacenziano, caratterizzata dalla presenza del marker associato a Globorotalia bononiensis e una superiore, riferibile al

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Gelasiano, dove si rinviene oltre al marker, *Bulimina marginata*. Il limite tra Piacenziano e Gelasiano è stato approssimato alla scomparsa di *Globorotalia bononiensis*. L'ambiente deposizionale per questi sedimenti oscilla dal circolitorale, per i sedimenti più fini, all'infralitorale per le sabbie e le biocalcareni ("Macco") che chiudono la successione pliocenica. Il passaggio alle biocalcareni è graduale e in corrispondenza di questo si osservano livelli ad *Amphistegina*. Il mancato rinvenimento della Zona a *Globorotalia margaritae*/*Globorotalia puncticulata* (MPL3) ha indotto ad ipotizzare una lacuna stratigrafica. Inoltre non è stato possibile localizzare il contatto Zona a *Globorotalia puncticulata*-Zona a *Globorotalia aemiliana* per mancanza di dati.

I sedimenti del Pleistocene inferiore (Zona a *Globigerina cariacensis*) poggiano trasgressivi su quelli pliocenici, presentano giaciture suborizzontali e sono costituiti da litotipi argillo-sabbiosi e sabbie più o meno cementate. Alla base della successione pleistocenica si individua un livello centimetrico siltoso con buone frequenze di *Elphidiella* cf. *arctica*, seguito da una biocalcareni ricca di *Arctica islandica* e *Terebratula ampulla* con gusci solforizzati per la presenza di sorgenti sulfuree nell'area. L'associazione a foraminiferi presenta forme tipiche del Pleistocene inferiore (*Bulimina etnea*, *Globigerinoides tenellus*) ed indica un ambiente deposizionale infralitorale con lievi oscillazioni più profonde in corrispondenza delle litologie più fini.

INTRODUCTION

In 1994 the Earth Science Department of the Rome University "La Sapienza" planned a multi-disciplinary (sedimentology, paleontology, mineralogy) research project on the Neogene-Quaternary sequences of the Tyrrhenian coast South of Rome, as far as Torre Astura.

The first stage of this research regards the foraminiferal assemblages of the Plio-Pleistocene sediments outcropping along the coast (about 6 km) extending from Tor Caldara to Anzio (Text-fig. 1).

These deposits represent the structural high of Anzio. The area investigated has a half-graben structure (Faccenna *et al.*, 1994), due to intense tectonic activity in the Pliocene. Faccenna *et al.* (1994) reported that the Plio-Pleistocene compressive tectonics (shown by Apennine-trending folds) gave rise to an anticline in the Anzio area. The axis of this anticline (formerly reported by Segre, 1957) lies close to Tor Caldara. The

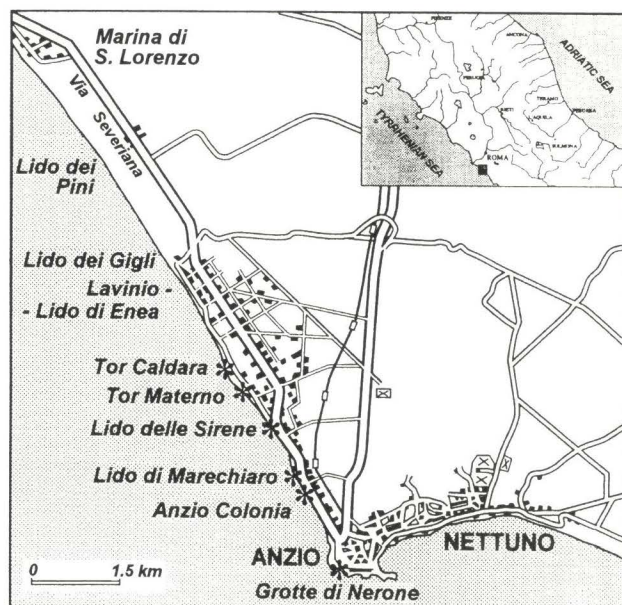
Pliocene sediments have ESE dipping, from subhorizontal near the nucleus of the fold to over 20° near Anzio. The Pleistocene sediments, however, are subhorizontal and transgressively overlie the Pliocene sediments (Malatesta & Zarlenga, 1985). Therefore, in the area of structural high, sedimentation stopped in the Late Pliocene and resumed in the Early Pleistocene, with occasionally cemented, sulphur-impregnated clayey-sands, containing *Arctica islandica* (Compagnoni & Conato, 1969).

The sequences examined were tentatively located in a chronostratigraphic scheme, following the recent proposals on the subdivision of the Plio-Pleistocene (Rio *et al.*, 1994; Cita & Castradori, 1995; Cita *et al.*, 1996). For the micropaleontological data the zonal scheme of Iaccarino & Salvatorini (1982) was adopted and correlated to the Mediterranean zonations of Cita (1975) as emended by Sprovieri (1992). As the relevant data were obtained from foraminifers alone, the base of the Gelasian was assumed to correspond to the disappearance of *Globorotalia bononiensis*.

METHODS

The sediments studied outcrop on vertical-wall cliffs of the coast, a few meters away from the sea. Sampling was carried out wherever possible, because of the numerous anthropic barriers existing on the coast. For a greater understanding of the geological-stratigraphic issues, the area is divided into five geographic sectors (Tor Caldara, Tor Materno, Lido delle Sirene, Lido di Marechiaro, Anzio) proceeding from North (Tor Caldara) to South (Anzio). Many single samples were collected and, where possible, also some sections, the most significant of which were described and plotted: Tor Caldara (TC), Lido di Marechiaro (LM), Lido Garda (LG) and Villa di Nerone (VN).

For each sample, about 300 g of dry sediment (dried at 40°C) were collected, treated with H₂O₂



Text-fig. 1 - Location map of the Tor Caldara-Anzio area (with asterisked the sampled sectors).

and then passed through a 0.088 mm screen. Qualitative analyses were made on the entire washing residue, whereas semi-quantitative and quantitative analyses involved 300-350 specimens, obtained through a microsplitter taking into account the fraction coarser than 125 μm . For paleoecological investigation (Corliss, 1985; Corliss & Chen, 1988; Murray, 1991) the abundance of the species, P/(P+B) ratio, epifaunal and infaunal percentages and *Globigerinoides* genus curve were considered.

TOR CALDARA AREA

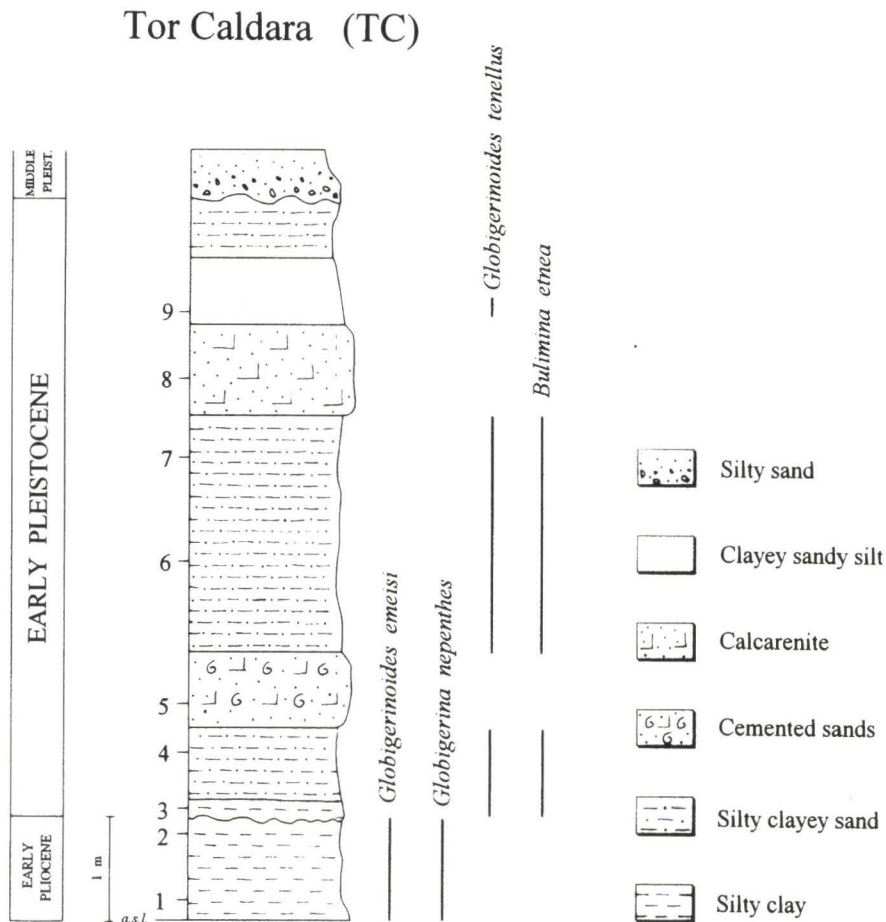
This sector is the northernmost part of the area investigated. It represents the northern boundary of the Anzio high. Beyond this boundary, there is the Ardea basin, one of the deepest in the Latium Tyrrhenian margin. Sampling was made along the cliff outcropping at Tor Caldara. Southwards, however, only localized sampling was feasible, owing to a reduction in the cliff thickness.

TOR CALDARA SECTION (TC) (Text-fig. 2)

This section is located in the "Riserva Naturale Tor Caldara", a natural oasis which spreads out along the Latium coast between Lido di Lavinio (N) and the Anzio promontory (S). Samples were collected at the Tor Caldara end, where the sediments are better exposed and where the transgressive contact between Pliocene and Pleistocene deposits is well visible (Text-fig. 3).

The sequence is about 8 m thick. At its base, the Pliocene sediments are subhorizontal and outcrop for about 1 m. They consist of compact, gray, clayey-silty terms with gypsum and Fe oxides. In this portion of the section, two samples were collected: the first (TC1) a few cm above sea level and the second (TC2) below the transgression surface.

Both samples have a good planktonic fraction (66.75 and 70.92%, respectively) and a well-diversified benthos. The planktonic assemblage (Tab. 1) is dominated by the *Globigerinoides* (19.03-23.52%), *Globigerina* (16.44-21.6%), *Orbulina* (10.64-4.84%) and *Neogloboquadrina* (7.42-



Text-fig. 2 - Lithology and distribution of the main taxa in the Tor Caldara Section.



Text-fig. 3 - Tor Caldara Section. Pleistocene deposits transgressive on the Lower Pliocene clays.

13.54%) genera. The *Globigerinoides obliquus* group is the most common one (12.26-10%), followed by *Globigerina falconensis* (6.77-8.7%) and *G. bulloides* (6.45%-7.74%).

Globigerinoides emeisi (3.55-2.26%) and *Globigerina nepenthes* (0.64-1.29%) are also present. The *Globorotalia* genus is represented by *G. scitula* and *G. obesa*, with values <2%.

The benthic assemblage is rich in species, the most significant being: *Bolivina leonardii* (1.19%), *B. placentina* (<0.97%), *Bulimina costata* (3.22%), *Chilostomella oolina* (1.29-2.58%), *Globocassidulina subglobosa* (3.87-3.22%), *Lenticulina vortex* (1.29%), *L. cultrata* (2.26%), *L. orbicularis* (0.97%), *Planulina ariminensis* (2.9-3.87%), *Marginulina costata coarctata* (<1%) and *Uvigerina rutila* (2.9-2.26%). The benthic fraction lacks typical shallow water forms (Tab.1). The infauna (21.93-17.72%) prevails over the epifauna (11.3-9.04%; Text-fig. 5), with a dominance of species typical of fine-grained sea floors and which live at a depth of 0-4 cm in the sediment such as *Bulimina* spp. and *Globocassidulina sub-*

globosa (Kaiho, 1991; Violanti, 1994). The benthic assemblage and the high planktonic fraction indicate a scarcely oxygenated, upper epibathyal environment, which favored high benthic productivity at the bottom.

A definite biostratigraphic attribution of these samples is not possible because of the characteristics of the assemblage and the absence of markers. There is no integrated data available (for example: calcareous nannoplankton) and so these sediments may be attributed to the comprehensive interval of first two biozones of Pliocene (MPL1-MPL2). Four single samples showing similar assemblages to those described above, were collected between Tor Caldara and Tor Materno (TCa, TCb, TCc, TCd; Tab. 1), where *G. margaritae* occurs. Samples TCa is attributed to the lower part of the *Globorotalia margaritae* Zone; samples (TCb, TCc and TCd), where the marker is associated with *Globorotalia hirsuta prae-hirsuta*, are assigned to the upper part of *Globorotalia margaritae* Zone.

