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BIOSTRATIGRAPHY OF THE RIO MAZZAPIEDI-CASTELLANIA SECTION (TYPE-SECTION OF THE TORTONIAN) BASED ON CALCAREOUS NANNOPLANKTON (**)

Riassunto — E' stato effettuato lo studio al microscopio ottico del Nannoplancton calcareo della Sezione di Rio Mazzapiedi-Castellania (stratotipo del Tortoniano).

Esso ha rivelato alcune novità interessanti, rispetto ai risultati precedentemente conseguiti da E. MARTINI [1975] e da D. RIO *et Al.* [1976].

La zonazione usata per questo studio è quella di D. BUKRY [1973, 1975].

Nel Tortoniano tipo sono state riconosciute quattro zone che dal basso verso l'alto sono:

— Zona a *Discoaster hamatus*
— » » » *neohamatus*
— » » » *berggrenii*
— » » Amaurolithus primus

E' stato possibile, inoltre, migliorare la conoscenza della distribuzione stratigrafica di alcuni importanti taxa come *Amaurolithus primus, A. delicatus* e *A. amplificus.*

In particolare il presente studio ha permesso di definire la comparsa di queste specie rispetto a quella di alcuni markers planctonici con un dettaglio maggiore di quello indicato da D. RIO *et Al.* [1976], e cioè:

— la comparsa di *A. primus* avviene in prossimità della comparsa di *Globorotalia suterae* ed è seguita immediatamente da quella di *A. amplificus.*

— la comparsa di *A. delicatus* è correlabile con quella di *Globorotalia conomiozea.*

Sempre tra i Ceratoliti è stata notata la presenza di forme di probabile transizione tra *A. delicatus* e *A. tricorniculatus,* significative ai fini del riconoscimento dell'inizio della deposizione evaporitica.

Abstract — The study of the calcareous nannoplankton assemblages from the Rio Mazzapiedi-Castellania Section (Tortonian stratotype) has allowed to recognize

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(**) Investigation carried out with the grant of the Consiglio Nazionale delle Ricerche.

the following nannofossil zones modified after D. BUKRY [1973, 1975]:

— *Discoaster hamatus* Zone
— » *neohamatus* Zone
— » *berggrenii* Zone
— *Amaurolithus primus* Zone.

The use of Ceratoliths as stratigraphic indicators is very significant in this interval. The succession of the appearances of *A. primus* and *A. delicatus* seems to be correlable with that of *Globorotalia suterae* and *G. conomiozea* respectively.

It must be pointed out that some specimens of probable transition from *A. delicatus* to *A. tricorniculatus* occur in a position slightly preceding the Tortonian-Messinian boundary as defined by M. B. CITA *et Al.* [1965].

INTRODUCTION

The necessity to improve the knowledge of the fossiliferous content of the stratotypes is more and more felt by the stratigraphers. As far as the Tortonian stratotype is concerned, it must be pointed out that several specialists as A. GIANOTTI [1953], M. B. CITA *et Al.* [1965]; C. C. VERVLOET [1966], M. B. CITA & W. H. BLOW [1969], E. ROBBA [1968, 1970], P. ASCOLI [1968], have investigated and illustrated its fossiliferous content (Foraminifera, Mollusca, Ostracoda). However, the literature is lacking in an accurate account of the calcareous nannoplankton species; the only available works are those of E. MARTINI [1975] and D. RIO *et Al.* [1976].

E. MARTINI has preliminary presented the nannofossil biostratigraphy of the Tortonian type-section (Rio Mazzapiedi-Castellania) during the VIth Congress Regional Committee on Mediterranean Neogene Stratigraphy in Bratislava. According to this Author, the zones NN9 (*Discoaster hamatus*), NN10 (*D. calcaris*) and NN11 (*D. quinqueramus*) are recognizable in this section. It seemed that a conclusive study provided with a detailed account of the nannoplankton species had to follow this preliminary one, but it has not been so.

D. RIO *et Al.* have investigated only the upper part of this section (together with other Italian Late Miocene and Early Pliocene sections) in order to define the biostratigraphic position of the Mediterranean evaporites.

The present study, born with the purpose of showing the calcareous nannoplankton content of the Tortonian stratotype, takes

up the meaning of verification and completion of the overmentioned works.

The sampling (44 samples on the whole) has been effected in correspondence with the Tortonian type-section proposed by G. F. GINO [1953] and described by A. GIANOTTI [1953] (fig. 1). A. BOSSIO, L. GIANNELLI and G. SALVATORINI have collected the samples concerning the lower part of the section (about 150 m); S. D'ONOFRIO et Al. [1976] those of the upper part (about 200 m).

