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HIGH RESOLUTION BIOCHRONOLOGY IN THE MONTE NARBONE
FORMATION OF THE CAPO ROSSELLO SECTION
AND THE MEDITERRANEAN FIRST OCCURRENCE OF
GLOBOROTALIA TRUNCATULINOIDES

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Riassunto. L'analisi quantitativa delle associazioni a Foraminiferi planctonici nel segmento riferibile al Pliocene superiore e al Pleistocene inferiore nella sezione di Capo Rossello ha evidenziato lo stesso numero di fluttuazioni di abbondanza relativa della unità tassonomica *Globigerinoides ruber* riconosciuto nello stesso intervallo stratigrafico di altre successioni mediterranee.

Tra il livello di comparsa di *Globorotalia inflata* e il livello di scomparsa di *Discoaster browneri* sono presenti 4 fluttuazioni di abbondanza relativa. Poichè l'estinzione di *D. browneri* nel Mediterraneo è al di sotto della base dell'evento magnetico Olduvai e coincide con la fluttuazione 73, la comparsa di *Gt. inflata* coincide con la fluttuazione 80. La comparsa di *Globorotalia truncatulinoides* coincide con la seconda fluttuazione al di sopra della comparsa di *Gt. inflata* e con la seconda fluttuazione al di sotto della scomparsa di *D. browneri*. Pertanto tale evento coincide con la fluttuazione 77. L'età attribuita a questi 3 eventi biostratigrafici è rispettivamente di 1.99, 2.07 e 2.13 MA. I principali eventi a nannofossili calcarei, riconosciuti su basi quantitative, sono stati correlati con le fluttuazioni di abbondanza relativa della unità tassonomica a *Globigerinoides ruber*.

Abstract. Quantitative analysis on the planktonic foraminiferal assemblages in the Late Pliocene - Early Pleistocene segment of the Capo Rossello section evidences the same number of relative abundance fluctuations of the *Globigerinoides ruber* taxonomic unit recorded in the same stratigraphic interval of other Mediterranean sequences.

Between the *Globorotalia inflata* FO and the *Discoaster browneri* LO 4 relative abundance fluctuations are present. Since the *D. browneri* LO is recorded in the Mediterranean basin below the base of the Olduvai magnetic event and in coincidence of relative abundance fluctuation 73, the *Gt. inflata* FO is coincident with fluctuation 80. The first appearance of *Globorotalia truncatulinoides* is recorded on the second fluctuation above the *Gt. inflata* FO and on the second fluctuation below the *D. browneri* LO. Therefore the *Gt. truncatulinoides* FO is coincident with fluctuation 77. The absolute age proposed for these 3 bio-events is 1.99, 2.07 and 2.13 MA respectively. The most important calcareous nannofossil events, recognized by quantitative analysis, have been correlated to the abundance fluctuations of the *Globigerinoides ruber* taxonomic unit.

Introduction.

In the upper part of the Pliocene, from just below the *Discoaster tamalis* LCO (Last Common Occurrence) (Sprovieri et al., 1993) to the Plio-Pleistocene boundary, the relative abundance of the *Globigerinoides ruber* taxonomic unit (TU) underwent large, periodic fluctuations correlatable with the obliquity astronomical cycles (Sprovieri, 1992, 1993). They allow a detailed chronological estimates of the several bio-events occurring in this stratigraphic interval, since to every bio-event the age of the corresponding fluctuation can be ascribed.

In order to further control the data reported by Sprovieri (1992, 1993), the abundance fluctuations of the planktonic foraminiferal assemblage in the upper part of the Capo Rossello section, referable to the Late Pliocene and Early Pleistocene, have been studied.

Materials.

The Plio-Pleistocene sequence outcropping in the Capo Rossello area (Fig. 1) has been studied by several Authors (Cita & Gartner, 1973; Sprovieri, 1978; Rio et al., 1984; Zachariasse et al., 1989; Langereis & Hilgen, 1991; Hilgen, 1991, among others). Many of these papers dealt essentially with the segment between the base of the Plio-

