



First Emilian record of the boreal-affinity bivalve *Portlandia impressa* Perri, 1975 from Montefiore dell' Aso (Marche, Italy)

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ABSTRACT - We report the first record of the bivalve *Portlandia impressa* from Pleistocene sediments of Marche. The finding is represented by a few shells retrieved from inner shelf deposits exposed at Grotti, in the municipality of Montefiore dell' Aso (Ascoli Piceno). The sediments that yielded the fossils belong to the upper part of the Marchean Quaternary marine sequence (Qm), here referred to the Early Pleistocene. In particular, the integration among foraminifer, calcareous nannoplankton, and mollusk data supports an Emilian age for the fossiliferous level.

This record extends the chronostratigraphical range of the Early Pleistocene boreal affinity species *P. impressa*, traditionally retained Santernian in age. From the paleoecological point of view, the comparison among the very few mollusk assemblages containing *P. impressa* enables us to retain this fossil protobranch as a tolerant pelophilous taxon that inhabited inner-shelf soupy bottoms.

RIASSUNTO - [Prima segnalazione del bivalve ad affinità boreale *Portlandia impressa* nell'Emiliano di Montefiore dell' Aso (Marche, Italia)] - *Portlandia impressa* è un raro bivalve finora segnalato esclusivamente nel Pleistocene inferiore del bacino Padano: Valle dello Stirone (Parma) e Val Chero (Piacenza). Tradizionalmente la sua distribuzione stratigrafica è limitata al Santerniano ed anche se non può essere annoverato tra i veri "ospiti nordici" (essendo la specie endemica del Mediterraneo) il genere condivide tuttavia il carattere boreale di questo gruppo di taxa. Nel presente lavoro viene segnalata per la prima volta la presenza di *Portlandia impressa* nel Pleistocene delle Marche. I sedimenti che contengono questa specie affiorano in località Grotti (Montefiore dell' Aso, Ascoli Piceno) e sono costituiti da argille siltose completamente bioturbate deposte in ambiente di piattaforma interna. Essi rappresentano i depositi litorali regressivi (RLD) che caratterizzano la parte sommitale della successione marina del Quaternario delle Marche (Qm). L'integrazione dei dati biostratigrafici basati sui microfossili, foraminiferi e nannoplankton calcareo, con quelli ottenuti dai sopravvissuti pliocenici tra i molluschi permette di riferire tali depositi all'Emiliano, estendendo in tal modo il range cronostratigrafico finora conosciuto (Santerniano) di *P. impressa*, basato su un unico riferimento. La malacofauna, composta da 39 taxa di cui 18 bivalvi, 19 gasteropodi e 2 scafopodi, rappresenta una paleocomunità a *Venus multilamella* instaurata su un substrato fangoso. La non applicabilità di metodologie quantitative non consente un preciso riferimento alla profondità che comunque rimane con tutta probabilità inquadrabile nell'ambito dell'infralitorale. Questo dato appare in buon accordo con quello fornito dall'associazione a foraminiferi. La comparazione della malacofauna nel suo complesso con quelle associate agli altri scarsi rinvenimenti di *P. impressa*, consente di ritenere questo taxon una forma pelofila tollerante che popolava ambienti di piattaforma interna.

INTRODUCTION

The Early Pleistocene malacofauna of the Mediterranean Basin was characterized by repeated immigrations of cold-water taxa (northern guests) and progressive disappearances (already begun in the Pliocene) of warm-water ones (Raffi, 1986).

Even though the presence of northern guests was observed for the first time by Philippi (1836-1844),

their climatic interpretation is due to De Stefani (1876). De Stefani (1891), and few years later Gignoux (1910, 1913), proposed the first documented syntheses of Pleistocene stratigraphy from which it is possible to extract a list of about twenty cold-water mollusks. Since the 1948 International Geological Congress of London, where it was officially accepted the proposal of a Pleistocene age for sediments yielding northern guests, their number rose progressively (Moroni, 1967;

Raffi, 1986) up to the revision of Malatesta & Zarlenga (1988) in which 53 cold-water taxa are examined in detail.

Almost all elements included in this stock live today out of the Mediterranean; however, there are two particular cases (Bellomo & Raffi, 1991; Sami & Taviani, 1996). *Macoma obliqua* originated in the Early Pliocene of the North Sea and spreads during the Pliocene, reached the Mediterranean Sea at the top of the Emilian and here disappeared before the end of Sicilian (Kafanov, 1999). *Portlandia impressa* is not known out of the Mediterranean and has been up to now recorded only in two Early Pleistocene sections of Italy (Chero Valley, Piacenza, and Stirone River, Parma); its chronological range is traditionally limited to the Santernian (Perri, 1975; Raffi, 1986; Taviani et al., 1997).

In this paper, we discuss the Pleistocene succession that yielded the fossils and describe the mollusk remains, highlighting their chronological and paleoenvironmental implications. Foraminiferal and calcareous nannofossil assemblages have been examined in order to obtain biostratigraphic constraints. The first Emilian record of *Portlandia impressa* from Montefiore dell'Aso (Ascoli Piceno, Italy) allows us to infer some insights about its life environment and to revalue the chronological role of this species in the frame of the faunal elements of "cool" affinity characterizing the Early Pleistocene Mediterranean malacofauna.

