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UPPER MIOCENE PRE-TERRIGENOUS DEPOSITS OF THE QUEGLIA UNIT (ABRUZZO, CENTRAL APENNINES, ITALY): BIOSTRATIGRAPHIC DATA

Abstract - An integrated biostratigraphic study (calcareous nannofossils, planktic and benthic foraminifera) of the Upper Miocene pre-terrigenous deposits of the Queglia unit was carried out. The section studied (Pescosansonesco, Central Apennines-Abruzzo) is representative of a deepening-upward foreland ramp occupying a relatively external position with respect to the well-known Laga foredeep basin in the Messinian.
Amaurolithus primus and *Globorotalia* gr. *miotumida* were observed at the base of the section, where a gradual change from shallow to deeper water shelf was recognized. In the overlaying hemipelagic sediments, FO of *Bulimina echinata*, FO and FCO of *Turborotalia multiloba*, and FO of *Amaurolithus amplificus* were recorded.
These events enabled us to recognize of the planktic foraminifera *Turborotalia multiloba* Subzone and the calcareous nannofossil *Calcidiscus leptoporus* MA Subzone.

Key words - Biostratigraphy, Calcareous Nannofossils, Foraminifera, Central Apennines.

Riassunto - *I depositi pre-terrigeni del Miocene superiore dell'unità Queglia (Abruzzo, Appennino centrale, Italia): dati biostratigrafici.* - È stato condotto uno studio biostratigrafico integrato (nannofossili calcarei, foraminiferi planctonici e bentonici) sui depositi pre-terrigeni alto miocenici dell'unità Queglia. La sezione studiata, situata nei pressi dell'abitato di Pescosansonesco (Abruzzo, Italia), è costituita da depositi di rampa *deepening-upward* d'avampaese, che durante il Messiniano occupava una posizione più esterna rispetto al ben noto bacino d'avanfossa della Laga.
La presenza di *Amaurolithus primus*, e di *Globorotalia*. gr. *miotumida* è stata registrata sin dalla base della sezione, dove si assiste ad un passaggio graduale da sedimenti di mare basso a sedimenti più distali. Nei sovrastanti depositi emipelagici sono state registrate la FO di *Bulimina echinata*, le FO e FCO di *Turborotalia multiloba*, e la FO di *Amaurolithus amplificus*.
Questi bioeventi hanno consentito di riconoscere la Subzona *Turborotalia multiloba* e la Subzona *Calcidiscus leptoporus* MA.

Parole chiave - Biostratigrafia, Nannofossili calcarei, Foraminiferi, Appennino centrale.

INTRODUCTION

The Queglia unit, outcropping North and West of the Maiella mountain, belongs to a paleogeographic domain located between the Laga (inner) and Maiella (outer) domains (Fig. 1).
According to Patacca *et al.* (1991) the Queglia unit consists of Cretaceous-Paleogenic basinal carbonates, evolving to outer ramp deposits in the late Oligocene? - Middle Miocene and to inner ramp deposits in the early Tortonian. During the early Messinian the deposition of hemipelagic sediments testified to the drowning of the carbonate platform. As in many Mediterranean sequences the «Lower evaporitic Cycle» was registered and above this the «Lago Mare» deposits were recorded. In the latest Messinian the onset of the synorogenic turbidite siliciclastic deposition («flysch Teramano») occurred.
The object of this study is the biostratigraphy of the hemipelagic deposits marking the change from carbonate to terrigenous sedimentation.
Patacca *et al.* (1991) assign these sediments to the early Messinian, on the basis of the occurrences of *Amaurolithus primus*, *Amaurolithus delicatus*, *Amaurolithus amplificus*, *Turborotalia multiloba* and *Bulimina echinata*.
The aim of this study is to provide further information about the calcareous benthic and planktic assemblages of these sediments.

LITHOSTRATIGRAPHY

The section studied is located near the Pescosansonesco village (Lat. 4677270.31; Long. 4074439.58; F°146-II NE) along the road to the village of Corvara (Fig. 2).
The interval sampled is about 40 meters thick starting from the boundary with the underlying carbonate platform sediments of the Bolognano formation. Four different superposed lithofacies are recognized (Fig. 3).
The lower part of the section (lithofacies 1) is made up of about 6 metres of grey glauconitic, bioturbated marly-limestones with abundant macrofossils, and thin interlayers of brownish-grey marls with bivalves and planktic foraminifera.
The overlaying hemipelagic sediments consist of 4 metres of grey marls and clayey marls with pteropods (lithofacies 2).
Upsection, the marls with pteropds give way to a marly

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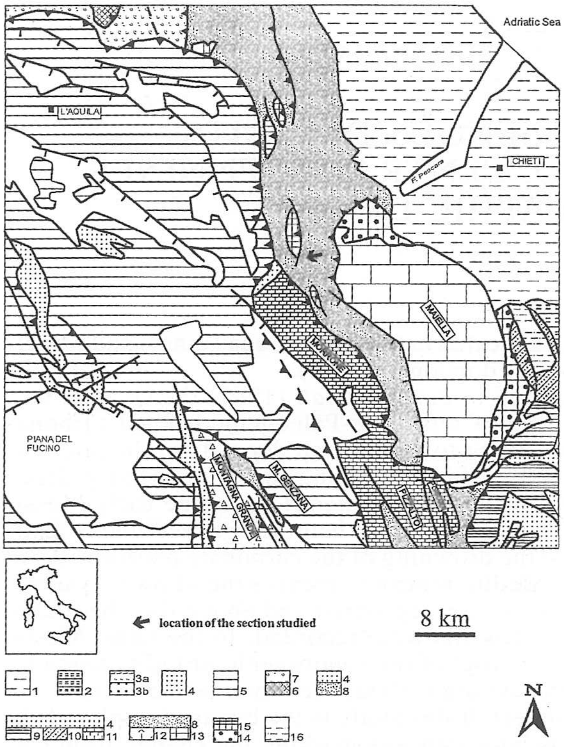

Fig. 1 - Geologic-structural scheme of the Central Apennines-Abruzzo (Patacca *et al.* 1991, modified).
1) Upper Pliocene p.p.-Pleistocene cycle; 2) Upper Pliocene p.p. cycle; 3a) Messinian-«Lagomare»-Lower Pliocene cycle; 3b) Palena and La Vicenne conglomerates; 4) foredeep deposits of the pre-evaporitic early Messinian: «flysch abruzzesi» and «flysch molisani» (Cantalupo, S.Massimo, S.Elena, and Agnone flysch, Olmi formation and Treste formation); 5) pre-terrigenous deposits of Gran Sasso and eastern Marsica units; 6) pre-terrigenous deposits of Montagna dei Fiori unit; 7) foreland deposits of pre and post evaporitic Messinian (Laga flysch); 8) foredeep deposits of the Messinian «Lagomare»-Early Pliocene p.p.; 9) Agnone; 10) Tufillo; 11) pre-terrigenous deposits of Scontrone-Porrara unit; 12) pre-terrigenous deposits of the Montagna Grande; 13) pre-terrigenous deposits of the Queglia unit; 14) pre-terrigenous deposits of the Maiella unit; 15) Lower Pliocene p.p. foredeep deposits; 16) foreland pelitic deposits of the Casoli-Bomba unit (Late Pliocene p.p.-Early Pliocene).