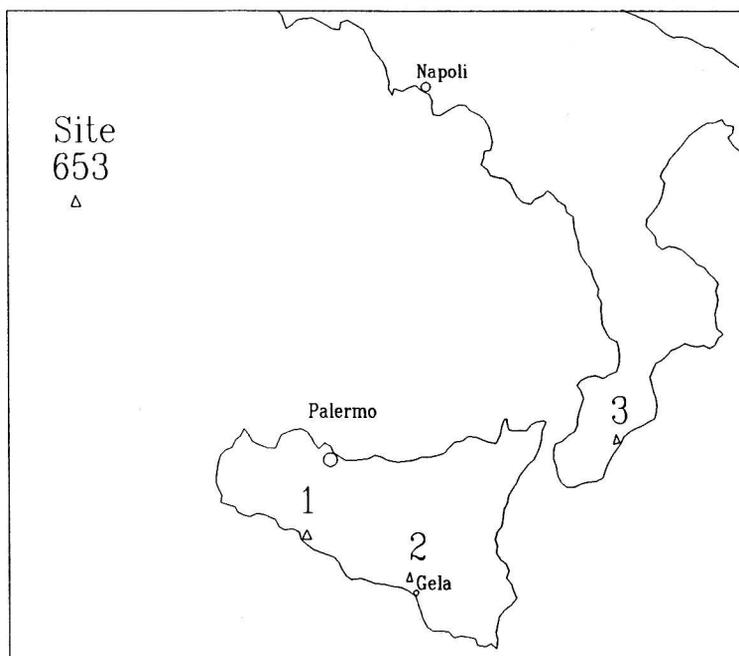


Fig. 1 - Index map of the considered sections. 1) Capo Rossello; 2) Monte S. Nicola; 3) Singa. Location of ODP Site 653 is also indicated.

cene and the lower part of the marls of the Monte Narbone Formation, below the extinction level of *Discoaster pentaradiatus*. In this paper the marly interval between this biostratigraphic level and the biocalcarenic bed rich in *Arctica islandica* outcropping at the top of the section is studied.

Samples have been collected each meter, for a total thickness of 214 m. Some segments above the *Globorotalia inflata* FO have been sampled every 50 cm. The lowermost sample is 1 m below a 20 cm thick laminitic black level which is 15 m below the *D. pentaradiatus* LO. It is correlatable with the laminitic black level that in the Monte S. Nicola section outcrops just below the *D. pentaradiatus* LO and only 1 m above the Gauss/Matuyama boundary (Channell et al., 1992). According to Sprovieri (1992), in the Monte San Nicola section this level coincides with the *Gd. ruber* TU abundance fluctuation labelled with number 103. Other laminated levels outcrop at 132, 141 and 166 m above the base. The first and third level are about 20 cm thick and black in colour. The second one is about 150 cm thick and reddish. The uppermost laminated level is 5 meters above the base of the *Globigerina cariacensis* Zone. The sequence is more and more silty upwards. The presence of more clastic sediments is evidenced by discrete, brownish coloured bands intercalated with gray coloured, less thick bands interpreted as condensed intervals in coincidence of relatively high stands.

The section is closed at the top by a thick bioclastic, fossiliferous bed in which *Arctica islandica* is present. The uppermost studied sample comes from a level about 7 meters below the base of the biocalcarenic bed. A total of 226 samples has been studied.

Methods.

Standard techniques of preparation and study have been used for the planktonic foraminiferal analysis. Quantitative data come from the residue greater than 125 microns from which not less than 300 specimens have been counted. Raw data have been normalized to 100.

The calcareous nannofossil biostratigraphic analysis has been carried out by polarizing light microscope on smear slides prepared from each of the samples used for planktonic foraminifera. A small quantity (5-10 mm³) of sediment from a fresh surface of rock sample was smeared onto a glass slide, using a drop of distilled water. Following Backman & Shackleton (1983) and Rio et al. (1990) quantitative data have been obtained by two different methodologies. Quantitative data on discoasterids have been obtained by counting the number of the index species in a prefixed area of the slide (4.15 mm²). Percent values of *D. triradiatus* are plotted versus the total number of *D. brouweri* morphotypes. Quantitative data on *Calcidiscus macintyreii* and *Gephyrocapsa* spp. > 5.5 μ m have been obtained by counting the index species vs. a fixed number (100 specimens) of taxonomically related forms, *Calcidiscus* spp. and *Gephyrocapsa* spp. > 4 μ m respectively. Finally, the *Gephyrocapsa oceanica* s.l. FO has been identified by counting 300 specimens of placoliths larger than 3 μ m. We intentionally adopted these quantitative methodologies in order to compare our results with already published quantitative data from other Pliocene Mediterranean sequences, in which quantitative distribution patterns were obtained following the same methods (Rio et al., 1990; Channell et al., 1992). Quantitative data were produced only from just above or just below the extinction or appearance level of the considered marker.

Lourens et al. (1992) report an in-phase relationship between SST, PCA-2 and $\delta^{18}\text{O}$ isotope fluctuations for the Pliocene of the Upper Singa section. SST and PCA-2 positive values, that strongly depend from abundance of *Globigerinoides* species among which *Gd. ruber* is dominant, equate with negative $\delta^{18}\text{O}$ values and viceversa. It is therefore assumed that abundance fluctuations of the *Gd. ruber* TU respond in phase with $\delta^{18}\text{O}$ record, with high values of relative abundance of *Gd. ruber* which equate negative $\delta^{18}\text{O}$ values and viceversa.

