BIOSTRATIGRAPHY OF SARAKHS (N.E. IRAN) AND NAFTE- SHAHR (N.W. IRAN) SECTIONS

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Abstract

It is the first time that biostratigraphic zonations of calcareous nannoplankton from Maestrichtian to Lower Tertiary deposits of Iran are reported. The required samples from the north-eastern and western parts of the country were selected from the stocks of the National Iranian Oil Company. Taxonomic descriptions were not the main objectives, although a new species and genus are apparently present in the assemblages. The main purpose of this study is to establish the biostratigraphic zonations and correlate them with the universally accepted standard biozones. Both petrographic and scanning electronic microscopes were used in this investigation.

Introduction

Calcareous nannoplankton are marine planktonic calcareous algae that first appeared in the Lower Jurassic and quickly established themselves as important constituents of the phytoplankton populations. They evolved rapidly, particularly in the Cenozoic and thus show great promise in becoming effective biostratigraphic tools and in recent years there have been great strides in the establishment of a high resolution biozonation based on coccoliths and discoasters in the tropical-subtropical areas. Their paleobiogeographic patterns in higher latitudes are now being studied and once the migrationary patterns of assemblages through time and space are well known, it is hoped that this group of microfossils will also become a useful tool for high latitude biostratigraphy.

This report describes the Maestrichtian and Lower Tertiary biostratigraphy of the Sarakhs and Nafte-Shahr sections of Iran. Over 250 samples selected from the National Iranian Oil Company were analyzed for their nannofloral content with the help of a petrographic light microscope (LM) and a scanning electron microscope (SEM).

Keywords: Iran; Nannoplankton; Biostratigraphy; Biozonation; Maestrichtain-lower eocene; Range charts

The only previous study of the Iranian calcareous nannoplankton was made by Haq [8], in which Paleocene flora of the Garau Valley and Tange-Bijar sections were described.

Sixteen tables and range charts were prepared and presented for this study. Due to the problems of space limitation priniting of these charts have been omitted. All the tables and the species charts are available and can be mailed to those who are intereseted.

Methodology

Smear-slides were prepared from raw samples for LM examination. No centrifuging was done so as to make more accurate counts for the relative percentage of various species. A Zeiss research microscope at 1200X magnification was used. Both phase-contrast and cross-polarized light conditions were employed for recognition of diagnostic criteria.

For SEM relatively better preserved samples were selected and first treated with sodium hexametaphosphate for 72 hours, then ultrasoned at low frequency and centrifuged to concentrate coccoliths. Single drops of these concentrated suspensions were dried on SEM sticks, coated with about 400Å of gold in a vacuum evaporator for SEM examination. For details of the centrifuging method, see Edwards [5], and for the SEM methods see Haq [7].

Biostratigraphy was established with the help of LM only. SEM was used only to illustrate important or diagnostic species.

Preservation of Nannofossils

Preservation in most samples is from poor to very poor. Very few samples show "fair" preservation and have been used for SEM study. However, even in poorly preserved samples most species of coccoliths can be recognized. Discoasters, when they are present, usually show at least some recrystallization, in most cases the arms of discoasters show heavy overgrowth of calcite so as to thicken them. In extreme cases the arms thicken to the extent that they coalesce, making the species unrecognizable.

It would seem that both sections (Sarakhs and Nafte-Shahr) show signs of extensive diagenetic effects. In parts of the sections diagenesis has wiped out all signs of calcareous microfossils. In general, Lower and Middle Eocene parts show relatively lesser signs of diagenesis than Paleocene or Upper Eocene-Oligocene, and the Sarakhs Section shows a better preservation and more diverse assemblages than the Nafte-Shahr Section.

Biostratigraphy

The biostratigraphic zonation used in the range charts is the "standard" zonation of Martini [14] for tropical and subtropical regions. A summary of Martini's zonation and ranges of the important species is provided in Tables 1 and 2. The biostratigraphy of the individual sections is discussed below.

Sarakhs Section

Although the assemblages are mostly poor preserved in this section, they show great diversity and a total of 59 species were recorded from the Paleocene to Upper Eocene interval of this section. Samples 1764 to 1766 could not be placed within a zone due to lack of diagnostic zonal species. However, the 14 species recorded place these samples within the Middle to Upper Paleocene. Samples 1767 to 1774 can be placed within the *Discoaster gemmeus* and *D. multiradiatus* Zones of Upper Paleocene although zonal markers themselves are usually absent or very rare. However, the presence in large numbers of *Toweius craticulus*, a species that appears in the upper two zones of Paleocene, places these samples within the two zones mentioned. There seems to be either a sampling gap or a hiatus between samples 1774 and 1775 because two of the Lower Eocene Zones *(Marthasterites contortus* and *Discoaster binodosus)* are absent. Samples 1775 and 1776 are placed within the *Marthasterites tribrachiatus* Zone of Lower Eocene due to co-occurrence of *M. tribrachiatus* and *Discoaster lodoensis* in these samples. Samples 1777 and 1778 are placed in the *D. lodoensis* Zone of Middle Eocene; samples 1779 and 1780 within *Chiphragmalithus alatus* Zone and sample 1781 in *Discoaster tani nodifer* Zone also of Middle Eocene. *Discoaster saipanensis* first appears in sample 1782 and therefore samples 1782 to 1783 are placed in the *D. saipanensis* Zone of Upper Eocene.

Chiasmolithus oamaruensis first appears at level 1794 and then occurs sporadically throughout up to sample 1821, although in very rare numbers. There is a barren to nearly barren interval from samples 1838 to 1864 and *Isthmolithus recurvus* first appears in sample 1866. All samples between 1794 and 1865 (including the barren interval) are therefore considered to belong to the *Chiasmolithus oamaruensis* Zone of Upper Eocene. All samples between 1866 and 1875 are placed within the *Ismolithus recurvus* Zone of Upper Eocene due to the continued occurrence of *Discoaster barbadiensis* and D. *saipanensis* and also because of the lack of *Sphenolithus pseudoradians* which appears in the uppermost Eocene.

Nafte- Shahr Section

The Nafte-Shahr Section was provided in three suites of samples, two covering Upper Maestrichtian to Lower Tertiary, and one covering Upper Paleocene-Lower Oligocene interval. The preservation of nannofossils in all samples of this section is very poor and show greater effects of diagenesis and recrystallization of calcite. That is one reason why the assemblages of this section are much less diverse than the Sarakhs section assemblages.

Suite 1 (samples NP100-117). Samples NP100 to 102 are placed within the uppermost Maestrichtian. Due to lack of diagnostic zonal species this part is not zoned.

