Stratigraphical and paleoenvironmental features of the Pleistocene sediments of M. Mario (Rome)

Autor(en):   **Bergamin, Luisa / Carboni, Maria Gabriella / Di Bella, Letizia**

Stratigraphical and paleoenvironmental features of the Pleistocene sediments of M. Mario (Rome)

Luisa Bergamin[1], Maria Gabriella Carboni[1-3], Letizia Di Bella[1],
Fabrizio Marra[2] & Isabella Palagi[1-3]

ABSTRACT

The marine succession of Monte Mario (Rome) has been considered a classical section of the Plio-Pleistocene boundary and the related transgressive phase in Italy.

A detailed micropaleontological study on the Monte Mario marine subsurface succession permitted to re-interpret the stratigraphy and the evolution of the basin. Here, we present the results achieved by means of data supplied by three boreholes. The composite section, 90 m thick, includes clay and sand deposits previously attributed to the Pliocene and early Pleistocene.

The Pliocene age assignment, previously attributed to the lower richly fossiliferous marine clayey unit, located under the *Arctica islandica* level, is refuted. New data from foraminifers and ostracods allow us to refer the entire succession to the Pleistocene, for the presence of *Globigerina calabra*, *G. cariacoensis* and *Loxoconcha turbida*. Consequently, the well-known *Arctica islandica* level, a local marker bed, may no longer be considered the transgressive unit marking the beginning of the Pleistocene cycle.

The paleoecological study evidenced a gradual shallowing from upper circalittoral, with low dissolved oxygen values (VTC), to sandy oxygenated infralittoral environment, sometimes characterised by vegetate bottoms.

The evolution of the basin seems controlled by tectonics more than by glacioeustatism. In fact, palinspastic restoration of the investigated sequence and the presence of reworked Pliocene foraminifers allowed us to relate the observed sea level changes to regional tectonic phases and to infer no direct influence of climate on the transgression.

RIASSUNTO

La successione marina di Monte Mario (Roma), ben nota in letteratura, è stata fino ad oggi considerata una classica sezione per limite Plio-Pleistocene e della relativa fase trasgressiva in Italia. Un dettagliato studio micropaleontologico effettuato sui sedimenti marini incontrati nel sottosuolo di Monte Mario ha permesso di reinterpretare la stratigrafia e l'evoluzione del bacino.

In questo lavoro vengono presentati i risultati ottenuti dall'analisi di tre sondaggi. La successione presenta complessivamente uno spessore di circa 90 m ed è costituita da litotipi argillosi e sabbiosi in precedenza attribuiti al Pliocene e al Pleistocene inferiore. Nuovi dati forniti dall'analisi delle associazioni a foraminiferi ed ostracodi ha consentito di attribuire l'intera successione al Pleistocene per la presenza di *Globigerina calabra*, *G. cariacoensis* e *Loxoconca turbida* sin dalla base. Pertanto, il noto livello ad *Arctica islandica* non è più ritenuto, come in passato, l'unità trasgressiva che segna l'inizio del ciclo pleistocenico poiché le argille marine riccamente fossilifere ad esso sottostanti sono pure attribuibili al Pleistocene.

Studi paleoecologici hanno evidenziato una graduale diminuzione della batimetria da un ambiente circalitorale superiore scarsamente ossigenato (VTC) ad un ambiente infralitorale con fondali sabbiosi ben ossigenati, talvolta interessati da una copertura vegetale.

L'evoluzione del bacino, evidenziata dalla ricostruzione palinspastica della sequenza studiata, sembra controllata più dalla tettonica regionale che da una influenza diretta del clima.

Introduction

This is the first detailed micropaleontological study on foraminiferal and ostracod assemblages from the subsurface sediments of the Monte Mario area (Fig. 1). It is aimed to investigate the Pliocene-Pleistocene boundary in a classical sequence of Central Italy. The M. Mario hill is a structural high of the Tyrrhenian Sea margin (Marra et al. 1995), where the syn-rift basin deposits have been uplifted. Collapses linked with extensional tectonics and a thick cover of volcanic products have hidden the marine sequences during middle Pleistocene times. For this reason, M. Mario is one of the few locations along the Tyrrhenian margin of Central Italy where the Plio-Pleistocene deposits are easily accessible. A great number of geologic-stratigraphic data were produced within the framework of "Progetto Strategico Roma Capitale" (Carboni et al. 1991). However, it was seldom possible to study thick sections, owing to the lack of good exposures in the urban area of Rome. We have tried to overcome this problem by means of boreholes drilled by the State Railways (F.S.) and by the mu-

[1] Earth Science Department, "La Sapienza" University. P.le A. Moro, 5, I–00185 Rome, Italy. E-mail: gcarboni@axrma.uniroma1.it
[2] ING (Geophysical National Institute), Via di Vigna Murata, I–00143 Rome, Italy
[3] CNR, Centro di Studio per il Quaternario e l'Evoluzione Ambientale, Ple A. Moro, 5, I–00185 Rome, Italy
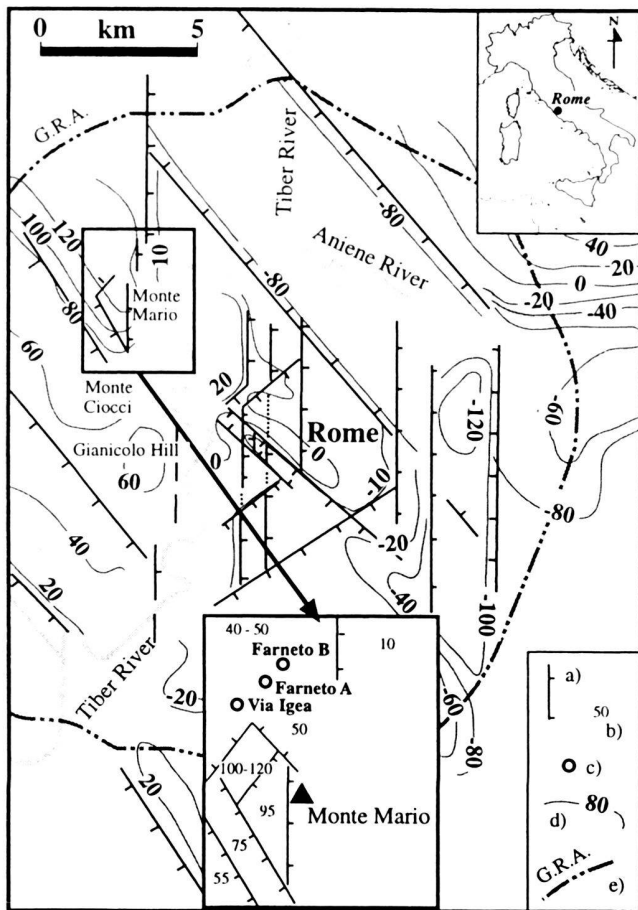
Fig. 1. Location map showing the structural setting of the marine substratum in the area of Rome (from Marra et al. 1995, modified). Legend: a) faults affecting the Monte Vaticano unit (dashes indicate lowered sectors); b) elevation in m a. s. l. of the surface of the Monte Vaticano unit inside the inset area; c) boreholes location; d) isobaths (in m a. s. l.) of the Lower Pleistocene marine deposits (Monte Vaticano + Monte Mario units); e) extent of the Rome's urban beltway (G. R. A.).