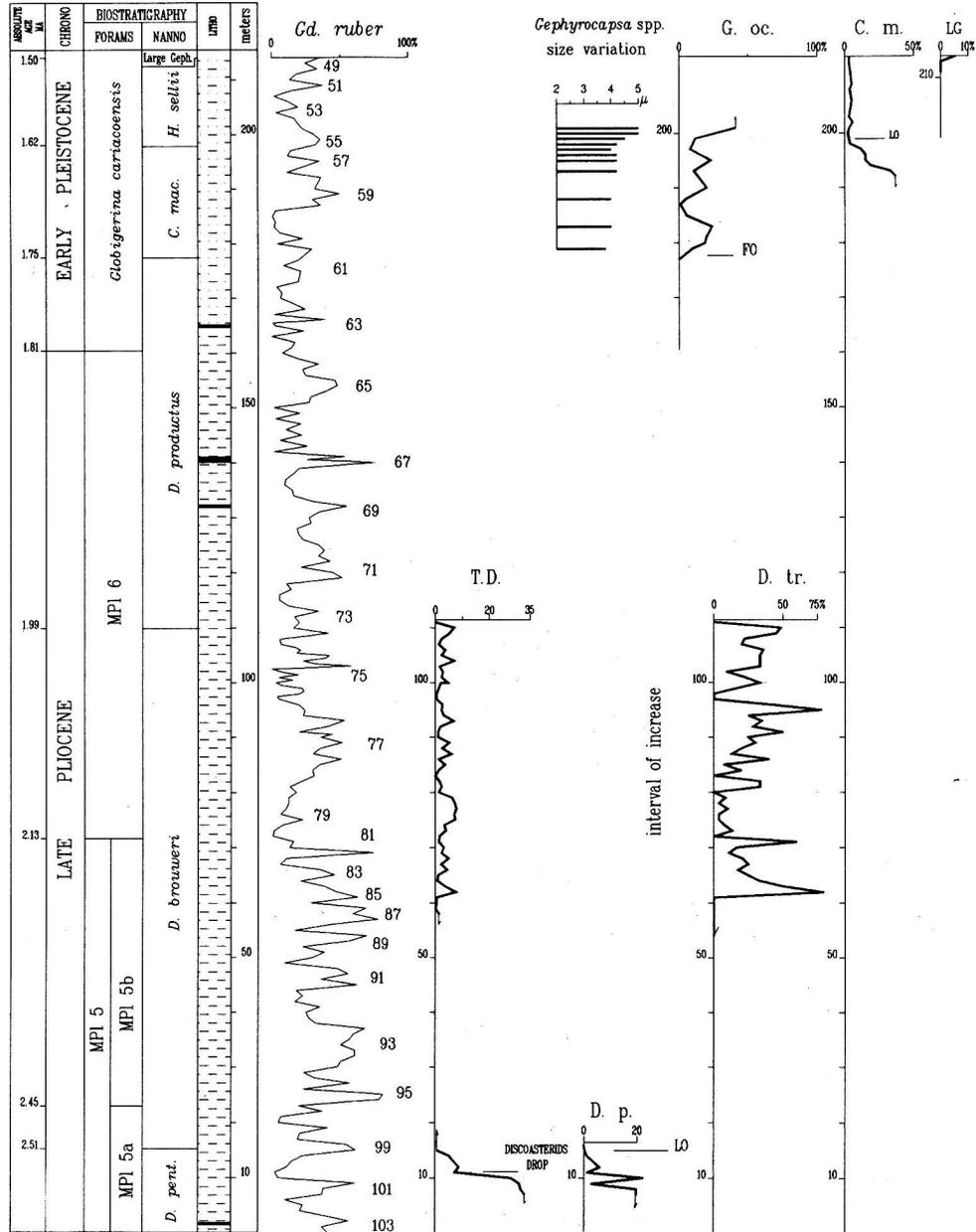
Biostratigraphy.