Due to the sudden abundance of *Thoracosphaerids* in

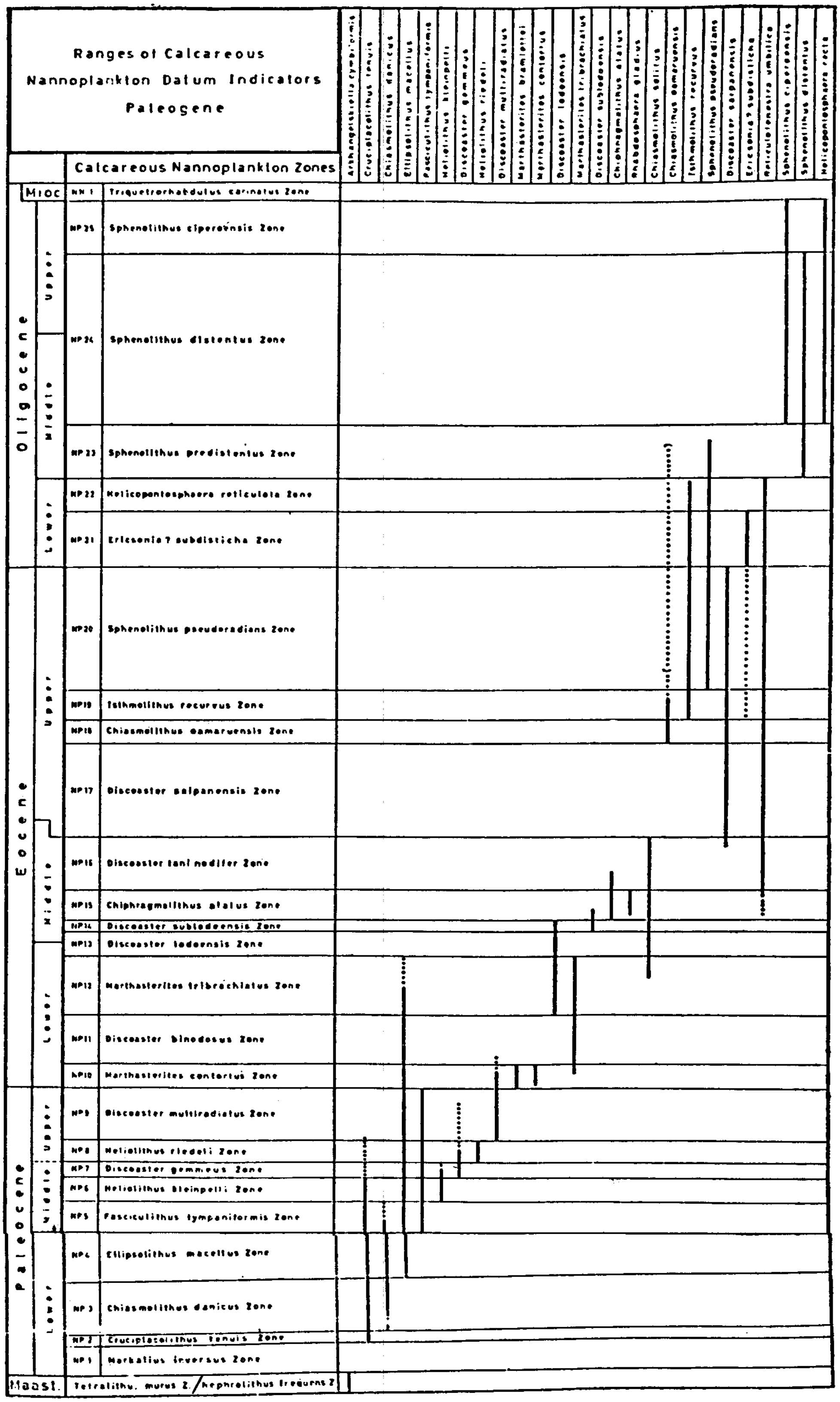
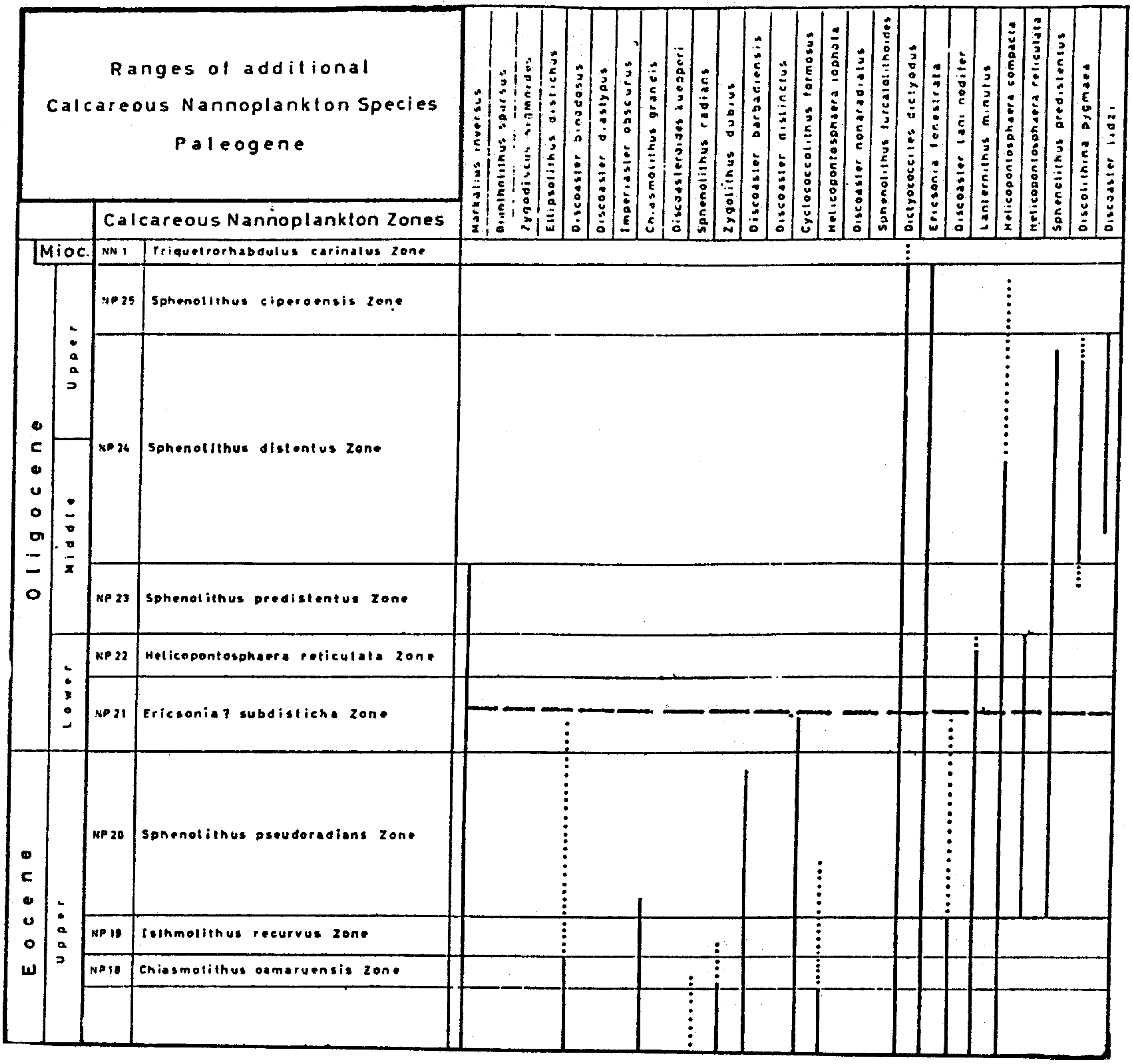


Table I: Ranges of important diagnostic species in Lower Tertiary. (after Martini-1971).


Ranges of additional
Calcareous Nannoplankton Species
Paleogene
Calcareous Nannoplankton Zones
Markalius inversus
Zygodiscus
Ellipsolithus distichus
Discoaster binodosus
Discoaster deflandrei
Imperiaster obscurus
Chiasmolithus grandis
Discoasteroides kuepperi
Sphenolithus radians
Zygolithus dubius
Discoaster barbadiensis
Discoaster distinctus
Cyclococcolithus formosus
Helicopontosphaera lophota
Discoaster nonaradiatus
Sphenolithus furcatolithoides
Dictyococcites dictyodus
Ericsonia fenestrata
Discoaster lani nodifer
Lanternithus minutus
Helicopontosphaera compacta
Helicopontosphaera reticulata
Sphenolithus predistentus
Discolithina pygmaea
Discoaster lidzi
Mioc.
Oligocene
Eocene
Upper
Middle
Lower
Upper
NN 1 Triquetrorhabdulus carinatus Zone
NP 25 Sphenolithus ciperoensis Zone
NP 24 Sphenolithus distentus Zone
NP 23 Sphenolithus predistentus Zone
NP 22 Helicopontosphaera reticulata Zone
NP 21 Ericsonia? subdisticha Zone
NP 20 Sphenolithus pseudoradians Zone
NP 19 Isthmolithus recurvus Zone
NP 18 Chiasmolithus oamaruensis Zone

sample 103 that sample is placed within the lowermost zone *(Markalius astroporus)* of Danian. This abundant occurrence of *Thoracosphaerids* at the bottom of Danian stage has been noticed in sections from many other parts of the world.

Ellipsolithus macellus- a marker of Upper Danian zone- appears in sample NP104. In sample NP105 already the Upper Paleocene marker *Discoaster multiradiatus* appears. There is an apparent gap between samples NP104 and 105. Due to the presence of *Marthasterites tribrachiatus* and the absence of *Discoaster lodoensis* in sample NP106, it is tentatively placed within the *Discoaster binodosus* Zone of Lower Eocene. Sample NP107 shows a Lower Eocene assemblage, but due to lack of diagnostic species it cannot be placed within a zone. Similarly samples NP108 to 111 and NP112 to 117 are placed in unzoned Middle Eocene and Upper Eocene respectively due to lack of diagnostic zonal marker species.

Suite 2 (Samples NP118-NP199).

Samples NP118 to NP134 contain a normal Upper Maestrichtian assemblage without diagnostic zonal markers. However, in samples NP135 to NP141 *Micula mura* appears which is a marker species for the uppermost Upper Maestrichtian in tropical-subtropical areas.

