

## 21. CENOZOIC DINOCYST STRATIGRAPHY OF SITES 403 TO 406 (ROCKALL PLATEAU), IPOD, LEG 48

Lucy I. Costa<sup>1</sup> and Charles Downie, Geology Department, The University, Mappin Street, Sheffield S1 3JD, United Kingdom

### INTRODUCTION

During Leg 48 of IPOD, four holes were drilled at four sites on the southwestern margin of the Rockall Plateau. Palynological preparations were made of samples from all four sites. Most of the samples proved rich in palynomorphs, especially dinoflagellate cysts; the greatest abundance occurs in the Eocene; younger sediments, mainly pelagic oozes, yield poorer assemblages. Preservation is good to excellent throughout most of the sequences.

The samples studied and selected species lists for each site are given in Tables 1-4. A combined range chart is shown in Table 5; this is based mostly on species known to have restricted stratigraphic range in European and North American reference sections. These ranges permit the establishment of nine informal partial-range zones which, it is hoped, allow comparison with several zonal schemes published for dinocyst sequences in various parts of the world.

The abundance and type of pollen were studied, although not in great detail. Note was also taken of the nature and amount of palynological debris, and of the extent to which the material has been affected by temperature. The Thermal Index, based on the coloration scale by Staplin and Evans (1973), was approximately determined for indigenous material in each interval. Evidence for reworking was also recorded.

The results will be discussed in chronological order.

### LATE PALEOCENE

At Site 403, Cores 42 and below are very poor in dinocysts and rich in terrestrial plant debris and pollen, particularly of Taxodiaceae and conifers. This interval represents an environment with only minor and occasional marine incursions. The dinocysts recorded are consistent with a late Paleocene-early Eocene dating, but are too few to give any satisfactory characterization.

Zone Ia, defined by the occurrence of *Apectodinium* spp., is found at Site 403, Cores 35 to 41, and at Site 404, Cores 21 and below. *Apectodinium* aff. *augustum*, a late Paleocene indicator, occurs in Core 23 of Site 404, but it is absent from all other samples examined. *A. sumissum*, a species known to disappear shortly above the Paleocene/Eocene boundary, is common in most assemblages from this zone. Due to the absence of critical species, it is not possible to pinpoint the Paleocene/Eocene boundary in these sections. By comparison with northwest European assemblages, this is assumed to lie within Zone Ia, and possibly close to the top of the zone. The assemblages from this

interval are slightly richer in dinoflagellate cysts, suggesting a more continuous marine sedimentation, but terrestrial debris and pollen are strongly dominant, indicating a near-shore situation. The marine element is slightly more abundant at Site 404 than at Site 403. *Pediastrum* sp., a fresh-water Chlorophyta, is present in several samples from Zone Ia, but never reaches proportions greater than 8 per cent. There is no evidence of reworking in this interval.

The Thermal Index is generally low (1.5-2), but at Site 403, Core 42, Section 1, it rises to 4, indicating temperatures around 350°C and a local high heat source.

### EARLY EOCENE

The early Eocene includes Zones Ia (*pars.*), Ib, II, III, and IVa, and is present at all four sites.

Zone Ib is present at Site 403, Cores 34 to 29, and in Cores 21 to 16, Section 2 of Site 404. The zone is marked by the incoming of *Wetzeliella meckelfeldensis*, and its lower part correlates with the *W. meckelfeldensis* Zone of northwest Europe (Costa and Downie, 1976). *Apectodinium sumissum* occurs at the base of Zone Ib, which permits close comparison with the lowermost Ypresian and, in particular, with the upper intrabasaltic sediments of the Blossville Basalts of east Greenland (Soper et al., 1976). *Dracodinium similis* occurs shortly above the base of Zone Ib, indicating that the interval also includes the *D. similis* Zone of northwest Europe (Costa and Downie, 1976). The proportion of terrigenous material continues to be high, indicating a near-shore environment; conifer and taxodiacean pollen dominate the terrigenous assemblage. A marked increase in the number and diversity of dinocysts at the top of Zone Ib, at Site 403, Core 29 and at Site 404, Core 17, indicates a rapid change to a more off-shore environment. The assemblages, dominated by *Michrystidium*, *Spiniferites* and *Cyclonephelium*, closely resemble those from the London Clay (Downie et al., 1971).