The planktonic foraminiferal biostratigraphic schemes proposed for the Mediterranean Pliocene by Cita (1973, 1975) and emended by Rio et al. (1984) and Sprovieri (1992, 1993) and proposed by Ruggieri et al. (1984) for the Pleistocene interval have been used. For the calcareous nannofossil assemblage taxonomic concepts and zonation are after Rio et al. (1990), but the definition of the top of the *Discoaster tamalis* Zone has been amended. Rio et al. (1990), followed by Channell et al. (1992) and Sprovieri (1992) defined this biostratigraphic event at the level in which *D. tamalis* percent values in the *Discoaster* population drop below 1%. This level is difficult to be detected in terrigenous sequences in which reworking noise may easily affect small percent values. Therefore Sprovieri et al. (1993) propose to define the top of the *D. tamalis* Zone in coincidence of the consistent drop in percent values which occurs above the top of the *D. tamalis* paracme. The biostratigraphic subdivision of the studied section and the results of quantitative distribution of the calcareous plankton nannofossil markers just above or below the relative biostratigraphic event are plotted in Fig. 2. In terms of planktonic foraminifera biostratigraphy the studied segment belongs to the MPL 5 (pars), MPL 6 and *Globigerina cariacensis* Zones. In terms of calcareous nannofossil biostratigraphy it belongs to the *Discoaster pentaradiatus* (upper part), *Discoaster brouweri*, *Dictyococcites productus*, *Calcidiscus macintyreii* and *Helicosphaera sellii* Zones. In the top sample the base of the Large *Gephyrocapsa* Zone is recognized. In the same sample *Hyalinea baltica* is present and therefore this level coincides with the base of the Emilian substage (Ruggieri et al., 1984; Rio et al., 1991). According to the chronological estimates proposed by Sprovieri (1992, 1993) the studied segment spans a time interval of 1.1 MA, between 2.59 and 1.50 MA.

Fig. 2 - Calcareous plankton biostratigraphy and quantitative distribution of the calcareous nannofossil markers in the Capo Rossello section. Quantitative data have been produced only just above and below the first or last occurrence level of the considered markers. T.D. = Total *Discoaster* (number of specimens \times mm^2); D. p. = *Discoaster pentaradiatus* (number of specimens \times mm^2); D. tr. = percent of *Discoaster triradiatus* vs. total number of *D. brouweri*; G. oc. = *Gephyrocapsa oceanica* s. l., % of 300 placoliths; C. m. = *Calcidiscus macintyreii*, % of 100 *Calcidiscus*; LG = *Gephyrocapsa* spp. > 5.5 μm , % of 100 *Gephyrocapsa* spp. > 4 μm . For comparison, abundance fluctuations of *Gd. ruber* are reported on the left. Black bars indicate laminitic levels.

Correlability of calcareous nannofossil events.

Quantitative analysis has been used to identify calcareous nannofossil events in the marls of the Monte Narbone Formation of the Capo Rossello section. Results are plotted against depth and the *Gd. ruber* TU relative abundance fluctuations in Fig. 2.



The identified biostratigraphic events result respectively correlated with the same abundance fluctuations on which they have been reported in other Mediterranean sequences (Monte S. Nicola, ODP Site 653, Vrica, Singa; Sprovieri, 1992, 1993). Therefore they are synchronous in these sections. These sections are located in different basins and different sedimentary settings and we extrapolate that the considered bio-events are synchronous within the Mediterranean.

Most of them can be easily identified both in pelagic and terrigenous sequences, but the recognition of the *C. macintyreii* LO in the 2 different sedimentary environments deserves more comments. Traceability is one of the most important requisite of a biostratigraphic marker. In order to make this event consistently traceable among different sections Rio et al. (1990) proposed the *C. macintyreii* LO at the level in which the relative abundance of *C. macintyreii* within the *Calcidiscus* population drops below 1%. The so identified extinction level occurs between the *G. oceanica* s.l. FO and the appearance of *Gephyrocapsa* spp. 5.5 μm . This level is coincident with the abundance increase of *G. oceanica* s.l., which is less frequent below. Rio (1982) proposed an evolutionary trend in the gradual increase in size within the *Gephyrocapsa* population from 2-3 to 6-7 μm in the Late Pliocene-Early Pleistocene stratigraphic interval (from the *D. brouweri* Zone to the Large *Gephyrocapsa* Zone). The *C. macintyreii* LO is just below the level in which specimens 5 μm in size are dominant in the *Gephyrocapsa* population. In the terrigenous Pleistocene sequence of Capo Rossello reworked calcareous nannofossil specimens are frequent (Rio et al., 1984) and they may affect the recognition of this bio-event. *C. macintyreii* is abundant up to 198 m (Fig. 2). At this level its abundance sharply decreases, but it is present with percent values of 2-5 % up to the top of the sequence which belongs to the Large *Gephyrocapsa* Zone, when *C. macintyreii* is surely extinct (Backman & Shackleton, 1983; Takayama & Sato, 1987; Rio et al., 1990). Just above the drop in abundance of *C. macintyreii*, *G. oceanica* s.l. abundance increases and morphotypes about 5 μm in size appear (Fig. 2). Since relative abundance values of *C. macintyreii* greater than 1% are still present at levels belonging to the Large *Gephyrocapsa* Zone, the proposed threshold of 1% of relative abundance to identify its extinction level cannot be used. Therefore we recognize with the best approximation the extinction level of *C. macintyreii* in coincidence of its sharp drop in relative abundance identified at 198 m. This drop occurs just below the appearance of morphotypes of *Gephyrocapsa* spp. about 5 μm in size and just below the increase in relative abundance of *Gephyrocapsa oceanica* s.l. (Fig. 2). Similar distribution pattern of *C. macintyreii* is present in other terrigenous sequences outcropping in southern Sicily, in which *C. macintyreii* is continuously present with relative abundance values greater than 1-2% even in the stratigraphic interval referable to the Large *Gephyrocapsa* Zone or younger.