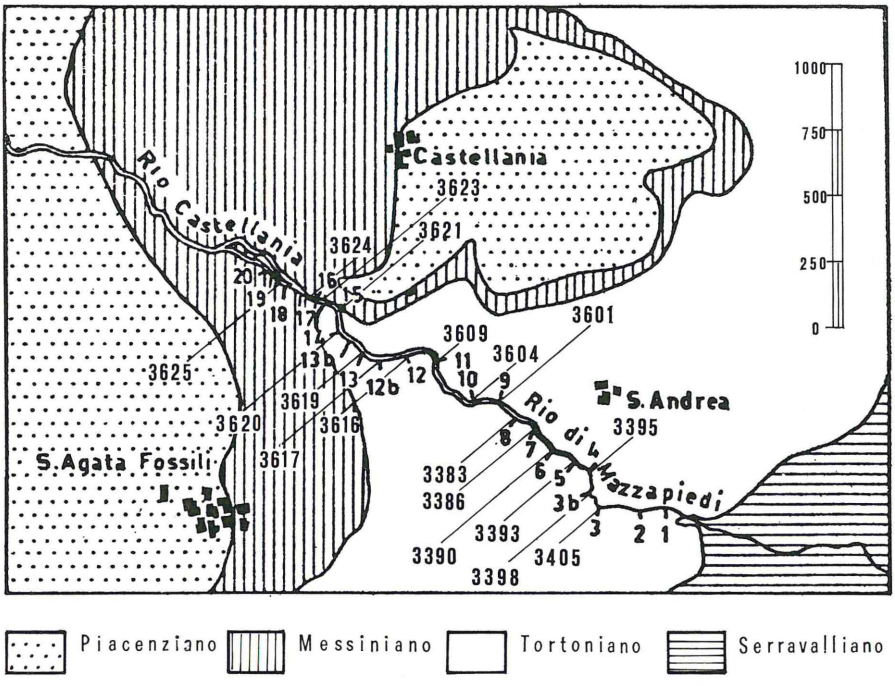

Fig. 1 - Geological sketch map of the area Castellania-S. Agata Fossili near Tortona, Piedmont (by M. B. CITA *et Al.* [1965]) with the approximate location of some selected samples.

The use of the same columnar log reported by M. B. CITA *et Al.* [1965] allows to show the mutual relations between the two samplings (fig. 2).

The coccolith assemblages of this section have been studied with light-microscope techniques.