Both *Markalius astroporus* and *Prinsius martinii* appear in samples NP142 and 143, indicating the Lower Danian *M. astroporus* Zone. Samples NP144 and 145 are placed in the middle Danian *Cruciplacolithus tenuis* Zone and NP146 in the Upper Danian *Chiasmolithus danicus* Zone and NP147 is tentatively placed within the *Ellipsolithus macellus* Zone of Lower Paleocene. The *Fasciculithus tymapaniformis* Zone of Middle Paleocene is assigned to sample NP148. Already in NP149 *Discoaster gemmeus*, a zonal marker of Upper Paleocene, appears indicating a sample gap or a possible hiatus between NP148 and 149.

Samples NP151 to 154 are placed within the *Discoaster multiradiatus* Zone of uppermost Paleocene. The *Marthasterites contortus* Zone of Lowermost Eocene is indicated for samples NP155 to 157. Due to the absence of *Discoaster lodoensis* in NP158 and 159 these samples are placed in the *Discoaster binodosus* zone of Lower Eocene. Concurrent occurrence of *D. lodoensis* and *Marthasterites tribrachiatus* in samples NP160 to 163 places them within the *M.tribrachiatus* Zone of the upper part of Lower Eocene.

Due to poor preservation and lack of diagnostic zonal marker species, samples NP164 to NP199 could not be zoned. However, NP164 to 183 show a typical assemblage of Middle Eocene and NP184 to 189 an assemblage of Upper Eocene. Samples NP190 to 196 can only be placed within the Upper Eocene- Lower Oligocene interval. Samples NP197-199 were barren and devoid of nannofossils.

Suite 3 (Samples NP247 to 200).

A total of 11 species found in samples NP247 and 246 are typical of the *Discoaster multiradiatus* Zone of Upper Paleocene. Sample NP245 contains rare *Marthasterites contortus*, indicative of the lowermost Lower Eocene. Samples NP244 to 241 are placed in the *Discoaster binodosus* Zone and the co- occurrence of *Marthasterites tribrachiatus* and *Discoaster lodoensis* places samples NP240 to 237 within the *M. tribrachiatus* Zone of the upper part of Lower Eocene.

Again, due to lack of diagnostic zonal species, most of the rest of this section could not be placed within an established zonation scheme. Samplse NP236 to NP219 contain Middle Eocene species and samples NP218 to 215 Upper Eocene species. Due to the presence of *Sphenolithus pseudoradians* in NP215, this sample could belong to the uppermost Upper Eocene Zone. The absence of *Discoaster barbadiensis* in samples NP214 to NP209 places these samples within Lower Oligocene. All samples above this level (NP208 to 200) were devoid of calcareous nannoplankton.

Paleoecology

In the Sarakhs Section the variations in relative abundances of *Discoasters* and *Chiasmoliths* reflect the fluctuations in the climates of Eocene Epoch. *Discoasters* are warm water forms, preferring the tropical and subtropical regions. On the contrary, *Chiasmoliths* show a definite preference for the cooler waters of the higher latitudes. Thus, the fluctuations in the abundances of these taxa ought to reflect the corresponding warming or cooling of the basin. In the Sarakhs Section such an inverse relationship is seen when in Sample 1779 the relative abundance of *Discoasters* is suddenly decreased and slightly higher in sample 1780 the *Chiasmoliths* become much more common than *Discoasters*. This obvious cooling trend continues throughout the Middle and part of the Upper Eocene. *Discoasters* occur in rarer

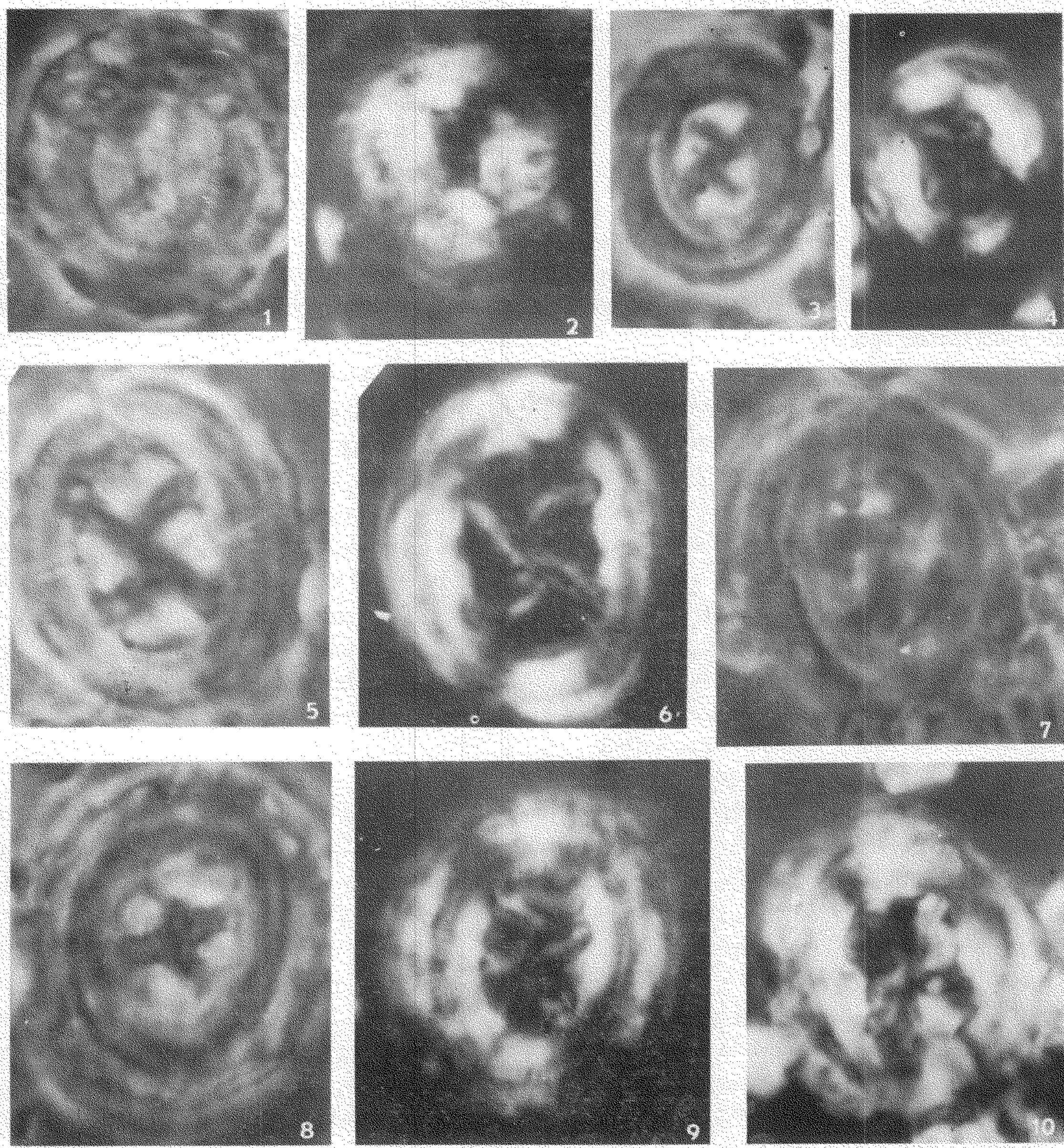


Plate I

(All figure light micrographs at X7000)

Figs. 1&2 **Coccolithus eopelagicus**
Figs. 3&4 **Chiasmolithus solitus**
Figs. 5&6 **Chiasmolithus consuetus**
Figs. 7&10 **Chiasmolithus** cf. **grandis**
Figs. 8&9 **Chiasmolithus oamaruesis**