Quantitative analysis.

For the quantitative analysis of the planktonic foraminiferal assemblage the taxonomic units (TU) reported in Tab. 1 have been considered. For the purpose of this

<i>Globigerina bulloides</i> s.l.	<i>Globigerinoides obliquus</i> s.l.
<i>Neogloboquadrina dutertrei</i>	<i>Globigerinoides ruber</i> s.l.
<i>Neogloboquadrina pachyderma</i>	<i>Globigerinoides quadrilobatus</i>
<i>Globorotalia acostaensis</i> (and <i>G. planispira</i>)	<i>Hastigerina siphonifera</i>
<i>Globorotalia crassaformis</i> s.l.	<i>Orbulina</i> spp.
<i>Globorotalia inflata</i> s.l.	<i>Turborotalita quinqueloba</i>
<i>Globorotalia scitula</i>	<i>Sphaeroidinella debiscens</i>
<i>Globorotalia truncatulinoides</i> s.l.	

Tab. 1 - Taxonomic units counted in the planktonic foraminiferal assemblage. The component members of each category are reported in Sprovieri (1992).

paper only the relative abundance of the *Globigerinoides ruber*, *Globorotalia inflata* and *Globigerinoides quadrilobatus* TUs are reported in Fig. 3. The *Gd. ruber* TU clearly shows periodic fluctuations throughout the section. The interval between the base of the sequence and the *D. brouweri* LO has been preliminarily considered. The absolute ages of these 2 levels can be estimated at 2.59 and 1.99 MA respectively (Sprovieri, 1993) and therefore this segment covers a time interval of 0.6 MA. In this interval 15 main abundance fluctuations of the *Gd. ruber* TU are present, more or less equally spaced. They are reported and labelled in Fig. 3. Therefore the periodicity of these main abundance fluctuations is 40 KA. Between the *D. brouweri* LO and the *Gephyrocapsa oceanica* s.l. FO 6 fluctuations are present (Fig. 3). Again a periodicity of 40 KA is present in this segment, which covers a time interval of 0.24 MA (Sprovieri, 1993). Finally, 6 irregularly thick fluctuations are present between the *G. oceanica* s.l. FO (at 1.75 MA) and the top of the section (Fig. 3), which is coincident with the base of the Large *Gephyrocapsa* Zone and has an absolute age of 1.50 MA (Sprovieri, 1993). Therefore also in this segment a periodicity of about 40 KA is obtained. The value of these periodicities is well referable to the periodicity of the obliquity astronomical cycles, which have a mean value of 41 KA (Berger, 1984). The same number of fluctuations of the *Gd. ruber* TU in the Monte S. Nicola section and at Site 653 (Sprovieri, 1992, 1993) is present in the correlatable stratigraphic intervals and biostratigraphic events coincide with the same fluctuation in which they have been recorded in the other 2 sequences.

The thickness of fluctuations in the uppermost segment, above the *Calcidiscus macintyreii* LO, is irregular, with the "warm" intervals generally less expanded than the cold ones. In this part of the sequence the repeated condensed intervals, which coincide with the "warm" fluctuations of the *Gd. ruber* TU, can explain this irregularity.

The Mediterranean First Occurrence of *Globorotalia truncatulinoides*.

Rio et al. (1984) reported the first Mediterranean occurrence of *Gt. truncatulinoides* well below the Plio-Pleistocene boundary as defined in the Vrica section and near the *Globorotalia inflata* FO. Since then, other Authors reported the first appearance of *Gt. truncatulinoides* in Pliocene levels (Glaçon et al., 1990, at Site 653;