GEOLOGY AND STRATIGRAPHY

General geologic and stratigraphic setting

The Pleistocene succession exposed at Montefiore dell'Aso (Ascoli Piceno Province, AP) is part of the Periadriatic Basin infill (Fig. 1). The Plio-Pleistocene sedimentary evolution of this basin is closely related to the tectonic evolution of the Apennine chain, and its

sediments are strongly affected by the occurrence of deep-seated active thrusts. Ricci Lucchi (1986) and Cantalamessa et al. (1986) recognized four main unconformity-bounded units (P2, Qm, Qm1, and Qc, acronyms for "Pliocene," "Quaternary marine," and "Quaternary continental," respectively), and provided a first, general sequence stratigraphic framework for the middle Pliocene-Pleistocene sedimentary fill of the Periadriatic Basin.

Sequence Qm is mainly composed of a mudstone-rich slope succession ("Argille Azzurre Superiori" of Cantalamessa et al., 2002) that passes, gradually, into intensely bioturbated and massive shelf silty mudstones and shallow-marine sandstones and conglomerates. In particular, when completely preserved, the shallowing- and coarsening-up facies succession at the top of Qm (regressive littoral deposits, RLD of Cantalamessa & Di Celma, 2004) is composed of hummocky cross-stratified sandstones interbedded with minor mudstones (offshore transition zone). These pass upward first into lower shoreface swaley cross-stratified sandstones and upper shoreface interfingering layers of sandstones and conglomerates and, then, into clinostatified beachface conglomerates. Because a detailed account of the sedimentary facies occurring within RLD and of its sequence stratigraphic architecture is beyond the scope of this paper, for a full and more comprehensive description of these aspects please refer to Massari & Parea (1988) and Cantalamessa & Di Celma (2004), respectively.

According to Bigi et al. (1997), the Qm-Qm1 bounding unconformity is placed in correspondence with an erosional surface that extends throughout the whole Periadriatic area and is correlated to the Emilian substage regression of Ruggieri (1980). This sequence-bounding unconformity is a complex surface that has different physical expressions on the basis of the local depositional responses to the ensuing rise in relative sea-level (Cantalamessa & Di Celma, 2004).

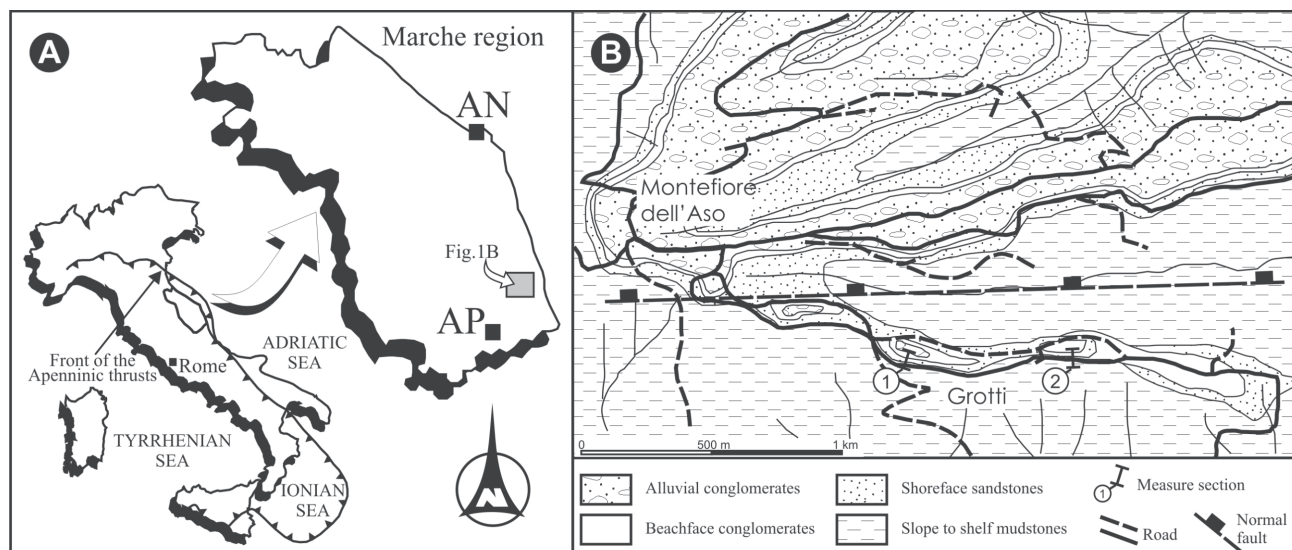


Fig. 1 - A) Location map of the study site on the Marche coast in central Italy. B) Schematic geological map of the Montefiore dell'Aso area. Location of measured sections used to construct Fig. 2 is shown.

