

BIOSTRATIGRAPHIC CORRELATION BETWEEN THE CENTRAL SUBBETIC (SPAIN) AND UMBRO-MARCHEAN (ITALY) PELAGIC SEQUENCES AT THE EOCENE/OLIGOCENE BOUNDARY USING FORAMINIFERA.

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ABSTRACT

The most significant events, which occurred during the time interval spanning from the Late Eocene to the Early Oligocene, are preserved in the continuous pelagic sequences of the Subbetic basin (Spain) and Umbro-Marchean basin (Italy). A comparative analysis has been carried out between events common to both areas, based on planktonic and benthic foraminifera.

The relationship between Hantkeninidae and other selected taxa were used to identify and correlate the biozones identified in the two areas. We show that below the Eocene/Oligocene boundary several successive extinctions occur in the same order both in Spain and in Italy. Particularly, the Turborotalia cerroazulensis group extinction is slightly prior to the Hantkeninidae and large Pseudohastigerina extinctions, which latter mark the Eocene/Oligocene boundary.

INTRODUCTION

This paper deals with the comparison of the biostratigraphic data concerning the Eocene/Oligocene transition from southern Spain (Molina et al., this volume) and Umbro-Marchean region (Italy) (Nocchi et al., this volume). Such a comparison is one of the results of the strict collaboration among scientists from different countries, which occurred under sponsorship of IGCP Project 174 on "Terminal Eocene Events".

The sequences here considered, from both Spain and Italy, are well exposed, continuous, pelagic and offer a good biostratigraphic resolution. Sections of this type and age are seldom found in the Mediterranean area because of the general regressive trend related to the Alpine orogenesis.

The stratigraphic interval studied extends from the Middle Eocene/Upper Eocene boundary to the Lower Oligocene/Middle Oligocene boundary, from P14/P15 to P20/P21 of Blow's (1969) biozonation. This comparative study based mainly on planktonic foraminifera, allowed us to recognize many events common to both sequences and to demonstrate a close isochrony between Spanish and Italian foraminiferal events.

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This comparison permits to resolve some biostratigraphic problems concerning the correlations between Mediterranean sections and the standard biozonation of Blow (1969).

GEOLOGICAL SETTING AND LITHOSTRATIGRAPHY

The Umbro-Marchean and Subbetic sequences (see fig.1) consist of deep water marls and calcareous marls. These pelagic and hemipelagic sediments contain intercalations of calcareous turbidites derived from adjacent carbonate platforms in both areas.

The Spanish sequences of Fuente Caldera, Molino de Cobo and Torre Cardela belong to the Cañada Formation of the Cardela group defined by Comas (1978). The sediments of this formation were deposited in the Median Subbetic trough, which was subsiding during the Eocene. This trough belongs to the external Zone of the Betic Cordillera, which represents the westernmost mountain system of the European Alpine chain.

The coeval Umbro-Marchean sequences of Collecstellano, Visso and M. Cagnero sections, belong to the informally named "Scaglia variegata" and "Scaglia cinerea" units. The M. Cagnero section was previously studied by Baumann and Roth (1969) and was revisited to carry out the present comparison.

During the Eocene and Oligocene, the Umbro-Marchean area was characterized by a system of basin, seamounts and platforms connected to the Adriatic promontory, which was part of the African plate (Channel et al., 1979).

Pelagic sediments, rich in calcareous plankton, accumulated in the basin at the edge of which, in southern part, the calcareous turbidites intercalated testify the vicinity of the Latium-Abruzzi carbonate platform.

The dominant lithotypes of the "Scaglia" and Cañada Formation are pelagites and hemipelagites. In the Umbro-Marchean sequences the pelagic limestones and marls are reddish and gray in the Upper Eocene, and gray at the top of the Eocene and in the Lower Oligocene (see Monaco et al., in press), while Spanish sequences consist entirely of gray marls. In addition, the sediments of the Spanish sequences contain more clay and less carbonate than the Italian sections. The Subbetic marly intervals have varying amounts of microfossils as well as rare glassy spherules. The planktonic foraminifera are well preserved and abundant, constituting 85% of almost all the washed samples.