The subhorizontal Pleistocene deposits (7 m

Globorotalia margaritae Zone Tor Caldara area Section and single samples	TC1	TC2	TCa	TCb	TCc	TCd
Benthos						
<i>Amphicoryna sublineata</i>	0,00%	0,00%	2,26%	0,00%	0,97%	0,00%
<i>Anomalinoides helicinus</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Bigenenerina nodosaria</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Bolivina</i> sp.	0,00%	0,00%	0,00%	1,61%	0,00%	0,00%
<i>Bolivina dilatata</i>	1,29%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Bolivina leonardii</i>	0,00%	1,29%	0,00%	0,00%	0,00%	0,00%
<i>Bolivina punctata</i>	0,00%	0,00%	1,26%	0,00%	0,00%	1,29%
<i>Bulimina aculeata</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Bulimina costata</i>	3,22%	0,00%	0,00%	0,00%	1,26%	1,29%
<i>Bulimina minima</i>	1,61%	0,97%	1,26%	2,26%	0,00%	0,97%
<i>Cancris oblongus</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Chilostomella oolina</i>	1,29%	2,58%	0,00%	0,00%	0,00%	0,00%
<i>Cibicidoides pseudoungerianus</i>	0,00%	1,94%	2,26%	0,00%	1,26%	0,00%
<i>Cibicidoides ungerianus</i>	0,97%	0,00%	0,00%	1,61%	1,58%	0,97%
<i>Dentalina leguminiformis</i>	1,29%	0,97%	2,58%	0,97%	0,00%	0,97%
<i>Dimorphina tuberosa</i>	0,00%	0,00%	1,29%	0,00%	0,97%	0,00%
<i>Eggerella bradyi</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Globocassidulina subglobosa</i>	3,87%	3,22%	0,00%	3,55%	1,26%	2,58%
<i>Gyroidinoides</i> sp.	0,00%	0,00%	0,00%	0,00%	1,26%	0,00%
<i>Gyroidinoides neosoldanii</i>	0,97%	0,00%	0,00%	0,00%	1,26%	0,00%
<i>Heterolepa dertonensis</i>	0,00%	0,00%	0,00%	0,00%	1,26%	0,00%
<i>Heterolepa floridana</i>	0,00%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Lenticulina calcar</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Lenticulina cultrata</i>	2,26%	0,00%	1,26%	0,00%	1,61%	0,00%
<i>Lenticulina curvissepta</i>	0,00%	2,26%	1,61%	0,00%	0,00%	0,00%
<i>Lenticulina orbicularis</i>	0,00%	0,97%	0,00%	0,00%	0,00%	0,00%
<i>Lenticulina peregrina</i>	0,00%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Lenticulina rotulata</i>	0,00%	0,00%	1,61%	0,00%	0,97%	0,97%
<i>Lenticulina vortex</i>	1,29%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Marginulina costata</i>	0,00%	1,60%	1,61%	0,00%	0,00%	0,00%
<i>Marginulina glabra</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Martinottiella communis</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Nodosaria</i> sp.	0,00%	0,00%	0,00%	0,00%	1,61%	0,00%
<i>Nodosaria ovicula</i>	0,00%	0,00%	1,94%	0,00%	0,00%	0,00%
<i>Oridorsalis umbonatus</i>	0,00%	0,00%	1,94%	0,00%	0,00%	0,97%
<i>Orthomorphina tenuicostata</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Planularia auris</i>	0,00%	0,00%	1,29%	0,00%	0,00%	0,00%
<i>Planulina ariminensis</i>	2,90%	3,87%	0,00%	1,29%	1,58%	2,26%
<i>Præoglobulimina ovata</i>	0,00%	0,00%	1,61%	0,00%	0,00%	0,00%
<i>Pullenia bulloides</i>	1,29%	0,00%	0,00%	1,29%	0,97%	0,97%
<i>Saracenaria italica</i>	0,00%	1,29%	1,61%	0,00%	0,00%	0,00%
<i>Sigmollinita tenuis</i>	0,00%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Sigmolopsis celata</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Siphonina reticulata</i>	0,00%	0,00%	0,00%	0,97%	0,97%	1,61%
<i>Sphaeroidina bulloides</i>	2,26%	2,90%	0,00%	0,97%	1,29%	0,97%
<i>Stilostomella consobrina</i>	0,00%	0,00%	1,26%	0,00%	0,97%	0,00%
<i>Stilostomella monilis</i>	0,00%	0,00%	0,00%	0,00%	1,26%	1,61%
<i>Stilostomella pyrula</i>	0,00%	0,00%	2,26%	0,00%	0,00%	0,00%
<i>Stilostomella vertebralis</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Uvigerina canariensis</i>	0,00%	0,97%	0,00%	0,00%	0,00%	0,00%
<i>Uvigerina peregrina</i>	0,00%	1,93%	1,93%	0,00%	4,52%	2,26%
<i>Uvigerina pygmaea</i>	0,00%	0,00%	1,93%	0,00%	4,84%	0,97%
<i>Uvigerina rutila</i>	2,90%	2,26%	2,25%	0,00%	1,61%	1,29%
Plancton						
<i>Globigerina apertura</i>	0,00%	0,00%	1,61%	0,00%	2,26%	2,26%
<i>Globigerina bulloides</i>	6,45%	7,74%	5,16%	7,74%	5,48%	4,19%
<i>Globigerina decoraperta</i>	2,58%	3,87%	5,48%	5,81%	2,26%	2,79%
<i>Globigerina falconensis</i>	6,77%	8,70%	11,62%	7,74%	8,70%	7,10%
<i>Globigerina nepenthes</i>	0,97%	1,29%	0,00%	0,00%	0,00%	0,00%
<i>Globigerinita glutinata</i>	1,61%	0,00%	0,00%	1,29%	0,00%	0,00%
<i>Globigerinoides bollii</i>	0,97%	2,26%	0,00%	0,00%	0,00%	0,00%
<i>Globigerinoides elongatus</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Globigerinoides emeisi</i>	3,55%	2,26%	0,00%	0,97%	0,00%	0,00%
<i>Globigerinoides obliquus extremus</i>	7,42%	10,00%	4,20%	12,60%	10,00%	7,42%
<i>Globigerinoides obliquus obliquus</i>	4,84%	0,00%	2,26%	0,00%	0,00%	0,00%
<i>Globigerinoides quadrilobatus</i>	1,61%	3,20%	6,12%	0,00%	0,00%	0,00%
<i>Globigerinoides ruber</i>	0,00%	0,00%	0,00%	0,00%	2,26%	0,97%
<i>Globigerinoides trilobus</i>	0,00%	5,80%	13,22%	1,93%	6,13%	1,93%
<i>Globigerinoides sacculifer</i>	0,00%	0,00%	9,35%	0,00%	1,61%	0,97%
<i>Globorotalia hirsuta prae-hirsuta</i>	0,00%	0,00%	0,00%	0,97%	1,94%	5,16%
<i>Globorotalia incompta</i>	0,00%	0,00%	0,00%	2,26%	1,29%	0,00%
<i>Globorotalia margaritae</i>	0,00%	0,00%	0,97%	3,88%	2,88%	3,68%
<i>Globorotalia obesa</i>	0,00%	1,61%	0,00%	0,00%	0,00%	0,00%
<i>Globorotalia scitula</i>	1,93%	0,97%	0,97%	5,16%	0,97%	4,84%
<i>Hastigerina siphonifera</i>	5,81%	0,00%	1,26%	1,61%	2,26%	0,00%
<i>Neoglobobulimina acostaensis acostaensis</i>	3,55%	10,64%	0,00%	14,52%	7,74%	1,61%
<i>Neoglobobulimina humerosa humerosa</i>	0,97%	0,00%	1,29%	6,45%	0,97%	0,00%
<i>Neoglobobulimina pachyderma</i>	2,90%	2,90%	0,00%	2,90%	0,00%	4,84%
<i>Orbulina bilobata</i>	2,90%	1,29%	0,00%	0,00%	0,00%	0,00%
<i>Orbulina universa</i>	7,74%	3,55%	1,29%	2,58%	5,16%	19,35%
<i>Sphaeroidinellopsis seminulina</i>	0,00%	0,97%	0,00%	0,00%	0,00%	0,00%
<i>Turborotalita quinqueloba</i>	3,87%	3,87%	0,00%	7,10%	0,00%	5,16%

Tab. 1 - Relative abundances of planktonic and benthic species (the species <0.97% are not considered).

thick) are transgressive on the Lower Pliocene clays and have variable lithologies; from bottom to top:

20 cm of gypsum-rich, silty clay (TC3); 1.30 cm of fossiliferous, occasionally cemented (TC5), gray, silty-clayey sands (TC4) with gypsum, sulphur, *Arctica islandica* and *Terebratulina ampulla*; 2.50 m of mica-rich, gray, silty-clayey sands (TC6-TC7); about 1 m of gray-yellowish calcarenite (TC8); 1.60 m of clayey-sandy silt (TC9) and silty-clayey sands (TC10), both sterile. These samples are not considered.

All the samples have a high benthic foraminiferal component, declining towards the top of the sequence (83.55% in TC3; 53.87% in TC8).

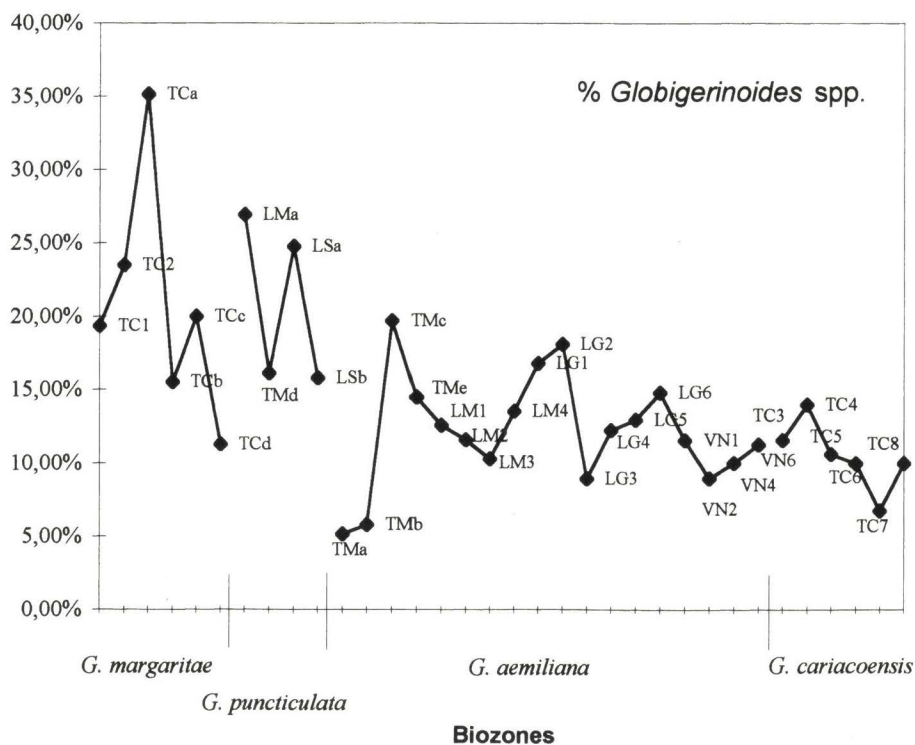
Sample TC3 is dominated by the *Elphidium* genus (>22%9), with dominance of *E. macellum* (12%) and *E. complanatum* (5.48%). *Elphidiella* cf. *arctica* (2.26%) was observed only in this level. The same level with *Elphidiella* was also reported in Dai Pra' & Arnoldus Huyzendveld (1984). There are also occurrences of the *Ammonia* genus (8.06%; *A. beccarii* and *A. inflata*), *Asterigerinata planorbis* (6.77%), *Cibicides lobatulus* (6.45%), *Florilus boueanus* (5.48%), *Buccella frigida granulata* (5.16%) and *Cassidulina neocarinata* (4.52%). The *Bulimina* genus (10.98%) is well-diversified and characterized by: *B. aculeata*, *B. corsiniana*, *B. elegans marginata*, *B. fusiformis*, *B. lappa* and *B. marginata*. Rare specimens of *B. etnea* occur. The

abundance of infralittoral epifaunal species (59.98%) and the grain size of the sediments (silty clay) indicate a low-energy shallow water environment. The occurrence of *E. cf. arctica*, never reported in Pleistocene deposits of the Latium area, may indicate the preference of this species for fine-grained sea floors.

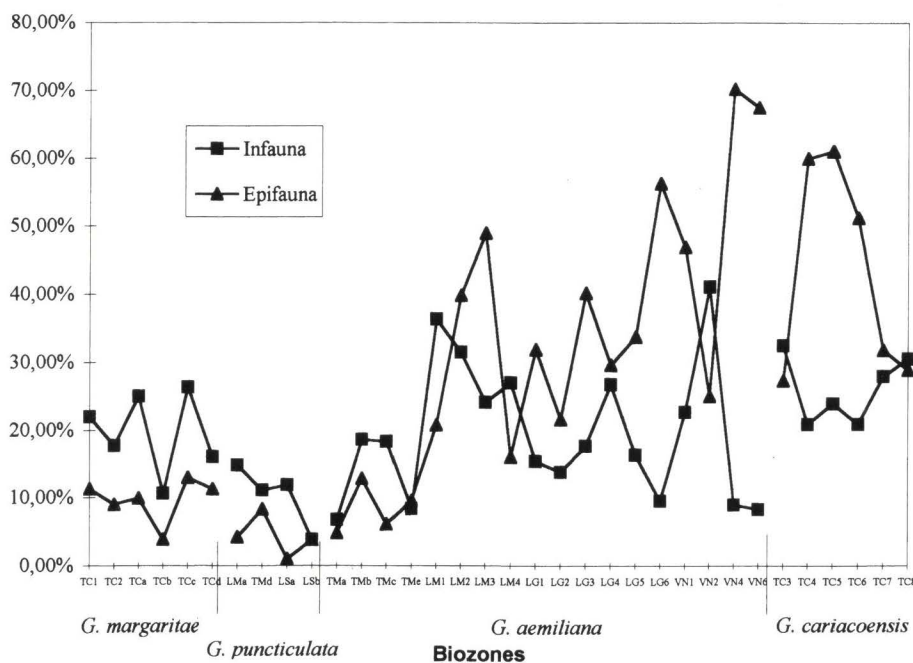
The much scarcer planktonic fraction is featured by the *Globigerinoides* genus (11.58%; Text-fig. 4): *G. ruber* (6.10%) and *G. elongatus* (3.22%) are the most abundant species, whereas *G. tenellus* together with *Globigerina rubescens* and *Turborotalita quinqueloba* have lower percentages (Tab. 7).

In TC4, *Arctica islandica* level, the microfauna is very scarce and the count was not made on 300 specimens; only 50 were considered. The benthos increases with respect to previous and subsequent samples, with three dominant epifaunal forms of infralittoral habitat (*Cibicides lobatulus*, *Asterigerinata planorbis*, *Elphidium aculeatum*). The frequency of *C. neocarinata* is due to reworking. This level represents the most significant infralittoral fluctuation of the entire Pleistocene sequence. Here, molluscan shells are almost always replaced by sulphur, because of the proximity of sulphurous water springs.

TC5 is qualitatively similar to TC3. However, some of its species have significant abundance variations. The *Elphidium* (13.23%), *Florilus*



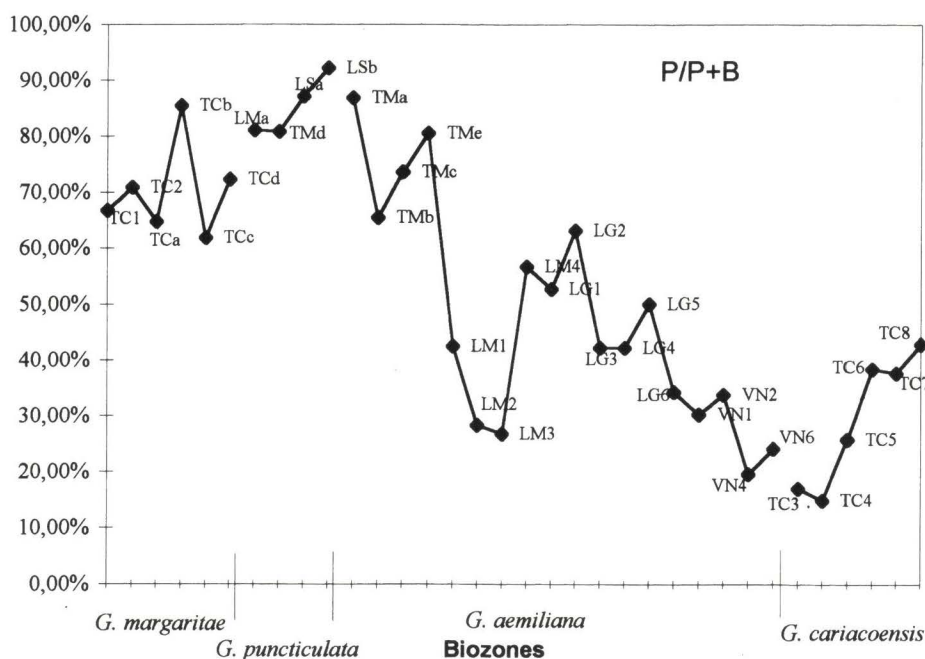
Text-fig. 4 - Relative abundance fluctuations of *Globigerinoides* spp. in the succession studied.



Text-fig. 5 - Epifauna-Infauna diagram in the succession studied.