nicipality of Rome. Among these, three were chosen and analysed in order to reconstruct a 90 m thick (from 117.5 to 30.0 m a.s.l.) composite section of the M. Mario succession. Analyses of foraminiferal and ostracod assemblages allowed a detailed biostratigraphic and paleoecological reconstruction.

The oldest data in the literature about the stratigraphy of the urban area of Rome date back to Clerici (1893), but a more detailed stratigraphy was not available until the beginning of the 1970s. Bonadonna (1968) and Conato et al. (1980) described the transgressive contact between a clay sequence attributed to the Lower Pliocene ("Marne Vaticane fm." Auctorum) and an overlying sand horizon with *Arctica islandica* in an outcrop at Farneto, located on the northern flank of the M. Mario hill (Fig. 1). According to these authors, in the area of M. Mario, a transgressive Quaternary marine succession is deposited during an early Pleistocene cold climate phase ("Ac-

quatraversa erosive phase" of Bonadonna 1968), starting with the grey sands with *Arctica islandica*. This latter horizon was then included in the lower portion of the M. Mario Formation, which represented the Quaternary transgressive cycle for the Roman area (Malatesta & Zarlenga, 1986). Subsequently, Carboni et al. (1991) and Marra et al. (1995) found sandy-clay sediments indicative of a circalittoral environment with *Bulimina etnea*, below the grey sands with *Arctica islandica* at Farneto, attributing them to the Santernian .

Two lithostratigraphic units are considered: the Monte Vaticano Unit and the younger Monte Mario Unit. The first is constituted by clay and sandy-clay alternating with sand horizons attributed by Marra et al. (1995) to the Pliocene; the second comprises sandy-clay and sand horizons of circalittoral to infralittoral environment, bearing *Bulimina etnea*, and the grey sands with *A. islandica* (Marra et al.1995).

Materials and methods

Three boreholes were studied: Farneto A, (26 samples, Fig. 2), Farneto B (6 samples, Fig. 3), and Igea (24 samples, Fig. 4), about 30, 30 and 80 m thick respectively.

The investigated marine sediments consist of grey clays and clayey sands from 30 to 57.5 m a.s.l. (Farneto A). A 3–5 m thick grey sand horizon with abundant molluscs is present (among them *A. islandica* is found) on the top of the clayey sequence. The lithological transition from clayey sands and sands is gradual. The sand is followed by clayey grey sand grading upward into oxidised yellowish sand. These sands (Igea borehole) are overlain by continental transgressive sediments (sands and gravel).

Each sample had a volume of about 200 cm^3. It was treated with H_2O_2 and washed with an 88 μm sieve. Qualitative analysis was conducted on the entire residue considering foraminifers as well as ostracods, while the quantitative analysis involved only foraminifers (no less than 300 specimens from split samples).

On the whole, 56 samples were considered and 44 samples included quantitative foraminiferal analysis. On the remaining 12 samples (Farneto A: Fa1–Fa7; Farneto B: Fb2, Fb3; Igea: Ig1–Ig3) only the qualitative study was carried out because strong reworking was noticed. In fact, in these samples, except rare specimens of Pleistocene species, taxa occurring both in Upper Pliocene and in Lower Pleistocene are present, so that it is not possible to distinguish the reworked part of the assemblage.

For the chronostratigraphy, we referred to the recent proposal of Cita & Castradori (1995). In this scheme, which is not officially accepted by SQS, early Pleistocene (Calabrian stage) is divided in three substages: Santernian, Emilian and Sicilian.

For the biostratigraphy, we used the scheme of Cita (1975) emended by Sprovieri (1992) and the one of Iaccarino & Salvatorini (1982).