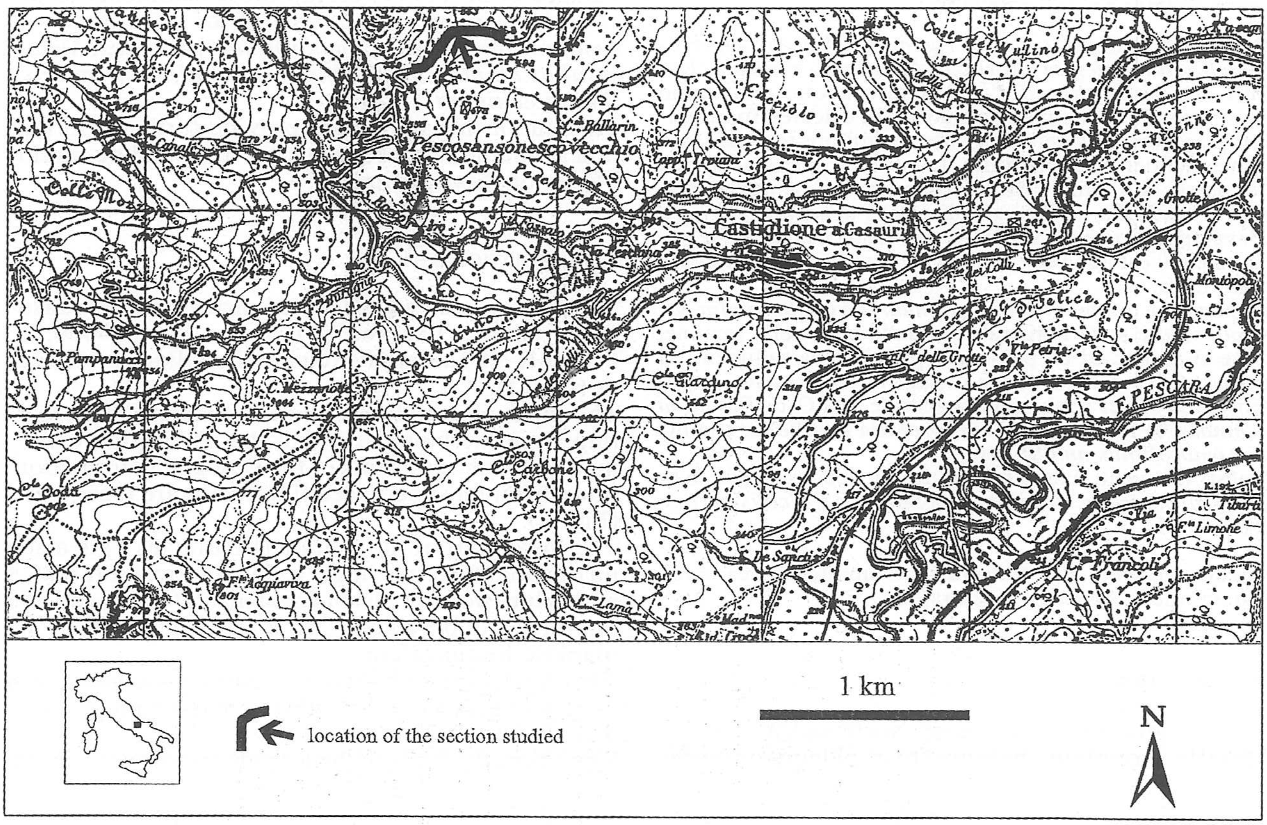

Fig. 2 - Location map of the Pescosansonesco section (from the IGM Carta d'Italia, scale 1:25.000, sheet 146 I SE, Popoli).

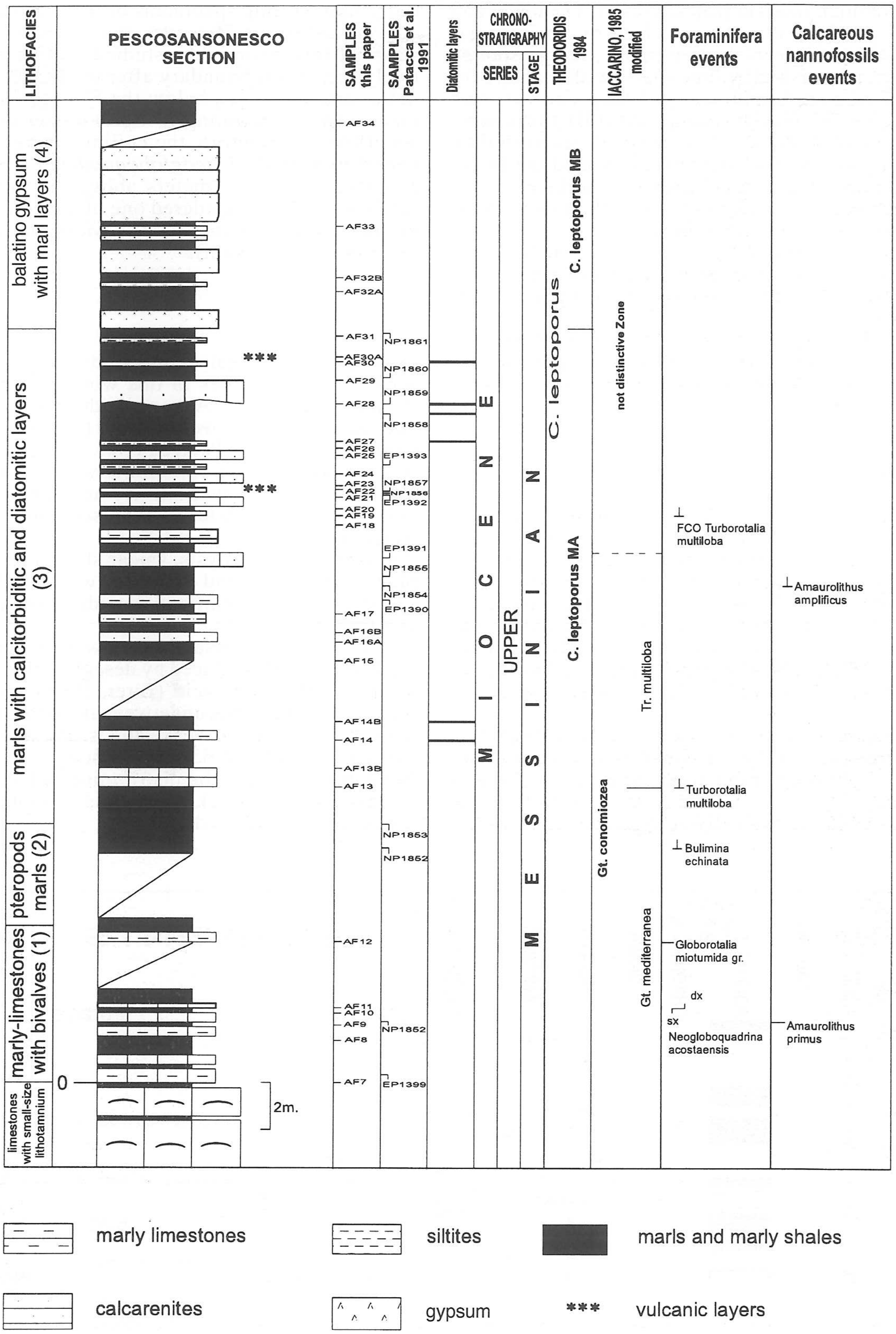

Fig. 3 - Lithostratigraphy, chronostratigraphy, biochronology and bioevents of the Pescosansonesco section.

18 metre thick interval (lithofacies 3). The lower and middle portions are characterized by an irregular alternation of greenish-grey marls rich in sponge spicules, greenish-grey lime-marls with planktic foraminifera, rare thin brownish siltites, and very rare dark shales with bivalves (sample AF16B). In the upper part of this lithofacies an increase of calcitorbiditic layers is observed, characterized by medium to coarse-grained bioclastic calcarenites interlayered with greenish-grey marls, lime-marls with planktic foraminifera, and brownish siltites.
In the upper part of lithofacies 3 two volcaniclastic levels were recognized. Some diatomitic layers were recorded both in the lower and in the upper part of this lithofacies.
The section ends with about 10 metres of balatino gypsum (lithofacies 4). In the lower portion of this interval intercalations of green marls and rare grey siltites occur.