(3.54%), *Bulimina* (9.36%) genera and *Buccella frigida granulata* (1.29%) decrease. Other species increase, such as *A. planorbis* (8.71%) and *C. lobatulus* (10.32%); the latter form continues to increase up to the top of the section. The planktonic assemblage is qualitatively and quantitatively similar to that of sample TC3. However, the occurrence of *Globorotalia inflata* (1.61%) and of *G. oscitans* (2.58%) and the reappearance in Pleistocene sediments of *Globigerina falconensis* (3.87%) are observed.

Sample TC6 shows a further decline of the *Elphidium* (6.44%) and *Florilus* (1.29%) genera, a minimum content of *Asterigerinata* (3.55%), an increase in *C. neocarinata* (which in this sample has the highest value, 9.68%) and *Pandaglandulina dinapolii* (6.77%); finally, only in this level are present *Bolivina alata* (4.84%) and *Valvulineria bradyana* (5.8%). The planktonic foraminiferal component has the highest values in all of the Pleistocene sequence (ca. 40%; Text-fig. 6), with



Text-fig. 6 - P/(P+B) ratio diagram in the succession studied.

dominance of *G. ruber* (6.77%), *G. bulloides* (5.81%), *G. falconensis* (4.84%) and *T. quinqueloba* (4.19%). In samples TC5 and TC6, the decrease in infralittoral species, the presence of *B. alata* (typical of fine-grained and poorly oxygenated sea floors), *V. bradyana* (opportunistic species) and of *G. inflata* suggest a transition to a slightly deeper and more stressed environment, not particularly favourable to benthic life.

Sample TC7 differs from samples TC6 and TC8, as it shows an increase in the *Elphidium* genus (10.11%) and a slight decrease in *C. lobatulus*. *C. neocarinata* remains around 10%, whereas the *Bulimina* and *Bolivina* genera slightly rise, although with rare occurrences. The planktonic component (37.64%) is similar to that of the previous sample, but *G. inflata* and *G. oscitans* are absent. The depositional environment is similar to that of the previous sample.

The last sample (TC8) marks the re-establishment of a typically infralittoral environment with dominance of *C. lobatulus* (11.29%) and *A. planorbis* (5.81%). The *Elphidium* genus decreases further (6%), whereas the *Bulimina* and *Bolivina* genera are very rare; the *Bolivina* genus is mostly represented by *B. spathulata* (2.9%).

The plankton is dominated by *G. falconensis* (12.9%), *G. ruber* (9.03%), *N. pachyderma* (4.84%), *G. bulloides* (4.19%), *G. rubescens* (3.87%) and *T. quinqueloba* (2.29%) are fairly frequent. Pleistocene sediments are characterized by the presence of *Globigerinoides tenellus* and rare specimens of *Bulimina etnea*, and so they are attributed to Early Pleistocene (Calabrian stage, *Globigerina cariacensis* Zone).

The top of the sequence is cut by an erosional surface, which is overlain by about 1 m of silty sand with interbedded pebbles and chert. These sediments are more recent than 0.6 Ma (Bellotti *et al.*, 1997).

TOR MATERNO AREA (TM)

This sector follows the Tor Caldara site southwards; silty-clay Pliocene sediments (3–6 m thick) with some sandy levels are exposed. Only single samples were collected. Pleistocene deposits are present (about 3 m thick) but at the moment it is hard to collect samples, owing to anthropic barriers or thick vegetation. The sediments are almost subhorizontal or with a very weak dipping.

SINGLE SAMPLES

Five samples were collected. Sample TMd (Tab. 2), collected few cm above sea level, may be ascribed

to the *Globorotalia puncticulata* Zone (MPL4a, Zanclean). The sample has a good planktonic fraction (80.76%), dominated by the marker (15.8%) and also by *Hastigerina siphonifera* (10.6%), *Orbulina universa* (8.7%) and *G. falconensis* (7.74%). In comparison with the samples from the *Globorotalia margaritae* Zone, it shows a decrease in *N. acostaensis* (4.52%) and *Globigerinoides* genus (6.11%; Text-fig. 4), whose most abundant species are *G. ruber* (5.8%) and *G. obliquus* group (5.2%). *Dentoglobigerina altispira altispira* (3.5%), never before reported in the area, is common.

The benthic fraction (19.51%) is scarcely differentiated. The two dominant species, i.e. *Bulimina costata* and *Planulina ariminensis*, have similar abundances (2.2% and 2.58% respectively). *Cibicides pseudoungerianus*, *Dentalina leguminiformis*, *Globobulimina pyrula*, *Melonis padanus* and *Sphaeroidina bulloides* have smaller percentages (<2%; Tab. 2). The depositional environment is always deep because of the high planktonic fraction and the occurrence of mainly infaunal benthic forms (11.16%), typical of a circalittoral environment. On the sea floor, there may have been less favourable conditions, indicated by a low specific diversity of the assemblages. Furthermore, the abundance of *H. siphonifera*, *G. sacculifer* and *G. ruber* may indicate further warming of the waters.

Samples TMa, TMb, Tmc and TMe may all be ascribed to the lower part of the *Globorotalia aemiliana* Zone (MPL5, Piacenzian), because of the presence of the zonal marker and *G. crassaformis*; the concomitance of *G. bononiensis* excludes the upper part of this zone from the biostratigraphic attribution. The planktonic fraction exceeds 50% (65.51%–86.91%) and dominated by the *Globigerina* genus (*G. bulloides*, 5.8–18%; *G. falconensis*, 5.43–14.48%), *G. bononiensis* (3–4%) and *O. universa* (4.52–7.42%). The *Globigerinoides* genus is poorly represented (Text-fig. 4): the most common taxon is the *G. obliquus* group with lower values (3.55–6.77%) than in more ancient sediments, except for sample TMc, where there is a positive peak (19.7%) with dominant *G. trilobus* (9.06%). Finally, samples TMa, TMb and TMc have morphotypes which belong to the *G. bononiensis*/*G. inflata* trend (*sensu* Spaak, 1981), with frequencies varying from 2.9 to 9.03%.

The benthic fraction is poorly abundant (19.35–34.21%) and represented by *Cancris oblongus*, *D. leguminiformis*, *L. cultrata*, *M. padanus*, *P. ariminensis*, *Siphonina reticulata* and *Uvigerina* spp. (Tab. 3). In sample TMc, *B. alata* (2.9%), particularly abundant in the Upper Pliocene–Lower

Globorotalia puncticulata Zone				
Tor Materno, Lido delle Sirene, Lido di Marechiaro areas - Single samples				
	LMa	TMd	LSa	LSb
Benthos				
<i>Bolivina punctata</i>	0,00%	0,00%	0,97%	0,00%
<i>Bulimina costata</i>	0,00%	2,20%	0,00%	0,00%
<i>Cibicidoides pseudoungerianus</i>	0,97%	1,29%	0,00%	0,00%
<i>Cibicidoides robertsonianus</i>	0,00%	0,00%	0,97%	0,00%
<i>Cylindroclavulina rudis</i>	0,97%	0,00%	0,00%	0,00%
<i>Dentalina leguminiformis</i>	0,00%	1,90%	0,00%	0,00%
<i>Globobulimina affinis</i>	0,97%	0,00%	5,50%	0,00%
<i>Globobulimina pyrula</i>	0,00%	0,97%	0,00%	0,00%
<i>Globobulimina spinescens</i>	4,84%	0,00%	1,29%	0,00%
<i>Karrerella bradyi</i>	0,00%	0,00%	1,29%	1,29%
<i>Lenticulina cultrata</i>	0,00%	1,29%	0,00%	0,00%
<i>Lenticulina rotulata</i>	1,29%	0,00%	0,00%	1,61%
<i>Lenticulina stellata</i>	0,00%	1,90%	0,00%	0,00%
<i>Marginulina hirsuta</i>	0,00%	0,00%	0,97%	0,00%
<i>Martinottiella communis</i>	0,97%	0,00%	0,00%	0,00%
<i>Melonis padanus</i>	0,00%	0,97%	0,00%	0,00%
<i>Planularia auris</i>	0,97%	0,00%	0,00%	0,00%
<i>Planulina ariminensis</i>	0,97%	2,58%	0,00%	2,26%
<i>Pullenia bulloides</i>	0,00%	0,00%	0,00%	0,97%
<i>Sigmoilopsis celata</i>	0,00%	1,90%	0,00%	0,00%
<i>Sphaeroidina bulloides</i>	0,97%	1,29%	0,00%	0,00%
<i>Trifarina forasini</i>	3,55%	0,00%	0,00%	0,00%
<i>Uvigerina peregrina</i>	1,29%	1,93%	1,93%	1,93%
<i>Uvigerina pygmaea</i>	1,29%	0,00%	0,00%	0,00%
Plancton				
<i>Dentoglobigerina altispira altispira</i>	0,00%	3,50%	0,00%	10,00%
<i>Globigerina apertura</i>	1,93%	1,29%	4,19%	3,22%
<i>Globigerina bulloides</i>	6,77%	2,26%	7,10%	15,81%
<i>Globigerina decoraperta</i>	0,00%	2,26%	2,58%	0,00%
<i>Globigerina falconensis</i>	5,80%	7,74%	4,80%	4,52%
<i>Globigerina praecalida</i>	2,26%	0,00%	2,60%	0,00%
<i>Globigerinita glutinata</i>	0,97%	1,90%	0,00%	0,00%
<i>Globigerinoides elongatus</i>	0,00%	5,20%	0,00%	0,00%
<i>Globigerinoides obliquus extremus</i>	8,39%	0,00%	20,60%	0,97%
<i>Globigerinoides obliquus obliquus</i>	4,80%	0,00%	0,00%	0,00%
<i>Globigerinoides quadrilobatus</i>	1,90%	0,00%	1,60%	0,00%
<i>Globigerinoides ruber</i>	9,63%	5,80%	2,58%	14,52%
<i>Globigerinoides trilobus</i>	2,20%	1,29%	0,00%	0,00%
<i>Globigerinoides sacculifer</i>	0,00%	3,82%	0,00%	0,00%
<i>Globorotalia incompta</i>	0,00%	1,90%	1,60%	0,97%
<i>Globorotalia obesa</i>	0,97%	0,00%	2,20%	1,29%
<i>Globorotalia puncticulata padana</i>	2,20%	2,58%	5,80%	10,97%
<i>Globorotalia puncticulata puncticulata</i>	20,64%	15,80%	11,90%	13,54%
<i>Globorotalia scitula</i>	1,29%	0,00%	1,60%	2,90%
<i>Hastigerina siphonifera</i>	2,60%	10,60%	6,40%	4,84%
<i>Neogloboquadra acostaensis acostaensis</i>	0,00%	4,52%	4,48%	2,26%
<i>Orbulina universa</i>	7,10%	8,70%	7,10%	6,13%
<i>Spaeroidinellopsis seminulina</i>	1,60%	0,00%	0,00%	0,00%
<i>Turborotalita quinqueloba</i>	0,00%	1,60%	0,00%	0,00%

Tab. 2 - Relative abundances of planktonic and benthic species (the species <0.97% are not considered).

Pleistocene sediments of Latium, occurs. Its occurrence and the sharp decrease in the *Globigerinoides* genus may suggest a period of water cooling. Infaunal species are always dominant (Text-fig. 4), indicating deep (circalittoral environment) sea floors; in the epifauna, *P. ariminensis* is the most abundant species, just as in MPL2 and MPL4 Zones.

LIDO DELLE SIRENE AREA (LS)

In this sector the Pliocene sediments outcrop to 4-5 meters, while the Pleistocene deposits are about 7 meters thick. Two samples were collected: LSa and LSb, about 1 m and 1.50 m above sea level respectively. Both samples belong to the *Globorotalia puncticulata* Zone (MPL4) and have

similar benthic and planktonic assemblages (Tab. 2). The benthos is scarce and poorly differentiated. The most significant species, all from a deep-sea (circalittoral/epibathyal) environment, are: *Cibicidoides robertsonianus*, *Karreriella bradyi*, *Planulina ariminensis* and *Uvigerina peregrina*. In LSa, the most abundant species is *Globobulimina affinis*, a deep infaunal form, typical of fine-grained and poorly oxygenated sea floors (Violanti, 1994). In sample LSb, however, similar infaunal and epifaunal values may infer a more oxygenated sea floor. As to the planktonic fraction, sample LSb has rising percentages of *D. altispira altispira* (10%) and *G. ruber* (14.52%), whereas sample LSa has a 20% peak of *G. obliquus obliquus*. The marker, *G. puncticulata puncticulata*, has values over 10% in both samples.

LIDO DI MARECHIARO AREA

One single sample was collected and two sections, about 8 m thick, were sampled.

Sample LMa (Tab. 2), collected about 30 cm above sea level, is attributed to the *Globorotalia puncticulata* Zone (MPL4a, Zanclean). The planktonic fraction is extremely abundant (>80%; Text-fig. 6) and the marker has a peak value of >20%.

The benthic fraction (19%) is featured chiefly by *Trifarina fornasinii* (3.55%) and *Globobulimina spinescens* (4.84%); both are infaunal circalittoral forms, indicative of anoxic environments and fine-grained sea floors. This finding is substantiated by a sharp drop in epifaunal forms (4.2%; Text-fig. 5), as against infaunal ones (14.85%). It is confirmed by the persistence of sea floors which must have been poorly favourable to benthic life, as reported for the LSa sample (Lido delle Sirene).

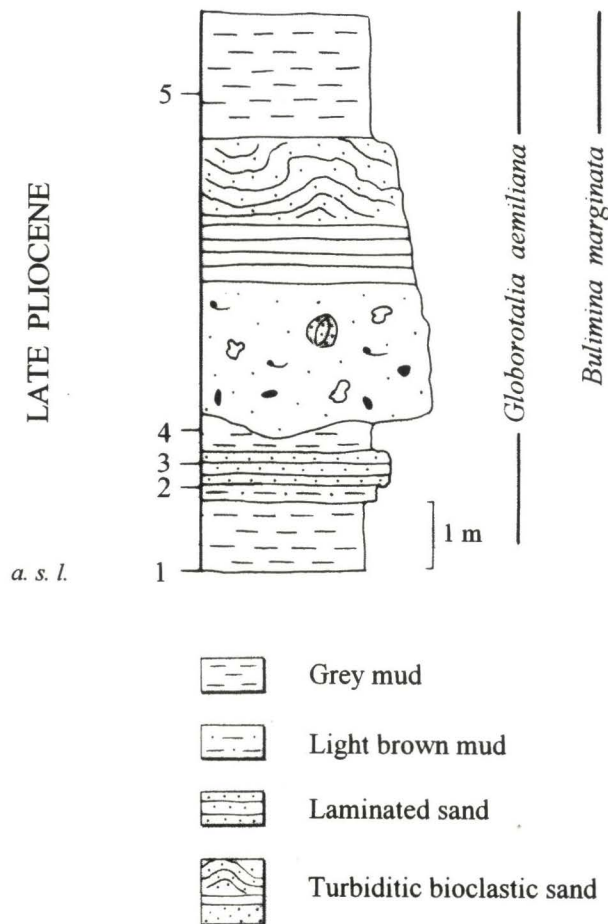
LIDO DI MARECHIARO SECTION (LM) (Text-fig. 7)

This section was sampled starting from 0 m above sea level and consists of: gray mud (LM1) for about 1 m; light brown mud (LM2) with bioturbations for about 30 cm; a turbiditic level of laminated, gray sands (LM3) of about 50 cm; 60 cm of gray mud (LM4); one turbiditic level about 4 m-thick with bioclastic sands; finally, another level about 2 m thick (LM5) of gray mud.