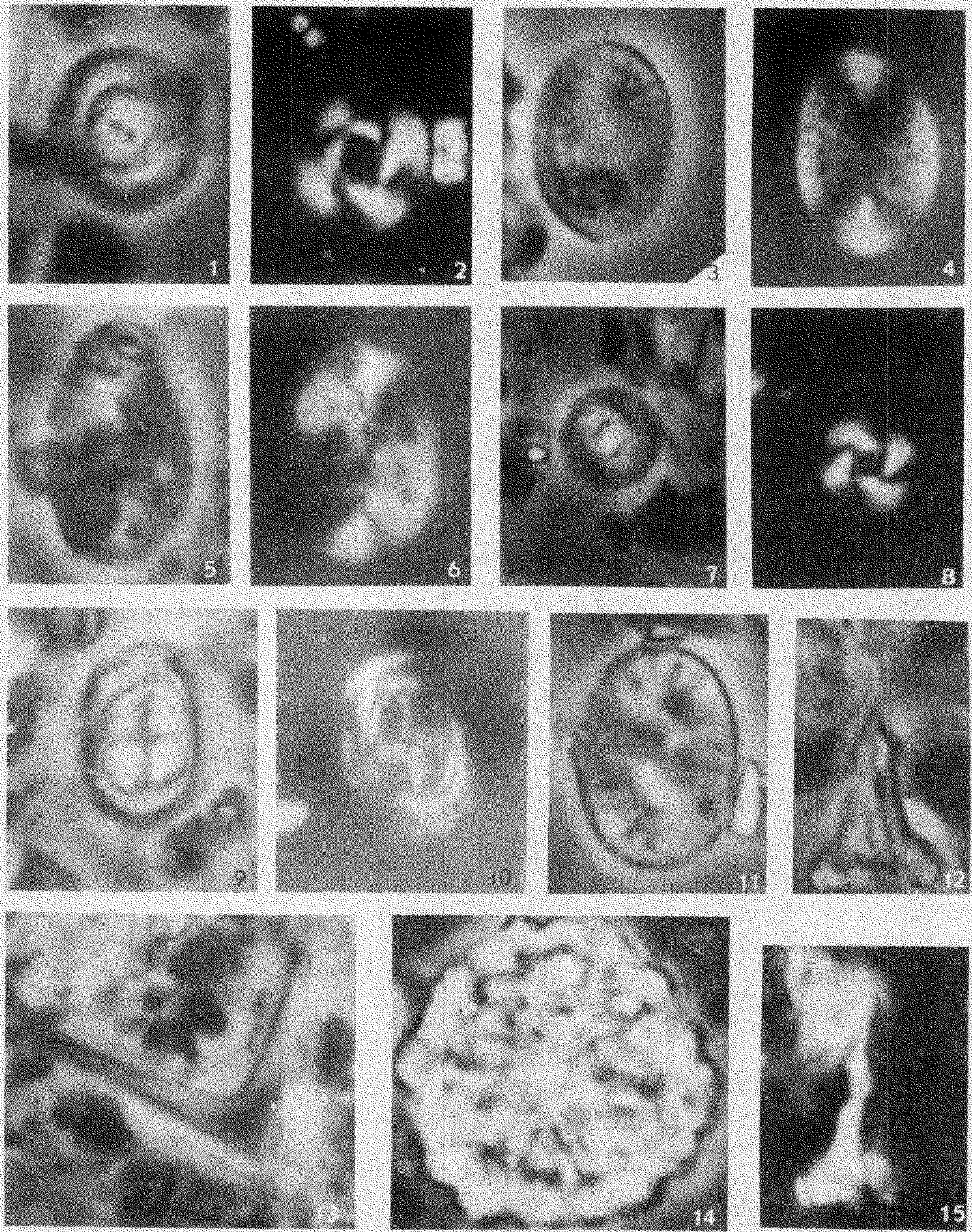


Plate II
(All figures light micrographs at X7000)

Figs. 1&2 **Cyclococcolithus neogammation**
Figs. 3&4 **Pontosphaera mutipora**
Figs. 5&6 **Pontosphaera plana**
Figs. 7&8 **Ercsonia hesslandii**
Figs. 9&10 **Campylosphaera dela**
Figs. 11 **Transversopontis pulcher**
Figs. 12&15 **Zygrhablithus bijugatus**
Fig. 13 **Micrantholithus vesper** (single crystal of pentalith)
Fig. 14 **Lithostromation perdurum**

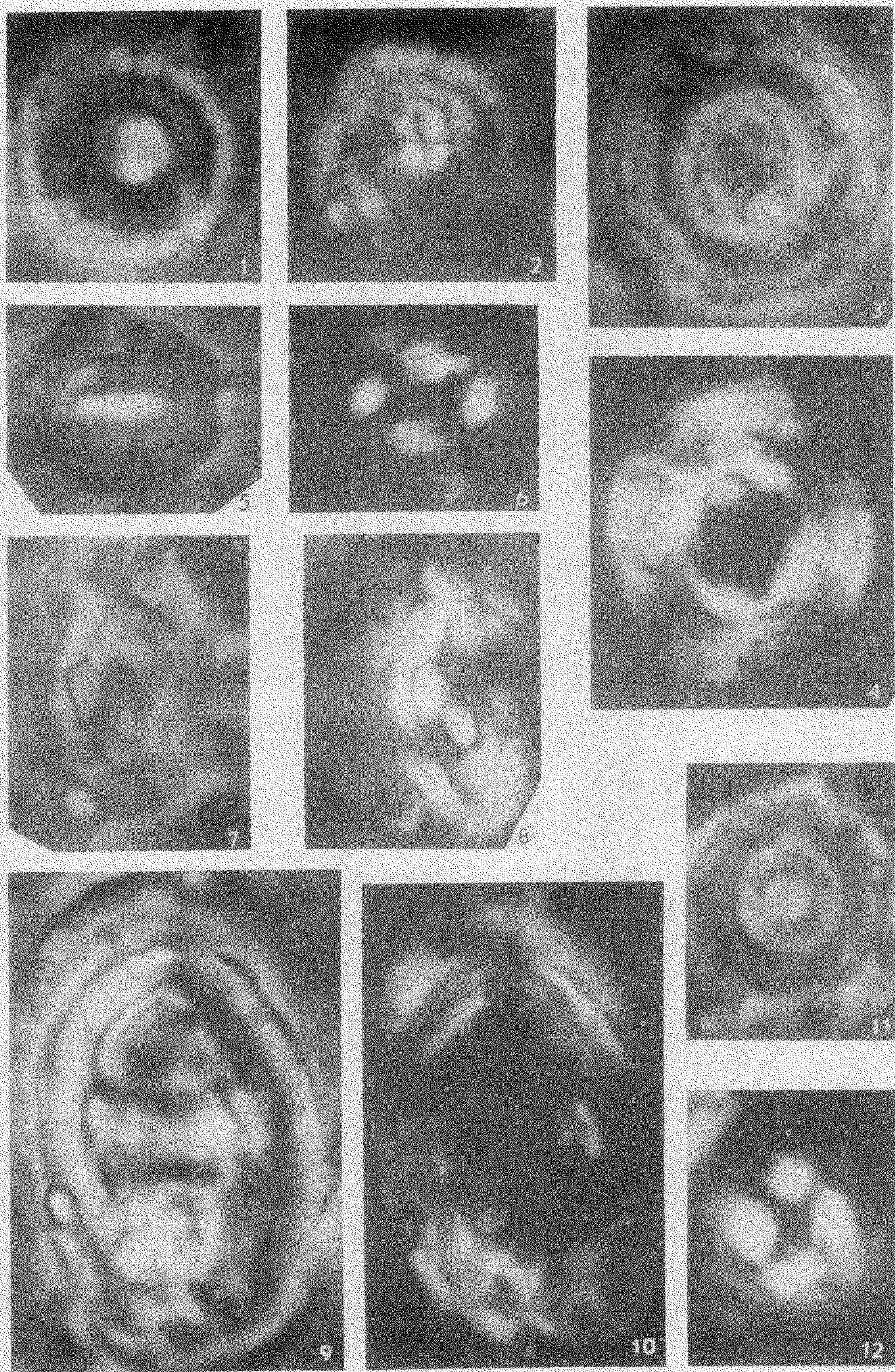


Plate III

(All figures X7000; except figs. 9&10 = X1000)

Figs. 1&2 **Markalius astroporus**
Figs. 3&4 **Reticulofenestra umbilica**
Figs. 5&6 **Ericsonia ovalis**
Figs. 7&8 **Helicopontosphaera lophota**
Figs. 9&10 **Helicopontosphaera seminulum**
Figs. 11&12 **Cyclococcolithus formosus**