Biostratigraphy

The biostratigraphic scheme used in this study for the Messinian interval is shown in Fig. 4.
For the planktic foraminifera biostratigraphy, the Mediterranean scheme of Iaccarino 1985 (modified according to Colalongo *et al.*, 1979, and Sprovieri *et al.*, 1996a and 1996b) is applied. The calcareous nannofossil zonation is based on the Mediterranean scheme of Theodoridis (1984) correlated to the zonal scheme of Martini (1971) and Okada & Bukry (1980).
The calcareous plankton events are recalibrated on the astronomical and geomagnetic time scale of Cande & Kent (1995) according to Sprovieri *et al.* (1996b).
Remarks - The base of «non distinctive Zone» (Iaccarino, 1985) is normally recognized when essentially right coiling specimens of *Neogloboquadrina acostaensis* occur. However, due to the scarce presence of this taxon in the studied section we tentatively locate this boundary after the FO of *Amaurolithus amplificus* just below the FCO of *Turborotalia multiloba* according to Sprovieri *et al.* (1996a and 1996b). Therefore, the coiling change from sinistral to dextral of *Neogloboquadrina acostaensis* recorded at about 4 meters above the base of the section could be considered one of the coiling changes of this species during early Messinian (Iaccarino, 1998, pers. comm).

Methods

49 samples were analyzed to study foraminifera assemblage (33 samples in this work, 16 samples in Patacca *et al.*, 1991). As regards the calcareous nannofossils 35 samples were studied (33 samples in this work, 2 in samples Patacca *et al.*, 1991).
In each sample, the foraminifera and nannofossil assemblages were qualitatively and semiquantitatively characterized in terms of preservation and abundance. (Tab. 1)
For nannofossil analysis, smear slides of each sample were prepared and examined with a light microscope at × 1200 magnification under cross-polarized and transmitted light.
The foraminifera assemblages were studied from washed residues produced by desegregating the rock-samples with acetic acid (Lirer, 1998) and sieving the residues. Residues underwent ultrasonic treatment in order to obtain cleaner residues. The analysis was carried out on the > 63 μm fraction.
In Tables 2, 3 and 4 the distribution of foraminifera (planktic and benthic), calcareous nannofossils and ostracods were plotted.

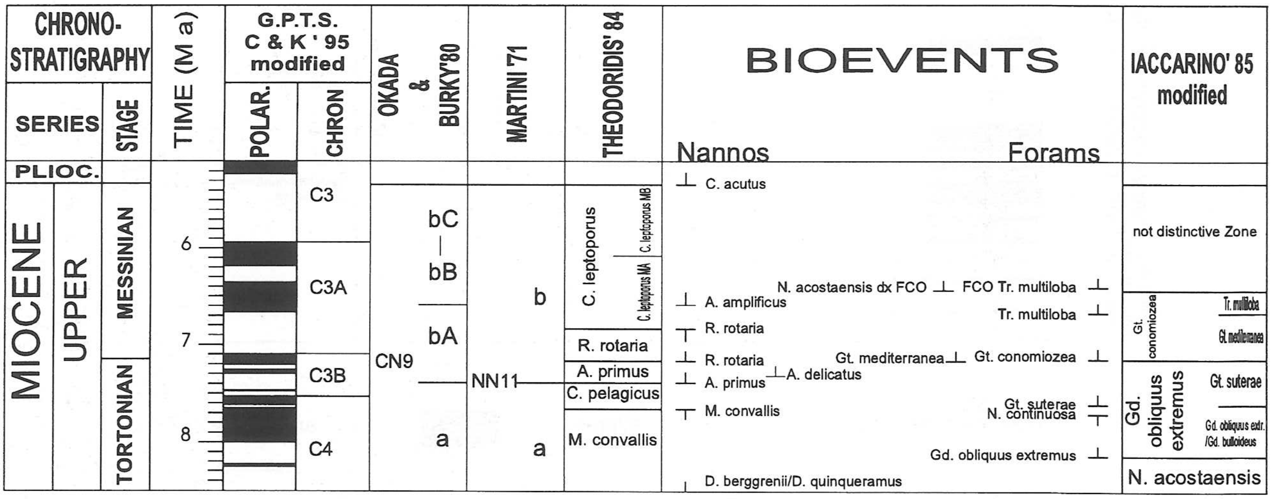

Fig. 4 - Adopted Late Miocene integrated biostratigraphic scheme according to: Cande & Kent (1995), Sprovieri *et al.* (1996b), (time scale and magnetic calibration); Shackleton *et al.* (1995) Sprovieri *et al.* (1996b), (calcareous nannofossils). Sprovieri *et al.* (1996b), (planktic foraminifera).

Tab.1

CALCAREOUS NANNOFOSSILS	FORAMINIFERA
TOT. AB. A = > 30 spec.s for view; C = 10 to 30 spec.s for view; F = 1 to 10 spec.s for view; R = < 0.1-1 spec.s for view; P = < 0.1 spec.s for view; B = barren	TOT. AB. A > 30%; C = 10-30%; F = 3-10%; R = 1-3%; P = less than 1%; B = barren
REL. AB. A = > 1 spec for view; C = 1 spec for view; F = 1 spec for 2-10 views; R = 1 spec for 10-100 views; P = 1 spec for 100-600 views	REL. AB. A > 30%; C = 10-30%; F = 3-10%; R = 1-3%; P = less than 1%
PRESERVATION: G (good): little or no evidence of dissolution and/or secondary overgrowth; fully preserved diagnostic characters. M (moderate): dissolution and/or secondary overgrowth; partially altered primary morphological characteristics; nearly all specimens can be identified at the species level. P (poor): severe dissolution, fragmentation and/or secondary overgrowth; largely destroyed primary features; many specimens cannot be identified at the species and/or at generic level.	PRESERVATION: G (good): little or no fragmentation, overgrowth and/or dissolution (> 90% of intact specimens); M (moderate): some signs of fragmentation, overgrowth and/or dissolution (30 to 90% of intact specimens); P (poor): severe fragmentation, heavy overgrowth and/or dissolution (< 30% of intact specimens)

Results

Foraminifera

The samples studied yielded a moderately preserved, low to high diversified and abundant foraminifera assemblages. Only a few samples, collected in the diatomitic layers, contained a very poor foraminifera fauna.

In the lowermost 11 metres of the section, the planktic assemblage is rich and moderately preserved, being characterized by: *Globorotalia miotumida* gr., *Globigerinella obesa*, *Neogloboquadrina acostaensis* sx., *N. acostaensis* dx., *Globigerinoides obliquus extremus, Gd. obliquus obliquus*, *Globorotalia humerosa praehumerosa*, *Hastigerina siphoniphera*, *Zeaglobigerina apertura*, *Zg. woodi woodi*, *Zg. nepenthes, Zg. decoraperta*, *Globigerina bulloides*, *Orbulina suturalis* and *O. universa* (Table 2).

With regard to the benthic foraminifera, the association consists of *Brizalina* sp., *B.* aff. *dilatata*, *B. dentellata*, *Rectuvigerina siphogenerynoides*, *R. gaudryinoides*, *Heterolepa* sp., *H. mexicana*, *Elphidium crispum*, *Uvigerina* sp., *Cancris oblungus, Gyroidina* sp., *Gyroidinoides* sp., *G. altiformis,* and rare *Cibicidoides pachyderma* (Table 3). The first occurrence of *Bulimina echinata* (sample NP 1852, Tab. 2 and Fig. 5) was recorded at about 10 metres from the base of the section.

In this portion of the section, the coiling change of *Neogloboquadrina acostaensis* (sample AF11, Tab. 3 and Fig. 3) and the appearance of *Globorotalia* gr. *miotumida* (sample AF12, Tab. 3) were also recorded. We did not consider the appearance of *Globorotalia* gr. *miotumida* as its FO, because it occurred when the area studied underwent a change from a shallow to deeper water shelf. To support our hypothesis we propose a stratigraphic correlation with the Pietrasecca section (Cosentino *et al.*, 1997, Pampaloni *et al.*, 1994), occupying an inner domain with respect to the Queglia unit. In the Pietrasecca section the FO of *Globorotalia* gr. *miotumida* occurs in the upper part of the «Marne ad Orbulina» formation, which represents the involvement of Pietrasecca area in a foredeep system (foreland flexure stage) while in the Queglia domain the sedimentary record was still represented by foreland shallow water carbonate deposits (Scandone, 1998, pers. comm.).

Throughout the remaining portion of the section the organic content is poorly diversified both in benthic and planktic foraminifera (Fig. 5).