Zone II is present in Core 16, Section 1 to Core 14 at Site 404, and in Core 43, Section 6 of Site 405, but has not been identified at Site 403, where the sediments overlying Zone Ib are barren of palynomorphs. Zone II, characterized by the first occurrence of *Dracodinium varielongituda*, is equivalent to the *D. varielongituda* Zone of northwest Europe (Costa and Downie, 1976) and correlates with the upper London Clay. The lower sequence of the Kap Dalton sediments of east Greenland (Soper et al., 1976) appears to be of the same age. Dinocysts are varied and abundant, tending to dominate over terrigenous material. The proportion of taxodiacean and conifer pollen decreases markedly as does the abundance of plant debris. The variability of the pollen/plankton ratio and the composition of the dinocyst

<sup>1</sup>Present address: Phillips Petroleum Co., Bartlesville, Oklahoma.

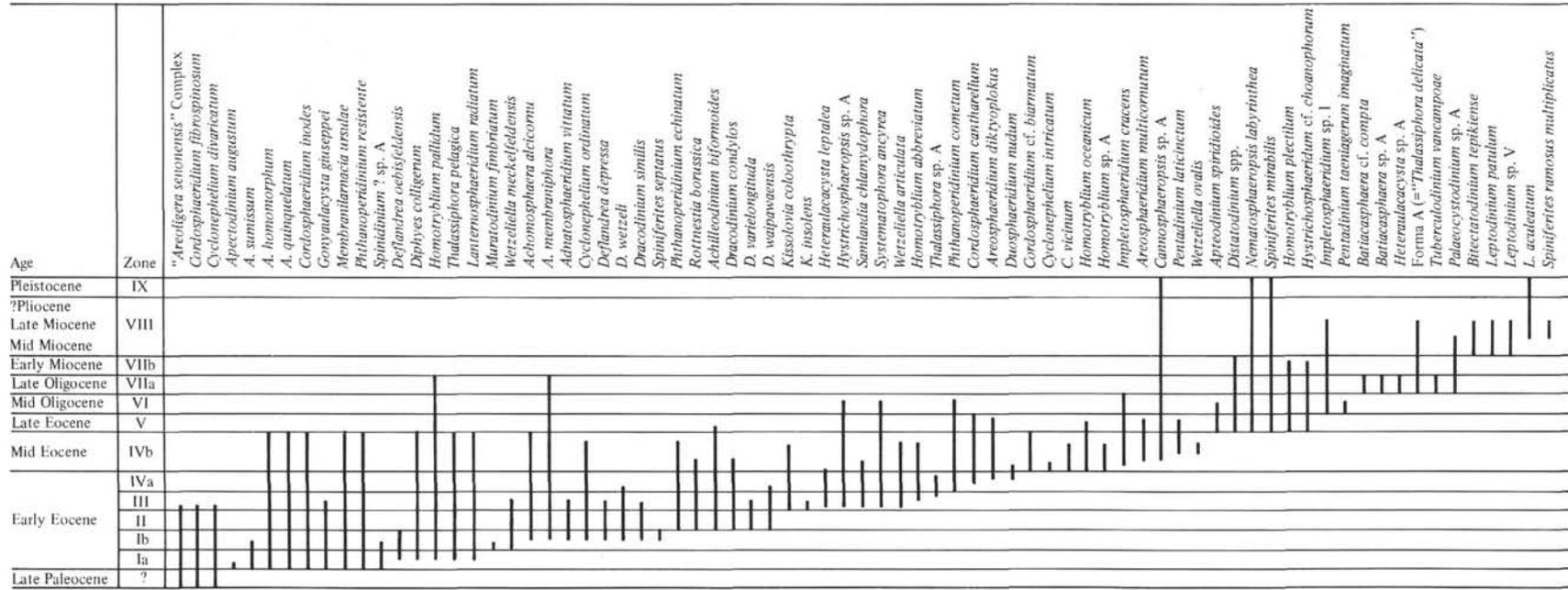








TABLE 5  
 Combined Range Chart for Selected Species and Dinocyst Stratigraphy of Sites 403 to 406



succession appear to be the Upper Barton and Headon Beds, but there are marked differences in the composition of the dinocyst assemblages.