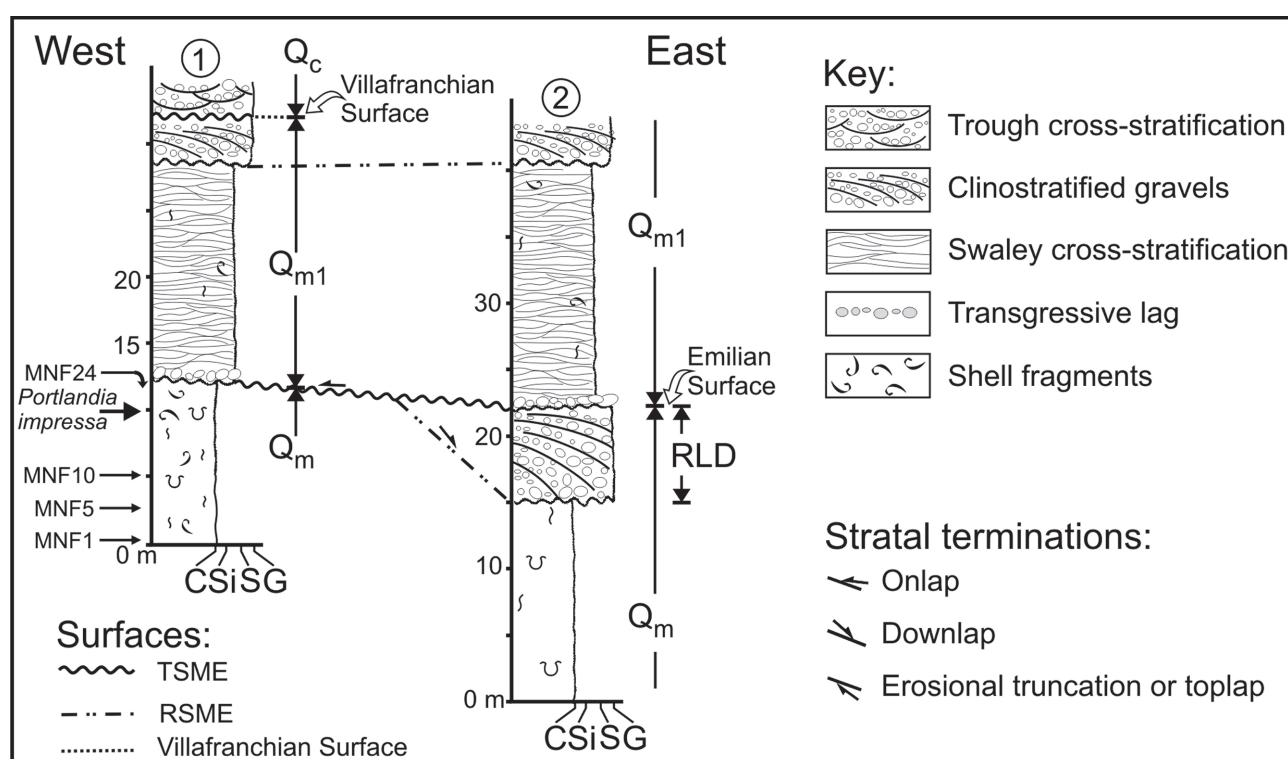


Fig. 2 - Depositional dip-oriented stratigraphic cross section showing facies and sequence architecture of the upper part of cycle Q_m (RLD) and Q_{m1} . Section 1 is also shown in Fig. 3.

Shells of the bivalve *Portlandia impressa* have been retrieved within the lower portion of the RLD at the top of the sequence Q_m , whose stratigraphy will be briefly described in the following section.

Stratigraphy of the Grotti section

The stratigraphic logs illustrated in Fig. 2 refer to the upper part of sequence Q_m and to sequence Q_{m1} and Q_c cropping out at Grotti, about 1 km south-east of the town of Montefiore dell'Aso (Fig. 1). Here, the Q_m - Q_{m1} bounding unconformity (Fig. 3) is a transgressive surface of marine erosion (TSME) whereas the regressive littoral deposits (RLD) at the top of Q_m are sharp-based rather than gradationally based on the underlying silty mudstones and are separated from these by a regressive surface of marine erosion (RSME) carved during a period of relative sea-level fall (forced regression; Plint & Nummedal, 2000).

The fossil shells have been recovered within sediments laid down within an inner shelf setting where massively bioturbated silty muds were deposited.

RESULTS

Mollusk fauna

Specimens are very dispersed in a silty mudstone which appears locally barren. As bulk samples (overall 50 litres) contain very few specimens, the fossil assemblage is characterized only by qualitative grounds based on field observations and manual picking at outcrop level.