In sample AF13 the FO of *Turborotalia multiloba* (Tab. 3 and Fig. 5) was recorded; this allowed the recognition of the *Turborotalia multiloba* Subzone (Iaccarino, 1985, modified). After this biostratigraphic event the planktic and benthic foraminifera assemblages become progressively oligotypical.

The planktic foraminifera assemblage is characterized by *Orbulina suturalis, O. universa, Turborotalia quinqueloba, Zeaglobigerina decoraperta, Zg. apertura, Globigerina bulloides* and rare *Neogloboquadrina acostaensis* sx.

The benthic foraminifera assemblage is characterized by *Bulimina aculeata minima*, *B. echinata*, *Brizalina* sp., *B.* aff. *dilatata*, *B. dentellata*, *Elphidium crispum* and *Cibicidoides* sp.. *Rectuvigerina siphogenerynoides*, *R. gaudryinoides* are present only in the lowermost part of this interval. This benthic assemblage corresponds to the one recorded in the Tripoli Fm by Colalongo *et al.* (1979).

11 metres below the evaporitic episode, the FCO of *Turborotalia multiloba* was registered; this is in substantial agreement with the data of Sprovieri *et al.* (1996a and 1996b).

Some horizons (Fig. 5 and Tab. 2) with planktic association characterized by the 80-90% of *Orbulina*, were recognized. These levels are very similar to the «Orbuliniti», described in the upper part of the Tripoli Formation (Sprovieri *et al.*, 1996a and 1996b, Colalongo *et al.*, 1979).

Table 2 - Distribution of planktic foraminifera in the Pescosansonesco section.

LITHOFACIES	SAMPLES	Total abundance	Preservation	Sponge spicules	Radiolarians	Echinids spines
balatino gypsum with marl layers (4)	AF 34	B				
	AF 33	B				
	AF 32B	B				
	AF 32A	B				
	NP 1861	F	P			
	AF 31	B		R	R	
marls with calcitorbiditic and diatomitic layers (3)	AF 30A	F	P			R
	AF 30	B				
	NP 1860	A	M			R
	AF 29	B				
	AF 28	B				
	NP 1859	F	M-P	A		
	NP 1858	C	M	A		F
	AF 27	B		F		
	AF 26	C	P			F
	EP 1393					
	AF 24	F	P			
	AF 23	B				
	AF 22	F	P			
	NP 1857	A	M	P		
	NP 1856	A	M	R		F
	EP 1392	C	P	F		R
	AF 21	C	M	R	R	
	AF 20	C	M	P	R	
	AF 19	C	M-P	R	P	
	AF 18	F	P	P		
	NP 1855	B				
	NP 1854	C	M-P			
	EP 1390	R	P	P	R	
	AF 17	B		C	F	
	AF 16B	R	P	R		
	AF 16	F	M-P	F		
	AF 15	C	M-P			
	AF 14B	B		R	R	
	AF 14	P	P	F	R	
	AF 13B	A	M-P	R		
	AF 13	C	P	R		
pteropods marls (2)	NP 1853	A	M-P			R
	NP 1852	C	M-P	R		R
	AF 12	C	P			R
marly limestones with bivalves (1)	AF 11	C	P			
	AF 10	A	M-P			
	NP 1851	C	P	R		
	AF 9	A	M			
	AF 8	A	M-P			C
	EP 1389	C	P			
	AF 7	A	M-P			

	Ostracods									
SAMPLES	*indeterminate ostracods*	*Aurila* sp.	*Aurila convexa*	*Aurila freudentali*	*Aurila impressa*	*Aurila philippii*	*Cytherelloidea cretensis*	*Hestoleberis* sp.	*Loxoconca* sp.	*Loxoconca puntatella*
AF 34										
AF 33										
AF 32B										
AF 32A										
NP 1861										
AF 31										
AF 30A										
AF 30										
NP 1860			P			P				
AF 29										
AF 28										
NP 1859										
NP 1858										
AF 27										
AF 26					P					
EP 1393										
AF 24	R		P	R						
AF 23										
AF 22										
NP 1857					P				P	P
NP 1856		P								
EP 1392										
AF 21										
AF 20	P									
AF 19										
AF 18										
NP 1855										
NP 1854										
EP 1390										
AF 17										
AF 16B										
AF 16										
AF 15										
AF 14B										
AF 14										
AF 13B										
AF 13								P		
NP 1853							P			
NP 1852										P
AF 12			P	P	P					
AF 11										
AF 10										
NP 1851										
AF 9										
AF 8										
EP 1389										
AF 7										

	Benthic foraminifera													
SAMPLES	*Indeterminate benthic forams*	*Ammonia beccari tepida*	*Anomaloides* sp.	*Bolivina* sp.	*Brizalina* sp.	*Brizalina* aff. *dentellata*	*Brizalina arta*	*Brizalina dilatata*	*Bulimina* sp.	*Bulimina echinata*	*Bulimina aculeata minima*	*Cancris oblungus*	*Cibicidoides* sp.	*Cybicidoides pachyderma*
AF 34														
AF 33														
AF 32B														
AF 32A														
NP 1861				R						F	R		R	
AF 31														
AF 30A	R													
AF 30														
NP 1860										R	P		R	
AF 29														
AF 28														
NP 1859				F									F	
NP 1858								C					A	
AF 27														
AF 26	C													
EP 1393														
AF 24	F													
AF 23														
AF 22														
NP 1857					P					P	P			
NP 1856				F	R					R	R			
EP 1392	F				R					R				
AF 21	F				R									
AF 20	F				R					R	R			
AF 19					R					P				
AF 18	F													
NP 1855														
NP 1854						R		R		R	R			
EP 1390					R				R	P				
AF 17														
AF 16B														
AF 16														
AF 15	R													
AF 14B														
AF 14										P				
AF 13B	A							F		F				
AF 13	F				F				P	F	R			
NP 1853		R		C		F				R	R			
NP 1852						C		F		R	F			
AF 12	F													
AF 11	F				C									
AF 10	P						R							
NP 1851	F			C		F			C		F	P		
AF 9			R		C	P	R					P		P
AF 8					C	F								R
EP 1389	F													
AF 7	P								P					

	Benthic foraminifera (continued)													
SAMPLES	*Elphidium aculeatum*	*Elphidium crispum*	*Floridus* sp.	*Gyroidina* sp.	*Gyroinoides* sp.	*Gyroidinoides altiformis*	*Heterolepa* sp.	*Heterolepa mexicana*	*Lenticulina*	*Rectuvigerina* sp.	*Rectuvigerina elegans*	*Rectuvigerina gaudryinoides*	*Rectuvigerina siphogenerinoides*	*Uvigerina sp.*
AF 34														
AF 33														
AF 32B														
AF 32A														
NP 1861														
AF 31														
AF 30A														
AF 30														
NP 1860		F					R							
AF 29														
AF 28														
NP 1859		R												
NP 1858		F		P										
AF 27														
AF 26		R												
EP 1393														
AF 24		F												
AF 23														
AF 22														
NP 1857	P	R					P					F	R	
NP 1856	P	F												
EP 1392		F												
AF 21		F												
AF 20		R												
AF 19														
AF 18														
NP 1855														
NP 1854		P												
EP 1390		P												
AF 17														
AF 16B														
AF 16														
AF 15													R	
AF 14B														
AF 14												R	R	
AF 13B														
AF 13	P	P								P				
NP 1853		P		P								F	F	
NP 1852		R										F	F	
AF 12	R	R								P	P	P		
AF 11		P								F			P	
AF 10		P												P
NP 1851				R								F	F	C
AF 9		R			P	R		P		F			P	R
AF 8			R				F	R	P	F		F	F	F
EP 1389					R					R			R	F
AF 7												P		P

The organic content decreases near the evaporitic episode (lithofacies 4, Fig. 5), and the marls interlayered with the balatino gypsum are completely barren (Fig. 5). Marine ostracods of inner neritic environment are present in some horizons of the pteropods marls interval and marls with diatomitic layers in the specimens: *Cytherelloidea cf. cretensis*, *Loxoconcha puntatella*, *Xestoleberis sp.*, *Aurila philippii*, *A. convexa*, *A.* cf. *impressa*, *A. freudentali*. (specific identification by B. Dell'Antonia; Tab. 3)

Table 3 - Distribution of benthic foraminifera in the Pescosansonesco section.