In all section the benthic fraction is dominant (>50%); sample LM5 presents a slight increase (43.22%) in the planktonic fraction. The count was not made on sample LM3, as it had a significant degree of reworking and contained a scarce number of foraminifera.

The section is ascribed to the upper part of the

Lido di Marechiaro (LM)



Text-fig. 7 - Lithology and distribution of the main taxa in the Lido di Marechiaro Section.

Globorotalia aemiliana Zone (MPL5b, Gelasian) because the presence of the marker and the absence of *G. bononiensis*. In the top sample (LM5) *G. aemiliana* (3.23%) is associated with *Bulimina marginata* and *Bolivina alata*. The planktonic assemblage is qualitatively similar throughout the section, but some quantitative variations were noted (Tab. 4). The most abundant species are *G. bulloides*, *Globigerinita glutinata* (both with a peak of 7.74% and 4.19% in the topmost sample, LM5); *G. obliquus obliquus* whose abundance remains high (around 4% throughout the section); *G. ruber*, the most abundant species in all the samples (>6% except for the basal sample, where it is less frequent, i.e. 4.52%).

The benthos is well diversified. From bottom to top of the sequence, *U. peregrina* and *C. neocarinata* progressively decrease. Based on the values

Globorotalia aemiliana Zone				
Tor Materno area - Single samples	TMa	TMb	TMc	TMe
Benthos				
<i>Anomalinoides helacinus</i>	0,00%	0,97%	0,00%	0,00%
<i>Bigenenerina nodosaria</i>	0,00%	1,93%	0,00%	0,00%
<i>Bolivina aenariensis</i>	0,00%	0,97%	1,29%	0,00%
<i>Bolivina alata</i>	0,00%	0,00%	2,90%	0,00%
<i>Bolivina aff. alata</i>	0,00%	0,97%	0,00%	0,00%
<i>Bolivina dilatata</i>	0,00%	0,00%	0,97%	0,00%
<i>Bulimina costata</i>	0,97%	0,97%	0,97%	0,00%
<i>Cancris oblongus</i>	0,97%	1,61%	0,00%	0,00%
<i>Cassidulina carinata</i>	0,00%	0,00%	1,29%	0,00%
<i>Cibicoides pseudoungerianus</i>	0,97%	0,00%	2,60%	0,00%
<i>Cibicoides ungerianus</i>	0,97%	0,00%	1,61%	1,93%
<i>Dentalina leguminiformis</i>	0,97%	2,26%	0,97%	1,29%
<i>Fursenkoina schreibersiana</i>	0,00%	0,00%	0,97%	0,00%
<i>Globobulimina pyrula</i>	0,00%	0,97%	0,00%	0,00%
<i>Globocassidulina subglobosa</i>	0,00%	0,00%	0,97%	0,97%
<i>Hanzawaia boueana</i>	0,00%	0,00%	0,00%	1,61%
<i>Karrenella bradyi</i>	0,97%	0,00%	0,97%	0,00%
<i>Lenticulina cultrata</i>	0,00%	2,26%	0,97%	1,61%
<i>Lenticulina echinata</i>	0,00%	0,97%	0,00%	0,00%
<i>Lenticulina inornata</i>	0,97%	0,00%	0,00%	0,00%
<i>Lenticulina orbicularis</i>	0,00%	0,97%	0,00%	0,00%
<i>Lenticulina rotulata</i>	0,00%	0,97%	0,00%	0,97%
<i>Martinottiella communis</i>	0,00%	0,97%	0,00%	0,00%
<i>Melonis padanus</i>	0,97%	1,29%	1,29%	0,00%
<i>Planulina ariminensis</i>	0,97%	5,16%	0,00%	2,58%
<i>Plectofrondicularia inaequalis</i>	0,00%	0,97%	0,00%	0,00%
<i>Pleurostomella alternans</i>	0,00%	0,97%	0,00%	0,00%
<i>Pullenia quinqueloba</i>	0,00%	0,00%	1,29%	0,00%
<i>Saracenaria italica</i>	0,00%	0,97%	0,00%	0,00%
<i>Sigmoilopsis celata</i>	0,00%	0,00%	0,00%	1,94%
<i>Siphonina reticulata</i>	1,61%	1,61%	1,90%	1,29%
<i>Sphaeroidina bulloides</i>	0,00%	1,29%	1,29%	2,26%
<i>Stilostomella monilis</i>	0,97%	0,00%	1,29%	0,00%
<i>Uvigerina peregrina</i>	0,00%	0,97%	1,93%	1,93%
<i>Uvigerina pygmaea</i>	1,96%	0,97%	0,00%	0,00%
<i>Valvulineria bradyana</i>	0,00%	0,00%	0,97%	0,97%
Plancton				
<i>Globigerina apertura</i>	7,40%	4,20%	2,20%	4,19%
<i>Globigerina bulloides</i>	18,06%	5,81%	8,41%	5,80%
<i>Globigerina decoraperta</i>	3,20%	4,52%	2,90%	2,58%
<i>Globigerina falconensis</i>	14,48%	5,49%	5,43%	18,67%
<i>Globigerina praecalida</i>	1,29%	0,00%	0,97%	0,00%
<i>Globigerinita glutinata</i>	0,00%	0,00%	1,90%	0,00%
<i>Globigerinoides obliquus extremus</i>	0,97%	0,00%	2,26%	0,00%
<i>Globigerinoides obliquus obliquus</i>	4,20%	3,55%	6,77%	4,19%
<i>Globigerinoides quadrilobatus</i>	0,00%	0,97%	0,00%	0,00%
<i>Globigerinoides ruber</i>	0,00%	1,29%	0,00%	3,87%
<i>Globigerinoides trilobus</i>	0,00%	0,00%	9,06%	3,86%
<i>Globigerinoides sacculifer</i>	0,00%	0,00%	1,61%	2,58%
<i>Globorotalia aemiliana</i>	0,00%	3,23%	0,00%	5,81%
<i>Globorotalia bononiensis</i>	3,20%	4,52%	3,20%	3,87%
<i>G. bononiensis/G. inflata</i>	2,90%	9,03%	4,80%	0,00%
<i>Globorotalia crassaformis</i>	0,97%	1,61%	1,90%	0,00%
<i>Globorotalia incompta</i>	1,61%	0,00%	0,00%	0,00%
<i>Globorotalia obesa</i>	0,00%	0,00%	1,29%	0,00%
<i>Globorotalia puncticulata padana</i>	9,68%	5,81%	5,48%	7,74%
<i>Globorotalia scitula</i>	1,90%	1,29%	2,60%	2,58%
<i>Hastigerina siphonifera</i>	2,60%	2,58%	0,00%	2,90%
<i>Neogloboquadrina acostaensis acostaensis</i>	7,40%	0,97%	4,20%	1,61%
<i>Neogloboquadrina humerosa humerosa</i>	0,00%	0,00%	1,29%	1,29%
<i>Neogloboquadrina pachyderma</i>	0,97%	1,93%	0,00%	1,61%
<i>Orbulina bilobata</i>	0,00%	1,61%	0,00%	0,00%
<i>Orbulina universa</i>	6,08%	4,52%	7,38%	7,42%
<i>Turborotalita quinqueloba</i>	0,00%	2,58%	0,00%	0,00%

Tab. 3 - Relative abundances of planktonic and benthic species (the species <0.97% are not considered).

Globorotalia aemiliana Zone				
Lido Marechiaro Section	LM1	LM2	LM3	LM4
Benthos				
<i>Ammonia beccarii</i>	0,97%	0,00%	0,00%	0,00%
<i>Amphistegina lessonii</i>	0,00%	0,00%	0,97%	0,00%
<i>Anomalinoides helycinus</i>	0,00%	0,00%	0,00%	0,00%
<i>Anomalinoides ornatus</i>	0,00%	0,97%	0,00%	0,00%
<i>Asterigerinata planorbis</i>	3,55%	9,35%	15,16%	4,84%
<i>Astrononion stelligerum</i>	0,00%	0,97%	1,61%	0,00%
<i>Bigenerina nodosaria</i>	0,97%	0,00%	0,00%	1,29%
<i>Bolivina</i> sp.	0,00%	0,00%	0,64%	1,29%
<i>Bolivina alata</i>	0,97%	0,97%	0,00%	3,23%
<i>Bolivina catanensis</i>	0,97%	0,00%	0,97%	0,97%
<i>Bolivina dilatata</i>	0,00%	1,61%	0,00%	1,93%
<i>Bolivina pseudoplicata</i>	0,00%	0,00%	1,29%	0,00%
<i>Bolivina spathulata</i>	0,00%	0,97%	1,29%	2,58%
<i>Bulimina aculeata</i>	4,52%	0,97%	0,97%	0,00%
<i>Bulimina marginata</i>	0,00%	0,00%	0,00%	1,61%
<i>Cancris auriculus</i>	1,29%	0,97%	0,97%	0,00%
<i>Cassidulina carinata</i>	4,84%	5,48%	3,22%	3,87%
<i>Cibicides lobatulus</i>	3,87%	8,71%	16,77%	3,55%
<i>Cibicides refulgens</i>	0,00%	0,97%	0,00%	0,00%
<i>Cibicidoides pseudoungerianus</i>	1,29%	1,61%	0,97%	0,00%
<i>Dorothia gibbosa</i>	3,55%	3,87%	0,97%	2,26%
<i>Elphidium complanatum</i>	2,16%	4,19%	3,87%	2,26%
<i>Elphidium crispum</i>	0,00%	1,61%	0,00%	0,97%
<i>Elphidium macellum</i>	0,00%	0,00%	1,93%	0,00%
<i>Florilus boueanus</i>	0,00%	0,97%	0,97%	0,00%
<i>Globobulimina pyrula</i>	2,26%	1,93%	0,00%	0,00%
<i>Globocassidulina subglobosa</i>	1,61%	1,93%	1,61%	0,97%
<i>Gyroidinoides neosoldanii</i>	1,29%	0,00%	0,00%	0,00%
<i>Gyroidinoides umbonatus</i>	1,93%	2,90%	0,00%	0,00%
<i>Hanzawaia boueana</i>	0,97%	1,93%	1,93%	1,61%
<i>Heterolepa bellincionii</i>	0,00%	0,00%	0,97%	0,00%
<i>Heterolepa floridana</i>	0,97%	3,50%	0,00%	0,00%
<i>Melonis barleeianum</i>	0,97%	0,00%	0,00%	0,00%
<i>Melonis pompilioides</i>	2,90%	2,26%	3,55%	0,00%
<i>Oridorsalis umbonatus</i>	0,00%	1,29%	0,00%	0,00%
<i>Pandaglandulina dinapoli</i>	0,00%	2,58%	0,00%	1,93%
<i>Planorbulina mediterraneensis</i>	0,00%	0,00%	1,93%	0,00%
<i>Planulina ariminensis</i>	1,61%	0,00%	0,00%	0,00%
<i>Pullenia bulloides</i>	1,61%	0,00%	1,29%	0,00%
<i>Reussella spinulosa</i>	0,00%	0,97%	0,97%	0,00%
<i>Rosalina globularis</i>	0,97%	0,00%	0,97%	1,93%
<i>Sigmoilopsis celata</i>	0,97%	1,29%	0,00%	0,00%
<i>Siphonina reticulata</i>	0,00%	0,00%	0,00%	0,97%
<i>Sphaeroidina bulloides</i>	2,58%	1,93%	1,61%	1,29%
<i>Textularia conica</i>	0,00%	0,00%	0,97%	0,00%
<i>Trifarina angulosa</i>	2,26%	0,00%	1,29%	0,00%
<i>Uvigerina canariensis</i>	0,00%	0,00%	1,29%	0,00%
<i>Uvigerina peregrina</i>	4,20%	3,87%	2,26%	2,58%
<i>Uvigerina pygmaea</i>	1,29%	0,97%	0,00%	1,29%
Plancton				
<i>Globigerina apertura</i>	1,93%	0,97%	0,97%	1,93%
<i>Globigerina bulloides</i>	5,16%	2,58%	3,22%	7,74%
<i>Globigerina decoraperta</i>	2,58%	0,97%	0,00%	0,00%
<i>Globigerina falconensis</i>	0,00%	0,97%	3,55%	1,61%
<i>Globigerinita glutinata</i>	3,22%	1,61%	0,00%	4,19%
<i>Globigerinoides elongatus</i>	0,97%	1,29%	0,97%	0,97%
<i>Globigerinoides obliquus obliquus</i>	3,87%	3,22%	2,26%	3,23%
<i>Globigerinoides ruber</i>	4,52%	6,13%	6,12%	6,77%
<i>Globigerinoides trilobus</i>	3,22%	0,97%	0,97%	2,58%
<i>Globorotalia aemiliana</i>	2,58%	1,61%	1,29%	3,23%
<i>Globorotalia incompta</i>	0,00%	0,00%	1,29%	0,00%
<i>Globorotalia obesa</i>	0,00%	0,00%	1,29%	0,00%
<i>Globorotalia puncticulata padana</i>	0,97%	1,29%	0,97%	2,26%
<i>Globorotalia scitula</i>	1,93%	0,97%	0,00%	1,61%
<i>Hastigerina siphonifera</i>	0,97%	0,00%	0,00%	0,97%
<i>Neogloboquadrina acostaensis acostaensis</i>	1,93%	0,00%	0,00%	1,93%
<i>Neogloboquadrina pachyderma</i>	0,00%	0,00%	1,29%	6,77%
<i>Orbulina universa</i>	5,49%	5,81%	1,61%	5,16%
<i>Turborotalia quinqueloba</i>	3,22%	0,00%	0,97%	5,81%

Tab. 4 - Relative abundances of planktonic and benthic species (the species <0.97% are not considered).