The assemblages continue to be poor in pollen. Dinocysts, although abundant and diversified, are less numerous than in older assemblages. Preservation is poorer than in older assemblages: compression and sometimes corrosion are evident. The dinocyst assemblages are consistently dominated by *Spiniferites* (*Operculodinium* and *Systematophora* being also abundant), and are more uniform in composition than in the zones below. They probably indicate distal (bathyal) conditions.

Reworked Late Cretaceous (most likely Senonian) and early Eocene elements are fairly common.

The Thermal Index of indigenous dinocysts is low (1-1.5).

### MIDDLE OLIGOCENE

Zone VI is middle Oligocene; it is found only at Site 406, Cores 36 to 33. The period is represented by barren samples or by absence of deposition at the other sites. Core 25, Section 1 of Site 403 may be mid or late Oligocene but the assemblage contains only species of little diagnostic value and Zone VI has not been identified there. The base of Zone VI is marked by the incoming of *Impletosphaeridium* sp. I (Manum, 1976) and *Pentadinium taeniagerum* subsp. *imaginatum*; a considerable number of Eocene species, including *Thalassiphora pelagica*, *Cordosphaeridium inodes*, *C. cantharellum*, *Areosphaeridium diktyoplokus*, and *A. multicornutum*, had by then become extinct. A hiatus probably equivalent to the early and part of the middle Oligocene, exists at the top of Zone V, because the assemblages of Zone VI most closely resemble the upper Rupelian-Chattian assemblages of north Germany (Benedek, 1972; Benedek and Müller, 1974). They are, however, poorer in species than the German assemblages. Zone VI appears to correlate with Zone III of Manum (1976) from the Norwegian-Greenland Sea.

Pollen and spores continue to be only a minor constituent of the palynological assemblage, but the proportion of conifer pollen increases significantly towards the top of this zone. *Spiniferites* prevails in the marine assemblage. The preservation of the indigenous dinocysts is similar to that in the late Eocene (i.e., some compression and corrosion evident). The environment is distal (bathyal). Reworking, mainly of Eocene and Senonian elements, is common.

The Thermal Index of indigenous material is low (1-1.5).

### LATE OLIGOCENE

The late Oligocene is represented by Zone VIIa, and has been recorded only from Core 29 of Site 406. Its base is marked by the occurrence of Forma A (= "*Thalassiphora delicata*" sensu Manum, 1976; = "*Thalassiphora* cf. *pelagica*" sensu Habib, 1971). *Batiacasphaera* cf. *compta*, *Heteraulacacysta* sp. A, and *Tuberculodinium vancampoae* are restricted to Zone VIIa. This zone appears to correlate closely with Zone IIb of Manum (1976). The pollen content, particularly bisaccates, is higher in the assemblage than in zones both below or above. The dinocyst assemblage is more diversified than in underlying sediments, and is dominated by *Impletosphaeridium* sp. I. At this level,

and subsequently, a close affinity seems to exist with the Norwegian-Greenland Sea assemblages described by Manum (1976). Reworking of early Eocene material is common.

From this level upward, the Thermal Index is invariably low (ca. 1).

### EARLY MIOCENE

Zone VIIb is early Miocene. It has been identified only at Site 406, Core 24, and has either been eroded or not deposited at other sites. The zone is a transitional assemblage, and only minor differences in composition, such as the disappearance of *Tuberculodinium vancampoae* and *Heteraulacacysta* sp. A and the first occurrence of *Palaeocystodinium* sp. A, distinguish it from the uppermost Oligocene Zone VIIa. *Distatodinium craterum*, *D. paradoxum*, and *Homotryblium plectilum* become extinct within Zone VIIb. The pollen content falls again to very low values; the marine assemblage is dominated by *Spiniferites*. There is some reworking of Eocene material.

### MID-LATE MIOCENE

Zone VIII has been recorded from Cores 18 and 9 of Site 403, Cores 4 and 2 of Site 404, and Cores 23 to 9 of Site 406; it appears to have been eroded from Site 405. The zone ranges from the mid-Miocene to the late Pliocene. It is characterized by the first occurrence of *Leptodinium* sp. V (Manum, 1976), *L. aculeatum*, *L. patulum*, *L. striatum*, and *Bitectatodinium tepikiense*. The Zone VII/VIII boundary is distinctly marked by the influx of a number of new dinocyst species and the extinction of several taxa, such as *Distatodinium* spp. and *Homotryblium plectilum*. Zone VIII is closely comparable to Manum's Zones Ia to Ic from the Norwegian-Greenland Sea; it also contains a number of species in common with the Miocene of the Bay of Biscay (Harland, this volume), but the assemblages are in general poorer and less diversified.