BIOSTRATIGRAPHIC ANALYSIS

The stratigraphic interval in this study extends from the Middle Eocene/Upper

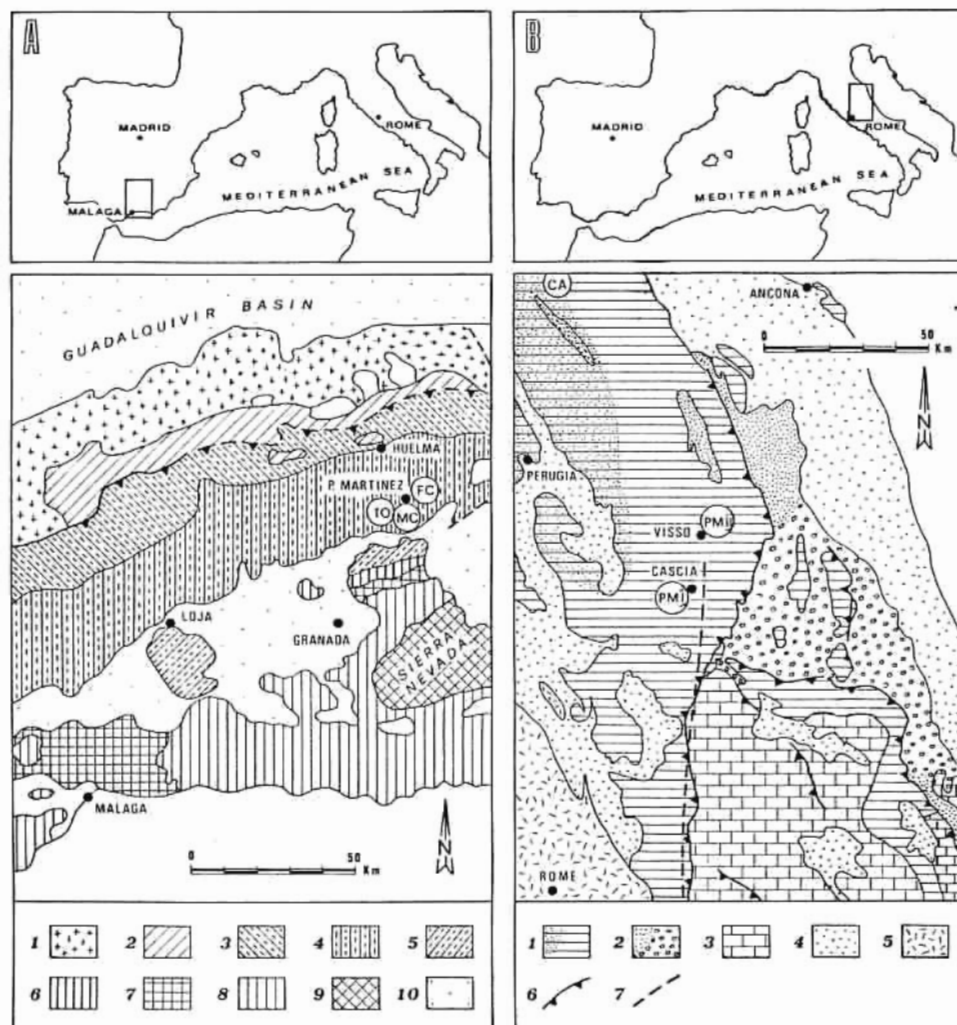


Fig. 1. Geological sketch maps of Betic Cordillera and Umbro-Marchean area and location of the sections studied. A): TO: Torre Cardela section; MC: Molino de Cobo section; FC: Fuente Caldera section. B): CA: M. Cagnero section; PM II: North Visso section; PM I: Collecstellano section.

A)- 1) Guadalquivir allocthonous units; 2) Intermediate units; 3) External Subbetic; 4) Median Subbetic; 5) Internal Subbetic; 6) Rondades or Betic dorsal; 7) Malaguide; 8) Alpujarride; 9) Nevado Filabride; 10) Upper Miocene-Pliocene-Quaternary.

B)- 1) Mesozoic and Cenozoic pelagic successions and flysches in the Umbro-Marchean basin; 2) Miocene-Pliocene late-orogenic successions; 3) Latium-Abruzzi carbonate platform; 4) Marine and continental Plio-Pleistocene post-orogenic successions; 5) Vulcanites of Tuscan-Latium system; 6) Overthrusts; 7) Fault.