LITHOFACIES	SAMPLES	Total abundance	Preservation	*Indeterminate planktic forams*	*Globigerina sp.*	*G. praebulloides*	*D. globularis*	*Globigerinoides sp.*	*P. siakensis*	*Ge. obesa*	*Gq. baromoenensis*	*Gd. quadrilobatus*	*Zg. woodi woodi*	*G. falconensis*	*Gd. trilobus*	*D. altispira altispira*	*Gt. acrostoma*	*Ge. praesiphoniphera*	*P. glomerosa*	*O. suturalis*	*O. bilobata*	*O. universa*	*Gd. bolli*	*Gd. obliquus obliquus*	*Zg. decoraperta*	*Tr. quinqueloba*	*Zg. nepenthes*	*Gt. gr. menardii*	*Gt. partimlabiata*	*Gt. merotumida*	*Zg. apertura*	*G. bulloides*	*N. acostaensis sx*	*Ge. siphoniphera*	*Gd. obliquus extremus*	*Gt. humerosa praehumerosa*	*Gt. gr. miotumida*	*Gt. conomiozea*	*N. acostaensis dx*	*Tr. multiloba*	PLANK. FORAM. ZONE (Iaccarino, 1985 modified)
balatino gypsum with marl layers (4)	AF 34	B																																							non distinctive Zone
	AF 33	B																																							
	AF 32B	B																																							
	AF 32A	B																																							
	NP 1861	F	P	R																																			
	AF 31	B																																							
marls with calcitorbiditic and diatomitic layers (3)	AF 30A	F	P												P																	R							cf				
	NP 1860	A	M																	A		A									P								cf				
	AF 29	B																																							
	AF 28	B																																							
	NP 1859	F	M-P																																						
	NP 1858	C	M	F		P					P											P																			
	AF 27	B																																							
	AF 26	C	P	F	F																																				
	EP 1393																																								
	AF 24	F	P												R							R																			
	AF 23	B																																							
	AF 22	F	P	F																						R															F	
	NP 1857	A	M	F																						C				P			R							C	
	NP 1856	A	M																			P					C					P		P							C	
	EP 1392	C	P	F	R															C		C		R															P	F	
	AF 21	C	M	F																C		C																		F	
	AF 20	C	M	F																									F											C	
	AF 19	C	M-P	F	F																				R	F	R				R									F	
	AF 18	F	P																																						
	NP 1855	B																																							*Turborotalia multiloba* subzone
	NP 1854	C	M-P	R	F									R						F	F	R	A											P							P	
	EP 1390	R	P		R																																				
	AF 17	B																																							
	AF 16B	R	P	R																																			R	
	AF 16	F	M-P	F																						R															R	
	AF 15	C	M-P	F																C		C	P	R							R		F		R				R		
	AF 14B	B																																							
	AF 14	P	P	R	P																																		P	
	AF 13B	A	M-P	F	R								R	R										R							R	R									P	
	AF 13	C	P	F	F																					C							P							R	
pteropods marls (2)	NP 1853	A	M-P	C					P			F			F				R	C		A									R	R	R		R				P		*Globorotalia mediterranea* subzone
	NP 1852	C	M-P	F	R				P	R				P			R			R				P			P		P		R	R	R	R	R				P		
	AF 12	C	P	F	F								F						F	F		C		F			R	P			F	R	R	R	R	P	R	cf	R		
marly limestones with bivalves (1)	AF 11	C	P		F				R													F					F				R	R	C		P	P			P		
	AF 10	A	M-P	C																													F	F		F					
	NP 1851	C	P	F	R										F				R	F		C		F							R		R		R						
	AF 9	A	M	F	C				R	P			C				R		F	F		F		R	R								R			R					
	AF 8	A	M-P	F	C	R		F		R			F			R		R		F		C		C	F						R	R			F						
	EP 1389	C	P	C	F			R												F		C		F		P	R				R		F	P	P						
	AF 7	A	M-P	C									R							C		C			R								F	R		cf					

Nannofossils

The nannofossils are generally abundant and moderately preserved throughout the section studied (Tab. 4). The assemblage consists mainly of abundant to common small-sized morphotypes of genera *Reticulofenestra* and *Dictyococcites*. *Calcidiscus leptoporus*, *Helicosphaera carteri*, *Sphenolithus* spp., *Syracosphaera* spp., *Scyphosphaera* spp. are commonly recorded as well. *Discoaster* spp. (five and six rayed morphotypes), *Amaurolithus primus*, *A. delicatus*, *A. amplificus* (whose FO was detected at about 27 meters

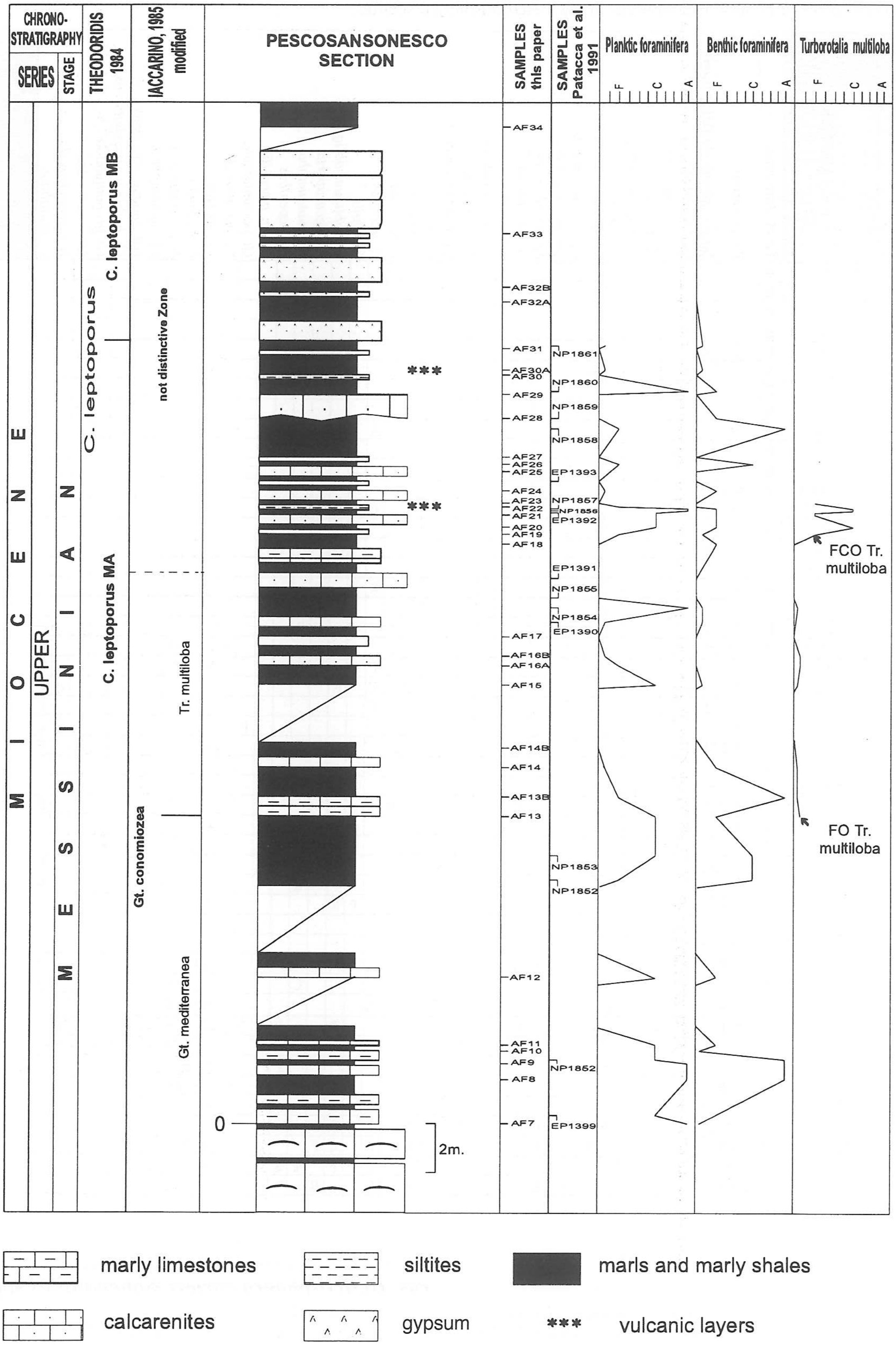

Fig. 5 - Abundance patterns of planktic, benthic foraminifera and *Turborotalia multiloba* in the Pescosansonesco section.