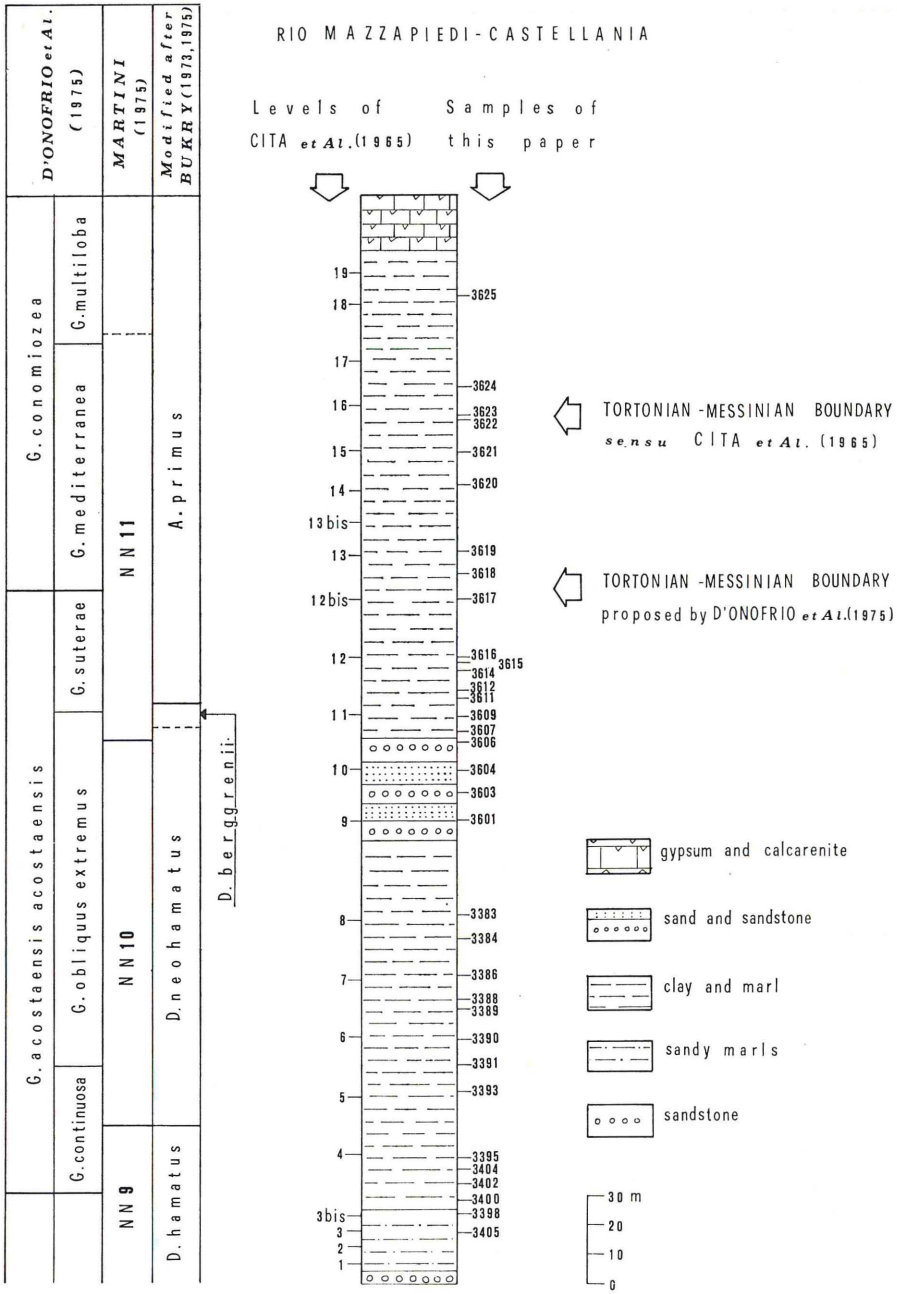

Fig. 2 - The log, the subdivisions in planktonic foraminiferal Zones (S. D'ONOFRIO *et Al.* [1976] and calcareous nannoplankton Zones (E. MARTINI [1975] and this paper), the position of the Tortonian-Messinian boundary as defined by M. B. CITA *et Al.* [1965] and the one indicated on the paleontological basis by D'ONOFRIO *et Al.* [1976], are reported here.

BIOSTRATIGRAPHY

Coccolith assemblages of the Rio Mazzapiedi-Castellania Section are characterized mainly by forms belonging to *Coccolithaceae, Pontosphaeraceae, Prinsiaceae, Rhabdosphaeraceae* and *Sphenolithaceae* families. Discoasters are rare, except for the upper-middle interval of this section where they are more frequent. Ceratoliths are always rare.

The range of the most significant and best known taxa is reported in fig. 3. Cretaceous, Paleogene and Miocene reworked species, which are fairly diffused throughout the Tortonian stratotype, have been excluded from the figure.

The used biostratigraphic zonation is that of D. BUKRY [1973, 1975], extablished in sediments from deep-sea cores and modified for this study. In respect to that of E. MARTINI [1971], it has the advantage to utilize Ceratoliths (2) as zonal markers for this time interval.

This group of horseshoe-shaped calcareous nannofossils includes a limited number of cosmopolitan solution resistant species readily recognizable and widely used for correlations of marine sediments owing to their relatively short stratigraphic range.

Fig. 2 shows the relation between the recognized calcareous nannoplankton zones (E. MARTINI [1975] and this paper) and the planktonic foraminiferal zones (S. D'ONOFRIO *et Al.* [1976]) in the Tortonian type-section (the data concerning the first appearances of *Globorotalia acostaensis acostaensis* and *Globigerinoides obliquus extremus* have been recovered from the study of M. B. CITA and W. H. BLOW [1969]).

The recognized biozones are the following (starting from the lower one):

Discoaster hamatus Zone

The lower boundary is defined by the appearance of *D. hamatus* and the upper boundary by the disappearance of this taxon.

(2) Ceratoliths are assignable to two different genera, *Amaurolithus* and *Ceratolithus*, on the basis of their crystallographic and optical properties (S. GARTNER & D. BUKRY [1975]). The *genus Amaurolithus* is limited to the marine sediments of the Upper Miocene and Lower Pliocene; the *genus Ceratolithus* to those of the Pliocene and Quaternary.

The occurrence of *D. hamatus* from sample 3398 up to sample 3395, allows the assignment of the basal part of the Tortonian type-section ([3]), to *D. hamatus* Zone of BUKRY (perfectly equivalent in its definition to the zone NN9 of MARTINI).