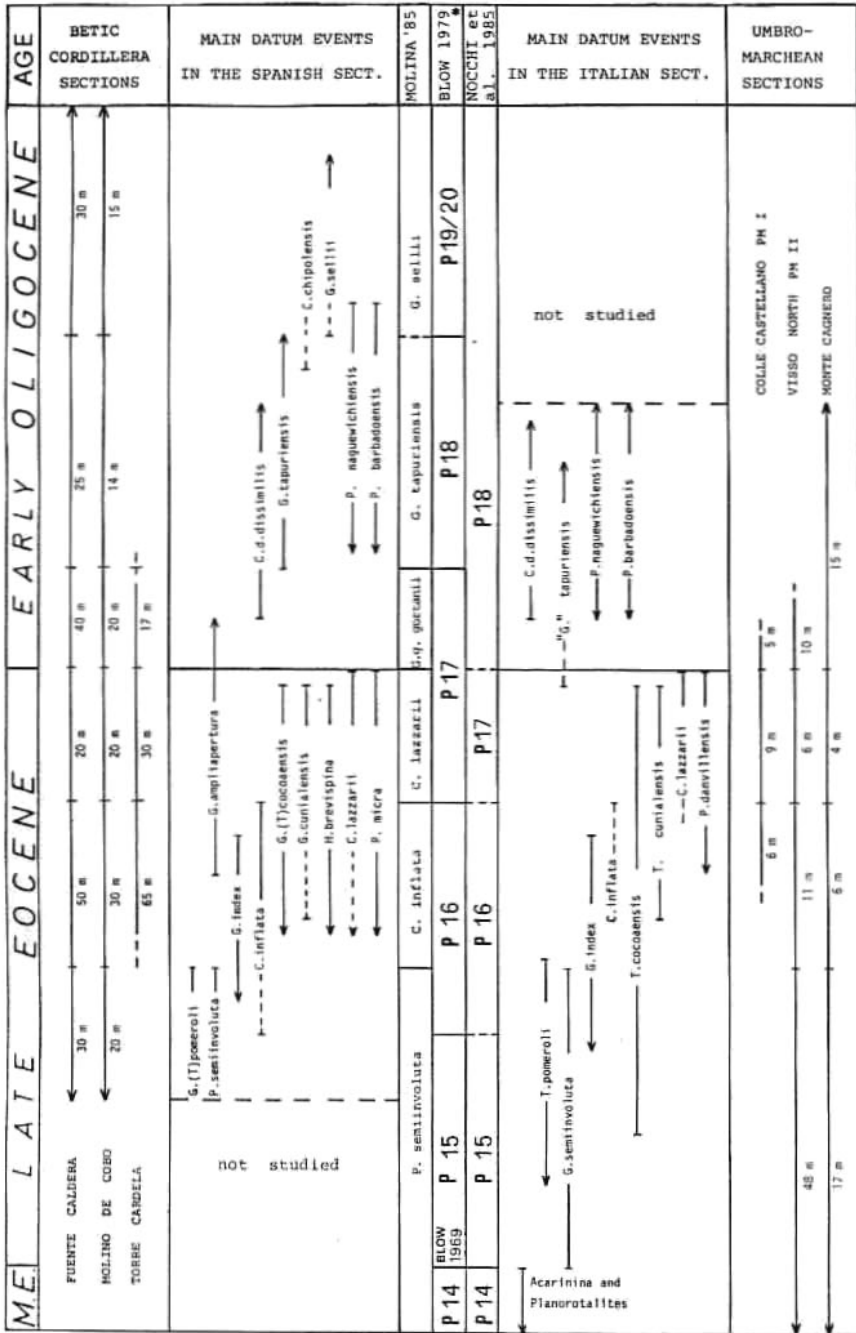


Fig. 2. Main planktonic foraminifera events in the Spanish and Italian sections. The dashed line indicates that the taxon is rare.

* As reported by Berggren et al., (1983).

Eocene boundary to just below the Lower Oligocene/Middle Oligocene boundary, and thus encompasses Blow's (1969) biozones P14 to P20. The Middle Eocene/Upper Eocene boundary has not been studied in the Italian sections. A synthesis of our data and a summary of the main planktonic foraminiferal events are indicated in fig.2. This figure shows the biozones from the Italian and Spanish sections, as well as the stratigraphic thickness of each biozone. These biozones are correlated to those defined by Blow (1969), which were plotted as having the same thickness, thus distorting their chronostratigraphic extent.

A comparison of the same biostratigraphic interval between the Spanish and Italian sections reveals that the Subbetic sequences are thicker than the Umbro-Marchean ones. The thickness ratio, calculated between LO of Globigerinatheka semiinvoluta and the Eocene/Oligocene boundary, ranges from 5/1 to 8/1. Consequently the biostratigraphic events are more diluted in the Spanish sections and the microfauna are better preserved in these more argillaceous sequences.