Globorotalia aemiliana Zone						
Lido Garda Section	LG1	LG2	LG3	LG4	LG5	LG6
Benthos						
<i>Ammonia beccarii</i>	0,00%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Amphistegina lessonii</i>	0,00%	0,00%	0,00%	0,97%	0,00%	0,00%
<i>Asterigerinata planorbis</i>	7,42%	4,84%	14,20%	7,42%	9,67%	12,20%
<i>Bolivina aenariensis</i>	0,00%	0,00%	0,00%	1,29%	0,00%	0,00%
<i>Bolivina alata</i>	0,97%	2,26%	0,00%	2,26%	0,00%	0,00%
<i>Bolivina catanensis</i>	0,00%	0,00%	0,97%	0,97%	0,97%	0,00%
<i>Bolivina dilatata</i>	1,29%	0,00%	0,00%	0,00%	0,97%	1,61%
<i>Bolivina spathulata</i>	0,97%	2,26%	2,58%	0,97%	1,61%	0,00%
<i>Bulimina costata</i>	0,00%	0,97%	0,97%	0,97%	0,00%	0,00%
<i>Bulimina fusiformis</i>	1,29%	0,00%	0,00%	0,97%	0,97%	0,00%
<i>Bulimina marginata</i>	0,00%	3,20%	1,93%	1,29%	1,90%	0,00%
<i>Bulimina minima</i>	0,00%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Cancris aurculus</i>	0,00%	0,97%	0,00%	0,97%	0,00%	0,00%
<i>Cassidulina neocarinata</i>	2,26%	1,61%	4,20%	4,52%	3,22%	1,93%
<i>Cibicides lobatulus</i>	8,10%	5,20%	12,20%	4,84%	10,60%	14,50%
<i>Cibicides refulgens</i>	0,00%	0,00%	0,00%	0,00%	0,00%	1,93%
<i>Cibicidoides pseudoungerianus</i>	0,00%	1,29%	1,61%	0,97%	0,00%	3,22%
<i>Cibicides decipiens</i>	0,97%	0,97%	0,00%	0,97%	0,00%	1,93%
<i>Elphidium aculeatum</i>	0,00%	0,00%	0,00%	1,93%	0,00%	1,61%
<i>Elphidium complanatum</i>	4,20%	3,87%	5,16%	2,58%	5,16%	4,84%
<i>Elphidium crispum</i>	0,00%	0,00%	0,00%	1,29%	0,97%	1,93%
<i>Elphidium macellum</i>	0,00%	0,00%	1,93%	0,00%	2,26%	2,58%
<i>Favulina hexagona</i>	0,00%	0,97%	0,00%	0,00%	0,00%	0,00%
<i>Fissurina marginata</i>	0,00%	0,00%	0,00%	2,26%	0,00%	0,00%
<i>Fissurina bradyana</i>	1,61%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Fissurina orbignyana</i>	0,00%	0,00%	0,00%	0,00%	1,61%	0,00%
<i>Fissurina pseudorbignyana</i>	0,00%	0,00%	0,00%	0,00%	0,97%	1,93%
<i>Florilus boueanus</i>	0,00%	0,00%	0,00%	0,00%	0,00%	1,61%
<i>Florilus citai</i>	0,97%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Globocassidulina crassa</i>	0,00%	0,00%	0,00%	1,93%	0,00%	0,00%
<i>Globocassidulina subglobosa</i>	0,97%	0,00%	0,97%	2,90%	1,61%	2,20%
<i>Gyroidinoides neosoldanii</i>	0,00%	0,00%	0,97%	1,29%	0,00%	0,00%
<i>Gyroidinoides umbonatus</i>	2,26%	0,00%	0,00%	1,29%	0,00%	0,00%
<i>Guttulina communis</i>	0,97%	1,61%	0,00%	0,00%	0,00%	0,00%
<i>Hanzawaia boueana</i>	1,61%	3,20%	2,26%	0,97%	1,93%	2,90%
<i>Heterolepa floridana</i>	2,26%	0,00%	0,00%	0,00%	0,00%	2,20%
<i>Melonis barleeianum</i>	0,00%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Melonis padanus</i>	1,61%	0,00%	0,97%	0,97%	0,00%	0,00%
<i>Planorbulina mediterraneensis</i>	1,29%	0,00%	0,00%	0,97%	1,29%	1,93%
<i>Praeglobobulimina pupoides</i>	0,00%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Pullenia bulloides</i>	0,00%	0,00%	0,00%	0,97%	1,29%	0,00%
<i>Pullenia quinqueloba</i>	0,00%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Pyrgo oblonga</i>	1,29%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Reussella spinulosa</i>	0,00%	1,61%	0,00%	1,29%	0,00%	0,00%
<i>Rosalina bradyi</i>	0,00%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Rosalina globularis</i>	1,61%	1,29%	0,97%	2,26%	0,97%	1,93%
<i>Siphonina reticulata</i>	0,00%	0,00%	0,00%	0,97%	0,00%	0,00%
<i>Spiroplectammina wrighti</i>	0,00%	0,00%	0,00%	0,97%	0,00%	0,00%
<i>Stainforthia complanata</i>	0,00%	0,00%	1,29%	0,00%	0,00%	0,00%
<i>Trifarina bradyi</i>	0,97%	0,00%	0,00%	0,97%	0,00%	0,97%
<i>Uvigerina peregrina</i>	1,29%	0,00%	0,97%	1,61%	1,29%	0,00%
<i>Uvigerina pygmaea</i>	1,29%	0,97%	0,00%	0,97%	0,00%	0,00%
Plancton						
<i>Globigerina apertura</i>	0,97%	1,29%	1,93%	0,97%	2,26%	0,00%
<i>Globigerina bulloides</i>	7,10%	13,50%	6,13%	4,84%	6,13%	4,84%
<i>Globigerina decoraperta</i>	2,90%	2,58%	3,87%	2,26%	4,84%	2,58%
<i>Globigerina falconensis</i>	1,29%	3,55%	8,06%	1,61%	4,19%	2,20%
<i>Globigerina rubescens</i>	0,00%	0,97%	0,00%	0,00%	0,97%	0,00%
<i>Globigerinita glutinata</i>	1,69%	1,61%	2,26%	0,97%	1,61%	0,97%
<i>Globigerinoides elongatus</i>	4,85%	3,20%	0,00%	1,61%	2,90%	1,61%
<i>Globigerinoides obliquus obliquus</i>	2,26%	2,58%	1,93%	2,90%	1,61%	3,87%
<i>Globigerinoides ruber</i>	8,39%	7,09%	4,82%	6,13%	5,20%	7,09%
<i>Globigerinoides trilobus</i>	1,29%	5,20%	2,20%	1,61%	3,22%	2,20%
<i>Globorotalia aemiliana</i>	2,60%	4,20%	2,58%	9,03%	2,90%	2,20%
<i>Globorotalia crassaformis</i>	0,00%	0,97%	0,00%	1,61%	0,00%	0,00%
<i>Globorotalia incompta</i>	2,90%	2,58%	3,22%	0,32%	1,61%	0,00%
<i>Globorotalia obesa</i>	1,29%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Globorotalia punctulata padana</i>	0,00%	0,00%	0,97%	0,00%	1,29%	1,29%
<i>Globorotalia scitula</i>	1,90%	1,29%	0,00%	0,97%	0,97%	0,00%
<i>Hastigerina siphonifera</i>	0,97%	1,29%	0,00%	1,61%	1,29%	0,00%
<i>Neoglobobulimina acostaensis acostaensis</i>	5,50%	4,50%	1,63%	2,26%	4,50%	0,00%
<i>Neoglobobulimina pachyderma</i>	2,90%	1,93%	1,29%	0,97%	0,97%	1,93%
<i>Orbulina universa</i>	0,97%	1,29%	1,29%	1,29%	1,29%	0,97%
<i>Turborotalita quinqueloba</i>	2,90%	3,55%	0,00%	1,29%	2,26%	2,58%

Tab. 5 - Relative abundances of planktonic and benthic species (the species <0.97% are not considered).

of the planktonic fraction and on the frequency variations of some species which are relevant for an understanding of the depositional environment, two assemblages were distinguished in this section: a deeper assemblage (assemblage A, identified in the basal sample LM1 and top sample LM5) and an assemblage which marks bathymetric reduction (assemblage B, present in the two intermediate samples LM2 and LM4). Assemblage A is characterized by a peak value of the plankton, deep infaunal species (*B. alata*, *B. marginata*, *D. gibbosa*, *S. bulloides*, and *U. peregrina*) and low frequencies of shallow water forms (*A. planorbis*, *C. lobatulus*, *E. complanatum*). Assemblage B has peaks of *A. planorbis* (9.35-15.16%), *C. lobatulus* (8.71-16.77%) and *Elphidium* spp. (5.8%), which are typically infralittoral species. This assemblage also has the lowest values of the planktonic fraction (28.39-26.77%) and dominance of epifaunal forms (39.94-49.02%; Text-fig. 5).

LIDO GARDA SECTION (ANZIO COLONIA) (LG)

This section, studied in the 1970s (Carboni, 1975), is located behind the "Lido Garda" beach. At the time of sampling, the thickness was approximately 8 m and consisted of clayey and clayey-sandy lithologies and sands. As the section is at present poorly exposed, it was not re-sampled and use was made of old samples (6 samples spaced 1.30 m apart: the first 5 from clay and clayey-sands and the last one from sands).

The entire section was attributed to the upper part of the *Globorotalia aemiliana* Zone (MPL5b, Gelasian). The absence of *G. bononiensis* and the presence of *B. marginata* suggest the Gelasian stage. The assemblages are abundant and well diversified; a reduction in the size of specimens and a slight degree of reworking are noted.

Plankton is less than benthos (Text-fig. 6), with a minimum value in the last sample (34.33%, in accordance with the increase in the sandy fraction) and a maximum value in the first two samples,

where the planktonic component exceeds the benthic one (LG1: 52.67%; LG2: 63.17%). The planktonic assemblage is similar in all samples and is characterized by *G. bulloides*, *G. decoraperta*, *G. falconensis*, *Globigerinita glutinata*, *G. elongatus*, *G. obliquus obliquus*, *G. ruber*, *G. trilobus*, *G. aemiliana*, *G. crassaformis* and *N. acostaensis*. In the *Globigerinoides* genus, *G. elongatus* and *Gd. ruber* are the most abundant in the two basal samples, but tend to decrease towards the upper part of the sequence, except in the last sample (LG6), where the entire genus slightly rises again (14.77%). The zonal marker has values of 2.2-4.2% and a peak (9.03%) in sample LG4.

In all samples, the benthic assemblage is dominated by epifaunal forms of shallow waters and vegetated sea floors, such as *A. planorbis* (4.84-14.2%), *C. lobatulus* (4.84-14.5%), *E. complanatum* (2.58-5.16%) and *Rosalina globularis* (0.97-1.93%). The *Bolivina* and *Bulimina* genera are mainly represented in the first two samples. A peak of *B. spathulata* (2.58%) is observed in sample LG3. Consequently, the depositional environment of this section ranges from the circalittoral/infralittoral transition (LG1, LG2, LG3 and LG4) to infralittoral (LG5 and LG6) with well-oxygenated and vegetated sea floors.

ANZIO AREA

Samples were collected from a cliff wall, topped by the remains of Villa di Nerone in Anzio city. The wall is a portion of the southern fold of the Anzio anticline. The layers are visibly inclined, dipping about 20°.

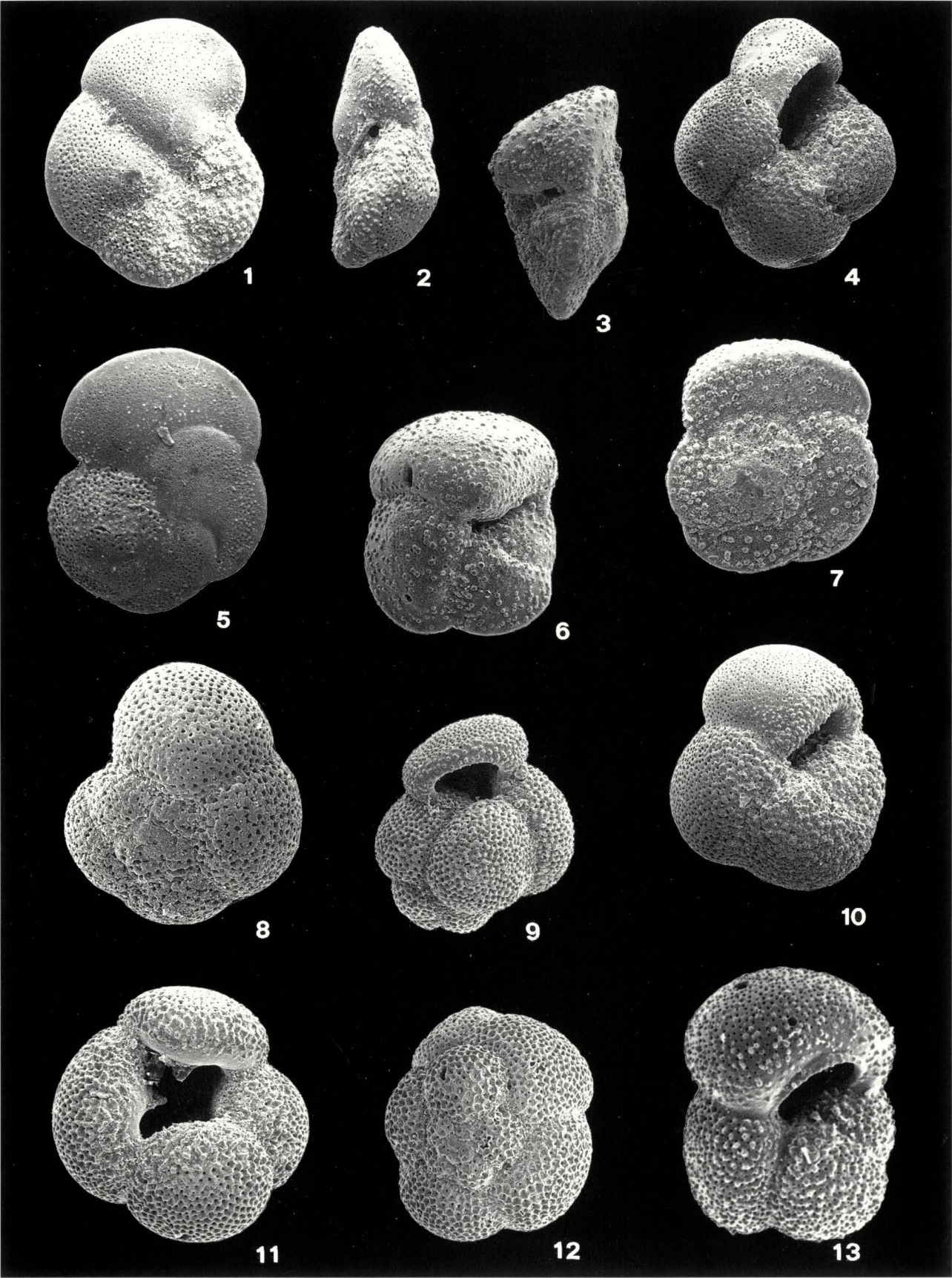
VILLA DI NERONE SECTION (VN) (Text-fig. 8)

The section is about 15 m thick; 12 samples were collected along it. On account of the high degree of reworking, quantitative analysis was carried out only on samples VN1, VN2, VN4 and VN6. From the base, the sequence is made up of:

1.50 m of muddy sands (VN1) and sandy mud

EXPLANATION OF PLATE 1

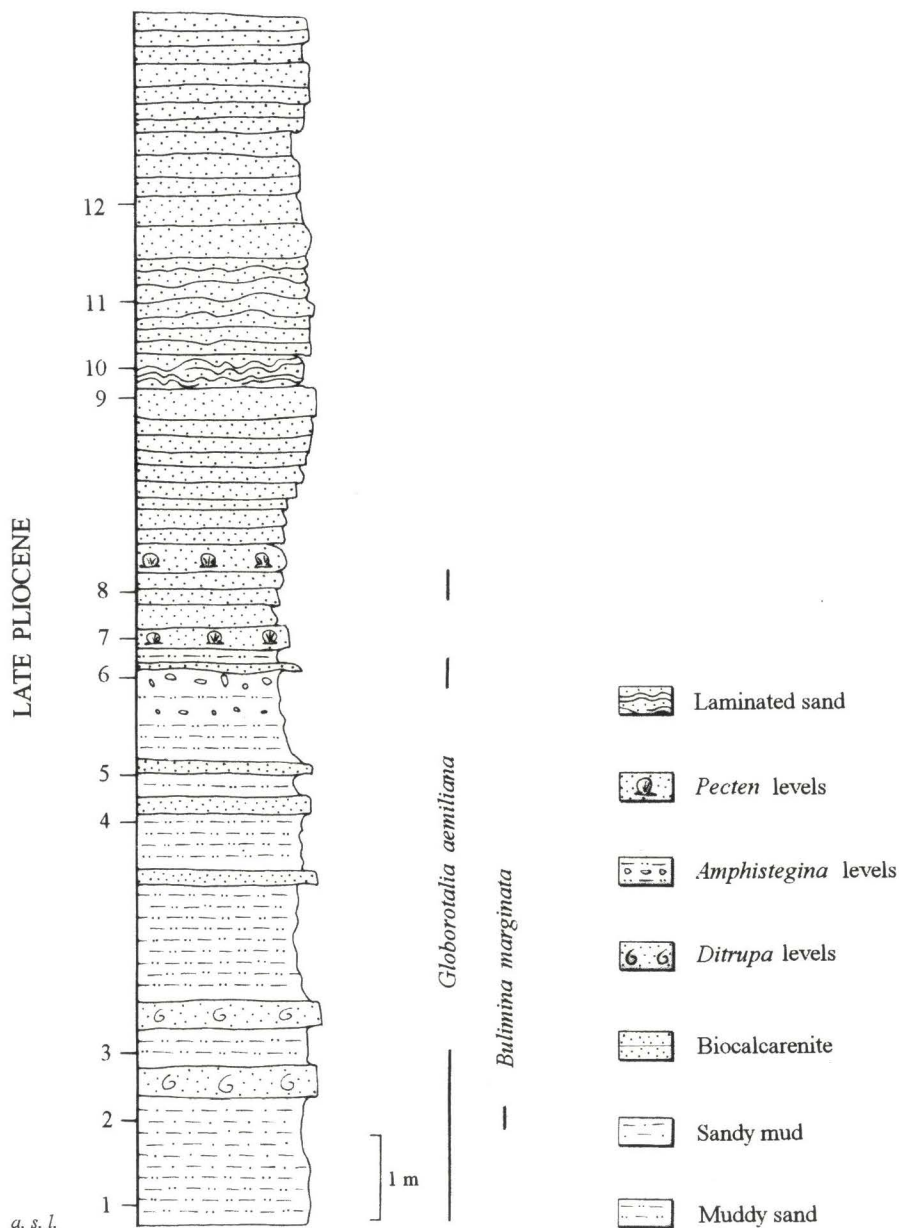
- Figs. 1, 2, 5 - *Globorotalia margaritae* (Bolli & Bermudez) (x 100): 1, umbilical view; 2, side view; 5, spiral view. Sample TCb.
 Figs. 3, 6, 7 - *Globorotalia aemiliana* Colalongo & Sartoni (x 100): 3, side view; 6, umbilical view; 7, spiral view. Sample VN2.
 Fig. 4, 8 - *Globorotalia bononiensis* Dondi (x 120): 4 umbilical view; 8 spiral view. Sample TMb.
 Fig. 9 - *Globigerinoides obliquus extremus* Bolli & Bermudez (x 90): umbilical view. Sample TC1.
 Fig. 10 - *Globorotalia puncticulata puncticulata* (Deshayes) (x 100): umbilical view. Sample LMa.
 Figs. 11, 12 - *Dentoglobigerina altispira altispira* Cushman & Jarvis (x 100): 11, umbilical view; 12, spiral view. Sample TMd.
 Fig. 13 - *Globorotalia oscitans* Todd (x 145): umbilical view. Sample TC5.



(VN2); 5.2 m of more or less cemented muddy sands (VN3, VN4, VN5) interbedded with biocalcarenites (the bottom of this level shows concentrations of *Ditrupa* and rhodolites, while its top has *Amphistegina* levels, VN6); gradually muddy sands with intercalations of a more or less cemented, yellowish, bioclastic calcarenite follow. These biocalcarenites become dominant towards the top of the section (VN7-VN12). The calcarenite levels show a rich biogenous component, with abundant pectinids, echinids, ostreids, bryozoan celeporids,

balanids, brachiopods, corallineous algae, rare gastropods and foraminifers (*Amphistegina lessonii*, *A. planorbis*, *Elphidium* spp.). This biocalcarenite is locally called "Macco". More or less cemented *Amphistegina* levels have been previously reported in more inland basins, such as in the middle and low Tiber valley (in the area just North of Rome), in the Monti della Tolfa and, farther northwards, in Tuscany (Bossio *et al.*, 1981; Conti *et al.*, 1983; Ambrosetti *et al.*, 1987; Iaccarino *et al.*, 1994; Di Bella, 1995). A more

Villa di Nerone (VN)



Text-fig. 8 - Lithology and distribution of the main taxa in the Villa di Nerone Section.

Globorotalia aemiliana Zone				
Villa di Nerone Section	VN1	VN2	VN4	VN6
Benthos				
<i>Ammonia beccarii</i>	0,00%	0,00%	1,29%	0,00%
<i>Ammonia parkinsoniana</i>	0,00%	0,00%	0,97%	0,97%
<i>Amphistegina lessonii</i>	0,00%	0,00%	2,58%	3,22%
<i>Asterigerinata planorbis</i>	10,30%	4,50%	23,00%	26,00%
<i>Astrononion stelligerum</i>	0,00%	0,00%	0,97%	0,00%
<i>Bigenerina nodosaria</i>	0,00%	1,29%	0,00%	0,00%
<i>Bolivina alata</i>	0,00%	2,26%	0,00%	0,00%
<i>Bolivina spathulata</i>	1,61%	1,61%	0,00%	0,00%
<i>Bulimina aculeata</i>	0,00%	0,97%	0,00%	0,00%
<i>Bulimina costata</i>	1,29%	1,29%	0,00%	0,00%
<i>Bulimina elegans</i>	0,00%	0,00%	0,97%	0,00%
<i>Bulimina lappa</i>	0,00%	0,97%	0,00%	0,00%
<i>Bulimina marginata</i>	0,00%	3,22%	0,00%	0,00%
<i>Cancris auriculus</i>	0,97%	2,26%	0,00%	0,00%
<i>Cassidulina neocarinata</i>	0,97%	3,22%	2,90%	0,00%
<i>Cibicides lobatulus</i>	13,20%	5,16%	25,00%	21,62%
<i>Cibicides refulgens</i>	0,00%	0,00%	0,00%	0,97%
<i>Cibicoides pseudoungerianus</i>	2,20%	0,00%	0,00%	0,00%
<i>Cibicoides robertsonianus</i>	1,61%	0,00%	0,00%	0,00%
<i>Cibicoides ungerianus</i>	0,00%	1,90%	0,00%	0,00%
<i>Dorothia gibbosa</i>	3,50%	5,50%	0,00%	0,00%
<i>Elphidium aculeatum</i>	1,61%	0,00%	1,29%	0,00%
<i>Elphidium complanatum</i>	6,13%	4,20%	3,82%	4,12%
<i>Elphidium crispum</i>	1,29%	0,97%	8,38%	3,87%
<i>Elphidium macellum</i>	0,00%	0,00%	0,97%	1,29%
<i>Fissurina marginata</i>	1,61%	0,97%	0,00%	0,97%
<i>Globobulimina pyrula</i>	0,00%	3,82%	0,00%	0,00%
<i>Globocassidulina subglobosa</i>	0,97%	0,00%	0,00%	0,97%
<i>Gyroidinoides neosoldanii</i>	1,29%	0,00%	0,00%	0,00%
<i>Guttulina communis</i>	0,00%	0,00%	1,29%	3,84%
<i>Hanzawaia boueana</i>	2,58%	2,26%	0,00%	0,00%
<i>Heterolepa floridana</i>	1,93%	1,60%	0,00%	0,00%
<i>Melonis padanus</i>	0,97%	1,29%	0,00%	0,00%
<i>Melonis pompilioides</i>	0,97%	2,60%	0,00%	0,00%
<i>Pandaglandulina dinapolii</i>	0,00%	1,90%	0,00%	0,00%
<i>Planorbulina mediterranensis</i>	0,00%	0,00%	0,00%	1,90%
<i>Planulina ariminensis</i>	0,97%	2,26%	0,00%	0,00%
<i>Pullenia bulloides</i>	2,20%	0,00%	0,00%	0,00%
<i>Quinqueloculina seminulum</i>	0,00%	0,00%	0,97%	0,00%
<i>Reussella spinulosa</i>	0,00%	0,00%	0,97%	1,29%
<i>Rosalina globularis</i>	1,61%	0,00%	0,97%	3,52%
<i>Sphaeroidina bulloides</i>	3,50%	3,50%	0,00%	0,00%
<i>Sigmioilopsis celata</i>	1,29%	1,29%	0,00%	0,00%
<i>Spiroloculina depressa</i>	1,29%	0,00%	0,00%	0,00%
<i>Spiroplectammina wrighti</i>	1,61%	0,00%	0,00%	0,00%
<i>Textularia conica</i>	1,29%	0,00%	0,97%	1,29%
<i>Textularia pseudorugosa</i>	0,97%	0,00%	0,97%	0,00%
<i>Trifarina angulosa</i>	0,00%	0,00%	0,97%	0,00%
<i>Uvigerina peregrina</i>	0,00%	3,22%	0,00%	0,00%
<i>Uvigerina pygmaea</i>	0,00%	2,26%	0,00%	0,00%
Plancton				
<i>Globigerina apertura</i>	1,29%	0,00%	0,97%	1,29%
<i>Globigerina bulloides</i>	3,22%	4,20%	1,29%	1,29%
<i>Globigerina decoraperta</i>	0,00%	2,26%	0,00%	0,97%
<i>Globigerina falconensis</i>	1,61%	1,29%	1,29%	1,90%
<i>Globigerinita glutinata</i>	0,00%	2,90%	0,97%	0,00%
<i>Globigerinoides conglobatus</i>	1,29%	0,00%	0,00%	0,00%
<i>Globigerinoides elongatus</i>	1,61%	1,90%	0,00%	1,90%
<i>Globigerinoides obliquus obliquus</i>	2,20%	1,90%	0,00%	1,29%
<i>Globigerinoides ruber</i>	3,55%	3,87%	8,70%	7,09%
<i>Globigerinoides trilobus</i>	2,90%	1,29%	1,29%	0,97%
<i>Globorotalia aemiliana</i>	4,84%	1,61%	0,97%	2,60%
<i>Globorotalia crassaformis</i>	0,97%	0,00%	0,00%	0,00%
<i>Globorotalia incompta</i>	0,00%	1,90%	0,00%	0,00%
<i>Globorotalia obesa</i>	0,00%	1,61%	0,00%	0,00%
<i>Globorotalia puncticulata padana</i>	0,00%	0,00%	0,00%	0,97%
<i>Hastigerina siphonifera</i>	1,61%	0,00%	0,00%	0,00%
<i>Neoglobobadrina acost. acostaensis</i>	0,00%	1,29%	0,00%	0,00%
<i>Neoglobobadrina pachyderma</i>	0,00%	0,00%	0,97%	0,00%
<i>Orbulina universa</i>	5,16%	4,52%	3,20%	3,87%
<i>Turborotalita quinqueloba</i>	0,00%	3,22%	0,00%	0,00%

Tab. 6 - Relative abundances of planktonic and benthic species (the species <0.97% are not considered).

detailed study will be conducted on these deposits and on their origin, relying on the contribution of sedimentologists (Bellotti *et al.*, 1997) and geologists.

Like the Lido di Garda Section, this sequence has been attributed to the upper part of the *Globorotalia aemiliana* Zone (MPL5b, Gelasian).

In all samples, the P/B+P ratio (Text-fig. 6) indicates dominance of the benthic component and, from the base, progressive decrease in the planktonic one (minimum value 19.65%, in sample VN4). The planktonic assemblage is characterized by *G. bulloides*, *G. decoraperta*, *G. falconensis*, *G. elongatus*, *G. obliquus obliquus*, *G. ruber*, *G. aemiliana*, *G. crassaformis* and *O. universa*. The dominant species belong to the *Globigerinoides* genus (<15% Text-fig. 4).

The benthos is dominated by typically infralittoral species (*A. planorbis*, *C. lobatulus*, *E. complanatum*, *E. crispum*), whose abundance tends to increase towards the top of the sequence, except for sample VN2 (Tab. 6). In this sample, infralittoral species decline and deeper ones, tolerating low oxygen concentrations, slightly increase (*B. nodosaria*, *Bolivina* spp., *Bulimina* spp., *C. neocarinata*, *D. gibbosa*, *G. pyrula*, *H. boueana*, *Melonis soldanii*, *P. ariminensis* and *Uvigerina* spp.). As a result, sample VN2 is likely to belong to a circalittoral environment, whilst the remaining part of the section shows an infralittoral one.

CONCLUSIONS

Based on the analysis of the Plio/Pleistocene sediments outcropping along the coast of Latium, between Tor Caldara and Anzio (South of Rome), a preliminary bio/chronostratigraphic and paleoenvironmental reconstruction was made (Text-fig. 9). The most ancient clayey sediments are found in the Tor Caldara area, i.e. in the nucleus of the Anzio anticline. The basal portion

of the Pliocene succession may be attributed to the comprehensive interval *Sphaeroidinellopsis seminulina* s.l.-*Globorotalia margaritae* Zones (MPL1-MPL2, Zanclean) while the upper part is attributable to the *Globorotalia margaritae* Zone (MPL2, Zanclean), because of the presence of the zonal marker. These sediments are featured by similar values of the planktonic fraction and dominated by the *Globigerina* and *Globigerinoides* genera. *Globigerinoides* has peak values corresponding to *G. margaritae* occurrence. The planktonic assemblage is characterized by *Globigerina falconensis*, *G. nepenthes*, *Globigerinoides bollii*, *G. emeisi*, *G. gr. obliquus*, *Neogloboquadrina aostaensis*-*Neogloboquadrina humerosa* and *Sphaeroidinellopsis seminulina*.