The environmental reconstruction was based on the literature data concerning the Mediterranean basin (Blanc-Vernet,
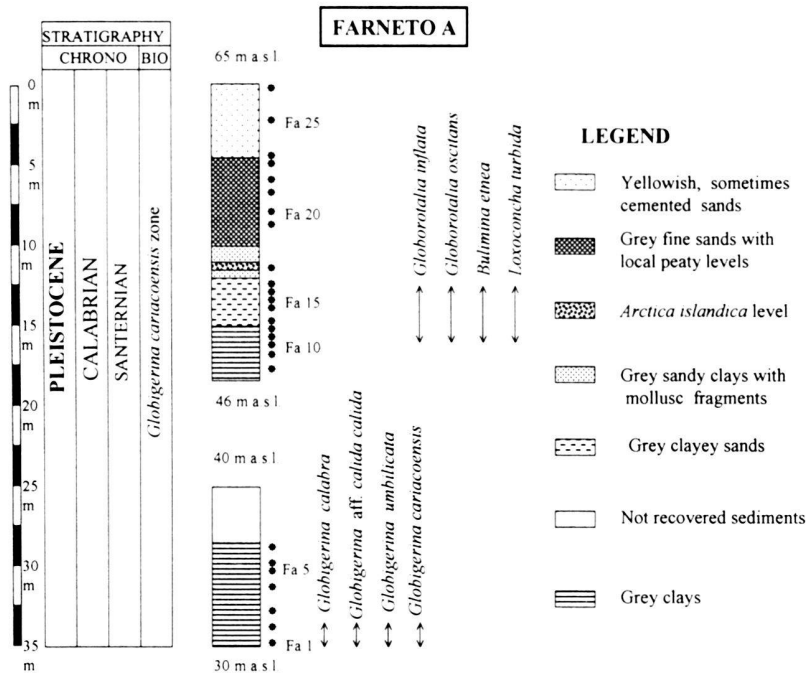
Fig. 2. Lithology and distribution of the most significant taxa in the Farneto A borehole.
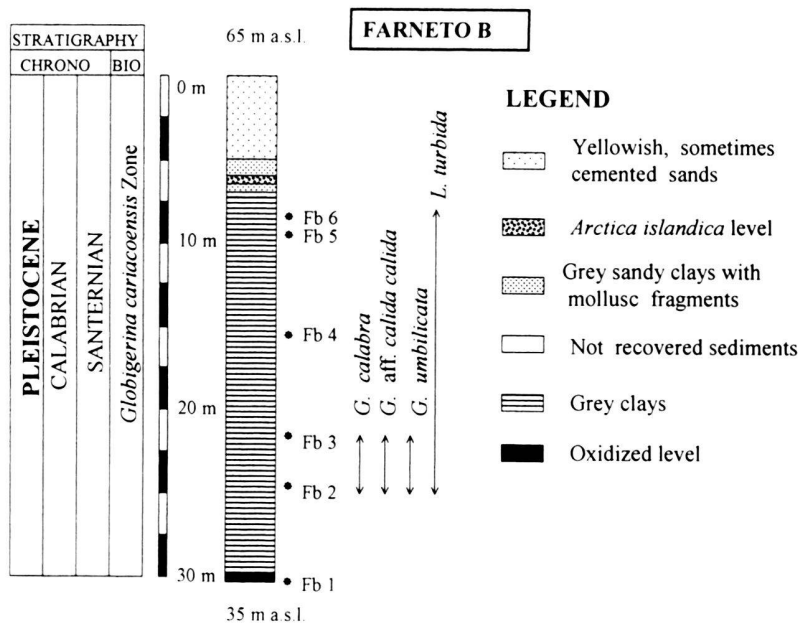
Fig. 3. Lithology and distribution of the most significant taxa in the Farneto B borehole.

1969; Jorissen, 1988; Murray, 1991; Sgarrella & Moncharmont-Zei, 1993). For Farneto A, the longest of the three boreholes, the results of the quantitative analyses were plotted in Fig. 5. The diagram shows the relative percentage of each family in the assemblage.

The taxonomic attribution above the specific level follows Loeblich & Tappan (1988), with simplifications at family level to facilitate the interpretation and synthesis of a great number of data. The complete list of species is reported in the paleontological appendix.

The data obtained from all the cores investigated from the Monte Mario drillholes were integrated. Therefore, the discussion of biostratigraphical and paleoecological results concerns the composite section.

Fig. 4. Lithology and distribution of the most significant taxa in the Igea borehole.

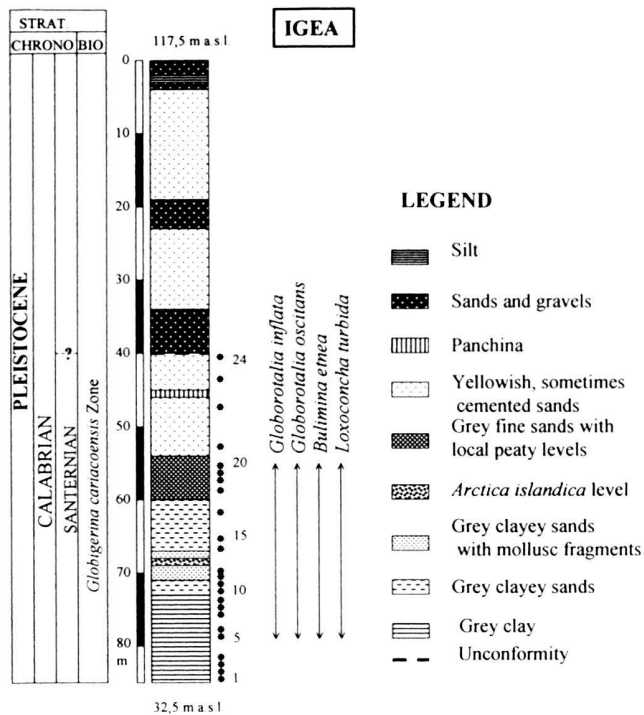Fig. 5. Results of quantitative analysis and paleoecological interpretation on the Farneto A borehole.

The study of calcareous nannofossils was attempted, but the strong reworking prevented us to obtain significant data.

A palinspastic restoration was attempted (Fig. 6) through the correlation of the biostratigraphic horizons, that allowed us to reconstruct the evolution of the sedimentary basins and the tectonics that affected this area during early Pleistocene.

Findings and discussion

1. Microfauna

The lower portion of the studied succession is present both at Farneto and at Igea sites.

In the basal meters of Farneto A borehole (Fa1, Fa2) the planktic foraminiferal assemblage contains typical species of Pleistocene as *Globigerina cariacoensis*, *Globigerina calabra*, *Globigerina* aff. *calida calida*, *Beella* aff. *digitata digitata*, *Globigerina umbilicata*, *Globigerina rubescens*. Moreover, *Globorotalia* gr. *puncticulata*, *Globorotalia aemiliana*, *Globigerina apertura*, *G. decoraperta*, *Sphaerodinellopsis seminulina* and *Anomalinoides helicinus* are found. As all these species disappear prior to the Pleistocene, it may be deduced that sediments of the *G. puncticulata* zone and *G. aemiliana* zone are reworked. *Globigerina bulloides*, *Globigerinoides ruber*, *G. sacculifer*, *Globigerina falconensis* are also present.

Benthos is represented by rare specimens of *Cassidulina neocarinata*, *Praeglobobulimina pupoides* and *Globobulimina pyrula*.

Similar assemblages are present in samples from Farneto B borehole (Fb2–Fb3) located about 300 m to the NE.

In samples Fa3–Fa7 and Ig1–Ig3 reworked forms decrease and stratigraphically significant planktic species are not found. Nevertheless, in these samples, benthic species like *C. neocarinata* and *P. pupoides* increase and *Bolivina alata* and *Globobulimina spinescens* are found. According with the record of Pliocene-Pleistocene boundary stratotype of Vrica (Aguirre & Pasini, 1985; Pasini & Colalongo, 1994), the presence of *G. calabra* and *G. cariacoensis* since the base of the succession allows us to attribute these sediments to the early Pleistocene (*Globigerina cariacoensis* Zone).