The LO of G. semiinvoluta is the first event that was considered because it can be indirectly used for identifying the P15/P16 zonal boundary. The identification of this boundary is based on the FO of Cribohantkenina inflata (Blow, 1969). In the Spanish sections the latter taxon overlaps for few meters with G. semiinvoluta, but it is rare in the lower portion of its range while in the upper part is more common. Cribohantkeninas are rare or absent in the Umbro-Marchean sections except at the top of the Upper Eocene. Molina et al., (this volume) in the Late Eocene retained a lower G. semiinvoluta Zone corresponding to the total range of the nominal taxon, according to the Bolli's (1957a) original definition, overlain by the C. inflata Zone, the interval from the extinction of G. semiinvoluta to the extinction of G. inflata, which, consequently, results to be shorter than Blow's (1969) Zone P16. Based on the Spanish data, in the Umbrian sections the P15/P16 boundary was located just below the LO of G. semiinvoluta.

The next event in this study is the FO of Turborotalia cunialensis (Globorotalia cunialensis sensu Molina) that occurs just above the LO of G. semiinvoluta. This event is less evident in the Spanish sections than in the Italian sections. It should be noted that this event always is within P16.

Globigerinatheka index (Globigerapsis index sensu Molina) is common from the base of the sequences in both area. Its extinction is distinct and occurs after the appearance of T. cunialensis and before the extinction of C. inflata. This event always falls within P16 and G. index and T. cunialensis coexist in each section examined. The disappearance of G. index is accompanied by a very strong decrease in abundance of all Globigerinathekae. In the Italian sections, only

rare forms of Globigerinatheka tropicalis continue up to the Eocene/Oligocene boundary, where they become extinct.

The P16/P17 boundary is defined by the LO of C. inflata that occurs above the LO of G. index.

At the top of the Upper Eocene there are further extinctions of the most typical Eocene forms, but they are not simultaneous. The extinction of the Turbo-rotaia cerroazulensis group coincident with the LO of Hantkenina brevispina in Spain, occurs before LO of Hantkeninids and Pseudohastigerinids with subacute margins and greater than 150 microns in diameter. These last events are considered to characterize the Eocene/Oligocene boundary.

The P17/P18 boundary is not clearly defined. In the Umbro-Marchean sections, we have specimens attributed to "Globigerina" tapuriensis at the Eocene/Oligocene boundary while in Spain this taxon, in agreement with Blow (1979), appears above the boundary. After the Eocene/Oligocene boundary the FO of Catapsydrax d. dissimilis occurs in both areas.

Cassigerinella chipolensis has not been found in the lowermost Oligocene in either area. In Spain, this form appears close to the boundary P18/P19 which is later than has been reported by Bolli (1957b).

The small Pseudohastigerinids, P. naguewichiensis and P. barbadoensis, which are present since the top of the Upper Eocene, continue into the Lower Oligocene, while larger forms (greater than 150 microns), named P. micra by Molina et al. (this volume) and P. danvillensis by Nocchi et al. (this volume) disappear at the Eocene/Oligocene boundary.

The comparison of deep water benthic foraminifera from the two areas has revealed some similarities. Benthic microfauna are always subordinate to the planktonic one. Nuttallides truempyi is present but discontinuous at the top of Eocene, and disappears before the Eocene/Oligocene boundary. In the Fuente Caldera section, the latter taxon disappears simultaneously with the T. cerroazulensis group; in the Italian sections N. truempyi disappears slightly before the T. cerroazulensis group.

After the disappearance of the T. cerroazulensis group, we find the FO of Anomalinoidea pompilioides and the LO of Alabama dissonata. After the LO of C. inflata there is in both areas, the occurrence of small forms of Bolivinids (Bolivina antegressa gr., B. floridiana and B. obscuranta) which characterize the fractions smaller than 150 microns. After the boundary P15/P16 Aragonia, represented mainly by A. janoscheki, disappear although they are already rather scarce since P15. After the FO of T. cunialensis we find the occurrence of large agglutinated foraminifera such as Cyclamina acutidorsata and Haplophragmoides sp.. Differences between the two areas concern the Uvigerinids, which are more

abundant in the Italian sections after the Eocene/Oligocene boundary, while in Spain they remain subordinate to other forms. In the Upper Eocene the *Uvigerinids* are represented by *U. rippensis*, *U. multistriata* and *U. havanensis*; after the boundary *U. eoacaena* is common. In the Upper Eocene of the Italian sections *Cibicidoides* and *Heterolepa* are more prevalent than *Anomalinoidea* and *Lenticulina*, whereas the opposite is found in the Spanish sections.