The most significant taxa are: *Discoaster bellus, D. prepentaradiatus, D. neohamatus, D. exilis, D. pseudovariabilis, D. calcaris, D. brouweri.* They are however very rare.

Coccolith assemblages consist mainly of *Coccolithus pelagicus, Cyclococcolithina macintyrei, C. leptopora, Helicopontospaera kamptneri, Holodiscolithus macroporus.* On the contrary, *Discolithina japonica, D. multipora, Lithostromation perdurum, Discoaster variabilis* s.l., *D.* aff. *pentaradiatus,* D. sp., *Reticulofenestra pseudoumbilica, Rhabdosphaera procera, Scyphosphaera apsteini, S. tubifera, Sphenolithus abies, S. neoabies* are rare.

Discoaster neohamatus Zone

The lower boundary is indicated by the last occurrence of *D. hamatus* and the upper boundary by the appearance of *D. berggrenii.*

This zone has been recognized from the sample 3393 up to sample 3607. According to D. BUKRY [1973], this zone is characterized in the oceanic sediments by a well observable succession of appearances and disappearances of some species. Unfortunately, the Rio Mazzapiedi-Castellania Section does not allow to follow completely such a succession. However, some occurrences as those of *Discoaster surculus, D. pentaradiatus, D. icarus, D.* aff. *quinqueramus* seem to be important, even if sporadic.

Common specimens of *Coccolithus pelagicus, Cyclococcolithina macintyrei, C. leptopora, Helicopontosphaera kamptneri, Reticulofenestra pseudoumbilica* occur associated to rare ones of *Discoaster pentaradiatus, D. variabilis* s. l., *D. pseudovariabilis, D. calcaris, D. brouweri, D.* sp., *Lithostromation perdurum, Discolithina japonica, D. multipora, Scyphosphaera apsteini, S. lagena, S. turris, Rhabdosphaera procera, Holodiscolithus macroporus, Sphenolithus abies, S. neoabies.*

([3]) As far as the lowermost part of the Rio Mazzapiedi-Castellania Section (up to sample 3405) is concerned, I remark the fact that there are no significant nannofossils, the assemblages consisting chiefly of *Coccolithus pelagicus, Cyclococcolithina macintyrei, C. leptopora, Helicopontosphaera kamptneri.*

Discoaster berggrenii Zone

The lower boundary is defined by the appearance of the zonal marker and the upper one by the appearance of *Amaurolithus primus.*

Discoaster berggrenii occurs from the sample 3608 on. The short interval included between this sample and the sample 3611 (level of appearance of *A. primus*) belongs to this zone.

Another five-rayed discoaster, *D. quinqueramus,* is recorded from sample 3609 on, together with *D. berggrenii.* These species are very rare.

Coccolithus pelagicus, Cyclococcolithina leptopora, Helicopontosphaera kamptneri are frequent; *Discolithina japonica, D. multipora, Holodiscolithus macroporus, Reticulofenestra pseudoumbilica, Rhabdosphaera procera* and *Sphenolithus abies* are fairly common. In this zone some species as *Discoaster pentaradiatus, D. surculus, D. calcaris, D. variabilis* s. l., always rare and sporadic in the preceding zone, become more common. *Braarudosphaera bigelowi, Cyclococcolithina macintyrei, Scyphosphaera apsteini* and *S. halldali* occur in rare specimens.

Amaurolithus primus Zone

The lower boundary is indicated by the appearance of *A. primus* and the upper boundary by the last occurrence of *Discoaster quinqueramus.*

The interval included between the sample 3611 (first occurrence of *A. primus*) and the top of the section, is assigned to this zone, though *D. quinqueramus* occurs up to sample 3621 only. In fact, indicative taxa of the *A. primus* Zone have been observed in marine sediments intercalated with the Messinian Mediterranean evaporites (H. STRADNER in M. B. CITA *et Al.* [1973]; F. BARBIERI & D. RIO [1974]) and, therefore, in a stratigraphic position overlying the top of the investigated section.

Amaurolithus amplificus and *A. delicatus* first occur in the lower part of this zone respectively in the samples 3612 and 3617.