Table 4 - Distribution of calcareous nannofossils in the Pescosansonesco section.

LITHOFACIES	SAMPLES	Total abundance	Preservation	Reworking	Diatoms	*Coccolithus pelagicus*	*Dictyococcites* spp.(small)	*Helicosphaera carteri*	*Calcidiscus leptoporus*	*Sphenolithus* spp. (*abies, compactus, verensis*)	*Discoaster* sp. 6 rays	*Calcidiscus macintyrei* (>11um)	*Triquetrorabdulus rugosus*	*Syracosphaera fragilis*	*Scyphosphaera* spp.	*Discoaster* spp. 5 rays	*Brarudosphaera bigelowii*	*Scapholithus fossilis*	*Reticulofenestra* spp.	*Geminilithella rotula*	*Pontosphaera multipora*	*Reticulofenestra pseudoumbilicus* (>7um)	*Amaurolithus* sp.	*Amaurolithus primus*	*Amaurolithus delicatus*	*Amaurolithus tricorniculatus*	*Amaurolithus amplificus*	NANNOFOSSIL ZONE (Theodoridis, 1984)
balatino gypsum with marl layers (4)	AF33	C	M	C																								Calcidiscus leptopurus Ma
	AF32B	C	M	C	C																							
	AF32A	C	M	C																								
marls with calcitorbiditic and diatonitic layers (3)	AF31	F	G	C		R		A	F																			
	AF30A	F	M	C			A	C		A	R			R					C	R	R				R		P	
	AF30	F	M	C			A	C		A	R			R					C	R	R				R		P	
	AF29	C	G	C			A	C		A	R			R					C	R	R				R		R	
	AF28	F	M	F	C		F	F	R	F									C									
	AF27	F	M	F	A		F	F	R	F									C									
	AF26	C	M	F			A	C											A									
	AF24	C	G	F			A	C		A				R					C	R	R		R	R	R	P	R	
	AF23	C	M/P	F		F	A	C	C												F		R	P	R		cf	
	AF22	F	M	C		R	F	C			R					F	R			F								
	AF21	F	M	C		R	F	C			R					F	R			F			P	P	R		P	
	AF20	C	M/P	F		F	A	A	C		F					P					F						cf	
	AF19	C	M/P	F		F	A	A	C		F					P					F						cf	
	AF18	C	M/P	C			C	C		A	C					P					C	R					cf	
	NP1854	C	M/P	C			C	C		A	C					P					C	R			R		R	
	AF17	C	M	F			A	C	C	A	R	R									F							
	AF16B	C	M	F			A	C	C	A	R	R									F							
	AF15	A	M	C			A	F		C	R			R		P						F			R			
	AF14B	F	M	C	A		F	F	R	F									C									
	AF14	F	M	F	A		F	C	R	F									C									
	AF 13	A	M/P	C		F	C	C	R	C	C	R	F	R	R	R	F	F	F	F			P	R	R			
	AF13B	F	M			R			A		R											F	P					
marly limestones with bivalvess (1) / pteropods marls (3)	AF12	C	M	C		F	A	C	C		R				F		F							P				
	AF11	C	P	F		F	C	F			R								F					P				
	AF10	C	M/P	C		R	C	C	C		F				C	P			C		F							
	NP1851	A	M/P	C		F	A	C	C	C	A	R			C	P		F		C	C	P	R	R				
	AF 9B	C	M	C		F	C	C	R	C	R	R	F	P	R	P	F	F	F									
	AF 9A	A	M/P	C		F	A	C	C	C	A	R			C	P		F		C	C	P	R	R				
	AF 8	C	M	C		F	C	C	R	C	R	R	F	P	R	P	F	F	F									
	AF 7	F	M	C		F	C	F	C		P	R	R	P	F								?	?				

from the base of the section, sample NP1854), *Calcidiscus macintyrei*, *Geminilitella rotula* and *Braarudosphaera bigelowii* occur in lower percentage. Common Late Cretaceous, Paleogene and Early Miocene reworked specimens are also present. For this reason, we place the section studied within the *Calcidiscus leptoporus* MA Subzone (Theodoridis, 1984), due to the occurrences of *Amaurolithus primus*, *Amaurolithus delicatus*, *Amaurolithus amplificus* and to the absence of *Reticulofenestra rotaria*.The abundance of Discoasterids is generally low throughout the section; noteworthy are the levels rich in siliceous microfossils and organic matter, that are devoid of Discoasterids. According to Raffi & Flores (1995) the occurrence of Discoasterid-depleted levels may be linked to enhanced upwelling conditions. Moreover, the state of preservation of *Discoaster* is so poor that specific identification is hampered; for this reason we prefer to label them only as *Discoaster* spp. six and/or five rayed forms.

The genus *Helicosphaera* is represented mainly by *Helicosphaera carteri*, occurring with high-frequency values (almost 90%); we were not able to detect the occurrence of «small» *Helicosphaera* whose LO follows the FO of *Amaurolithus* (Negri & Vigliotti, 1997).

The occurrence of *Amaurolithus* is scattered and with low-frequency values. We recorded the presence of *Amaurolithus primus*, *Amaurolithus delicatus* and the FO of *Amaurolithus amplificus*. The presence of many intermediate forms is noteworthy suggesting the possibility of more detailed analysis of this genus in this interval.

As for the occurrence of *Globorotalia miotumida* gr. (see previous paragraph), we do not consider the appearance of *Amaurolithus primus* in the lower part of the section as its first occurrence.

In the marls with diatomitic layers an oligotypical assemblage dominated by *Calcidiscus leptoporus* was recorded (sample AF 13). Similar levels were described from the Tripoli Formation by Sprovieri *et al.*, (1996a and 1996b).

Conclusions

This study provides new information about the early Messinian bioevents (calcareous nannofossils and foraminifera) in the hemipelagic deposits of the Queglia unit.

We were able to state more exactly the FO of *Bulimina echinata,* FO and FCO of *Turborotalia multiloba* and FO of *Amaurolithus amplificus.*

Noteworthy are the many analogies between the Pescosansonesco section and the typical lower Messinian Mediterranean sequences (Sprovieri *et al.*, 1996a and 1996b; Colalongo *et al.*, 1979) such as:

- the appearance of *Bulimina echinata* marking a change from highly diversified assemblages to oligotypical ones both for planktic and benthic foraminifera;
- the presence of «Orbuliniti» and diatomitic layers;
- the presence of oligotypical calcareous nannofossils assemblages dominated by *Calcidiscus leptoporus*;
- the FO of *Amaurolithus amplificus* predating the FCO of *Turborotalia multiloba* just below the evaporitic episode.

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Taxonomic references

Selected foraminifera and calcareous nannofossils considered in this study (in alphabetic order of generic epithets).