Shells are usually well-preserved retaining original shell smoothness and fine details of ornamentation. The

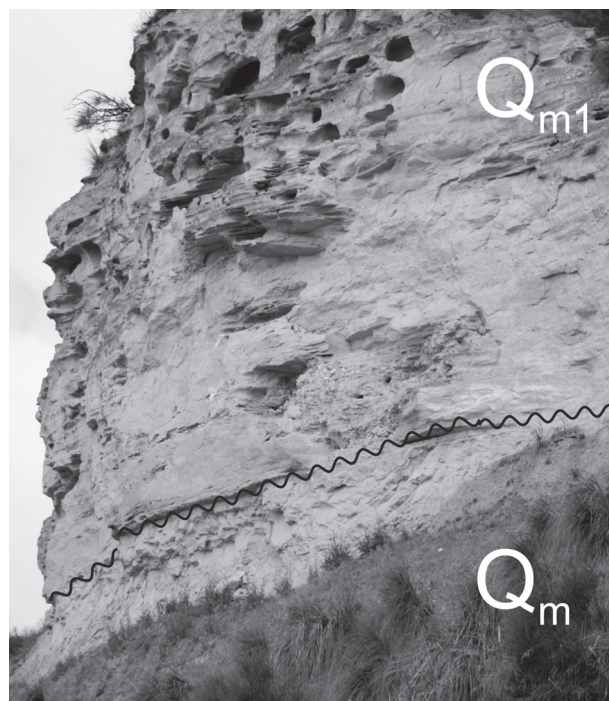


Fig. 3 - Outcrop of the measured section 1. Note the sharp, erosive contact (Emilian surface) between the silty mudstones of sequence Q_m and the overlying coarse sandstones of sequence Q_{m1} .

lacking of encrustation is explainable in terms of rate of sedimentation allowing a rapid burial of skeletal elements that result in a short period of *post-mortem* exposure (or no-exposure) on the sea floor. Almost all bivalves are disarticulated; besides rare conjoined shells of *Corbula gibba*, only the characterizing species *Venus multilamella* presents a few adult individuals in life position. It is impossible to evaluate the orientation of disarticulated valves owing to both the very dispersed biofabric and the pervasive and intense bioturbation obliterating original structures.

The association consists of 39 taxa among which 18 bivalves, 19 gastropods, and 2 scaphopods (see Paleontological Appendix). A neritic shallow-water marine environment fits well within the bathymetric range of all taxa; however, it is evident a puzzling co-occurrence of species with different substrate requirements. Pure and/or tolerant pelophilous taxa include *Acanthocardia paucicostata*, *Aporrhais uttingeriana*, *Eulima subulata*, *Nucula sulcata*, *Turritella tricarinata pliorecens*, and *Venus multilamella*, whereas *Aporrhais pespelecani*, *Azorinus chamasolen*, *Dentalium inaequicostatum*, and *Nuculana commutata* are considered mixtophilous. Moreover, *Mangelia attenuata* and *Tellina pulchella* are sand-related, and the sessile epifaunal *Anadara pectinata*, *Neopycnodonte cochlear* and *Calyptrea chinensis* need small or extensive hard substrata.

Of course, we cannot draw definite conclusions solely on this evidence: some observations can nevertheless be made. The fauna may be retained as a mixed fossil assemblage where only the pelophilous forms appear to be in functional agreement with the sediment grain size; other stocks with different substrate requirements are considered exotic elements. At a first glance, the association may be overall interpreted as a *Venus multilamella* paleocommunity probably lived in muddy, soupy infralittoral bottoms. Even though the presence of *Nucula sulcata* might suggest a circalittoral setting (Di Geronimo, 1974), this taxon is also recorded in *Venus multilamella* paleocommunities referred to the lower part of the infralittoral zone (20-40 m) (Taviani et al., 1997; Dominici, 2001). Anyway, a more accurate evaluation of the bathymetric interval appears to be too speculative without the numerical treatment of specimens.

The mixing process supplied skeletal elements by different sources from nearby habitats; it may be mainly attributed to gravity, and occasionally, to very gentle reworking produced by weak currents in a sheltered environment. This hypothesis is supported by the inconspicuous signs of abrasion of skeletal elements, the lacking of current-loving taxa, and the textural properties of the sediment.

The paleoenvironmental insights mentioned above appear well correlatable with those inferred for the other two Early Pleistocene fossil assemblages containing *Portlandia impressa*. In more details, in the Chero Valley (Piacenza Province), this taxon was found in silty sands (sandy silts) characterized by the presence of *Venus multilamella*, *Chlamys varia*, *Abra alba*, *Turritella tricarinata pliorecens*, *Aporrhais pespelecani*, *Nassarius gigantulus* etc. (Taviani et al., 1997). In the Stirone

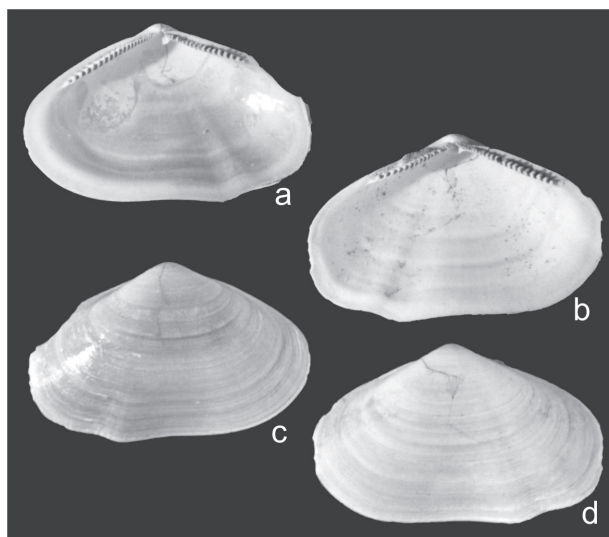


Fig. 4 - *Portlandia impressa* Perri, 1975. a) inside view of the right valve; b) inside view of the left valve; c) outside view of the right valve; d) outside view of the left valve. a, c length = 149 mm; b, d length = 147 mm.