Moreover, some meters above the appearance of *A. delicatus,* rare specimens of probable transition from *A. delicatus* to *A. tricorniculatus* occur. Such forms have a delicate construction which seems to exclude a close relation with species as *A. primus* and

A. amplificus, whereas certainly it makes them similar to *A. delicatus* and *A. tricorniculatus.* These forms have an apical spur as that shown sometimes by specimens of *A. delicatus* and short arms as *A. tricorniculatus.*

The following species are frequent throughout this interval: *Coccolithus pelagicus, Cyclococcolithina leptopora, Helicopontosphaera kamptneri, Discolithina japonica, D. multipora, Rhabdospaera procera, Sphenolithus abies. Discoaster variabilis* s. l., *D. surculus, D. brouweri, D. icarus, D. calcaris, Reticulofenestra pseudoumbilica* are fairly common, even if their frequency is variable. *Braarudosphaera bigelowi, Discoaster pentaradiatus, D. berggrenii, D. quinqueramus* and *Sphenolithus* neoabies are rare. An increase in specimens belonging to *genus Scyphosphaera* has been observed.

Conclusions

The main results of this study may be summarized as follows:

1) the following nannoplankton zones have been recognized in the Tortonian stratotype:

— *Discoaster hamatus* Zone
— » *neohamatus* Zone
— » *berggrenii* Zone
— *Amaurolithus primus* Zone.

These biostratigraphic results are substantially in concordance with those of E. Martini [1975] on the same section. Some doubts may be expressed about the position of the zonal boundary between the *D. neohamatus* Zone and the *D. berggrenii* Zone. In fact:

— in the Rio Mazzapiedi-Castellania Section, the *D. berggrenii* Zone is about 10 meters thick. On the contrary, in the chiefly marly sequence of the Mussotto Section (Piedmont Basin), this zone is 80 meters thick (D. Rio *et Al.* [1976]).

— the sedimentary interval, some meters under the first appearance of *D. berggrenii,* is characterized by sand sandstone with extremely poor nannoplankton assemblages. In particular, discoasters are very rare.

As a consequence, the appearance of *D. berggrenii,* in this section, is probably not isochronous with that in the Mussotto Section, but later.