For reasons of time it was not possible to examine the Neogene in as much detail as the Paleogene. The evidence obtained suggests that a finer division of the mid and late Miocene, based on the extinction and appearance of dinocyst taxa, should be possible.

The assemblages of Zone VIII are most commonly dominated by *Spiniferites*, but there is a certain variability in composition, possibly following changes in the climate or in the pattern of oceanic currents, which should be subject to more detailed analysis in the future. Terrigenous elements are scarce throughout Zone VIII. Some reworking of Eocene dinocysts is common in samples from this zone.

### PLIOCENE

Most of the Pliocene samples prepared are barren of palynomorphs. Core 2 of Site 404 yields an impoverished assemblage of Zone VIII, with no signs of reworking, as might be expected if drift ice was present.

### PLEISTOCENE

Zone IX was obtained from Site 403, Core 3 and Site 405, Core 3. It is characterized by an indigenous dinocyst assemblage composed mainly of *Spiniferites mirabilis*, *Cannosphaeropsis*, sp. A, and *Nematosphaeropsis*

*labyrinthea*, which closely resembles in composition the assemblages occurring in the northeast Atlantic area today (Williams, 1971; Reid and Harland, 1977). The assemblages from Zone IX are, however, dominated by reworked material from ice-rafted fragments.

### SUMMARY AND CONCLUSIONS

The dinocyst assemblages recovered from Sites 403 to 406 (southwest margin of the Rockall Plateau) allow a dating of the cores studied consistent with determinations based on other microfossils, and a detailed correlation of the four sites (Figure 1). Changes in the environment are also recorded in the palynological assemblages.

Sites 403 and 404 are similar. The late Paleocene to basal Eocene assemblages indicate an initial littoral environment; flooding of the area in the early Eocene is clearly shown by the assemblages from both sites. This is followed by a rapid change from inner shelf to oceanic conditions in the middle to upper part of the lower Eocene. The middle Eocene from both sites proves to be either barren or poor in palynomorphs, as does the mid-upper Oligocene samples from Site 403. Late Miocene assemblages from these sites indicate offshore (bathyal) conditions. The Pliocene is either barren or poor in palynomorphs. The Pleistocene core examined from Site 403 shows evidence of glaciation in the amount of reworked material.

The upper lower Eocene and middle Eocene of Sites 405 and 406 yield rich oceanic assemblages. Some differences, mainly in the preservation of dinocysts and the amount of reworking, have been observed between the middle Eocene assemblages of Sites 405 and 406; these may be attributed to differences in the pattern of currents at both sites. The uppermost part of the middle Eocene and lower part of the upper Eocene are missing from these sections, and the remainder of the upper Eocene to Pliocene does not occur at Site 405. In Site 406, the uppermost late Eocene assemblages indicate oceanic conditions which persist during the Oligocene and Miocene. The late Oligocene and early Miocene assemblages are similar, and clearly distinct from those of the middle and late Miocene. The Pleistocene assemblage from Site 405 is similar to that from Site 403.

Detailed changes in the abundance of various species have been noted throughout the sequence, but have not been discussed because their significance is as yet not fully understood. These changes are particularly marked in the early and mid Eocene, and are presumed to represent changing oceanic conditions. They allow close correlation between the holes wherever the sampling is adequate.

In broad terms, all four sites have dinocyst assemblages of similar types. From the late Paleocene to the middle Eocene, correlation with European dinocyst sequences is readily possible and similarities are close. During the uppermost late Eocene and Oligocene, the composition of the assemblages from Rockall becomes significantly different from that of northwest Europe. The Miocene assemblages are apparently similar to those from the Norwegian-Greenland Sea, and are noticeably poorer than contemporaneous assemblages from the Bay of Biscay (Harland, this volume); some affinity seems to exist between the Miocene assemblages from Rockall and those from offshore Atlantic Canada (Williams, 1975; Williams and Brideaux,

1975), but the available information is not detailed enough to attempt a closer comparison. Comparison with European areas is not yet possible due to the lack of information on Miocene dinocyst assemblages from on-shore sections.