The deep water assemblages in Spain are much rarer, however, they exhibit some similarity to those of the Italian basin considered in this work.

The shallow water microfaunas, which are found in the calciruditic and calcarenitic levels, are sometimes scattered in the marls, thus recording the presence of similar neritic source areas adjacent to the basins in both areas. The assemblages are generally characterized by *Discocyclinidae* and red algae. At the top of the Eocene, *Asterigerina rotula* and *Gypsinidae* become more common, while *Nummulites* are rare. In both areas, rare Cretaceous forms are sometimes present close to the Eocene/Oligocene boundary.

Upper Eocene shallow water microfaunas continue upward in to the portion of the Oligocene studied here. *Rotalidae* (mainly *Pararotalia* spp.) are the common forms at the base of the Oligocene in both areas. In the Fuente Caldera and Molino de Cobo sections of Spain, the first occurrence of *Lepidocyclina* is above the interval studied here, near the boundary between P20 and P21, before the FO of *Globigerina angulisuturalis*.

CONCLUSIONS

The comparison between the Subbetic and Umbrian areas has allowed us to recognize biostratigraphic events common to both areas occurring in the same vertical order as shown in fig.2.

Isochronous extinctions of *G. index* and *Discoaster barbadiensis* and *D. saipanensis* have been recognized by Nocchi et al. (this volume) and by Molina et al. (this volume). In absence of *C. inflata* these latter events were used to identify with same uncertainty the P16/P17 boundary in Italy. The comparison carried out in this work clearly shows that the events mentioned above occur below the LO of *C. inflata*. Therefore, the P16/P17 boundary must be drawn above the LO of *G. index* and not equated to it.

In the Spanish sections *Hantkeninidae* are common or abundant and continuously present, while in the Italian sections an increase in *Hantkeninidae* occurs after the disappearance of *G. index*. Moreover, it has been confirmed that the extinction of *T. cerroazulensis* group occurs slightly before the *Hantkeninidae* extinction, represented mainly by *Cribrohantkenina lazzarii* in both areas. The last occurrence of *Pseudohastigerina* with a diameter greater than 150 microns cor-

responds to the Hantkeninidae extinction which indicates the Eocene/Oligocene boundary.

The Subbetic sections and some Umbrian sections contain calcarenitic intercalations with reworked skeletal debris coming from a carbonate platform. The similar faunal content points out that in the Late Eocene there was an adjacent neritic environment with a high organic activity in both areas. In the lower planktonic biozones of the Oligocene Discocyclusinidae are dominant. Chapmanina and Pellatispira, which are taxa characteristic of the Upper Eocene, have been found in both the Spanish and Italian sections while Lepidocyclusinidae are absent and appear much later in the Late Oligocene.