In the upper part of the succession, starting from samples Fa8 (Farneto A), Fb4 (Farneto B) and Ig 4 (Igea), the degree of reworking decreases and a clear change of the assemblages is recorded. The benthic assemblages are rich and diversified and plankton is scarce. The most stratraphycally significant

a) Top of the clay horizon bearing *G. inflata* ; b) bottom of the clay horizon bearing *B. etnea* and *G. inflata*, c) partially erosional surface that corresponds to the regressive phase leading to the deposition of the *A. islandica* sands; d) top of the Monte Vaticano unit; e) Top of the grey sands of the Monte Mario unit; f) "panchina" horizon; h) investigated boreholes; i) investigated sections.
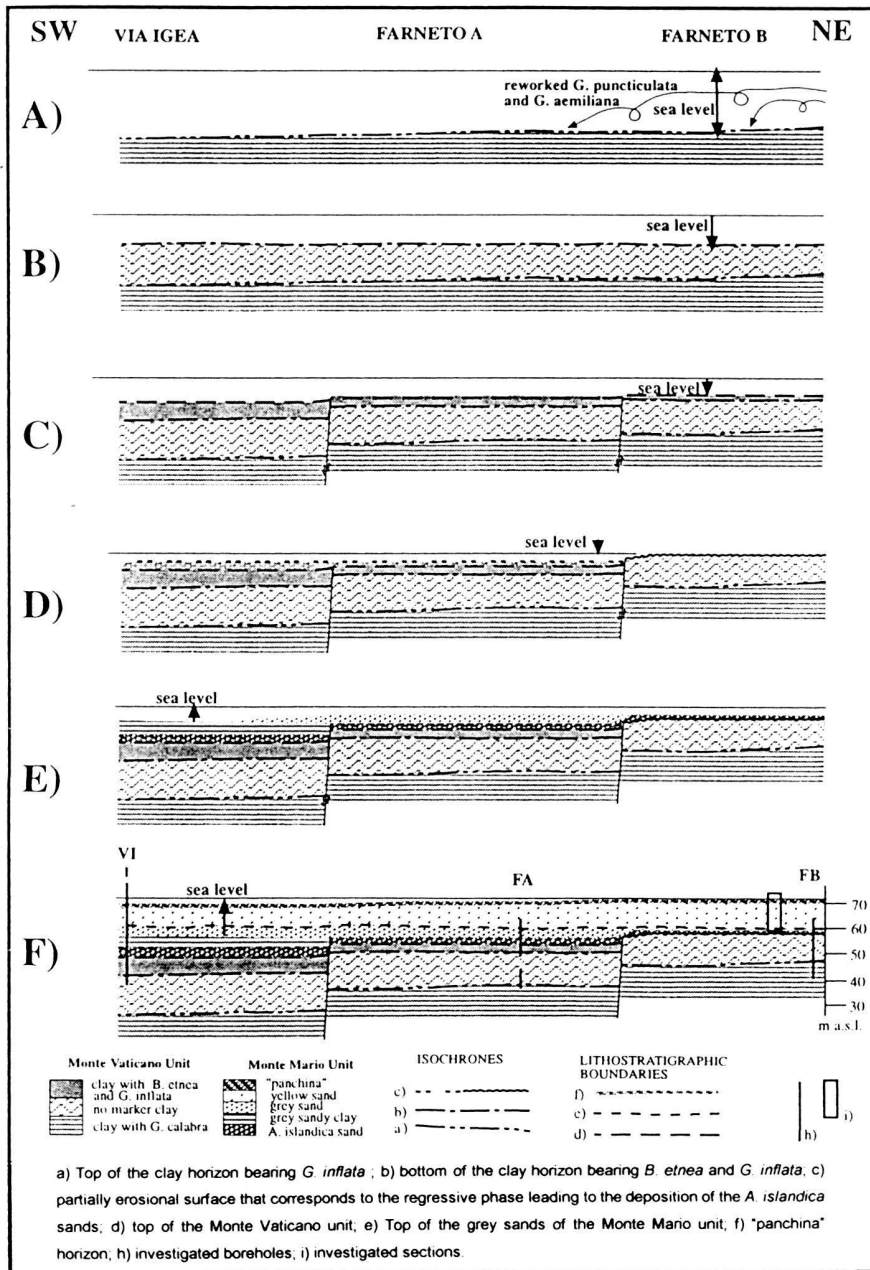
Fig. 6. Palinspastic reconstruction of the evolution of the sedimentary basin in the investigated area (see-text).

species are *Bulimina etnea, B. elegans marginata, Globorotalia inflata* and *G. oscitans*, in association with *Bolivina alata, Cassidulina neocarinata, Bulimina fusiformis, Coryphostoma perforata* and *Valvulineria bradyana*. These species decrease towards the top of the succession with the transition to shallower environments where *Ammonia* spp., *Elphidium* spp. and Miliolidae prevail. In the Farneto A and Igea boreholes, the shallower facies is represented by fine grey sands, in which layers with *Arctica islandica* levels are intercalated (Fa18, Ig12–13; Fig. 2, 4). The foraminiferal assemblage of these levels is scarce

and poorly diversified; it contains shallow water species like: *Ammonia beccarii, Asterigerinata planorbis, Elphidium* spp., *Florilus boueanus, Lobatula lobatula*. Plankton is represented by rare specimens of *Globigerina bulloides, Globigerina falconensis, Globigerinoides ruber* and *G. trilobus*.

The ostracod fauna is not abundant. From the stratigraphic standpoint, *Loxoconcha turbida*, a species which is found starting from the Santernian (Ruggieri, 1980), was recorded since the first samples (Fa9, Fb2 and Ig5). In the Igea and Farneto B boreholes, it is associated with very scarce specimens of *Aurila*

cruciata (samples Ig8–Ig14 and Fb4–Fb6). Although Ruggieri considered this species as a typical Emilian taxon, associated with *Hyalinea balthica*, Sissingh (1972) recorded it also in Pliocene and lower Pleistocene sediments of two Aegean Sea islands (at Karpathos in Pigadia Formation and at Rhodos in Kritika Formation).

2. Paleoecological reconstruction

The environmental evolution of the Pleistocene succession of Monte Mario was reconstructed based on the quantitative analysis of benthic foraminifers (Fig. 5), integrated by data from the qualitative analysis of ostracods, and on the identification of some significant associations.