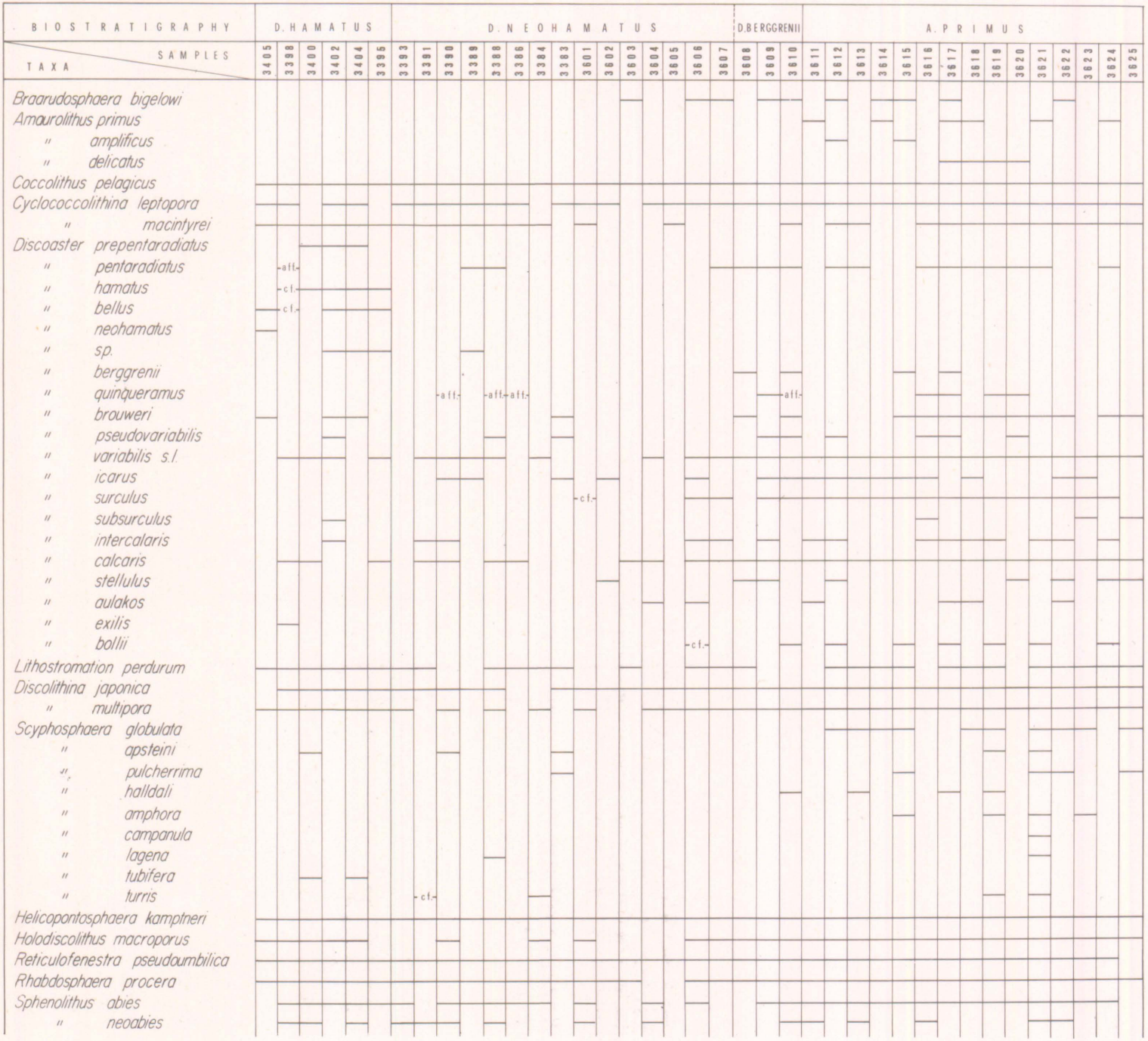

Fig. 3 - Range chart of selected taxa.

The mentioned doubts seem to be valid also as far as the appearance of *D. quinqueramus* is concerned.

2) The knowledge of the stratigraphic range of some very important taxa (i. e. *Amaurolithus primus, A. delicatus; A. amplificus*) has been improved.

It must be pointed out that in a recent investigation on some Italian Late Miocene sections including the upper part of the Rio Mazzapiedi-Castellania Section, D. Rio *et Al.* [1976] have always indicated the primitive Ceratoliths in a position very close to that of the appearance of *Globorotalia conomiozea* (4). This work has allowed to state something more:

— the first occurrence of *A. primus* takes place in proximity of that of *Globorotalia suterae* and it is immediately followed by that of *A. amplificus.*

— *A. delicatus* appears above *A. primus* and *A. amplificus* in a position slightly preceding the first occurrence of *G. conomiozea.*

Taking into account the remarkable rate of sedimentation in these terrigenous deposits, it may be assumed that the appearances of *A. primus* and *A. delicatus* take place respectively at the same time of those of *G. suterae* and *G. conomiozea.*

3) the occurrence of specimens of probable transition from *A. delicatus* to *A. tricorniculatus* in a short interval overlying the level of appearance of *G. conomiozea* seems to be very significant for the identification of the Tortonian-Messinian boundary as defined by M. B. Cita *et Al.* [1965].

Moreover, this event nearly predates the beginning of the evaporitic deposition.

Though these events in the ceratolith group have occurred in a interval in which the assemblages were subject to an environmental control, their succession is considered in any way valid since it has verified in other sections both in the Mediterranean basin (R. Mazzei in preparation) and in extra-Mediterranean areas (R. Mazzei in preparation).

In conclusion, it must be pointed out that the Ceratoliths may provide the best informations in order to solve bio-chronostratigra-

(4) The first appearance of *Globorotalia conomiozea* has been recently indicated as the most important and nearest event to the Tortonian-Messinian boundary by S. D'Onofrio *et Al.* [1976].

phic problems concerning the Late Tortonian-Early Messinian interval.

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TAVOLE

PLATE 1

Calcareous nannoplankton of the Rio Mazzapiedi-Castellania Section (Tortonian stratotype).

Fig. 1 - *Discoaster* cf. *hamatus* MARTINI & BRAMLETTE
Sample I.G.P. 3398 2000x

Fig. 2 - *Discoaster* cf. *bellus* BUKRY & PERCIVAL
Sample I.G.P. 3398 2000x

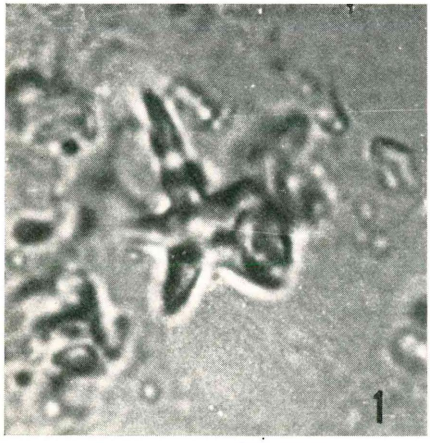
Fig. 3 - *Discoaster* cf. *hamatus* MARTINI & BRAMLETTE
Sample I.G.P. 3402 2000x