The Pliocene sediments from the southwest margin of the Rockall Plateau are barren or poor in palynomorphs. The indigenous assemblages recovered from Pleistocene cores differ only little from present-day assemblages in the northeast Atlantic.

Reworking of Cretaceous sediments is indicated at the southern edge of the Rockall Plateau, particularly at Site 406, but has not been recorded from the western part of this margin (Sites 403, 404). Reworking of Eocene sediments is present throughout Site 406 and in the Miocene of Sites 403 and 404. At all sites, Pleistocene assemblages are dominated by reworked elements, mainly of Cretaceous and Eocene age.

The thermal alteration increases slowly downhole, from about 1 to 1.5-2 in the early Eocene. Highly carbonized material from intermediate layers is associated with diagenesis in the cherty beds of the mid-upper Eocene or to reworking of ?Eocene material in the Oligocene and Miocene. An exceptional occurrence of carbonized material in the late Paleocene of Site 403 (Core 42, Section 1) is attributed to the proximity of a ?volcanic heat source.

### ACKNOWLEDGEMENTS

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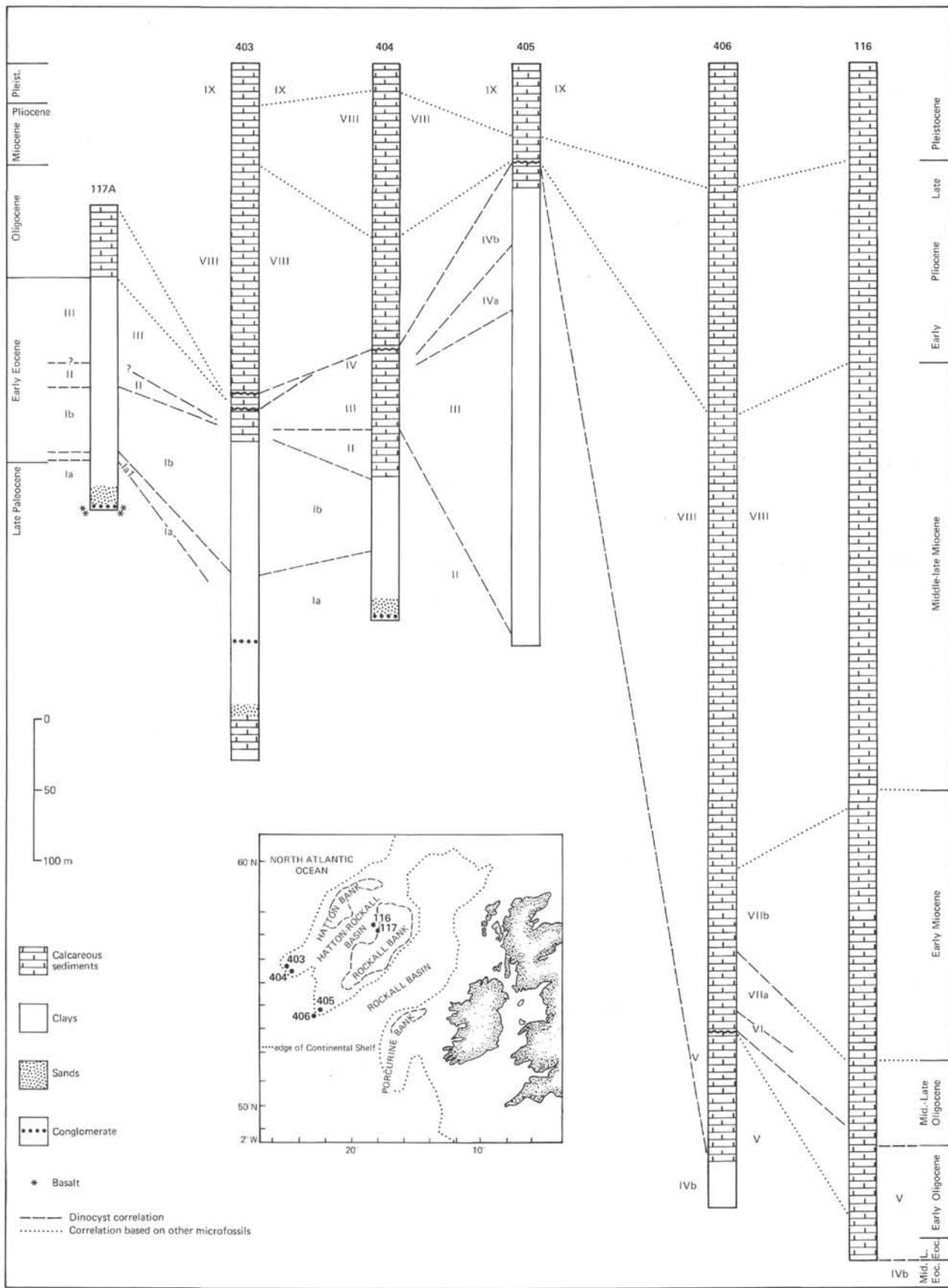