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PLATE 1

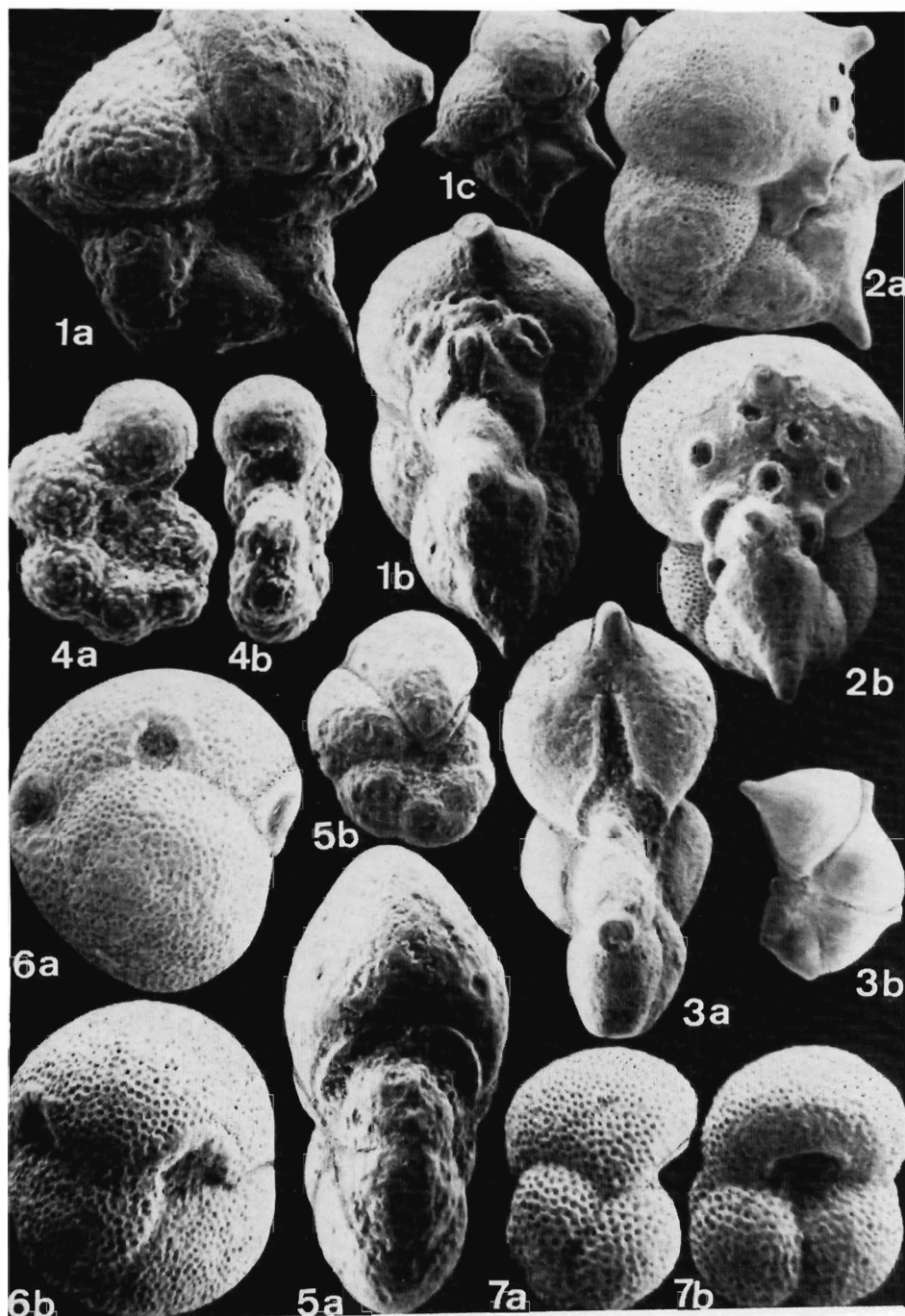


PLATE 2



PLATE 1

1. Cribrorotatoria lazzarii (PERICOLI). Sample FC 13,8 Spain. Zone of C. lazzarii. x 100 (a,b), x 50 (c).
2. Cribrorotatoria inflata (HOWE). Sample FC 12 Spain. Zone of C. inflata. x 100.
3. Hantkenina brevispina CUSHMAN. Sample FC 7 Spain. Zone of P. semiinvoluta. x 100 (a), x 50 (b).
4. Pseudohastigerina nagewichiensis (MYATLIUK). Sample TC 9. Zone of G. gortanii. x 200.
5. Pseudohastigerina micra (COLE). Sample FC 12 Spain. Zone of C. inflata. x 200 (a), x 100 (b).
6. Porticulasphaera semiinvoluta (KEIJZER). Sample FC 7 Spain. Zone of P. semiinvoluta. x 100.
7. Globigerina tapuriensis BLOW & BANNER. Sample FC 17 Spain. Zone of G. tapuriensis. x 100.

PLATE 2

1. Turborotalia cunialensis (TOUMARKINE & BOLLI). Sample PMI 0 Italy. Zone P 16. x 100.
2. Pseudohastigerina danvillensis (HOWE & WALLACE). Sample PMI 26 Italy. Zone P 17. x 100 (a,b).
3. Globigerinatheka tropicalis (BLOW & BANNER). Sample PMI 7 Italy. Zone P 16. x 100.
4. Bolivina gr. antegressa SUBBOTINA. Sample PMI 26 Italy. Zone P 17. x 100.
5. Bolivina gr. antegressa SUBBOTINA. Sample PMI 26 Italy. Zone P 17. x 100.
6. Uvigerina sp. Sample PMI 37 Italy. Zone P 18. x 100.
7. Uvigerina multistriata HANTKEN. Sample PMI 37 Italy. Zone P 18. x 75.
8. Uvigerina cf. multistriata HANTKEN. Sample FC 13,8 Spain. Zone of C. lazzarii. x 50.