The benthos, quantitatively poor, is well diversified. The most significant species are: *Anomalinoides helicinus*, *Chilostomella oolina*, *Cyclammina* cf. *cancellata*, *Lenticulina* spp., *Marginulina costata coarctata*, *Planularia auris*, *Plectofrondicularia inaequalis* and *Uvigerina rutila*. Because of the abundance of the *Globigerinoides* genus and the occurrence of keeled forms, these sediments are ascribed to the upper epibathyal environment with warm waters. The sea floor must have been fine-grained and poorly oxygenated, but favoring the development of intermediate- or low-depth infaunal forms.

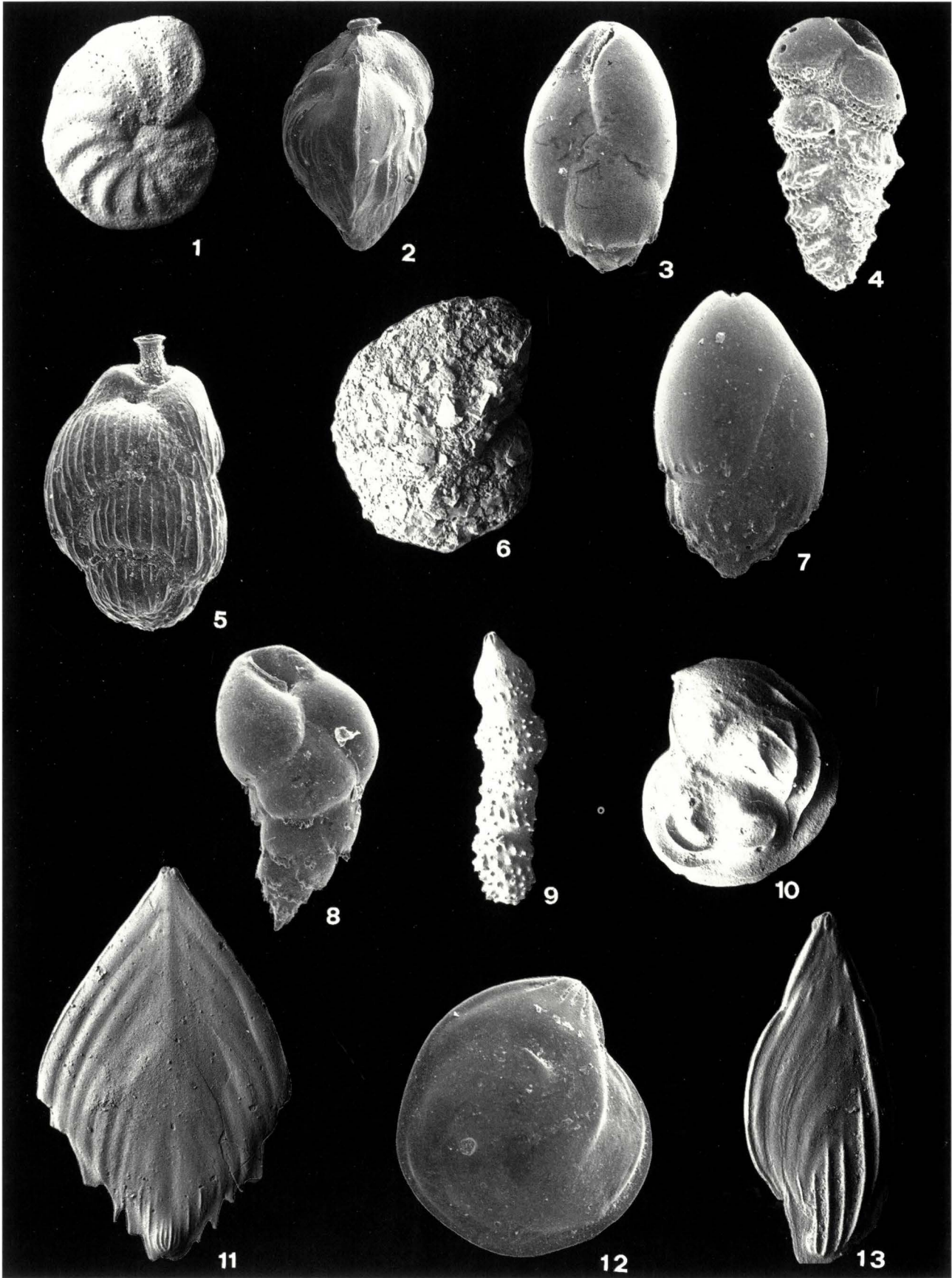
A stratigraphic hiatus including the MPL3 Zone and the lower part of MPL4a Zone is revealed (Text-fig. 9).

The sediments belonging to the *Globorotalia puncticulata* Zone (MPL4a, Zanclean) outcrop southwards, in the Tor Materno, Lido delle Sirene and Lido di Marechiaro areas, and are always represented by clayey or clayey-sandy lithologies.

The planktonic assemblage is always rich and abundant, with slightly lower abundance than in the previous biozone. Local, centimeter-scale con-

EXPLANATION OF PLATE 2

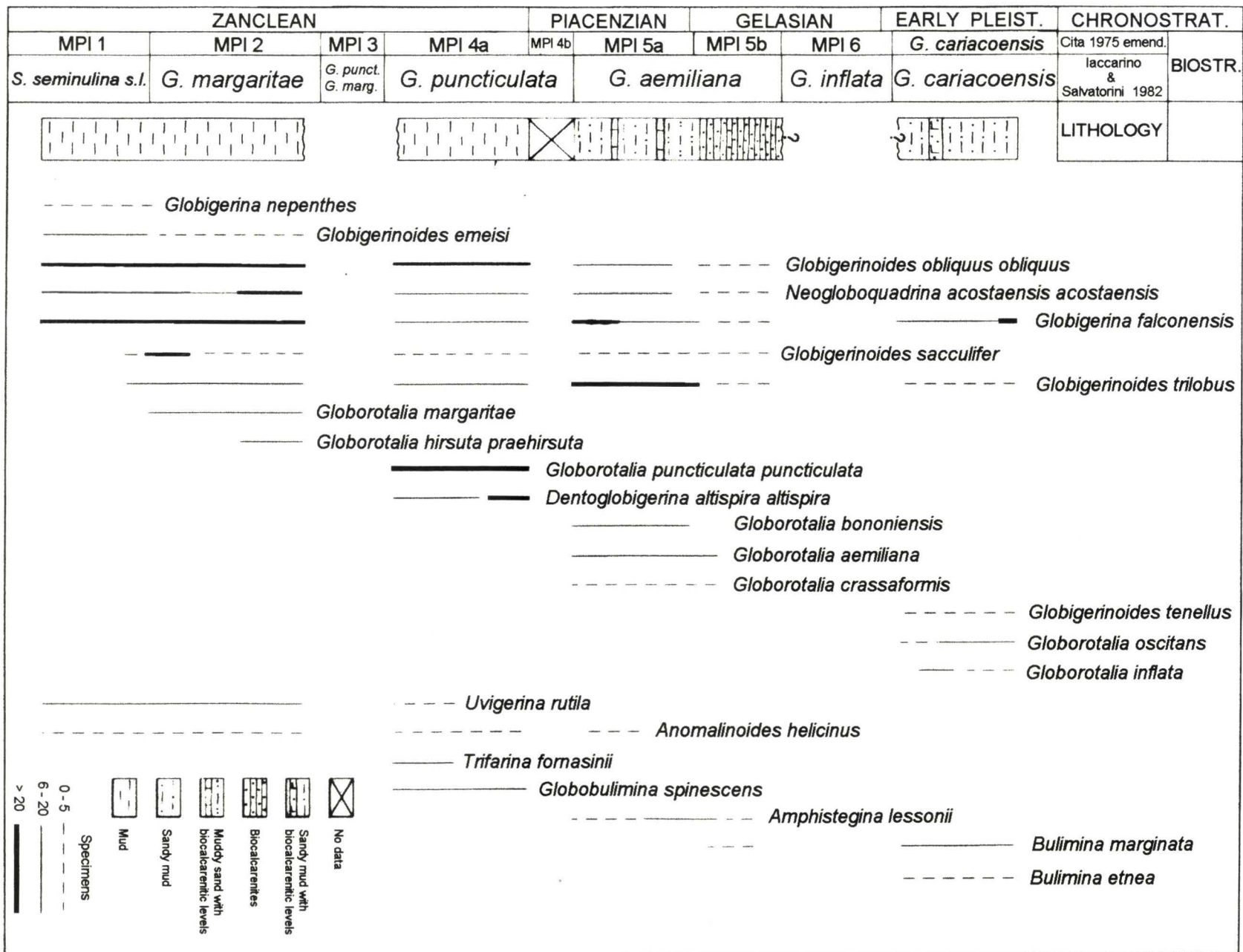
- Fig. 1 - *Anomalinoides helicinus* (Costa) (x 72). Sample TC2.
- Fig. 2 - *Trifarina fornasinii* (Selli) (x 56). Sample LMa.
- Figs. 3, 7 - *Globobulimina spinescens* (Brady) (x 105). Sample LMa.
- Fig. 4 - *Bolivina* cf. *subspinescens* Cushman (x 125). Sample TC5.
- Fig. 5 - *Uvigerina rutila* Cushman & Todd (x 105). Sample TC2.
- Fig. 6 - *Cyclammina* cf. *cancellata* Brady (x 65). Sample TC1.
- Fig. 8 - *Bulimina elegans marginata* Fornasini (x 80). Sample TC3.
- Fig. 9 - *Marginulina hirsuta* d'Orbigny (x 36). Sample TCa.
- Fig. 10 - *Lenticulina* sp. (x 33). Sample TCa.
- Fig. 11 - *Frondicularia denticulata* Costa (x 20). Sample TC2.
- Fig. 12 - *Lenticulina rotulata* (Lamarck) (x 80). Sample LMa.
- Fig. 13 - *Planularia auris* DeFrance (x 40). Sample TC1.



Globigerina cariacensis Zone						
Tor Caldara Section						
	TC3	TC4	TC5	TC6	TC7	TC8
Benthos						
<i>Ammonia beccarii</i>	5,48%	6,00%	2,90%	1,93%	1,29%	0,00%
<i>Ammonia inflata</i>	2,58%	0,00%	2,25%	0,00%	0,00%	0,00%
<i>Ammonia parkinsoniana</i>	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>"Ammonia" perlucida</i>	0,00%	0,00%	0,00%	0,00%	0,00%	1,29%
<i>Asterigerinata mamilla</i>	0,00%	0,00%	0,00%	0,00%	2,26%	0,00%
<i>Asterigerinata planorbis</i>	6,77%	12,00%	8,71%	3,55%	4,83%	5,81%
<i>Astrononion fessuratum</i>	0,97%	0,00%	2,26%	1,93%	0,00%	0,00%
<i>Bolivina alata</i>	0,00%	0,00%	0,00%	4,84%	0,00%	0,00%
<i>Bolivina cfr. alata</i>	0,00%	0,00%	0,00%	0,00%	0,00%	1,93%
<i>Bolivina catanensis</i>	0,97%	0,00%	2,26%	0,00%	1,90%	0,00%
<i>Bolivina dilatata</i>	0,00%	0,00%	0,00%	0,00%	1,93%	0,00%
<i>Bolivina spathulata</i>	0,00%	0,00%	0,00%	0,00%	0,00%	2,90%
<i>Bolivina spinescens</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Buccella frigida</i>	5,16%	0,00%	1,29%	1,61%	0,97%	0,00%
<i>Bulimina aculeata</i>	2,58%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Bulimina corsiniana</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Bulimina elegans marginata</i>	1,29%	0,00%	2,26%	1,29%	0,00%	0,00%
<i>Bulimina elongata</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,97%
<i>Bulimina fusiformis</i>	1,94%	0,00%	1,29%	0,00%	0,00%	0,00%
<i>Bulimina lappa</i>	1,94%	0,00%	1,29%	0,00%	0,00%	0,00%
<i>Bulimina marginata</i>	2,26%	0,00%	4,52%	2,26%	2,90%	0,97%
<i>Bulimina sublimbata</i>	0,00%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Cancris auriculus</i>	0,00%	0,00%	1,29%	0,00%	0,00%	0,97%
<i>Cassidulina neocarinata</i>	4,52%	16,00%	4,84%	9,68%	10,98%	9,68%
<i>Cibicides lobatulus</i>	6,45%	25,00%	10,32%	8,06%	3,87%	11,29%
<i>Cibicidoides pseudoungerianus</i>	1,94%	0,00%	1,29%	0,00%	1,90%	0,00%
<i>Coriphostoma perforata</i>	0,00%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Coriphostoma pseudodigitalis</i>	0,00%	0,00%	1,93%	0,00%	0,00%	0,00%
<i>Criboelphidium decipiens</i>	1,61%	0,00%	1,29%	1,61%	2,58%	0,00%
<i>Elphidiella cfr. arctica</i>	2,26%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Elphidium aculeatum</i>	0,00%	10,00%	0,00%	0,00%	0,00%	0,00%
<i>Elphidium advenum</i>	1,61%	0,00%	0,97%	0,00%	4,51%	0,97%
<i>Elphidium complanatum</i>	5,48%	0,00%	5,81%	3,86%	2,58%	2,90%
<i>Elphidium crispum</i>	2,84%	8,00%	2,45%	2,58%	3,22%	0,97%
<i>Elphidium macellum</i>	2,26%	0,00%	4,00%	0,00%	0,00%	1,29%
<i>Eponides sp.</i>	0,00%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Favulina hexagona</i>	0,00%	0,00%	0,00%	1,94%	0,00%	0,00%
<i>Fissurina pseudorbignyana</i>	0,00%	0,00%	0,00%	1,29%	0,00%	0,00%
<i>Florilus boueanus</i>	5,48%	0,00%	1,93%	0,00%	0,00%	1,29%
<i>Florilus citai</i>	3,22%	0,00%	1,61%	1,29%	0,00%	0,00%
<i>Globocassidulina subglobosa</i>	0,00%	0,00%	0,00%	0,00%	3,87%	0,00%
<i>Guttulina communis</i>	1,29%	8,00%	0,00%	0,00%	0,00%	1,61%
<i>Gyroidinoides umbonatus</i>	0,00%	0,00%	1,29%	0,00%	0,00%	0,00%
<i>Hanzawaia boueana</i>	0,00%	0,00%	1,93%	1,29%	0,00%	0,00%
<i>Pandaglandulina dinapolii</i>	1,29%	0,00%	0,00%	6,77%	2,90%	1,93%
<i>Patellina corrugata</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Protoelphidium granosum</i>	0,00%	0,00%	0,00%	0,00%	3,55%	2,26%
<i>Reussella sirenae</i>	0,00%	0,00%	1,29%	0,00%	0,00%	0,00%
<i>Reussella spinulosa</i>	0,00%	0,00%	1,29%	0,00%	1,29%	0,00%
<i>Rosalina globularis</i>	0,00%	0,00%	0,00%	0,00%	0,00%	0,97%
<i>Sphaeroidina bulloides</i>	0,97%	0,00%	0,00%	0,00%	0,97%	0,00%
<i>Uvigerina peregrina</i>	0,97%	0,00%	0,00%	0,00%	0,00%	0,00%
<i>Valvulinera bradyana</i>	0,00%	0,00%	0,00%	5,80%	0,00%	0,00%
Plancton						
<i>Globigerina bulloides</i>	0,97%	0,90%	3,55%	5,81%	5,48%	4,19%
<i>Globigerina falconensis</i>	0,00%	0,00%	3,87%	4,84%	0,00%	12,90%
<i>Globigerina rubescens</i>	0,97%	0,00%	1,29%	1,61%	3,20%	3,87%
<i>Globigerinita glutinata</i>	0,97%	0,00%	0,00%	3,87%	6,45%	0,00%
<i>Globigerinoides elongatus</i>	3,22%	0,00%	1,93%	1,61%	0,00%	0,97%
<i>Globigerinoides ruber</i>	6,10%	14,00%	6,77%	6,77%	5,48%	9,03%
<i>Globigerinoides trilobus</i>	0,97%	0,00%	0,97%	1,61%	1,29%	0,00%
<i>Globigerinoides tenellus</i>	1,29%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Globorotalia sp.</i>	0,00%	0,00%	0,00%	0,97%	0,00%	0,00%
<i>Globorotalia incompta</i>	0,00%	0,00%	0,97%	0,00%	0,00%	0,00%
<i>Globorotalia inflata</i>	0,00%	0,00%	1,61%	2,26%	0,00%	0,97%
<i>Globorotalia oscitans</i>	0,00%	0,00%	2,58%	2,90%	4,19%	1,93%
<i>Globorotalia scitula</i>	0,00%	0,00%	0,00%	0,00%	2,20%	0,97%
<i>Neogloboquadrina pachyderma</i>	0,97%	0,00%	0,00%	0,00%	1,61%	4,84%
<i>Orbulina universa</i>	0,00%	0,00%	0,00%	0,97%	0,97%	0,97%
<i>Turborotalia quinqueloba</i>	1,61%	0,00%	1,29%	4,19%	6,77%	2,26%

Tab. 7 - Relative abundances of planktonic and benthic species (the species <0.97% are not considered).