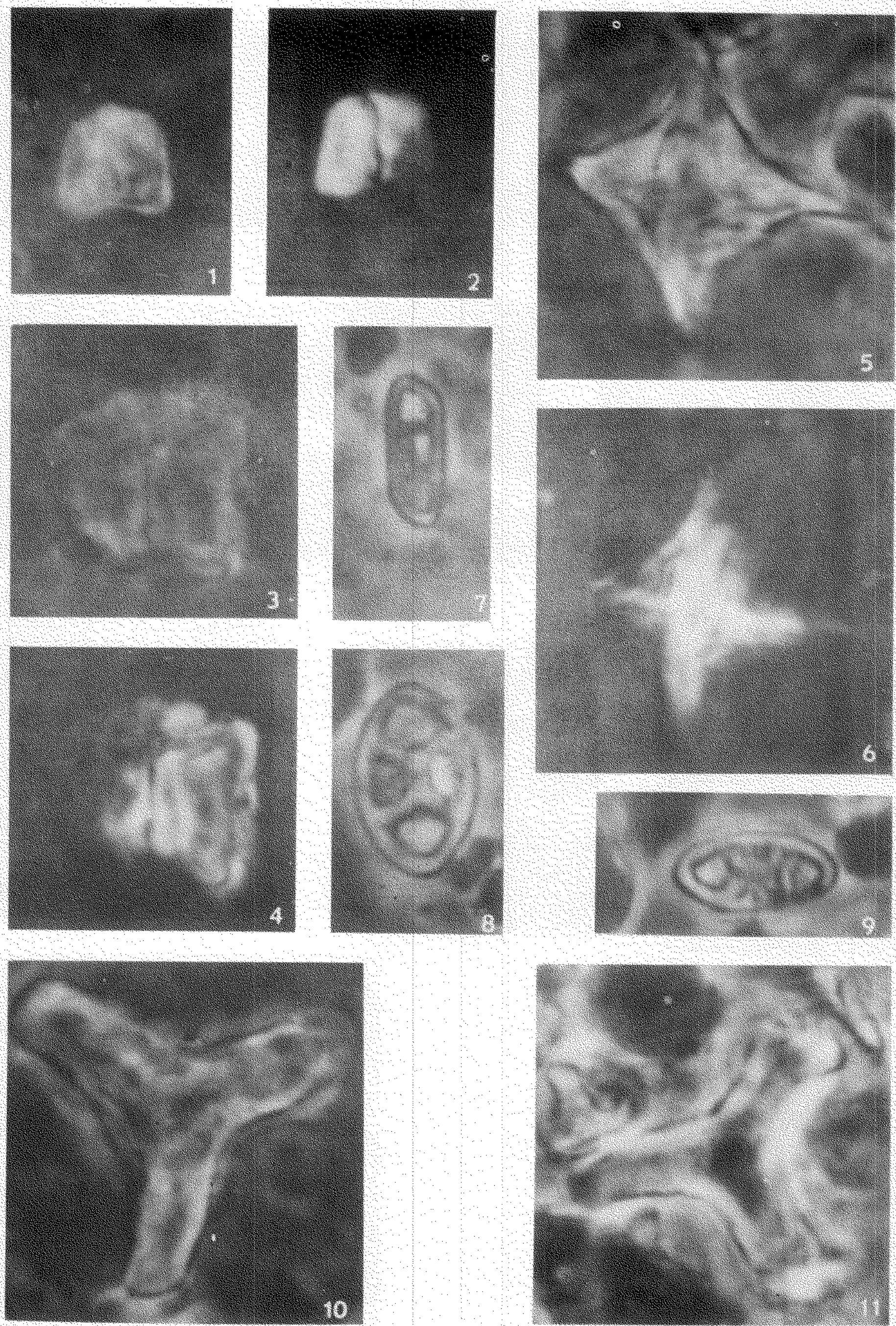


Plate IV
(All figures light micrographs at X7000)

Figs. 1&2 **Fasciculithus tympaniformis**
Figs. 3&4 **Fasciculithus ullii**
Figs. 5&6 **Chiphragmalithus alatus**
Fig. 7 **Isthmolithus recurvus**
Fig.8 **Zygolithus dubius**
Fig.9 **Zygolithus sp.**
Fig.10 **Marthasterites tribrachiatus**
Fig.11 **Marthasterites contortus**

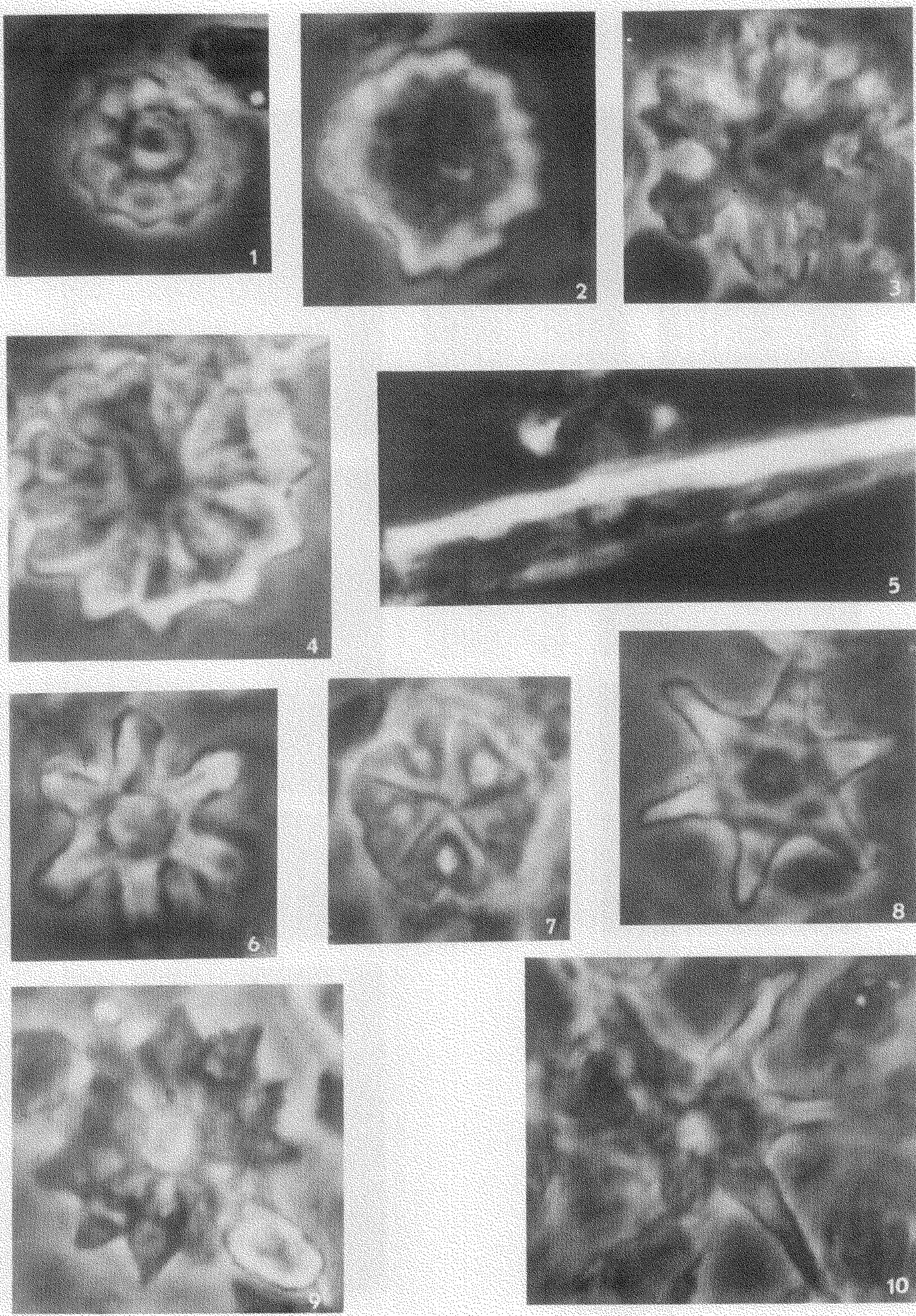


Plate V

(All figures light micrographs at X7000)

Fig. 1 **Discoasteroides kuepperi**
Fig. 2 **Discoaster gemmeus**
Fig. 3 **Discoaster distinctus**
Fig. 4 **Discoaster barbadiensis**
Fig. 5 **Blackites spinosus (stem only)**
Fig. 6 **Discoaster binodosus**
Fig. 7 **Micrantholithus basquensis**
Fig. 8 **Discoaster saipanensis**
Fig. 9 **Discoaster delicatus**
Fig. 10 **Discoaster lodoensis**