Fig. 4 - *Discoaster hamatus* MARTINI & BRAMLETTE
Sample I.G.P. 3404 2000x

Fig. 5 - *Discoaster hamatus* MARTINI & BRAMLETTE
Sample I.G.P. 3404 2000x

Fig. 6 - *Discoaster* sp.
Sample I.G.P. 3404 2000x

TAV I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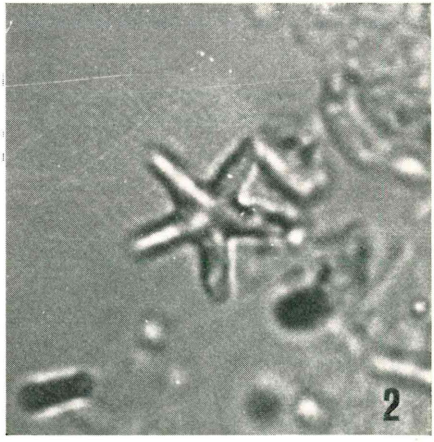
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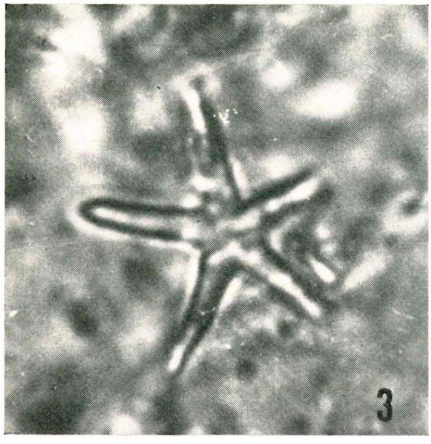
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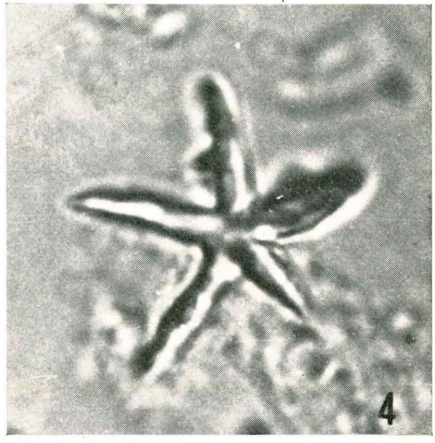
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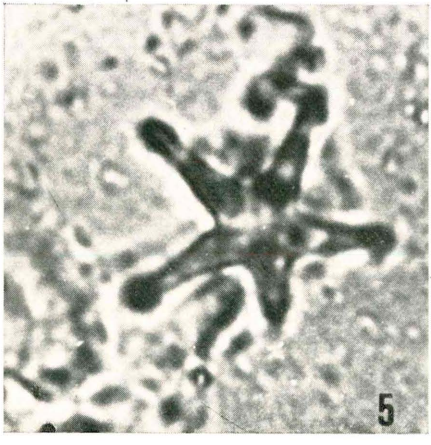
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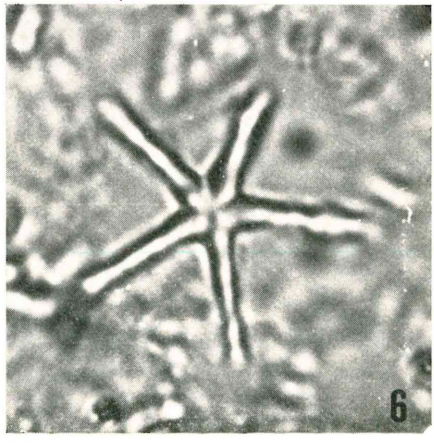
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PLATE 2

Calcareous nannoplankton of the Rio Mazzapiedi-Castellania Section (Tortonian stratotype).

Fig. 1 - *Discoaster* aff. *quinqueramus* GARTNER
Sample I.G.P. 3388 2000x

Fig. 2 - *Discoaster berggrenii* BUKRY
Sample I.G.P. 3608 2000x

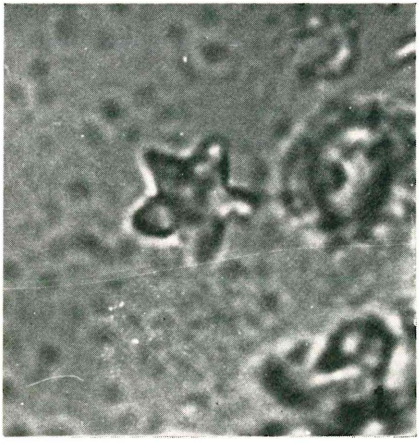
Fig. 3 - *Discoaster quinqueramus* GARTNER
Sample I.G.P. 3609 2000x