The low frequency of ostracods did not allow quantitative analysis. Nevertheless, the presence of some ecologically significant taxa confirmed the paleoecological reconstruction. In the Igea borehole the ostracod assemblages are in a good state of preservation and the number of individuals and species tends to decrease upward from sample Ig17, after which the fauna becomes very scanty (Ig18) and absent in the top samples (Ig21–Ig24). In the Farneto A and Farneto B borehole, the faunal assemblages with ostracods are relatively well preserved.

The strong reworking and the low abundance of benthos, in the lower 15 m of the succession (Fa1–Fa7; Fb2–Fb3, Ig1–Ig4), did not allow to confidently single out the autochthonous assemblage, so that the paleoecological interpretation was very difficult. Nevertheless, the absence of coastal taxa in the benthic foraminiferal assemblage let suppose an environment deeper than infralittoral. Tentatively, a circalittoral environment may be supposed on the base of the ostracod fauna. In fact, some circalittoral species (*Henryowella asperrima*, *Cytherella* spp. and *Krithe* spp.) may be considered autochthonous for the presence of frequent immature valves indicative of different ontogenetic stages.

Upper circalittoral association

In the deeper portion of the Pleistocene succession of the Igea borehole, an assemblage with prevailing *Valvulineria bradyana* and *Cassidulina neocarinata*, in which *Bulimina marginata* was always abundant, was encountered. All these species are typical of the "Vase Terrigène Côtière" biotope (Blanc-Vernet, 1969). They characterise an upper circalittoral environment with muddy bottoms having low dissolved oxygen content.

An organic matter-enriched environment may be deduced from the high frequency of *Valvulineria bradyana*, an opportunistic epifaunal species, which proliferate in habitats with high trophic resources, in spite of low oxygen contents (van der Zwaan & Jorissen, 1991).

Among Miliolidae, only *Pyrgo elongata*, which is frequent in circalittoral environments (Sgarrella & Moncharmont-Zei, 1993), has a significant abundance. This association was recognised only in the Igea section (Ig4–Ig7).

Circalittoral to infralittoral association

Higher in the section, the abundance of forms typical of VTC shows a significant decrease. This indicates a shallowing of the environment. Furthermore, the agglutinated taxa (*Textularia agglutinans* and *Dorothia gibbosa*) became more frequent. Blanc-Vernet (1969) considers *Textularia agglutinans* as typical of Détritique Côtiere biotope, while Jorissen (1988) found this species in infralittoral environment with high organic matter content. The increased frequency of shallow-water forms (*Ammonia inflata*, *Elphidium crispum*) testifies the transition towards an infralittoral environment. In addition, the ecological significance of the ostracods (*Aurila* spp., *Loxoconcha* spp., *Leptocythere* spp.) confirms this environmental reconstruction (Bonaduce et al. 1975).

The circalittoral to infralittoral association was found in all the three sections (Ig8–Ig13; Fa8–Fa18; Fb4–Fb6).

Infralittoral association with vegetation covers

The subsequent association in the succession (Ig 14–Ig 16; Fa 19–Fa 23) is characterised by *Lobatula lobatula*, which lives mainly in infralittoral environments both as epiphytic in the *Posidonia* prairies and free in the sediment (Blanc-Vernet, 1969), and *Elphidium crispum*, a keeled epifaunal species typical of the infralittoral (Murray, 1991), frequent in vegetate habitats (Langer, 1993). Miliolidae are always abundant and the prevailing species are *Quinqueloculina seminulum* and *Q. vulgaris*, which mainly live in the infralittoral, especially characterised by vegetation covers (Blanc-Vernet, 1969). *Ammonia beccarii*, which lives in shallower water than *A. inflata*, is the most abundant species of the genus. All these data indicate an infralittoral environment where bottoms are sandy, with a scarce clayey fraction. Moreover, there is always evidence of vegetation covers, probably *Posidonia* prairies. In particular in one episode, such as the one noticed in the Igea (Ig15) and in the Farneto A (Fa21) sections, epiphyte species reach particularly high abundance. This environment is the typical "Herbier des Posidonies" biotope (Blanc-Vernet, 1969). Among ostracods, taxa typical of infralittoral environment with fine sandy, silty sandy and clayey sandy bottoms are present (*Aurila* spp., *Cytherella* spp., *Leptocythere* spp., *Xestoleberis communis*).

Sandy infralittoral association

In the Igea (Ig17–Ig24) and Farneto A (Fa24–Fa26) sections, an assemblage with prevailing *Ammonia beccarii*, *Florilus boueanus* and *Elphidium crispum* was noticed. The disappearance of epiphytic Miliolidae and the decrease of *Lobatula lobatula* suggest that *Posidonia* prairies are no longer present in the infralittoral environment with sandy bottoms.

Locally, in the Igea section, high abundance of *Asterigerinata planorbis* was singled out. The literature does not offer data on the autoecology of this species; in our experience (unpublished data), we encountered it in the typical infralittoral

assemblages, but never with such a high abundance as here. Probably it can live, like *A. mamilla*, on the *Posidonia* rhizomes, but, in this case, an epiphytic life may be excluded due to the absence of epiphytic Miliolidae in the assemblage. Moreover, in the Igea and Farneto sections (Ig17, Ig24 and Fa24) high abundance of *Bulimina* spp. (in particular *B. marginata*) testifies a more or less substantial contribution of fine sediments to infralittoral environment. The abundance of this species is probably linked to the increase of the organic matter content, associated with low oxygen levels, rather than to a bathymetric deepening.

As regards ostracods, *Semicytherura incongruens*, *Pterygocythereis ionesi* and *Callystocithere flavidofusca* are frequent. These forms are typical of an infralittoral environment (Ciampo, 1971).

3. Paleogeography and tectonic evolution of the sedimentary basin

Active tectonics, causing local uplift of the sea-bottom, characterised the evolution of the sedimentary basins in the area of Rome during Plio-Pleistocene times, as pointed out by intensive reworking affecting the faunistic assemblages of the Monte Vaticano Unit (Marra et al. 1995). Probably the reworked *G. puncticulata* and *G. aemiliana* come from two source areas corresponding with the present Latium coast and the Sabatini Mounts area, to the SW and to the NE of Monte Mario, respectively.

The lowermost portion of the investigated Pleistocene sequence in the area of Monte Mario recorded this strong contamination: several specimens of well-preserved *G. puncticulata* and relatively few *G. aemiliana* are found together with *G. calabra* and *G. aff. calida calida*. These sediments have been attributed to the Pleistocene (*Globigerina cariacoensis* Zone) for the presence of *G. cariacoensis* and *G. calabra*.