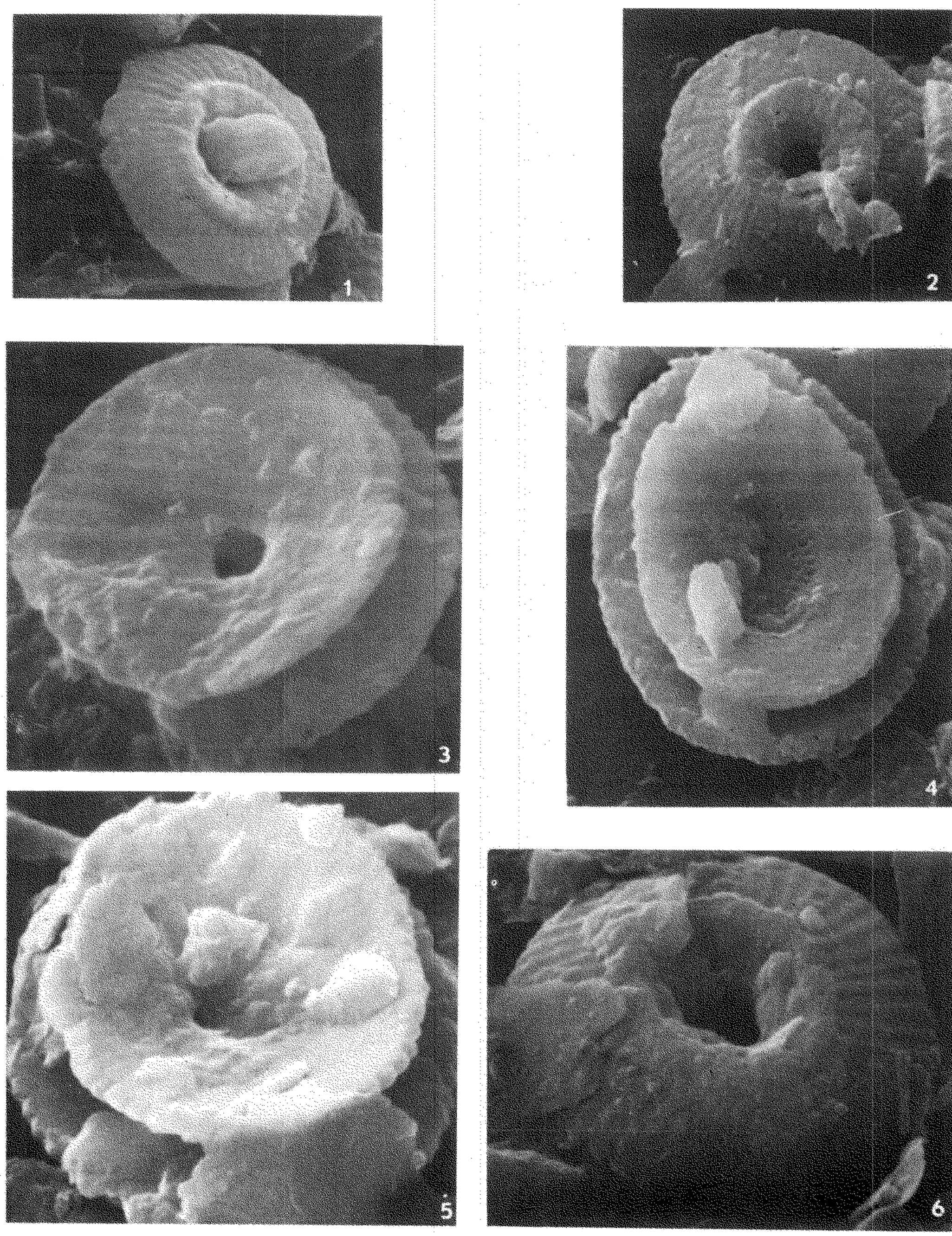


Plate VI

(All figures scanning electron micrographs)

Figs. 1&2 **Cyclococcolithus neogammation** (both figs. at X1000)

Figs. 3&5 **Cyclococcolithus formosus, (fig. 3-X18000; fig. 4-X20000)**

Fig. 4 **Reticulofenestra dictyoda,** 4-X20000)

Fig. 6 **Ericsonia ovalis,** X20, 000

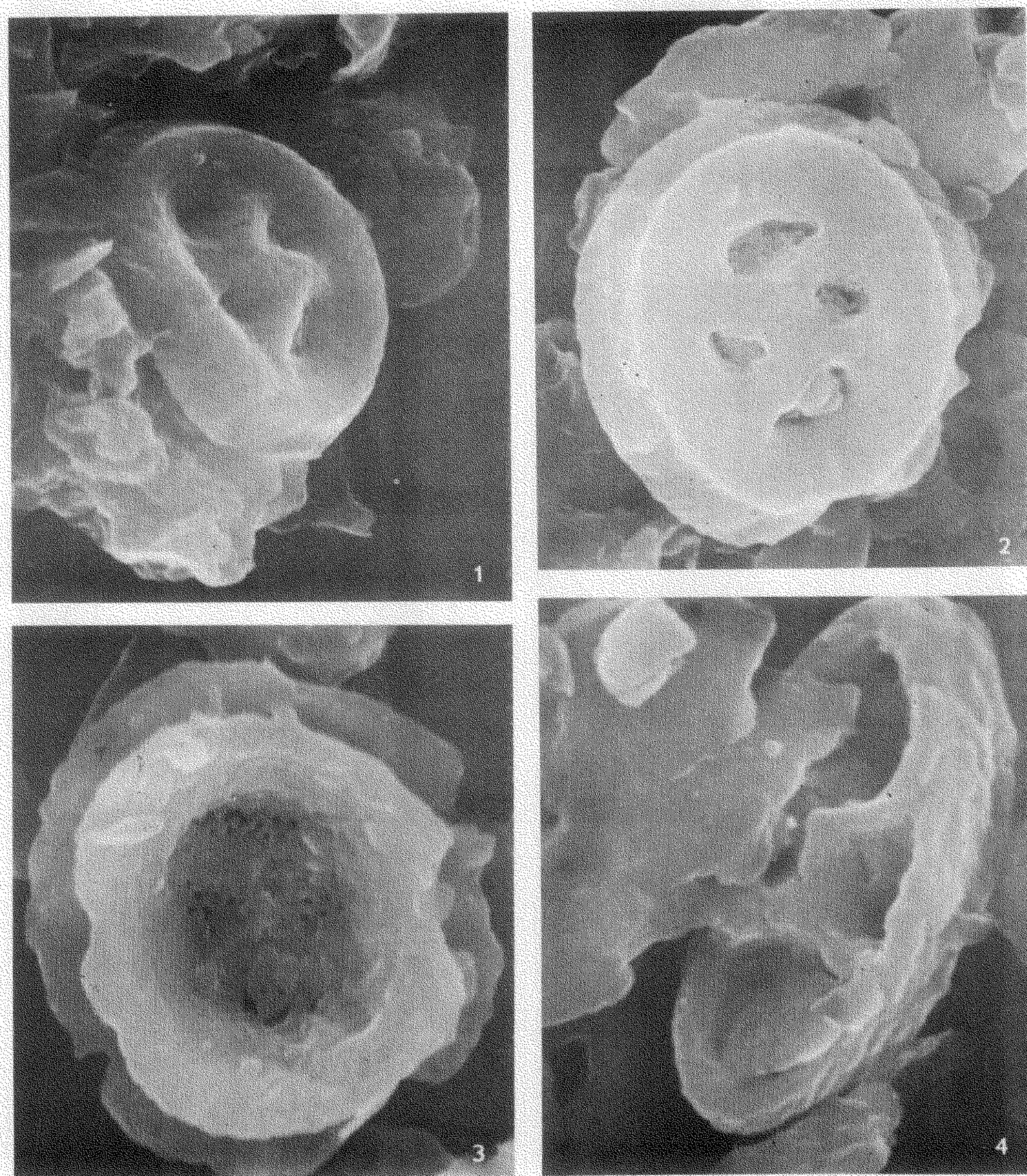


Plate VII

(All figures scanning electron micrographs)

Figs. 1&2 **Chiasmolithus oamaruensis** (fig. 1: X9, 000, fig. 2: X7, 000)

Fig. 3 **Chiasmolithus? consuetus** (X11, 000)

Fig. 4 **Zygolithus dubius** (X12, 000)