Figure 1. *Dinocyst stratigraphy and correlation of Holes 116, 117A (Leg 12), and Sites 403 to 406 (Leg 48).*

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#### APPENDIX:

##### Preliminary dinocyst stratigraphy of Site 116 and Hole 117A (Leg 12, IPOD)

No records of dinoflagellates were included in the reports of Leg 12. For comparative purposes, we prepared and examined material from Site 116 and Hole 117A. The resulting dinoflagellate assemblages are described here for the first time and compared with those from Sites 403 to 406 (Leg 48). Attention was focused on the late Paleocene-early Eocene of Hole 117A and on the late Eocene-early Oligocene of Site 116. The preliminary results are summarized in Figure 1. For more detail, see Laughton et al. (1972).

#### HOLE 117A

Hole 117A (57°20.17'N, 15°23.97'W) lies on the boundary between the Hatton-Rockall Basin and the Rockall Bank (for location, see inset in Figure 1). Total penetration at this Site was of 313 meters. A weathered and fractured olivine basalt occurs at 311 meters; this is overlain by a terrigenous transgressive succession of upper Paleocene and lower Eocene sediments including, in an upward sequence, sandy conglomerate, sandstone, silty clay, mudstone, and clay. The lower Eocene is unconformably overlain by mid-upper Oligocene cherty limestone and glauconitic ooze.

Cores 9 to 6, Section 3 yield late Paleocene assemblages richer in dinocysts and more diversified than those from the lowermost part of the sections at Sites 403 and 404. Terrigenous material is noticeably less abundant. The dinocyst assemblages include *Apectodinium hyperacanthum*, *A. sumissum*, and *A. aff. augustum*, and clearly belong to the *A. hyperacanthum* Zone of northwest Europe (Costa and Downie, 1976); the assemblages equate with the lower Zone Ia of Sites 404 and 403. However, the type of dinocyst associations in the late Paleocene of Hole 117A differ markedly from contemporaneous assemblages in Sites 403 and 404 and the Anglo-Paris-Belgian Basin.

Core 6, Section 1 yields a rich basal Eocene assemblage (Zone Ia1) containing primitive forms of *Wetzelietta*, intermediate between this genus and *Apectodinium*. Similar forms recently have been found to mark the base of the Eocene in the Anglo-Paris Basin (Denison, 1977; Costa et al., 1978). Zone Ia1 equates with the newly erected *Wetzelietta astra* Zone of northwest Europe (Costa et al., 1978).

Zone Ib with *Wetzelietta meckelfeldensis* occurs in Sections 4-3 and 3-6; the latter is rich in *Dracodinium similis*. Section 3-3 yields Zone II (= *D. varielongituda* Zone), and Cores 2 and above yield Zone III with *Kisselovia coleothrypta*. Section 1-1, a mid Oligocene limestone, produces an assemblage containing *Homotryblium plectilum*, but too poor to attempt any correlation with Site 406.

#### SITE 116

Site 116 (57°29.76'N, 15°55.46'W) was drilled on the eastern side of the Hatton-Rockall Basin; 854 meters of sediment were penetrated, including, at the base, a continuous section through the upper Eocene-lower Oligocene, consisting of light-gray to white limestone and ooze. The lower Oligocene is overlain by late Oligocene and younger ooze.