The disappearance of this association and the appearance of *B. etnea* (accompanied by *G. inflata*) allowed us to identify two horizons in the Pleistocene sequence. Other two horizons are represented by the local appearance of the *A. islandica* sands and by a characteristic level of cemented mollusc shells ("panchina" Auctorum). The stratigraphy in the area of Farneto has been integrated with field data in order to add this shell bed to our data set. A palinspastic reconstruction of the tectonic and stratigraphic history of the Pleistocene sedimentary basins in the area of Monte Mario is shown in figure 6. A rather homogeneous bathymetry characterises the time span corresponding to the deposition of the sediments of the *G. calabra – G. aff. calida calida* association (Fig. 6a). Reworked *G. puncticulata* and *G. aemiliana* are transported by paleostreams from emerged sectors into the sedimentary basin. A gradual shallowing, testified by the change of the benthic assemblage, is associated with the progressive disappearance of the reworked plankton. Probably the different paleogeographic condition prevents the reworked plankton to reach the sedimentary basin where an association characterised by the absence of stratigraphic markers is deposited (Fig. 6b).

Active tectonism controls the successive evolution of this area. For this reason, *B. etnea* is missing in the north-eastern borehole (Farneto B) while it is present in the grey sandy clay of the Monte Mario Unit in the southernmost one (Via Igea). No clear transgression between the clayey sediments of the Monte Vaticano Unit and the *A. islandica* sands has been observed in Via Igea as well as in the Farneto A boreholes (Fig. 6e). Therefore, we infer that the transition between the Monte Vaticano and the Monte Mario Units, contrary to previous interpretations, is continuous: the *A. islandica* sands represent a sharp climatically induced lithologic change associated with progressive shallowing. Only farther south of Monte Mario (Gianicolo hill and Monte Ciocci, fig. 1) a transgressive transition is present, and it is testified by the absence of the *A. islandica* sand horizon (Fig. 6e). In this area, yellow sands with *B. etnea* rest directly on the eroded top of the Monte Vaticano Unit and the passage is characterised by a small angular discordance (Marra et al. 1995).

The fragmentation of the sedimentary basins in the area of Rome is also inferred by the deposition of a thicker sequence of the Monte Mario Unit observed in the Via Igea borehole. A grey clayey sand horizon, bearing *B. etnea* and *G. inflata*, is deposited only in this area and its thickness corresponds to the accommodation space created by sin-sedimentary faulting, as inferred after the palinspastic reconstruction performed for this study (Fig. 6 e–f). Finally, differential tectonic evolution of the Pleistocene basins is sealed, at least in the investigated area, by the deposition of the horizon of cemented mollusc shells, known as "panchina" layer (Fig. 6f).

Conclusions

In the previous stratigraphical studies on this area (Marra et al. 1995; Carboni et al. 1991), mainly single samples from several outcrops, as well as spot-cored succession from boreholes, were analysed. The peculiarity of this paper is the study of a 90-m thick, densely sampled subsurface succession. The correlation of this composite section with other sites of the urban area, as the Gianicolo hill and Monte Ciocci localities (Marra et al. 1995), showed that significant lateral variations of the sedimentary succession occur probably deriving from the strong tectonics, acting since the Miocene, which interested the "Neoautochthonous Cycle" Auctorum.

The marine succession may be subdivided in two well distinct parts. The study of the lower portion (Fa1–Fa7, Fb1–Fb3 and Ig1–Ig4) was difficult due to strong reworking of Pliocene sediments. Nevertheless, the presence of *Globigerina calabra*, of rare specimens of *Globigerina cariacoensis* and *Loxochonca turbida* permits to attribute these sediments to the early Pleistocene (Santernian substage, *Globigerina cariacoensis* Zone). From an ecological viewpoint, *Loxochonca turbida* does not contradict the interpretation of a circalittoral environment; in fact, even if typical of infralittoral, it is also present in circalittoral (Bonaduce et al. 1975).

The upper part of the succession, comprising samples Fa8–Fa26, Fb4-Fb6 and Ig4-Ig24, is characterised by the lack of reworking and of planktic markers and by the presence of *Bulimina etnea*, associated with frequent *Globorotalia inflata* and *B. elegans marginata*.

A shallowing trend is recorded in the Pleistocene sediments with a transition from an upper circalittoral environment to an infralittoral one ("Grey sands with *Arctica islandica*" Formation). In these sediments, different associations allowed us to identify, in some cases, bottoms with more or less extensive vegetation covers and, in other cases, with variable abundance of clayey component.

From a biochronological and structural point of view, this study allowed us to infer some significant deductions that call for a re-interpretation of the classical stratigraphy of Rome.

- The Plio-Pleistocene boundary is not detectable at M. Mario. The transgressive contact between early Pliocene and early Pleistocene, hypothesized by previous authors (Bonadonna, 1968; Conato et al. 1980), seems only a lithological change (clay/sand) in a succession wholly attributable to early Pleistocene for the presence of *G. calabra*, *G. cariacoensis* and *B. etnea*.
- No significant transgression is detectable at the transition between the top of the clayey Monte Vaticano Unit and the basal portion of the Monte Mario Unit ("Grey sands with *A. islandica*) in Via Igea borehole. The faunistic assemblages are continuous and we found no indication of subaereal exposure at the top of the clayey unit. On the contrary, this clayey unit shows a progressive increase in the sand fraction in the uppermost succession, where fragments of mollusc shells appear before the *A. islandica* sand.

On the base of these objective data, some deductions may be proposed. The transition from the Monte Vaticano Unit to the Monte Mario Unit in the area of Rome is linked with a moderate retreat of the coastline and it assumes the character of a real transgression only in the south-eastern sector where the *A. islandica* sand is missing. However, the biostratigraphic record allowed us to infer that this hiatus represents a very short time span and occurs during a period of active tectonism in the early Pleistocene. Consequently, the well known *Arctica islandica* level, is now re-interpreted as controlled essentially by the tectonic evolution of the area, while glacio-eustatism may be considered of secondary importance.