Text-fig. 9 - Semiquantitative distribution of the most significant planktonic and benthic foraminifera in Plio-Pleistocene sediments of the Tor Caldara-Anzio area.



centrations of *Dentoglobigerina altispira altispira* are observed. The benthos is less diversified and occasionally dominated by *Trifarina fornasinii* and *Globobulimina spinescens*. The remaining part of the assemblage has a limited number of circalittoral species, such as *C. pseudoungerianus*, *C. ungerianus*, *G. affinis*, *L. rotulata*, *M. padanus*, *S. bulloides*, *U. peregrina* and *U. rutila*.

The abundant plankton, the qualitative characteristics of the benthic assemblages and the dominance of deep and intermediate infaunal forms (*Globobulimina* spp., *M. padanus*, *Trifarina* spp.) indicate a deep circalittoral environment with poorly oxygenated sea floors.

The boundary with the MPL5 Zone cannot be well identified (the samples collected were insufficient, owing to the numerous anthropic barriers existing along the coast). The sediments of the *Globorotalia aemiliana* Zone (MPL5) outcrop in the Tor Materno, Lido di Marechiaro and Anzio (Villa di Nerone) areas. The layer dip increases southwards, reaching its maximum (about 20°) in the area of Anzio. The biozone basal portion (Piacenzian), predating the *Bulimina marginata* occurrence, was identified (Text-fig. 9). This portion, which is exposed from Tor Materno to Lido di Marechiaro, consists of clayey-sandy lithologies. The planktonic fraction gradually tends to decrease with an increasing sandy component. In addition to the marker, this fraction includes *Globigerina bulloides*, *G. praecalida*, *Globorotalia bononiensis*, evolutionary forms from *G. bononiensis* to *G. inflata* and *Turborotalita quinqueloba*. The benthic assemblage gradually enriches with new species, such as *Bolivina aenariensis*, *B. alata*, *Cassidulina neocarinata*, and *Valvulineria bradyana*. Epifaunal forms increase and the infauna is dominated by deep or intermediate species. Sea floor conditions remain constant, but bathymetry decreases. The upper part of MPL5 is attributed to the Gelasian due to the absence of *G. bononiensis*. The Piacenzian/Gelasian boundary is close to the disappearance of this species and to the subsequent change in facies. In fact, the main lithologies consist of sands and frequent intercalations of biocalcarene ("Macco"). The microfauna comprises *Bulimina marginata* and *Globorotalia crassaformis*. The planktonic fraction rapidly decreases; it mainly consists of *Globigerina bulloides*, *Globigerinita glutinata*, *Globigerinoides* spp., *Orbulina universa* and *Turborotalita quinqueloba*. The benthic fraction is dominated by epifaunal species from an infralittoral environment, whereas the deeper forms decline significantly, except in some samples. These findings point to a well-oxy-

genated, high-energy, shallow-water environment, with locally deeper fluctuations and a maximum coastal fluctuation in the *Amphistegina* level.

The Lower Pleistocene subhorizontal sediments transgressively overlie both the sediments of the *Globorotalia margaritae* Zone (Tor Caldara) and more recent ones (Tor Materno). The sequence consists of mainly sandy lithologies with clayey-silty or biocalcarene intercalations.

The planktonic assemblage includes *Globigerinoides tenellus* and *Globorotalia oscitans* (Text-fig. 9). The benthos is dominated by epiphytic, infralittoral species in more coarse-grained lithologies, whilst infaunal forms appear in finer ones (*Bulimina* spp., *Coryphostoma perforata*, *Reussella* spp.). The Pleistocene sequence may be ascribed to the infralittoral environment with deeper fluctuations marked by finer lithologies.

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APPENDIX

LIST OF SPECIES

BENTHOS

- Ammonia beccarii* (Linné)
Ammonia inflata (Seguenza)
Ammonia parkinsoniana (d'Orbigny)
"Ammonia" perlucida (Heron Allen & Earland)
Amphicoryna proxima (Silvestri)
Amphicoryna sublineata (Brady)
Amphistegina lessonii d'Orbigny
Anomalinoides helacinus (Costa)
Anomalinoides ornatus (Costa)
Asterigerinata mamilla (Williamson)
Asterigerinata planorbis (d'Orbigny)
Astrononion fessuratum Compagnoni & Conato
Astrononion stelligerum (d'Orbigny)
Bigenerina nodosaria (d'Orbigny)
Bolivina aenariensis Costa
Bolivina alata (Seguenza)
Bolivina catanensis Seguenza
Bolivina cistina Cushman
Bolivina dilatata Reuss
Bolivina italica Cushman
Bolivina leonardii Accordi & Selmi
Bolivina placentina Zanmatti
Bolivina pseudoplicata Heron Allen & Earland
Bolivina punctata d'Orbigny
Bolivina spathulata (Williamson)
Bolivina spinescens Cushman
Bolivina cf. subspinescens Cushman
Bolivina subspinescens Cushman
Buccella frigida granulata (di Napoli)
Bulimina aculeata d'Orbigny
Bulimina corsiniana Perconig
Bulimina costata d'Orbigny
Bulimina elegans elegans d'Orbigny
Bulimina elegans marginata Fornasini
Bulimina elongata d'Orbigny
Bulimina etnea Seguenza
Bulimina fusiformis Williamson
Bulimina lappa Cushman & Parker
Bulimina marginata d'Orbigny
Bulimina minima Tedeschi & Zanmatti
Bulimina sublimbata Panizza
Cancris auriculus (Fichtel & Moll)
Cancris oblongus (Williamson)
Cassidulina neocarinata Thalmann
Cassidulinoides bradyi (Norman)
Chilostomella oolina Schwager
Cibicides lobatulus (Walker & Jacob)
Cibicides refulgens de Montfort
Cibicidoides robertsonianus (Brady)
Cibicidoides psudoungerianus Cushman
Cibicidoides ungerianus (d'Orbigny)
Coryphostoma perforata (di Napoli)
Coryphostoma pseudodigitalis (di Napoli)
Criboelphidium decipiens (Costa)
Cyclammina cf. cancellata Brady
Cylindroclavulina rudis (Costa)
Dentalina aciculata (d'Orbigny)
Dentalina inflexa (Reuss)
Dentalina leguminiformis (Batsch)
Dimorphina tuberosa d'Orbigny
Discorbinella bertheloti (d'Orbigny)
Dorothia gibbosa (d'Orbigny)
Eggerella bradyi (Cushman)
Elphidiella cf. arctica Parker & Jones
Elphidium aculeatum (d'Orbigny)
Elphidium advenum (Cushman)
Elphidium complanatum (d'Orbigny)
Elphidium crispum (Linné)
Elphidium macellum (Fichtel & Moll)
Eponides sp.
Favulina hexagona (Williamson)
Fissurina bradyana (Fornasini)
Fissurina marginata (Walker & Jacob)
Fissurina orbignyana Seguenza
Fissurina piriformis (Buchner)
Fissurina pseudorbignyana (Buchner)
Florilus boueanus (d'Orbigny)
Florilus citai (di Napoli)
Fronicularia denticulata Costa
Fursenkoina schreibersiana (Czjzek)
Globobulimina affinis (d'Orbigny)
Globobulimina ovula (d'Orbigny)
Globobulimina pyrula (d'Orbigny)
Globobulimina spinescens (Brady)
Globocassidulina subglobosa (Brady)
Globulina tuberculata d'Orbigny
Guttulina communis (d'Orbigny)
Gyroidina soldanii (d'Orbigny)
Gyroidinoides neosoldanii (Silvestri)
Gyroidinoides umbonatus (Brotzen)
Hanzawaia boueana (d'Orbigny)
Heterolepa bellincionii (Giannini & Tavani)
Heterolepa dertonensis (Ruscelli)
Heterolepa floridana (Cushman)
Hoeglundina elegans (d'Orbigny)
Karrerella bradyi (Cushman)
Lagena laevis (Montagu)
Lagena semistriata Williamson
Lagena striata (d'Orbigny)
Lenticulina sp.
Lenticulina calcar (Linné)
Lenticulina cultrata Montfort
Lenticulina curvisepta Seguenza
Lenticulina echinata (d'Orbigny)
Lenticulina inornata (d'Orbigny)
Lenticulina orbicularis (d'Orbigny)
Lenticulina peregrina (Schwager)
Lenticulina rotulata (Lamarck)
Lenticulina stellata (Seguenza)
Lenticulina vortex (Fichtel & Moll)
Marginulina costata coarctata Silvestri
Marginulina costata costata (Batsch)
Marginulina crebricosta Seguenza
Marginulina glabra d'Orbigny
Marginulina hirsuta d'Orbigny
Marginulinopsis nana (Costa)
Martinottiella communis (d'Orbigny)
Melonis barleeianum (Williamson)
Melonis padanus (Perconig)
Melonis soldanii (d'Orbigny)
Neoconorbina orbicularis (Terquem)

Nodosaria ovicula d'Orbigny
Nonion depressulum (Walker & Jacob)
Oridorsalis umbonatus stellatus (Silvestri)
Orthomorphina tenuicostata (Costa)
Pandaglandulina dinapolii Loeblich & Tappan
Patellina corrugata Williamson
Planorbulina mediterraneensis d'Orbigny
Planularia auris (Defrance)
Planulina ariminensis d'Orbigny
Plectofrondicularia inaequalis (Costa)
Plectofrondicularia raricosta (Karrer)
Pleurostomella alternans Schwager
Praeglobobulimina ovata (d'Orbigny)
Praeglobobulimina pupoides (d'Orbigny)
Protoelphidium granosum (d'Orbigny)
Pullenia bulloides (d'Orbigny)
Pullenia quinqueloba (Reuss)
Pyrgo depressa (d'Orbigny)
Pyrgo oblonga (d'Orbigny)
Quinqueloculina seminulum (Linné)
Rectuvigerina siphogenerinoides (Lipparini)
Reussella sirenae Compagnoni & Conato
Reussella spinulosa Reuss
Rosalina globularis d'Orbigny
Sagrina latialis Compagnoni & Conato
Saracenaria italica Defrance
Sigmoilinita tenuis (Czjzek)
Sigmoilopsis celata (Costa)
Sigmoilopsis schlumbergeri (Silvestri)
Siphonina planoconvexa (Silvestri)
Siphonina reticulata (Czjzek)
Sphaeroidina bulloides d'Orbigny
Spiroloculina depressa d'Orbigny
Spiroplectammina wrighti (Silvestri)
Stilostomella adolphina (d'Orbigny)
Stilostomella consobrina (d'Orbigny)
Stilostomella monilis (Silvestri)
Stilostomella pyrula (d'Orbigny)
Stilostomella vertebralis (Batsch)
Stainforthia complanata (Egger)
Textularia concava jugosa Silvestri
Textularia conica d'Orbigny
Textularia sagittula Defrance
Trifarina angulosa (Williamson)
Trifarina bradyi Cushman
Trifarina fornasinii (Selli)
Uvigerina auberiana d'Orbigny
Uvigerina canariensis d'Orbigny

Uvigerina peregrina Cushman
Uvigerina pygmaea d'Orbigny
Uvigerina rutila Cushman & Todd
Valvulineria bradyana (Fornasini)

PLANKTON

Dentoglobigerina altispira altispira Cushman & Jarvis
Globigerina apertura Cushman
Globigerina bulloides d'Orbigny
Globigerina decoraperta Takayanagi & Saito
Globigerina falconensis Blow
Globigerina nepenthes Todd
Globigerina praecalida Blow
Globigerina rubescens Hofker
Globigerinita glutinata (Egger)
Globigerinoides bolli (Blow)
Globigerinoides conglobatus (Brady)
Globigerinoides elongatus (d'Orbigny)
Globigerinoides emeisi Bolli
Globigerinoides helacinus (d'Orbigny)
Globigerinoides obliquus extremus Bolli & Bermudez
Globigerinoides obliquus obliquus Bolli
Globigerinoides quadrilobatus (d'Orbigny)
Globigerinoides ruber (d'Orbigny)
Globigerinoides sacculifer (Brady)
Globigerinoides tenellus Parker
Globigerinoides trilobus (Reuss)
Globorotalia aemiliana Colalongo & Sartoni
Globorotalia bononiensis Dondi
Globorotalia bononiensis / Globorotalia inflata
Globorotalia crassaformis Galloway & Wissler
Globorotalia incompta (Cifelli)
Globorotalia inflata (d'Orbigny)
Globorotalia margaritae Bolli & Bermudez
Globorotalia obesa Bolli
Globorotalia oscitans Todd
Globorotalia prae-hirsuta Blow
Globorotalia puncticulata padana Dondi & Papetti
Globorotalia puncticulata puncticulata (Deshayes)
Globorotalia scitula (Brady)
Hastigerina siphonifera (d'Orbigny)
Neogloboquadrina acostaensis acostaensis (Blow)
Neogloboquadrina humerosa humerosa (Takayanagi & Saito)
Neogloboquadrina pachyderma (Ehremberg)
Orbulina bilobata (d'Orbigny)
Orbulina universa d'Orbigny
Sphaeroidinellopsis seminulina (Schwager)
Turborotalita quinqueloba (Natland)