The oldest sample examined (Cores 27 and 26, Section 4) is rich in dinoflagellate cysts; the presence of *Spiniferites mirabilis* and *Distatodinium* spp. indicates Zone V, but the assemblages are considerably more diversified than in Zone V of Site 406 and contain several species characteristic of sequences in Europe and North America, including *Chiropteridium partispinatum*, *C. dispersum*, *Cyclonephelium semicirculatum*, and *Schematophora speciosa*. None of these species has been recorded from Zone V at Site 406. The assemblages show some affinity with those from the upper sequence of the Kap Dalton sediments (*Coeloma* Bed) of east Greenland (Soper and Costa, 1976). The sediments above section 26-4 become poorer in dinocysts and more similar in their palynological content to those from Site 406; preservation is, however, better than at Site 406, and reworking has not been observed.

There are no changes in the dinocyst assemblage above the Eocene/Oligocene boundary, except for a slight decrease in number and diversity. In general, the early Oligocene dinocyst assemblages appear to be indistinguishable from uppermost late Eocene; usually late Eocene and early Oligocene are allocated to the same dinocyst zone (Williams and Brideaux, 1975; Drugg and Stover, 1975).

The early Oligocene Sample 24, CC is richer in dinocysts, and the assemblage is unusual in that it contains abundant cavate Peridiniaceae (mainly *Deflandrea* aff. *heterophlycta*); this group is absent from the upper Eocene and lower Oligocene of Site 406.

The only upper Oligocene sample from Site 116 examined so far, Core 20, Section 1, yields a poor dinocyst assemblage which somewhat resembles Zone VII at Site 406, particularly in the presence of *Lingulodinium siculum*. However, Forma A (= *Thalassiphora delicata*, sensu Manum, 1976) has not been recorded from this Core and therefore, Zone VII cannot be identified.

#### CONCLUSIONS

In general terms, the samples examined from Hole 117A and Site 116 yield the index species for the zones established in Sites 403 to 406, and Zones Ia, Ib, II, III, and V have been identified. The greater abundance of dinocysts in the lower part of the sequence at Hole 117A also allows the determination of the Paleocene/Eocene boundary. The upper Eocene and lower Oligocene cannot be distinguished on dinoflagellate cysts at Site 116.

The sequences from Site 116 and Hole 117A shall be dealt with in more detail in the future.