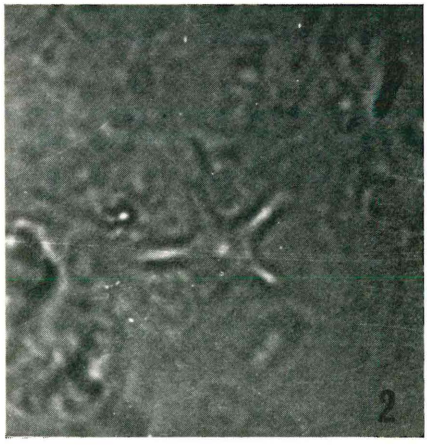
Fig. 4 - *Discoaster pentaradiatus* TAN SIN HOK
Sample I.G.P. 3617 3000x

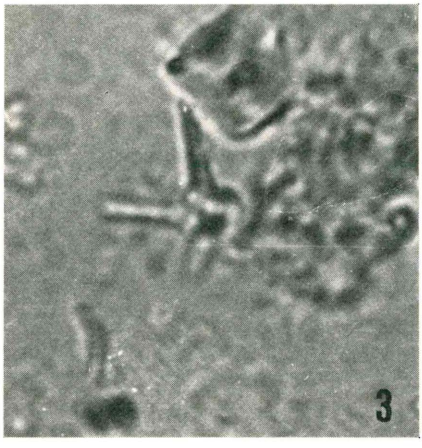
Fig. 5 - *Discoaster berggrenii* BUKRY
Sample I.G.P. 3617 3000x

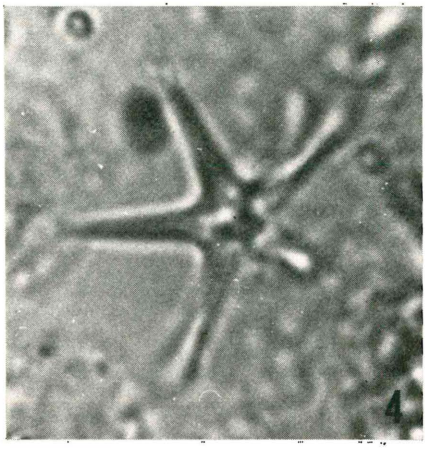
Fig. 6 - *Discoaster quinqueramus* GARTNER
Sample I.G.P. 3619 3000x

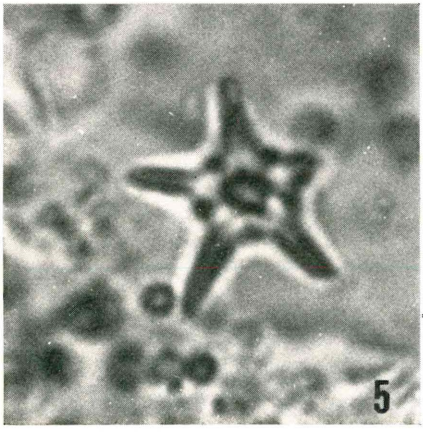
TAV. II











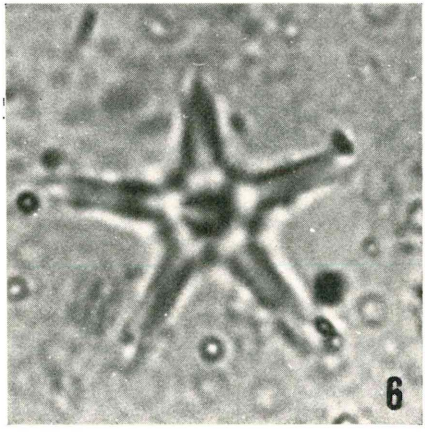


PLATE 3

Calcareous nannoplankton of the Rio Mazzapiedi-Castellania Section (Tortonian stratotype).

Fig. 1 - *Amaurolithus primus* (BUKRY & PERCIVAL) GARTNER & BUKRY
Sample I.G.P. 3611 3000x

Fig. 2 - *Amaurolithus delicatus* GARTNER & BUKRY
Sample I.G.P. 3617 3000x

Fig. 3 - *Amaurolithus delicatus* GARTNER & BUKRY
Sample I.G.P. 3618 3000x

Fig. 4 - *Amaurolithus delicatus* GARTNER & BUKRY
Sample I.G.P. 3620 3000x

Fig. 5 - *Amaurolithus delicatus* GARTNER & BUKRY
Sample I.G.P. 3620 4000x

Fig. 6 - *Amaurolithus primus* (BUKRY & PERCIVAL) GARTNER & BUKRY
Sample I.G.P. 3621 3000x

TAV. III