Planktic Foraminifera

Globigerina bulloides d'Orbigny, 1826

Globigerinoides obliquus extremus Bolli & Bermudez, 1965

Globigerinoides obliquus obliquus Bolli, 1957

Globorotalia humerosa praehumerosa Natori, 1976

Globorotalia gr. *miotumida* sensu Sierro *et al.*, 1993

PLATE 1

Figs. 1, 2	*Globigerinoides obliquus extremus* Bolli & Bermudez. Fig. 1: umbilical view; Fig. 2: spiral view. Sample AF8. (x 60).
Figs. 3, 4	*Globigerinoides obliquus obliquus* Bolli. Fig. 3: umbilical view; Fig. 4: spiral view. Sample AF8. (x 60).
Figs. 5, 6	*Globorotalia miotumida* gr. (*sensu* Sierro *et al.*, 1993). Fig. 5: umbilical view; Fig. 6: axial view. Sample AF12. (x 60).
Figs. 7, 8	*Globorotalia humerosa praehumerosa* Natori. Fig. 7: umbilical view; Fig. 8 spiral view. Sample AF9. (x 60).
Figs. 9, 10	*Neogloboquadrina acostaensis* (Blow) dx. Fig. 9: umbilical view; Fig. 10: spiral view. Sample AF11. (x 110).
Figs. 11, 12	*Neogloboquadrina acostaensis* (Blow) sx. Fig. 11: umbilical view; Fig. 12: spiral view. Sample AF11. (x 110).
Figs. 13, 14	*Turborotalia multiloba* (Romeo). Fig. 13: umbilical view; Fig. 14: spiral view. Sample AF13. (x 140).
Figs. 15, 16	*Turborotalia quinqueloba* (Natland). Fig. 15: umbilical view; Fig. 16: spiral view. Sample AF19. (x 140).
Fig. 17	*Brizalina arta* (Mac Fadyen). Sample AF9. (x 40).
Fig. 18	*Bulimina aculeata minima* Tedeschi & Zanmatti. Sample AF13. (x 110).
Fig. 19	*Bulimina echinata* d'Orbigny. Sample AF13. (x 110).
Fig. 20	*Rectuvigerina gaudryinoides* (Lipparini). Sample AF 8. (x 25).
Fig. 21	*Rectuvigerina siphogenerinoides* (Lipparini). Sample AF8. (x 30).
Fig. 22	*Brizalina dentellata* (Tavani). Sample AF20. (x 60).

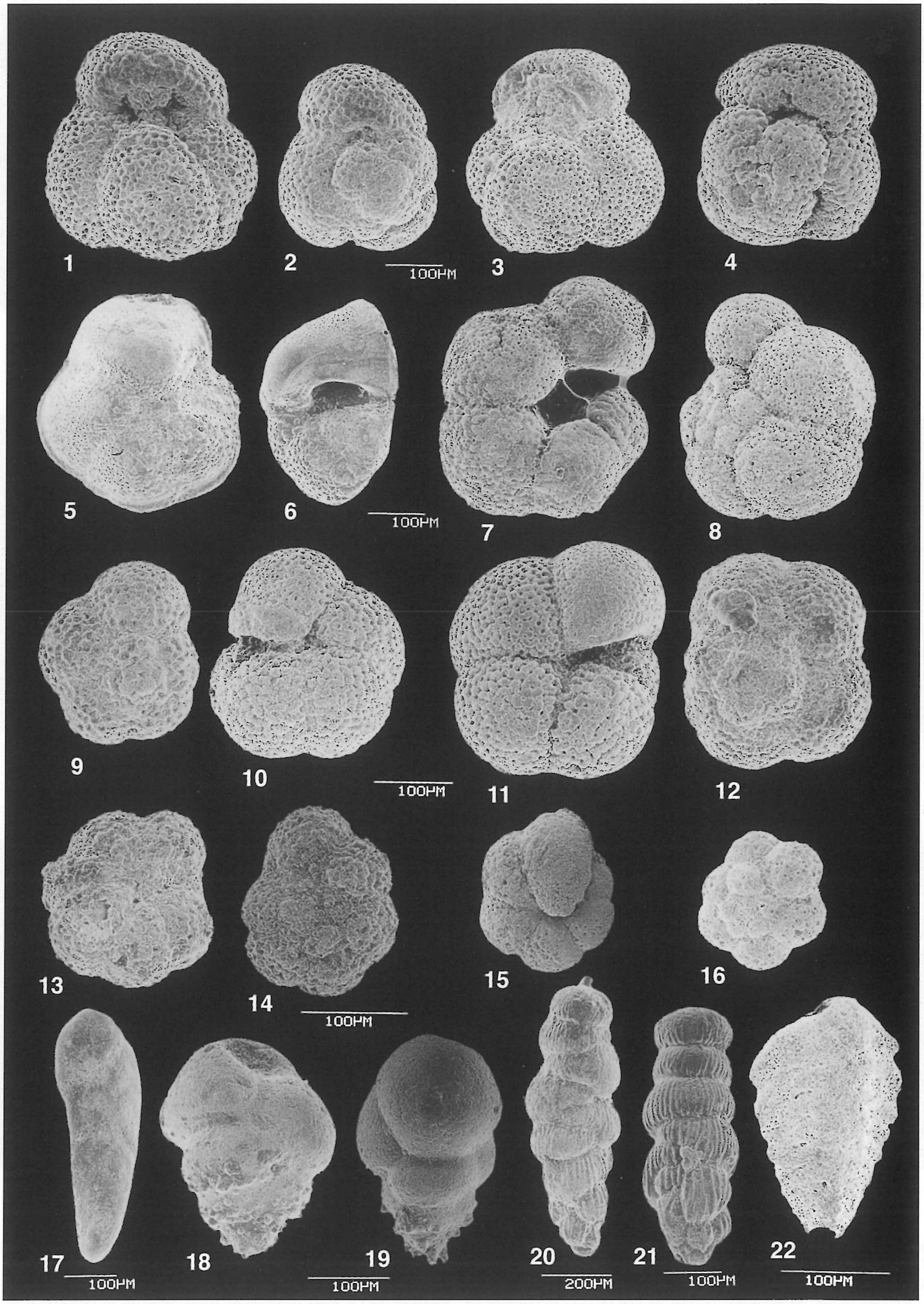
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PLATE 1