River, *P. impressa* is present at the top of a muddy level along with *Venus multilamella*, *Acanthocardia echinata*, *Turritella tricarinata pliorecens*, *Nassarius gigantulus*, etc. (Perri, 1975). Both fossil assemblages are referable to inner shelf environments.

In conclusion, the available information allows us to retain *P. impressa* (Fig. 4) as a tolerant pelophilous species that inhabited shallow-water marine environments.

Biostratigraphy

A total of 37 samples were collected for micropaleontological analyses: MFN 1-24 for calcareous nannofossils, and Mfi 1-5, Mfa 1-2, MF 11-13 for foraminifers, respectively. MF 02-04 samples were also collected from mudstones of the upper part of Qm sequence exposed about 40 m below the studied section (they are not reported in Fig. 3) and processed for both micropaleontological analyses. The obtained data were compared with the biostratigraphic schemes by Rio et al. (1990) and Colalongo & Sartoni (1979) for calcareous nannofossils, and benthic-planktic foraminifers, respectively. The Van Couvering's scheme (1997) was adopted for the chronostratigraphic classification, whereas biochronology is from Sprovieri (1993), Pasini & Colalongo (1994), and Sprovieri et al. (1998). The calibration of GPTS (Fig. 5) follows the proposal of Cande & Kent (1995).

Generally speaking, the foraminiferal assemblage (all recognized taxa are listed in the Paleontological Appendix) is well-preserved, scarcely diversified, and mainly composed of benthic species, whereas the planktic ones are usually small in size and are present only in some samples with few individuals. Evidences of reworking are scarce and mainly due to the occurrence of some Miocene taxa (*Paragloborotalia siakensis*, *Turborotalita quinqueloba*, *Neoglobobulimina acostaensis*, *Globigerinoides trilobus*) with size comparable to the inorganic residues. The general

features of the assemblage and the role of the main taxa are discussed below.

The samples of the Grotti section show a very poor assemblage mainly consisting of benthic forms, among which *Valvulineria bradyana* and *Cassidulina neocarinata* are the most abundant taxa; *Ammonia* spp., *Cribroelphidium* spp., and *Bulimina* spp. are also present. The planktic foraminifera are very scarce (*Globigerinoides ruber* and *Orbulina universa*) and totally lacking in the upper part of the section. As a whole, the foraminiferal assemblage points to an infralittoral zone (Sgarrella & Moncharmont Zei, 1993) and does not contain any significant taxa from the bio- and chronostratigraphic point of view.

The MF 02-04 samples coming from the mudstones cropping out below the studied section hold a planktic foraminifer assemblage mainly consisting of *Globigerinoides ruber*, *Globigerina bulloides*, and *Globorotalia inflata* besides *Globigerinoides tenellus*, a species characteristic of the *Globigerina cariacensis* Zone. Benthic foraminifera are well represented and largely dominated by *Cassidulina neocarinata* and

Valvulineria bradyana, that may account over 50% of individuals. Other characterizing faunal elements are *Brizalina* spp., *Bulimina* spp., and many agglutinated taxa belonging to *Dorothia* and *Textularia* genera. The occurrence of *Bulimina etnea* confirms an Early Pleistocene age (*Globigerina cariacensis* Zone).

Noteworthy is the lack of *Hyalinea balthica*, the marker of the homonymous Emilian zone (Pasini & Colalongo, 1994) that is typical of circalittoral-bathyal environments; the lack of this species in the Grotti section may be due to an ecological exclusion. On the other hand, the presence of this taxon is documented in pelitic and pelitic-arenaceous facies of the upper part of the Qm unit occurring, both in outcrop and subsurface, along the coastal area of Marche and Abruzzo Regions (Crescenti & Follador, 1965; D'Onofrio, 1968; Cantalamessa et al., 1997, among others). Moreover, some authors of the present paper recognized *Hyalinea balthica* in pelitic sediments underlying the sands of Qm1 unit in Colonnella and Tortoreto areas, a few kilometers south of the studied area (unpublished data). The correlation among these