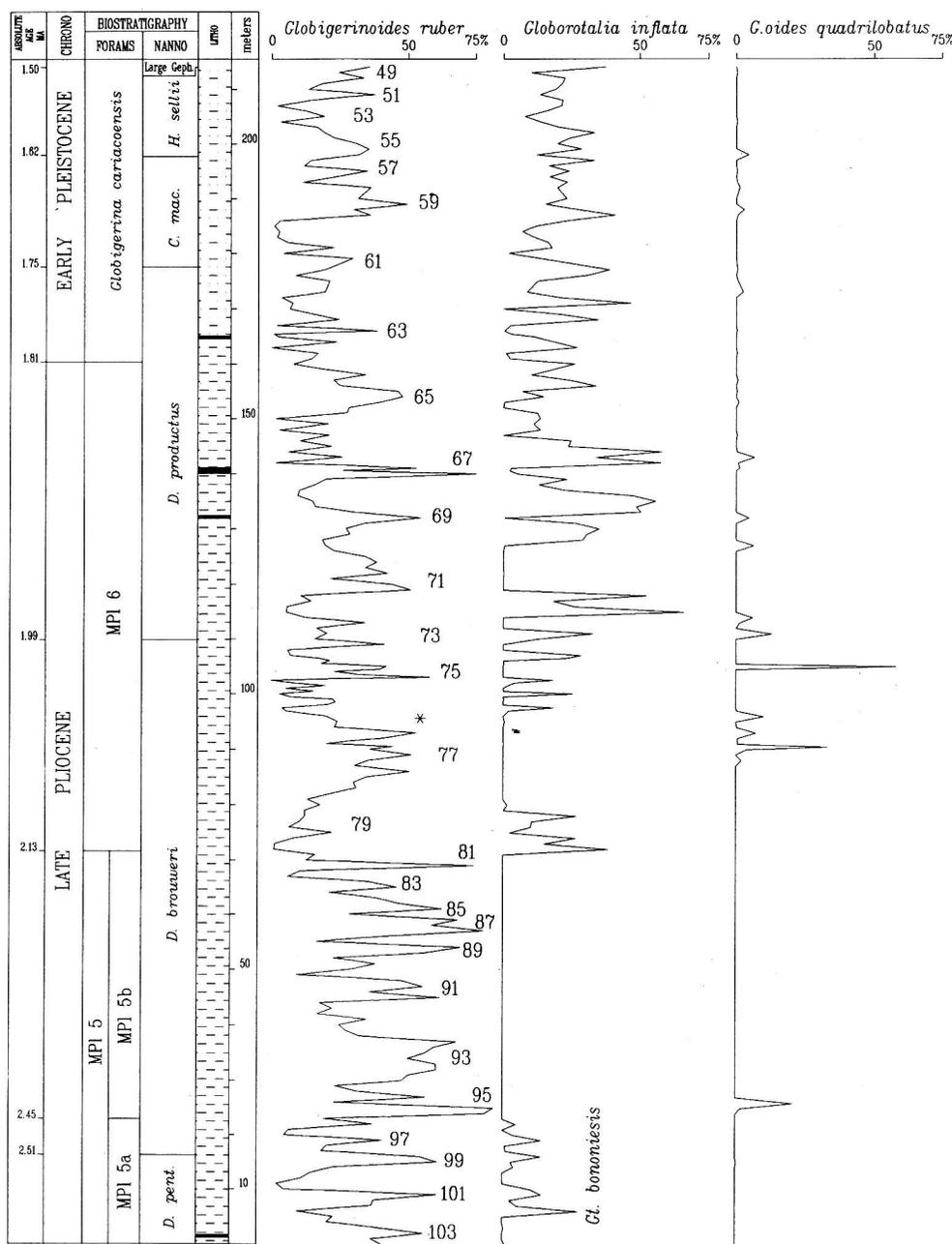


Fig. 3 - Abundance fluctuations of 3 planktonic foraminifera taxonomic units in the Capo Rossello section. Black bars indicate laminitic levels. Asterisk indicates the appearance level of *Gt. truncatulinoides*.

Zijderveld et al., 1991, and Lourens et al., 1992, in the Singa section; Channell et al., 1992, in the Monte S. Nicola section). Hilgen (1991) and Sprovieri (1992) respectively correlate the first occurrence of this species with cycle 75 and 77.

In the studied section the interval of 38 m between the *Gt. inflata* FO and the *D. brouweri* LO has been sampled each 50 cm. The samples collected in this segment has a mean time interval of 3 KA and therefore they allow to follow in detail the sequence of events at the appearance level of *Gt. truncatulinoides*. Its first appearance is recorded at 98 m (Fig. 3), in coincidence of the top of the second positive fluctuation of the *Gd. ruber* TU above the *Gt. inflata* FO, which occurs at 72 m, in coincidence of a negative fluctuation. Together with specimens of *Gt. truncatulinoides*, *Sphaeroidinella debiscens* is present, but rare. In coincidence with the abundance fluctuation of the *Gd. ruber* TU at the top of which the FO of *Gt. truncatulinoides* is recorded, the *Gd. quadrilobatus* TU is present and more or less abundant. Between fluctuations 81 and 79 and between 79 and 77 (Fig. 3) relative abundance peaks of *Gt. inflata* occur, but *Gt. inflata* is virtually absent in the long segment coincident with fluctuation 77. Between the appearance level of *Gt. truncatulinoides* and the *Discoaster brouweri* LO, which occurs in coincidence of a positive abundance fluctuation of the *Gd. ruber* TU (Fig. 3), one fluctuation is present, in which *Gt. truncatulinoides* is absent and *Gd. quadrilobatus* is again frequent. Relative abundances of *Gt. inflata* again coincide with fluctuations 76 and 74. Therefore between the *Gt. inflata* FO and the *D. brouweri* LO 4 positive abundance fluctuations of the *Gd. ruber* TU occurs, with *Gt. truncatulinoides* present in coincidence of the second fluctuation above the *Gt. inflata* FO.