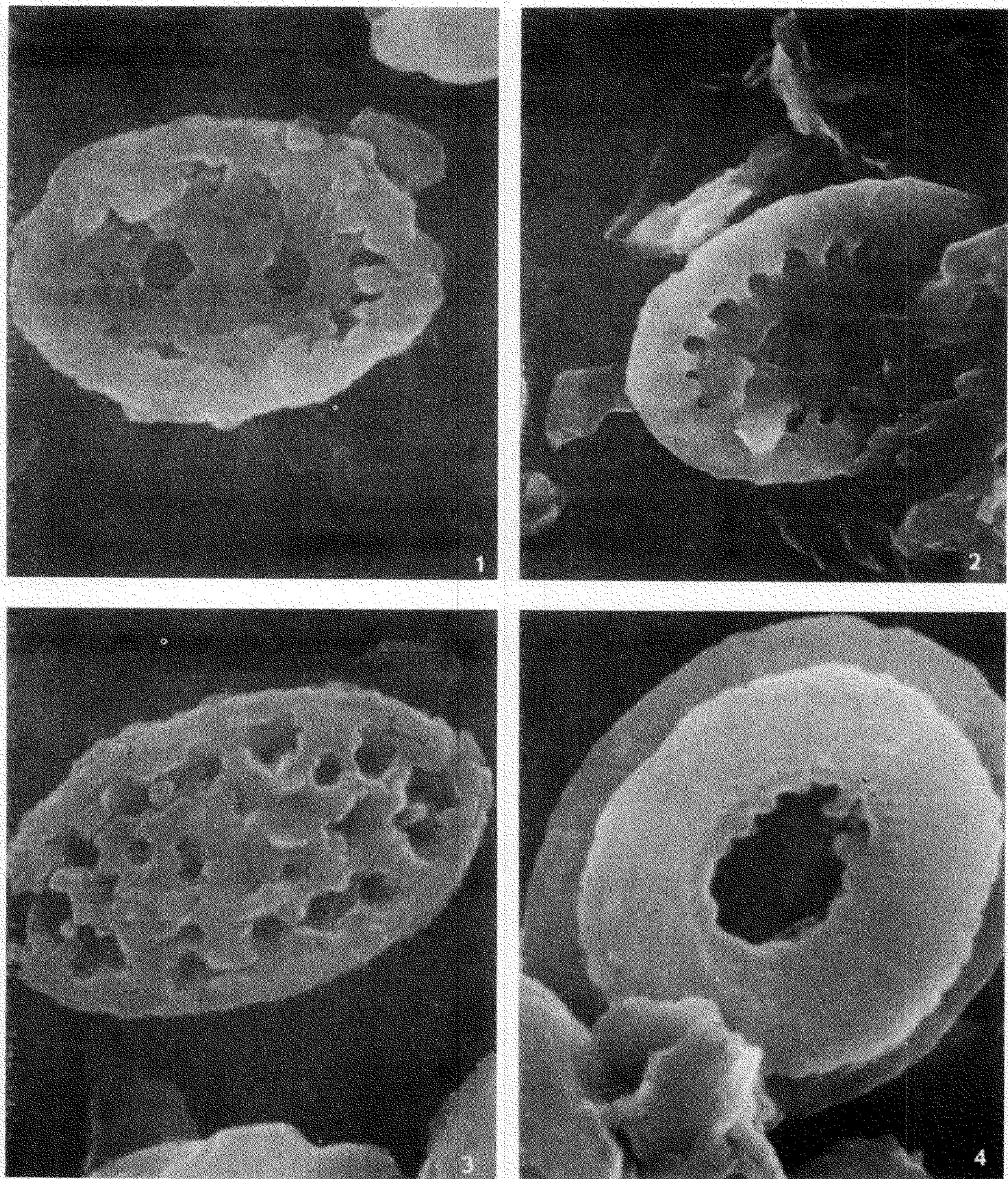


Plate VIII

(All figures scanning electron micrographs)

Fig. 1 **Discolithina panarium** (X10, 000) Fig. 3 **Pontosphaera mutipora** (X12, 000)

Fig. 2 **Transversopontis pulcher** (X7, 000) Fig. 4 **Reticulofenestra dictyoda** (X13, 000)

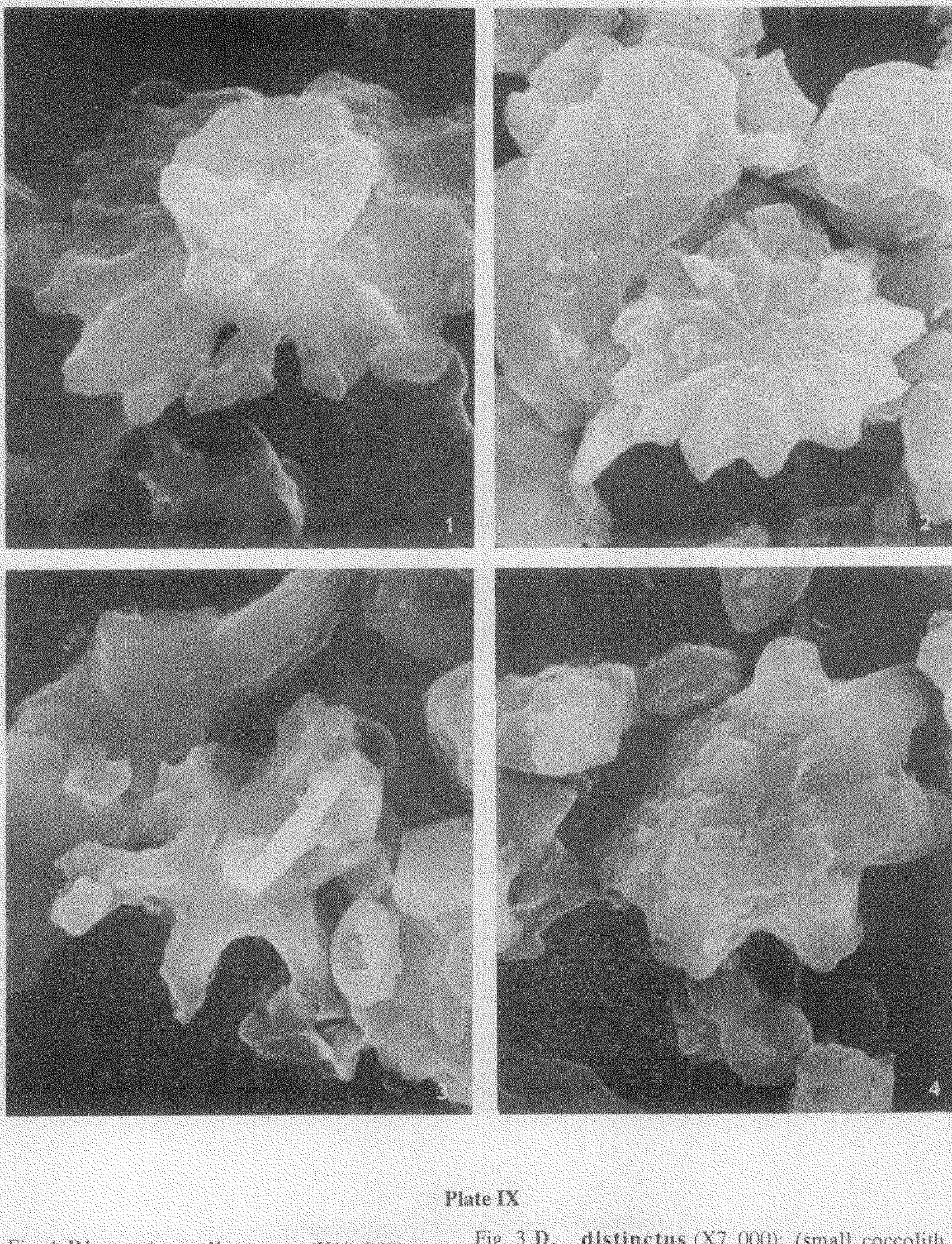


Plate IX

Fig. 1 **Discoaster diastypus** (X10, 000)

Fig. 2 **D. barbadiensis** (X, 000)

Fig. 3 **D. distinctus** (X7, 000); (small coccolith at right bottom; **Ericsonia hesslandi**)

Fig. 4 **D. mediosus** (X5, 000)