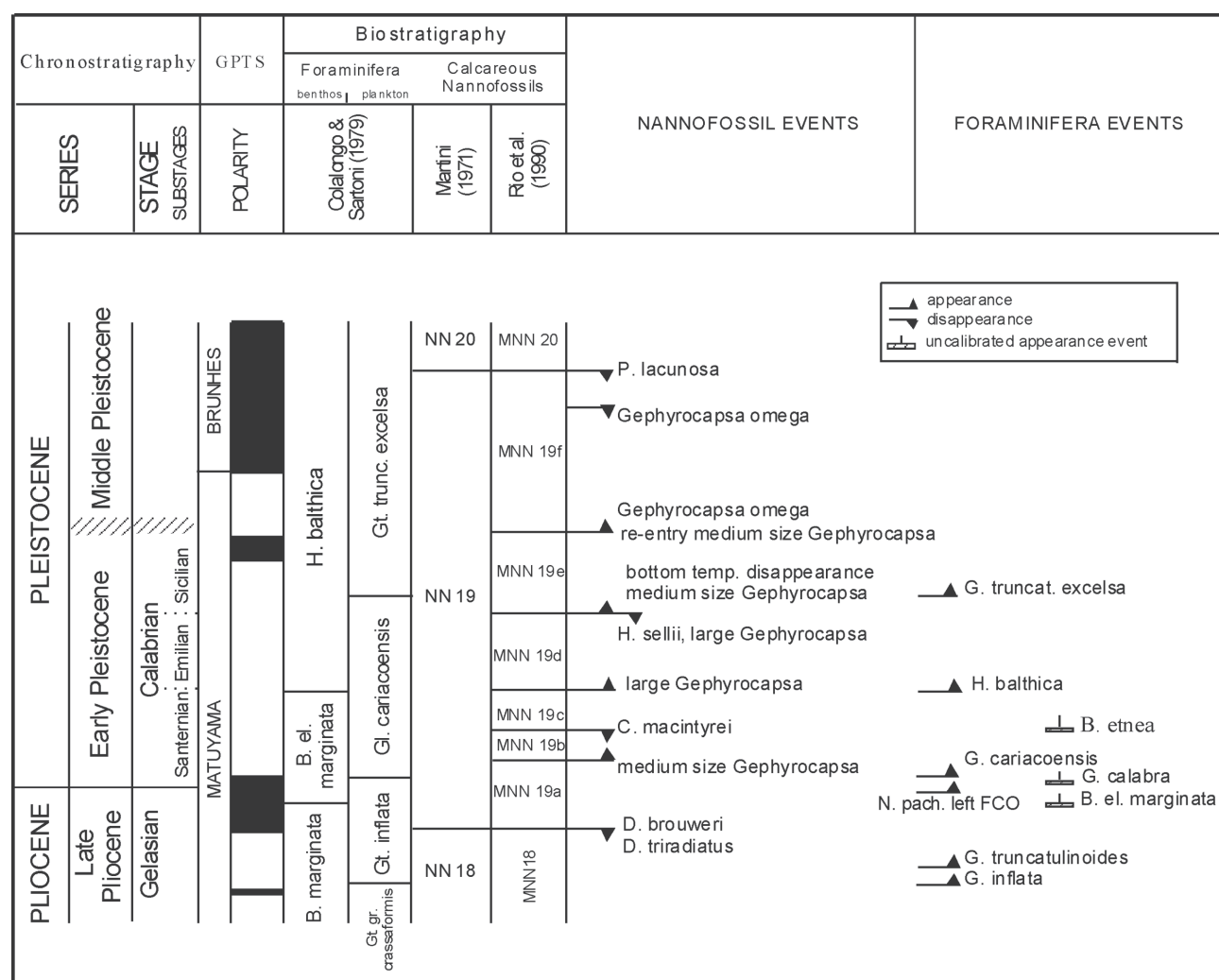


Fig. 5 - Stratigraphic scheme for the Late Pliocene-Early Pleistocene. See text for details.

sediments and those containing *Portlandia impressa* at Grotti section enable us to assume that the latter are not older than the Emilian substage.

As noted above, calcareous nannofossils were studied on 27 samples collected in the Qm unit of the Grotti section. Simple smear slides were prepared from unprocessed samples according to standard technique (Bown & Young, 1998) and analyzed under a polarized light microscope at the magnification of 1000 x. The nannofossil assemblages were determined by qualitative analyses, performed on 150 fields of view in every sample; the high dilution of Pleistocene assemblages observed in the samples and the great amount of inorganic input and reworked nannofossils prevented quantitative analyses. The nanoflora is represented by very rare and poorly preserved nannofossils whereas the inorganic input and the Cretaceous to Pliocene reworked species are abundant. The assemblages are indicative of the large *Gephyrocapsa* Zone (Fig. 5; MNN19d of Rio et al., 1990) owing to the presence of the biozonal marker and *Pseudoemiliania lacunosa*, *Coccolithus pelagicus*, *Calcidiscus leptoporus*, small *Gephyrocapsa*, *Gephyrocapsa oceanica* s.l., *Helicosphaera carteri*, and *Helicosphaera sellii*. In particular, rare and scattered specimens of large *Gephyrocapsa* have been recorded from sample MFN 5 upwards (Fig. 2) thus indicating the Emilian substage, according to Rio et al. (1982). In more details, the first appearance of large *Gephyrocapsa*, considered a near-synchronous event in the eastern Mediterranean and equatorial Atlantic (Lourens et al., 1998; Raffi, 2002), gives a fair approximation to the Santerian/Emilian boundary. At the Vrica section, the boundary has been proposed coincident with the first occurrence of *Hyalinea baltica* at 1.58 Ma (Pasini & Colalongo, 2001), an age slightly younger than the base of large *Gephyrocapsa* (1.608 Ma, Lourens et al., 1998).