The interval of 13 m between the *Gt. inflata* FO and the *D. brouweri* LO at Monte S. Nicola, originally studied every meter (Channell et al., 1992), has been sampled again every 30-35 cm. The study of these new samples allows a more detailed identification of the sequence of events (Fig. 4). *Gt. inflata* appears at 100 m, coincident with abundance fluctuation 80. *Gt. truncatulinoides* appears at 106.60 m, where it is present together with *Sphaeroidinella debiscens*. This level is at the top of the second

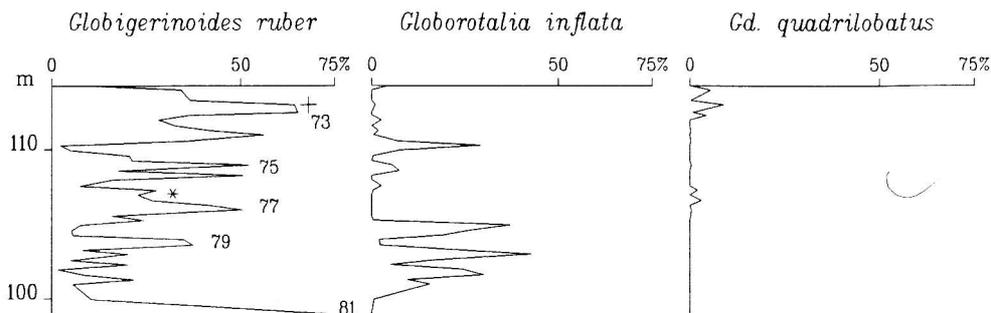


Fig. 4 - Abundance fluctuations of 3 planktonic foraminifera TUs in the interval between the *Gt. inflata* FO and the *D. brouweri* LO at Monte S. Nicola. Asterisk indicates the appearance level of *Gt. truncatulinoides*. Plus sign indicates the disappearance level of *D. brouweri*. Modified from Channell et al. (1992).

positive fluctuation of *Gd. ruber* above the *Gt. inflata* FO. Coincident with the same fluctuation *Gd. quadrilobatus* is present. Abundance fluctuations of *Gt. inflata* coincide with fluctuation 80 and 78 respectively. Between the *Gt. truncatulinoides* FO and the *D. brouweri* LO, which again is recorded in coincidence of a positive fluctuation of the *Gd. ruber* TU, 1 abundance fluctuation of the *Gd. ruber* TU is present. Relative abundance fluctuations of *Gt. inflata* again occur in coincidence of fluctuations 76 and 74. Therefore the sequence of events is well comparable with the results obtained from the Capo Rossello section.

The sequence of these biostratigraphic events in the Singa section, according to Lourens et al. (1992), is reported on the oxygen isotope curve in Fig. 5. The FO of *Gt. truncatulinoides* is recorded at 100.95 m (Zijderveld et al., 1991; Lourens et al., 1992), in coincidence of the second cycle above the *Gt. inflata* FO, as in the other sections. But only 1 "cold" isotopic stage is interpreted by Lourens et al. (1992) between the first appearance of *Gt. truncatulinoides* and the *D. brouweri* LO, which occurs at about 99 m (Driever, 1988). Nevertheless, the 2 fluctuations at 103.95 m, ascribed by Lourens et al. (1992) to the isotopic stage 74, can actually represent 2 isotopic stages. According to this interpretation, also in the Singa section the same sequence of events recorded in the other considered Mediterranean sections can be recognized. The *D. brouweri* LO is recorded in the Singa and Vrica sections (Zijderveld et al., 1991; Lourens et al., 1992; Rio et al., 1993) below the base of Olduvai magnetic event, in coincidence of fluctuation 73 (Fig. 5). If this bio-event is synchronous in the Calabrian and Sicilian sequences, the FO of *Gt. truncatulinoides* coincides with fluctuation 77. According to the chronological estimates of the abundance fluctuations reported by Sprovieri (1993) the *Gt. truncatulinoides* FO in the Mediterranean basin is estimated at 2.07 MA. The *Gt. inflata* FO, which occurs on the second negative fluctuation below