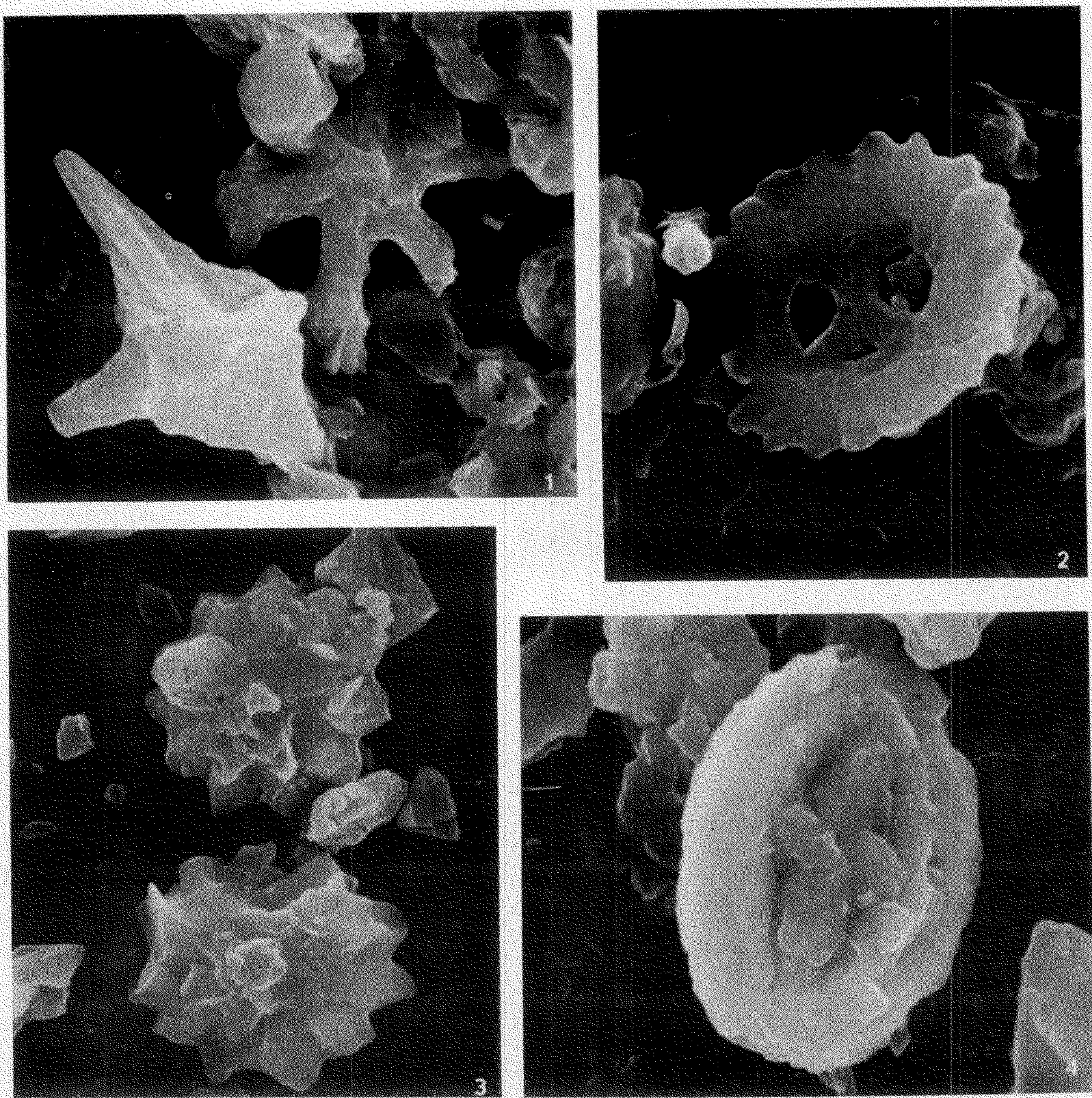


Plate X

Fig. 1 **Chiphragmalithus alatus** on letf, **Discoaster disinctus** on right (X6, 000)

Fig. 2 **New species of discoaster?** (sample no: **1809**) (X9, 000)

Fig. 3 **Discoaster barbadiensis** (X4, 000)

Fig. 4 **Broinsonia** sp. (a Cretaceous species reworked in Eocene) (X9, 000)

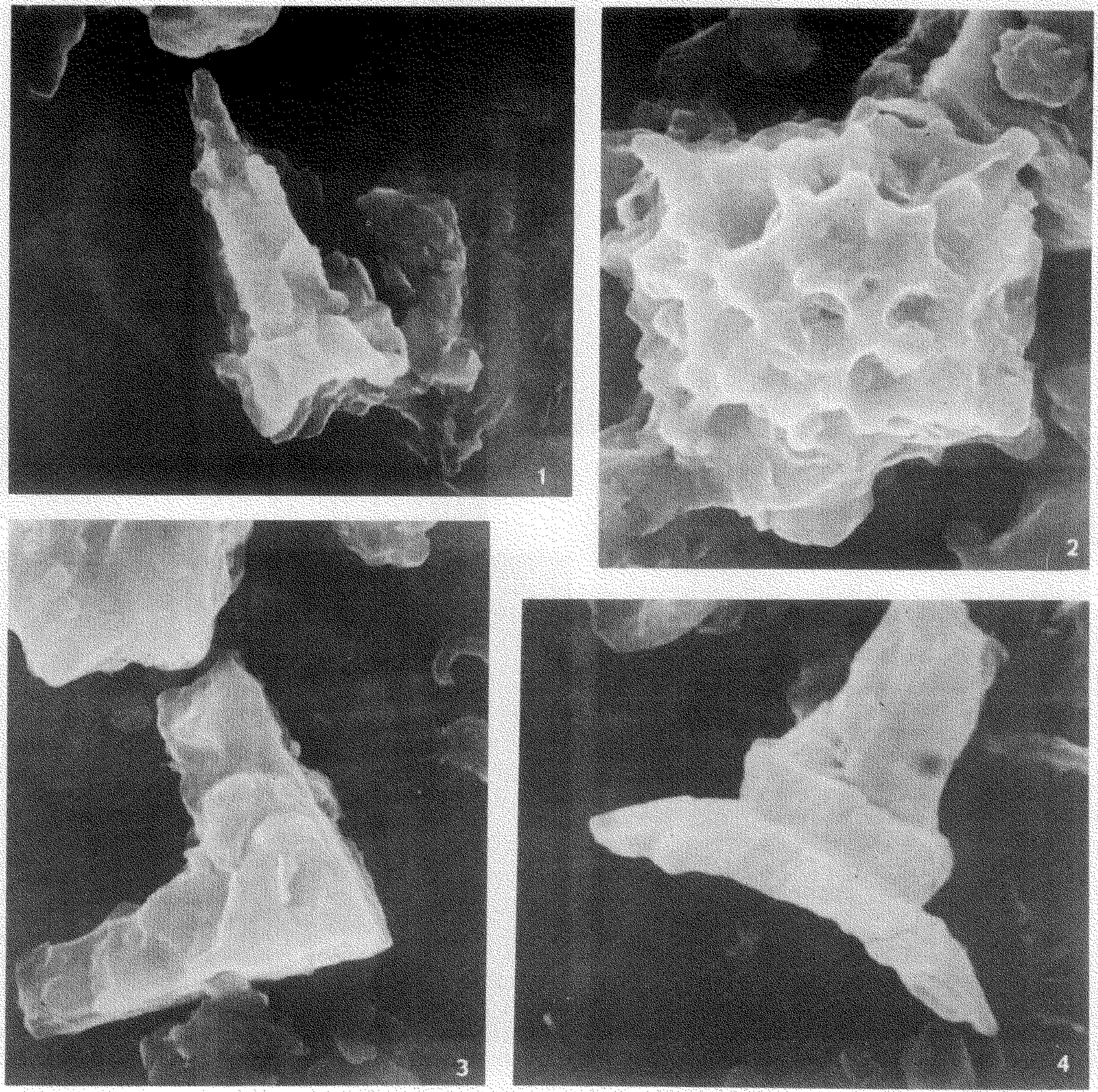


Plate XI

Fig. 1 **Sphenolithus? radians** (X7, 000)

Fig. 2 **Lithostromation perdurum** (X6, 000)

Fig. 3 Fragment of **Micrantholithus vesper** (X7, 000)

Fig. 4 **Blackites spinosus** (stem broken) (X12, 000)

Plate XII

Fig. 1 **Discolithina ocellata** (X11, 500)

Fig. 2 **Reticulofenestra umbilica** (central area missing) (X9, 000) numbers from 1780 to 1792 and then sample 1793 shows a complete absence of these forms indicating peak cooling. *Discoasters* begin to occur again in rare numbers after this level and become more common only in Sample 1806.

This Mid to Upper Eocene cooling is consistent with known oxygen-isotope paleotemperature data which shows a peak warming in early Eocene *(M. tribrichiatus* Zone) and a cooling throughout the remainder of Eocene. A sharp drop in temperature occurred at the Eocene/Oligocene boundary, eliminating most warm water species (such as *Discoasters*) from most parts of the world. This drop and a generally cooler Oligocene period is responsible for the low diversities and morphologically monotonous Oliogocene assemblages.

Also in the Sarakhs Section, the Upper Eocene *Chiasmolithus oamaruensis* Zone (samples 1794 to 1838) shows an exceptionally long duration indicating a definite increase in the sedimentation rates in the Upper Eocene. This, combined with the fact that this zone is followed by an interval of barren to nearly-barren samples, indicates that there was a greater influx of land-derived detritus during this time, pointing to intensified erosional processes, which in turn may have been affected by emergent continental morphology.

No paleoecological inferences can be made for the Nafte-Shahr Section due to the great diagenetic effects that have changed the original character of the assemblages to an extent where such inferences would be unreliable.

(All light micrographs with light background under phase-contrast light; all micrographs with dark background under X-nicols)

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