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PLATE I
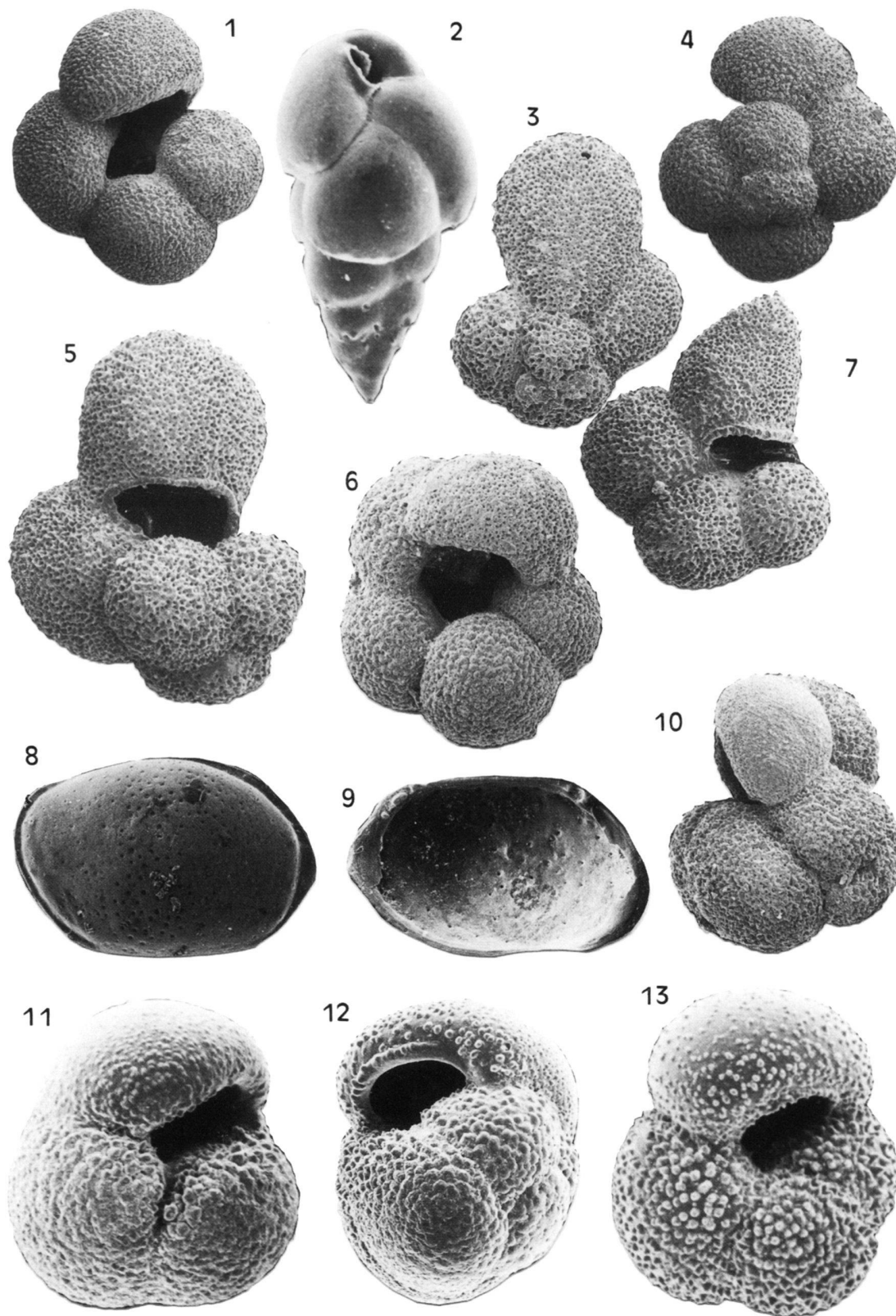
1, 4. *Globigerina calabra* Colalongo & Sartoni, × 75. 1) Umbilical view. 4) Spiral view. Sample Fa 1. – **2.** *Bulimina etnea* Seguenza, × 110. Side view. Sample Ig 5. **3, 5, 7.** *Beella* aff. *digitata digitata* (Parker), × 130. 3) Spiral view. 5, 7) Umbilical view. Sample Fa 2. – **6, 10.** *Globigerina cariacoensis* Rögl & Bolli, × 110. 6) Umbilical view. 10) Side view. Sample Fa 1. – **8, 9.** *Loxoconcha turbida* G. W. Müller, × 55. 8) Lateral exterior view of right valve. 9) Lateral interior view of right valve. Sample Fb 9. – **11, 12.** *Globorotalia inflata* (d'Orbigny), × 130. 11) Umbilical view. 13) Side view. Sample Ig 9. – **13.** *Globorotalia oscitans* Todd, × 170. Umbilical view. Sample Ig 8.

List of species: Foraminifera

BENTHOS

Adelosina cfr. *partschi* (d'Orbigny)
Adelosina partschi (d'Orbigny)
Ammonia beccarii (Linné)
Ammonia inflata (Seguenza)
Ammonia parkinsoniana (d'Orbigny)
Amphicoryna scalaris (Batsch)
Anomalinoides ornatus (Costa)
Asterigerinata planorbis (d'Orbigny)
Bigenerina nodosaria (d'Orbigny)
Bolivina aenariensis Costa
Bolivina alata (Seguenza)
Bolivina catanensis Seguenza
Bolivina dilatata Reuss
Bolivina italica Cushman
Bolivina pseudoplicata Heron Allen & Earland
Bolivina punctata d'Orbigny
Bolivina spathulata (Williamson)
Bolivina spinescens Cushman
Bolivina subspinescens Cushman
Buccella granulata (di Napoli)
Bulimina aculeata d'Orbigny
Bulimina costata d'Orbigny
Bulimina 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 sublimbata Panizza
Buliminella aldovrandii Conato
Buliminella inauris Conato
Cancris auriculus (Fichtel & Moll)
Cassidulina neocarinata Thalman
Cibicides refulgens de Montfort
Cibicides ungerianus (d'Orbigny)
Cibicidoides pseudoungerianus Cushman
Coryphostoma perforata (di Napoli)
Cribroelphidium decipiens (Costa)
Cycloforina contorta (d'Orbigny)
Dentalina inflexa (Reuss)
Dentalina leguminiformis (Batsch)
Dimorphina tuberosa d'Orbigny
Discorbinella bertheloti (d'Orbigny)
Dorothia gibbosa (d'Orbigny)
Eggerella bradyi (Cushman)
Elphidium complanatum (d'Orbigny)
Elphidium crispum (Linné)
Elphidium macellum (Fichtel & Moll)