Among the mollusks, age constraining elements belong to two significant groups: Pliocene survivors, which lasted from Pliocene and died out during the Early Pleistocene, and taxa of Atlantic origin first recorded in the Mediterranean Basin from the beginning of the Pleistocene that are usually referred to as "northern," "Celtic," or "Boreal" guests. In this group may be included also *P. impressa* as its immigrant significance is due to the biogeographic distribution of the genus *Portlandia*.

Among the first stock, *Anadara pectinata* and *Nassarius gigantulus* disappeared in the upper part of the Emilian substage, whereas *Aporrhais uttingeriana* in the upper part of the Sicilian one. *Acanthocardia echinata* and *Portlandia impressa* are included (Pelosio & Raffi, 1977; Raffi, 1986) in the first contingent of "northern guests" immigrated at the beginning of the Early Pleistocene. This protobranch is not known out of the Mediterranean and traditionally retained Santerian in age (Malatesta & Zarlenga, 1988; Taviani et al., 1997).

In conclusion, although at a first glance the traditional distribution of *P. impressa* suggests a Santerian age, data integration among the foraminiferal and calcareous nannofossil biozonal attribution (*Globigerina cariacensis* and *Hyalinea balthica* Zones

and MNN 19d Zone) and the Pliocene survivor mollusks point to an Emilian age. Consequently, due to its occurrence at Montefiore dell'Aso, the chronostratigraphical range of *P. impressa* results extended to the Emilian substage.

CONCLUDING REMARKS

The upper part of the sequence Qm of the Periadriatic basin records a progressive shallowing up of facies sequence that is composed, when complete, by a gradationally based succession passing from outer through inner shelf deposits into sandy shoreface and gravel-dominated beachface sediments; when incomplete, it is composed by a sharp-based succession of upper shoreface and beachface deposits laying erosionally upon deeper-marine mudstones.

The presence of the bivalve *P. impressa* in the silty mudstone deposits (regressive littoral deposits, RLD) of Grotti section (Montefiore dell'Aso, Ascoli Piceno) suggests the following two points:

a) this rare protobranch has been recorded only in three Early Pleistocene sections: the Chero Valley (Piacenza), the Stirone River (Parma) and Montefiore dell'Aso; comparing the related mollusk assemblages, *P. impressa* results always associated with *Venus multilamella*, *Turritella tricarinata pliorecens*, *Nassarius gigantulus*, etc. in inner shelf bottoms in which sediment texture ranges from mud to silty-sands. In this light, *P. impressa* may be regarded as a tolerant pelophilous taxon that inhabited shallow-water communities.

b) *P. impressa* is an endemic species of the Mediterranean Early Pleistocene with "boreal" affinity, i.e., the same "cool" character of most Atlantic immigrants; on the basis of the previous occurrences, it was restricted to the Santerian substage. The occurrence of this taxon in the Grotti section represents the first record in sediments referable to Emilian based on the presence of the calcareous nannofossil large *Gephyrocapsa* Zone, and probably of the *Hyalinea balthica* Zone recognized in coeval sediments outcropping near Grotti locality. This finding allows us to extend the chronostratigraphical distribution of *P. impressa* from Santerian to Emilian.

PALEONTOLOGICAL APPENDIX

Bivalvia

- Nucula sulcata* Bronn, 1831
- Portlandia impressa* Perri, 1975
- Nuculana commutata* (Philippi, 1844)
- Anadara pectinata* (Brocchi, 1814)
- Aequipecten opercularis* (Linneo, 1758)
- Chlamys varia* (Linneo, 1758)
- Chlamys* cf. *glabra* (Linneo, 1758)
- Cardium indicum* Lamarck, 1818
- Acanthocardia echinata* (Linneo, 1758)
- Acanthocardia paucicostata* (Sowewrby, 1841)
- Neopycnodonte cochlear* (Poli, 1795)
- Tellina distorta* Poli, 1791
- Tellina pulchella* Lamarck, 1818
- Abra* sp.
- Azorinus chamasolen* (Da Costa, 1778)
- Venus multilamella* (Lamarck, 1818)

Pitar rudis (Poli, 1795)
Corbula gibba (Olivi, 1792)