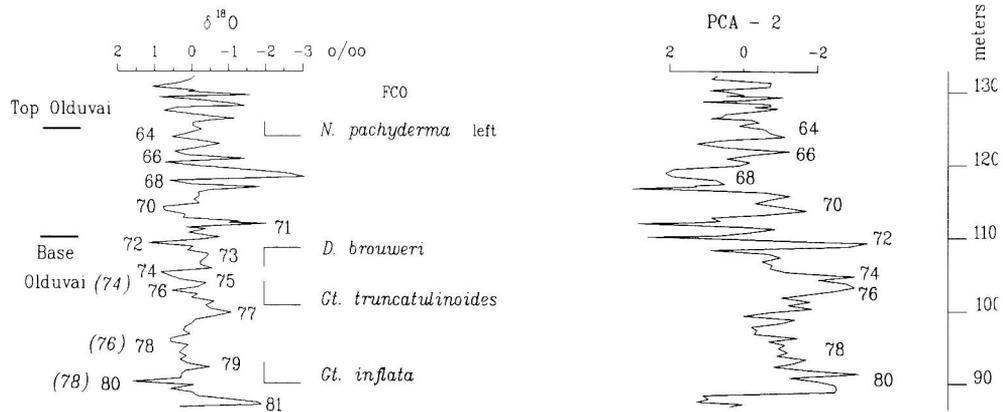


Fig. 5 - Correlation of biostratigraphic events to the oxygen isotope ($\delta^{18}\text{O}$) and PCA-2 fluctuations in the Singa section (from Lourens et al., 1992). Numbers in italic style indicate the interpretation reported by Lourens et al. (1992). *D. brouweri* extinction level is from Driever (1988).

the *Gt. truncatulinoides* FO, coincides with fluctuation 80, with an absolute age of 2.13 MA. The *D. brouweri* LO, which is coincident with fluctuation 73, has an absolute age of 1.99 MA. Finally, the beginning of the interval of the *D. triradiatus* increase coincides with fluctuation 85. The absolute age of this fluctuation is 2.23 MA (Sprovieri, 1993). Therefore an absolute age of 2.23 MA is proposed for this event.

The Early Pleistocene in the Capo Rossello section.

Above the base of the *Globigerina cariacensis* Zone, which approximates the Pliocene-Pleistocene boundary as defined in the Vrica section (Aguirre & Pasini, 1985), the amplitude of the *Gd. ruber* TU relative abundance fluctuations decreases. The same trend was reported at Site 653 (Sprovieri, 1992) and correlated with an increase in the climatic deterioration from the base of the Pleistocene. Even if with reduced amplitude, in this part of the Capo Rossello section several discrete fluctuations can be identified. According to the labelled fluctuations reported in Fig. 3, the *Gephyrocapsa oceanica* s.l. FO is coincident with fluctuation 61, the *Calcidiscus macintyreii* LO coincides with fluctuation 55 and the base of the Large *Gephyrocapsa* Zone coincides with fluctuation 49. Fluctuations 57, 53 and 51 are very short and coincide with segments of gray marls intercalated between brownish, more sandy levels. The 3 gray levels are interpreted as condensed intervals, in coincidence of a sea level rise. This interpretation is supported by their correspondence with positive fluctuations of the *Gd. ruber* TU, which at these stratigraphic levels indicate warm intervals. The 8 positive abundance fluctuations of the *Gd. ruber* TU in the Pleistocene segment of the Capo Rossello section perfectly match the result obtained for the same stratigraphic interval from other Early Pleistocene sections (Sprovieri, 1993).

Conclusions.

The same number of relative abundance fluctuations of the *Gd. ruber* TU reported from the same stratigraphic interval of other Mediterranean sections has been obtained in the Pliocene-Pleistocene segment of the marls of the Monte Narbone Formation outcropping at Capo Rossello above the *Discoaster pentaradiatus* LO. All the calcareous plankton biostratigraphic events can be correlated with the same abundance fluctuation in the different sections.

The *Gt. truncatulinoides* FO is recorded in coincidence of the second positive abundance fluctuation above the *Gt. inflata* FO, which occurs in a negative abundance fluctuation. The *D. brouweri* LO is recorded on the second abundance fluctuation above the *Gt. truncatulinoides* FO. Therefore the *Gt. inflata* FO is 4 fluctuations below the *D. brouweri* LO. Since in the Mediterranean basin the *D. brouweri* LO is recorded below the base of Olduvai magnetic event and in coincidence of isotopic stage (fluctuation) 73, the *Gt. truncatulinoides* FO is coincident with fluctuation 77 and the *Gt. inflata* FO is coincident with fluctuation 80. The base of the interval of increase of *D.*

triradiatus is coincident with fluctuation 85. The first occurrence of *G. oceanica* s.l. is coincident with fluctuation 61, the *C. macintyreii* LO is on fluctuation 55 and the base of the Large *Gephyrocapsa* Zone coincides with fluctuation 49.

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