Favulina hexagona (Williamson)
Fissurina bradyana (Fornasini)
Fissurina castanea (Flint)
Fissurina longirostris Seguenza
Fissurina marginata (Walker & Jacob)
Fissurina orbignyana Seguenza
Fissurina piriformis (Buchner)
Fissurina pseudorbignyana (Buchner)
Florilus boueanus (d'Orbigny)
Florilus citai (di Napoli)
Fursenkoina schreibersiana (Czjzek)
Globobulimina affinis (d'Orbigny)
Globobulimina ovula (d'Orbigny)
Globobulimina pyrula (d'Orbigny)
Globobulimina spinescens (Brady)
Globocassidulina subglobosa (Brady)
Guttulina communis (d'Orbigny)
Gyroidina soldanii (d'Orbigny)
Gyroidina umbonata (Silvestri)
Gyroidinoides neosoldanii (Brotzen)
Hanzawaia boueana (d'Orbigny)
Heterolepa floridana (Cushman)
Hoeglundina elegans (d'Orbigny)
Karrierella bradyi (Cushman)
Lachlanella undulata (d'Orbigny)
Lagena laevis (Montagu)
Lagena semistriata Williamson
Lagena striata (d'Orbigny)
Lenticulina calcar (Linneo)
Lenticulina cultrata Montfort
Lenticulina gibba (d'Orbigny)
Lobatula lobatula (Walker & Jacob)
Marginulina costata (Batsch)
Martinottiella communis (d'Orbigny)
Melonis barleeanus (Williamson)
Melonis pompilioides (Fichtell & Moll)
Neoconorbina orbicularis (Terquem)
Neolenticulina peregrina (Schwager)
Nonion depressulum (Walker & Jacob)
Nonionella turgida (Williamson)
Oridorsalis umbonatus var. *stellatus* (Silvestri)
Pandaglandulina dinapolii Loeblich & Tappan
Planorbulina mediterranensis d'Orbigny
Planulina ariminensis d'Orbigny
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 elongata (d'Orbigny)

Pyrgo oblonga (d'Orbigny)
Quinqueloculina bicarinata d'Orbigny
Quinqueloculina oblonga (Montagu)
Quinqueloculina seminulum (Linné)
Quinqueloculina sp.
Quinqueloculina vulgaris d'Orbigny
Reussella spinulosa Reuss
Rosalina globularis d'Orbigny
Sigmoilinita tenuis (Czjzek)
Sigmoilopsis celata (Costa)
Sigmoilopsis schlumbergeri (Silvestri)
Siphonaperta sp.
Siphonina reticulata (Czjzek)
Siphotextularia concava (Karrer)
Sphaeroidina bulloides d'Orbigny
Spiroloculina depressa d'Orbigny
Spiroplectinella wrighti (Silvestri)
Stainforthia complanata (Egger)
Stilostomella monilis (Silvestri)
Textularia agglutinans d'Orbigny
Textularia bocki Höglund
Textularia concava jugosa Silvestri
Textularia conica d'Orbigny
Textularia sagittula Defrance
Trifarina angulosa (Williamson)
Trifarina bradyi Cushman
Uvigerina peregrina Cushman
Uvigerina pygmaea d'Orbigny
Valvulineria bradyana (Fornasini)

PLANKTON

Beella aff. *digitata digitata* (Brady)
Globigerina aff. *calida calida* Parker
Globigerina bulloides d'Orbigny
Globigerina calabra Colalongo & Sartoni
Globigerina cariacoensis Rögl & Bolli
Globigerina falconensis Blow
Globigerina rubescens Hofker
Globigerina umbilicata Orr & Zaitzeff
Globigerinita glutinata (Egger)
Globigerinoides elongatus (d'Orbigny)
Globigerinoides helicinus (d'Orbigny)
Globigerinoides ruber (d'Orbigny)
Globigerinoides sacculifer (Brady)
Globigerinoides tenellus Parker
Globigerinoides trilobus (Reuss)
Globorotalia inflata (d'Orbigny)
Globorotalia oscitans Todd
Globorotalia scitula (Brady)
Hastigerina siphonifera (d'Orbigny)
Orbulina universa d'Orbigny
Turborotalita quinqueloba (Natland)

List of species: Ostracoda

Argilloecia sp.
Aurila aff. *puncticruciata* Ruggieri
Aurila bradleyana Ruggieri
Aurila bradleyana bradleyana Ruggieri
Aurila cfr. *speyeri* (Brady)
Aurila cimbaeformis (Seguenza)
Aurila cruciata (Ruggieri)
Aurila punctata (Munster)
Aurila sp.
Aurila versicolor Ruggieri
Callistocythere flavidofusca (Ruggieri)
Callistocythere pallida (G.W. Müller)
Callistocythere vexata (Bonaduce, Ciampo, Masoli)
Carinocythereis antiquata (Baird)
Carinocythereis carinata (Roemer)
Cistocythereis cfr. *chartaginensis* Barra, Bonaduce
Costa edwarsi (Roemer)
Costa edwarsi runcinata (Baird)
Cythereidea neapolitana Kolmann
Cytheretta subradiosa (Roemer)
Cytherella scutulum Ruggieri
Cytherella sp.
Cytherella vanderboldi Sissingh
Cytherella vulgata Ruggieri
Hemicyteria sp.
Henryhowella asperrima (Reuss)
Hiltermannicythere sp.

Hiltermannicythere aff. *rubra* (G.W. Müller)
Krithe praetexta (Sars)
Krithe sp.
Leptocythere bacescoi (Rome)
Leptocythere cfr. *ramosa* (Rome)
Leptocythere macella Ruggieri
Leptocythere multipunctata (Seguenza)
Leptocythere multipunctata transiens Pucci
Leptocythere ramosa (Rome)
Loxoconcha geometrica (Bonaduce, Ciampo, Masoli)
Loxoconcha ovulata (Costa)
Loxoconcha sp
Loxoconcha turbida G.W. Müller
Loxoconcha versicolor G.W. Müller
Pachicaudites sp.
Pterygocythereis ceratoptera (Bosquet)
Pterygocythereis jonesi (Baird)
Pterygocythereis sp.
Semicytherura incongruens (G.W. Müller)
Semicytherura rara (G.W. Müller)
Semicytherura ruggerii (Pucci)
Tirrenocythere sp.
Urocythereis favosa (Roemer)
Urocythereis sp.
Xestoleperis communis G.W. Müller
Xestoleperis plana G.W. Müller