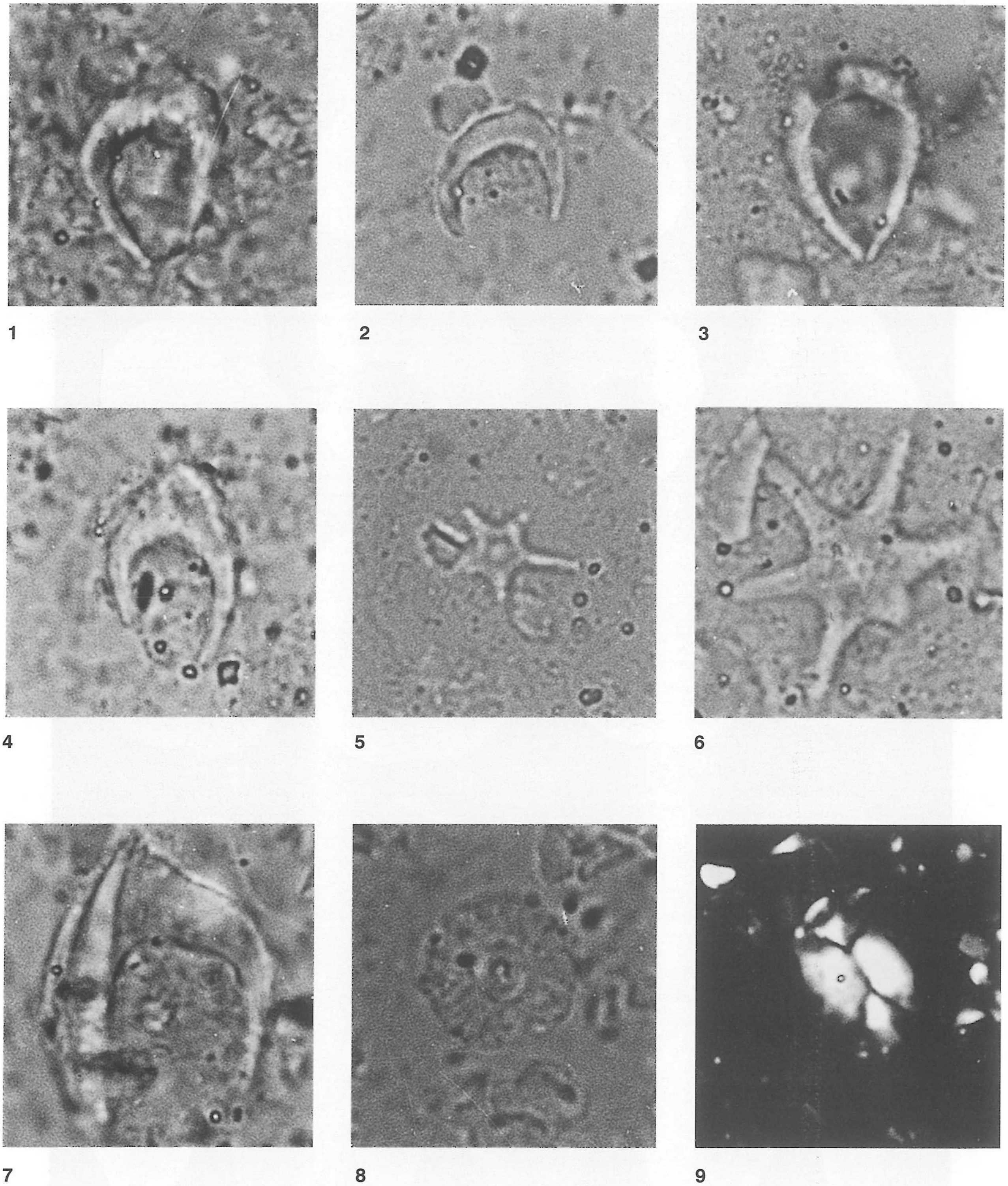

PLATE 2

All specimens x 2400. Fig. 1: *Amaurolithus primus* (Bukry and Percival) Gartner and Bukry. Sample AF9A. Fig. 2: *Amaurolithus* sp.. Sample AF13B. Fig. 3: *Amaurolithus delicatus* Gartner & Bukry. Sample AF23. Fig. 4: *Amaurolithus* sp.. Sample AF23. Fig. 5: five-rayed *Discoaster* sp., sample AF13. Fig. 6: six-rayed *Discoaster* sp.. Sample AF13. Fig. 7: *Amaurolithus amplificus* (Bukry & Percival) Gartner and Bukry. Sample NP1854. Fig. 8: *Calcidiscus leptoporus* (Murray & Blackman) Loeblich & Tappan. Sample AF13B. Fig. 9: *Helicosphaera carteri* (Wallich) Kamptner. Sample AF 13.

Hastigerina siphoniphera siphoniphera (d'Orbigny), 1839
Neogloboquadrina acostaensis acostaensis (Blow), 1959
Orbulina suturalis Brönnimann, 1951
Orbulina universa d'Orbigny, 1839
Turborotalia multiloba (Romeo), 1965
Turborotalia quinqueloba (Natland), 1938
Zeaglobigerina apertura (Cushman), 1918
Zeaglobigerina decoraperta (Takayanagi & Saito), 1962
Zeaglobigerina nepenthes (Tood), 1957
Zeaglobigerina woodi woodi (Jenkins), 1960
Benthic Foraminifera
Brizalina arta (MacFadyen), 1930
Brizalina dentellata (Tavani), 1955
Brizalina aff. Brizalina dilatata (Reuss, 1850)
Bulimina aculeata minima Tedeschi & Zanmatti, 1957
Bulimina echinata d'Orbigny, 1852
Cancris oblongus (Williamson), 1858
Cibicidoides pachyderma (Rzehak), 1886
Elphidium crispum (Linnè), 1758
Gyroidinoides altiformis (Stewart and Stewart), 1930
Heterolepa mexicana (Nuttall), 1932
Rectuvigerina gaudryinoides (Lipparini), 1932
Rectuvigerina siphogenerinoides (Lipparini), 1932
Calcareous Nannofossils
Amaurolithus amplificus (Bukry and Percival, 1971) Gartner and Bukry, 1975
Amaurolithus delicatus Gartner and Bukry, 1975
Amaurolithus primus (Bukry and Percival, 1971) Gartner and Bukry, 1975
Braarudosphaera bigelowii (Gran and Braarud, 1935) Deflandre, 1974
Calcidiscus leptoporus (Murray and Blackman, 1988) Loeblich and Tappan, 1978
Calcidiscus macintyrei (Bukry and Bramlette, 1969) Loeblich and Tappan, 1978
Geminilithella rotula (Kamptner, 1956). Backman, 1980
Helicosphaera carteri (Wallich, 1877) Kamptner, 1954
Reticulofenestra rotaria Theodoridis, 1984

References

Cande, S.C., Kent D.V., 1995. Revised calibration of the geomagnetic polarity time for the Late Cretaceous and Cenozoic. J. geophys. Res., 100: 6093-6095.

Colalongo, M.L, Di Grande, A., D'Onofrio, S., Iaccarino, S., Mazzei, R., Romeo, M., Salvatorini, G., 1979. Stratigraphy of the late Miocene italian sections straddling the Tortonian/Messinian boundary. Boll. Soc. paleont. ital., 18 (2): 258-302.

Cosentino, D., Carboni, M.G., Cipollari, P., Di Bella, L., Florindo F., Laurenzi M.A., Sagnotti L., 1997. Integrated stratigraphy of the Tortonian/Messinian boundary: The Pietrasecca composite section (Central Apennines, Italy). Eclogae geol. Helv. 90: 229-244.

Iaccarino S., 1985. Mediterranean Miocene and Pliocene Planktic Foraminifera. In: H.M. Bolli, J.B. Saunders and K. Perch-Nilsen (Eds.), Plankton Stratigraphy. Cambridge Univ. Press, 1: 283-314.

Lirer, F., 1998. A new technique for retrieving calcareous microfossils from lithified lime deposits. Palaeopelagos, 1998 (Submitted)

Martini, E., 1971. Standard Tertiary and Quaternary calcareous nannoplankton zonation. In: A. Farinacci (Eds.), Proceedings of the Second Planktonic Conference. Roma 1970. Tecnoscienza. 739-785.

Negri, A., Vigliotti, L., 1997. Calcareous nannofossil biostratigraphy and paleomagnetism of the Monte Tondo and Monte del Casino sections (Romagna Appennines, Italy). In: A. Montanari, G.S. Odin and R. Coccioni (Eds.), Miocene Stratigrapgy: an integrated approach. Elsevier Science D.V., 475-491.

Okada, H., Burky, D., 1980. Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation: Marine Micropalentology, 5: 321-325.

Pampaloni, M.L., Pichezzi R.M., Raffi I., Rossi M., 1994. Calcareous planktonic biostratigraphy of the marne a *Orbulina* unit (Miocene, central Italy). In: R. Coccioni , A Montanari, and G.S. Odin, (Eds), Miocene stratigraphy of Italy and adjacent regions. Gior. Geol., 3, 56 (1): 139-153.

Patacca, E., Scandone, P., Bellatalla, M., Perilli, N., Santini U., 1991. La zona di giunzione tra l'arco Appenninico Settentrionale e l'arco Appenninico Meridionale nell'Abruzzo e nel Molise. Studi Geologici Camerti, Vol. Speciale (1991/2), CROP 11: 417-441.

Raffi, I., Flores, J.A., 1995. Pleistocene through Miocene calcareous nannofossils from Eastern Equatorial Pacific Ocean (LEG 138). In: N.G. Pias, L.A.Mayer, *et al.* (Eds.), Proc. ODP, Scient. Res., 138: 233-286.

Shackleton, N.J., Baldauf, J.G., Flores, J.A., Moore, T.C. Jr, Raffi, I., Vincent, E., 1995. Biostratigraphic Summary for LEG 138 In: N.G. Pias, L.A. Mayer, *et al.* (Eds.), Proc. ODP, Scient. Res., 138: 517-533.

Sprovieri, R., Di Stefano, E., Caruso, A., Bonomo, S., 1996a. High resolution stratigraphy in the Messinian Tripoli Formation in Sicily. Palaeopelagos, 6: 415-435.

Sprovieri, R., Di Stefano, E., Sprovieri M., 1996b. High resolution chronology for late Miocene Mediterranean stratigraphic events. Riv. ital. Paleont. Stratigr., 102 (1): 77-104.

Theodoridis, S., 1984. Calcareous nannofossil biozonation of the Miocene and revision of the Helicoliths and Discoasters. Utrecht Micropaleont. Bull., 32: 1-271.

(ms. pres. il 30 luglio 1997; ult. bozze l'11 settembre 1998)