Gastropoda

Turritella tricarinata pliorecens Monterosato in Scalia, 1900
Aporrhais pespelecani (Linneo, 1758)
Aporrhais uttingeriana (Risso, 1826)
Calyptraea chinensis (Linneo, 1758)
Capulus hungaricus (Linneo, 1758)
Naticarius stercusmuscarum (Gmelin, 1791)
Euspira fusca (Blainville, 1825)
Galeodea echinophora (Linneo, 1758)
Epitonium cantrainae (Weinkauff, 1866)
Epitonium spiniferum (Seguenza, 1876)
Hadriania oretae (De Gregorio, 1885)
Nassarius cf. italicus (Mayer, 1876)
Nassarius gigantulus (Michelotti, 1840)
Mangelia attenuata (Montagu, 1803)
Mangelia ruperrima (Tiberi, 1855)
Teretia teres (Reeve, 1844)
Neoguraleus hispidulus (Jan in Bellardi, 1847)
Rhombostoma cf. carmelae (Brugnone, 1873)

Scaphopoda

Dentalium inaequicostatum (Dautzenberg, 1891)
Dentalium sp.

Foraminifera

Ammonia beccarii (Linneo, 1758)
Ammonia inflata (Seguenza, 1862)
Brizalina alata (Seguenza, 1862)
Brizalina catanensis (Seguenza, 1862)
Brizalina dilatata (Reuss, 1850)
Brizalina sp.
Brizalina spathulata (Williamson, 1858)
Buccella granulata (di Napoli, 1952)
Bulimina corsiniana Perconig, 1955
Bulimina elegans D'Orbigny, 1826
Bulimina elegans marginata Fornasini, 1901
Bulimina elongata D'Orbigny, 1846
Bulimina etnea Seguenza, 1862
Bulimina fusiformis Williamson *sensu* Fornasini, 1901
Bulimina marginata D'Orbigny, 1826
Bulimina minima Tedeschi & Zanmatti, 1957
Bulimina sublimbata Panizza, 1967
Cassidulina neocarinata Thalmann, 1950
Cibicides lobatulus (Walker & Jacob, 1798)
Criboelphidium decipiens (Costa, 1856)
Criboelphidium semistriatum (D'Orbigny, 1852)
Dorothia gibbosa (D'Orbigny, 1826)
Elphidium crispum (Linneo, 1758)
Elphidium macellum (Fichtel & Moll, 1798)
Elphidium sp.
Florilus boueanum (D'Orbigny, 1846)
Fursenkoina schreibersiana (Czjzek, 1848)
Globigerina bulloides D'Orbigny, 1826
Globigerinita glutinata (Egger, 1895)
Globigerinoides helcinus (D'Orbigny, 1826)
Globigerinoides ruber (D'Orbigny, 1839)
Globigerinoides tenellus Parker, 1958
Globigerinoides trilobus (Reuss, 1850)
Globorotalia inflata (D'Orbigny, 1839)
Globobulimina ovula (D'Orbigny, 1839)
Lagena striata (D'Orbigny, 1839)
Melonis padanum (Perconig, 1952)
Neoglobobulimina acostaensis (Blow, 1959)
Neoglobobulimina pachyderma (Ehrenberg, 1861)
Nonion depressulum (Walker & Jacob, 1798)
Orbulina suturalis Brönnimann, 1951
Orbulina universa D'Orbigny, 1839
Paragloborotalia siakensis (Leroy, 1939).
Pleurostomella alternans Schwager, 1866
Praeglobobulimina ovata (D'Orbigny, 1846)

Protelphidium granosum (D'Orbigny, 1846)
Quinqueloculina oblonga (Montagu, 1803)
Quinqueloculina sp.
Reussella spinulosa (Reuss, 1850)
Sigmoilinita sp.
Sigmoilinita tenuis (Czjzek, 1848)
Sigmoilopsis schlumbergeri (Silvestri, 1904)
Sigmoilopsis sp.
Sphaeroidina bulloides D'Orbigny, 1826
Spiroplectammia wrighti (Silvestri, 1903)
Textularia sagittula DeFrance, 1824
Textularia soldanii Fornasini, 1883
Textularia sp.
Trifarina bradyi Cushman, 1923
Turborotalita quinqueloba (Natland, 1938)
Valvulineria bradyana (Fornasini, 1900)

Calcareous nannofossils

Calcidiscus leptoporus (Murray & Blackman, 1898)
Calciosolenia spp.
Coccolithus pelagicus (Wallich, 1871)
Dictyococcites productus (Kamptner, 1973)
Florisphaera profunda Okada & Honjo, 1973
small *Gephyrocapsa* < 3.5 micron, *sensu* Gartner (1977)
Helicosphaera carteri (Wallich, 1877)
large *Gephyrocapsa* (> 5.5 micron) *sensu* Rio (1982)
medium *Gephyrocapsa* (4-5.5 micron) *sensu* Rio (1982)
Pseudoemiliania lacunosa (Kamptner, 1963)
Pontosphaera spp.
Reticulofenestra minuta Roth, 1970
Reticulofenestra minutula (Gartner, 1967)
Rhabdosphaera claviger Murray & Blackman, 1898
Syracosphaera histrica Kamptner, 1941
Syracosphaera pulchra Lohmann, 1902
Thoracosphaera heimii (Lohmann, 1919)
Umbilicosphaera spp.

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