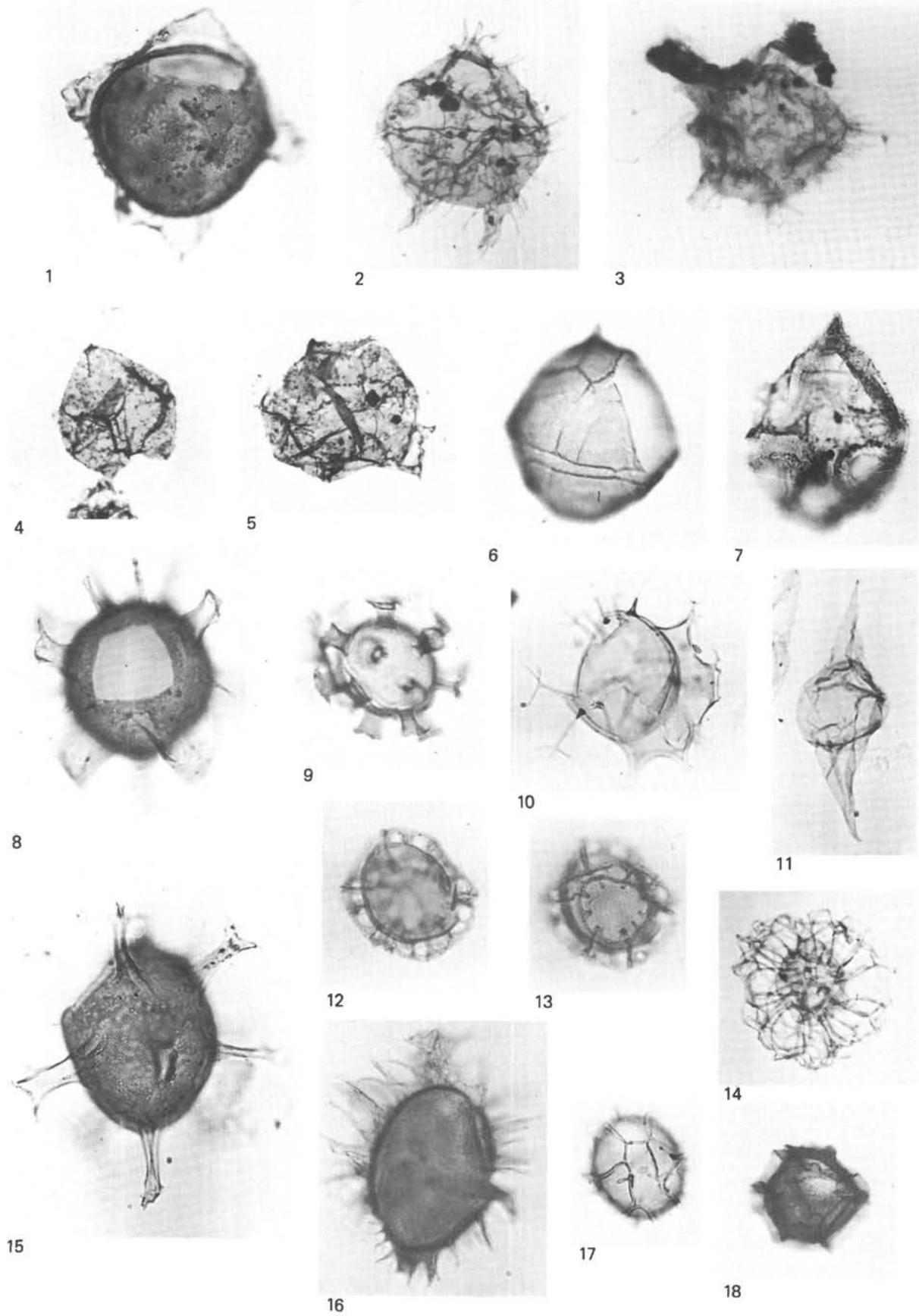


## PLATE 1

(Magnification  $\times 500$ , unless otherwise stated.)

- Figure 1 *Dracodinium condylos* (Williams and Downie) Costa and Downie, 1978. Sample 404-16-1, 139-142 cm.
- Figure 2 *Apectodinium sumisum* (Harland) Costa and Downie, 1978. Sample 404-23-1, 79-81 cm.
- Figure 3 *Apectodinium* aff. *augustum* (Harland) Costa and Downie, 1978. Sample 404-23-1, 79-81 cm.
- Figures 4,5 *Spinidinium* ? sp. A. Sample 404-18-2, 96-99 cm.
- Figure 6 *Gonyaulacysta giuseppei* (Morgenroth) Sarjeant, 1969. Sample 404-10-1, 56-58 cm.
- Figure 7 *Phthanoperidinium resistente* (Morgenroth) Eisenack and Kjellström, 1971a,  $\times 1000$ . Sample 404-10-1, 56-58 cm.
- Figure 8 *Achilleodinium biformoides* (Eisenack) Eaton, 1976. Sample 404-10-1, 56-58 cm.
- Figure 9 *Homotryblum abbreviatum* Eaton, 1976. Sample 406-46-3, 99-101 cm.
- Figure 10 *Achomosphaera membraniphora* (Agelopoulos) Eaton, 1976. Sample 405-16-1, 130-132 cm.
- Figure 11 *Palaeocystodinium* sp. A. Sample 406-9-1, 147-149 cm.
- Figures 12,13 *Leptodinium* sp. V. Manum, 1976. Sample 406-20-3, 61-65 cm.
- Figure 14 *Cannosphaeropsis* sp. A. Sample 406-29-3, 52-55 cm.
- Figure 15 *Cordosphaeridium* cf. *biarmatum* Morgenroth, 1966a. Sample 405-12-5, 23-25 cm.
- Figure 16 *Lanternosphaeridium radiatum* Morgenroth, 1966a. Sample 405-13-4, 114-116 cm.
- Figure 17 *Leptodinium* sp. A. Sample 404-8-2, 11-13 cm.
- Figure 18 *Leptodinium* sp. B. Sample 406-48-1, 98-100 cm.

PLATE 1

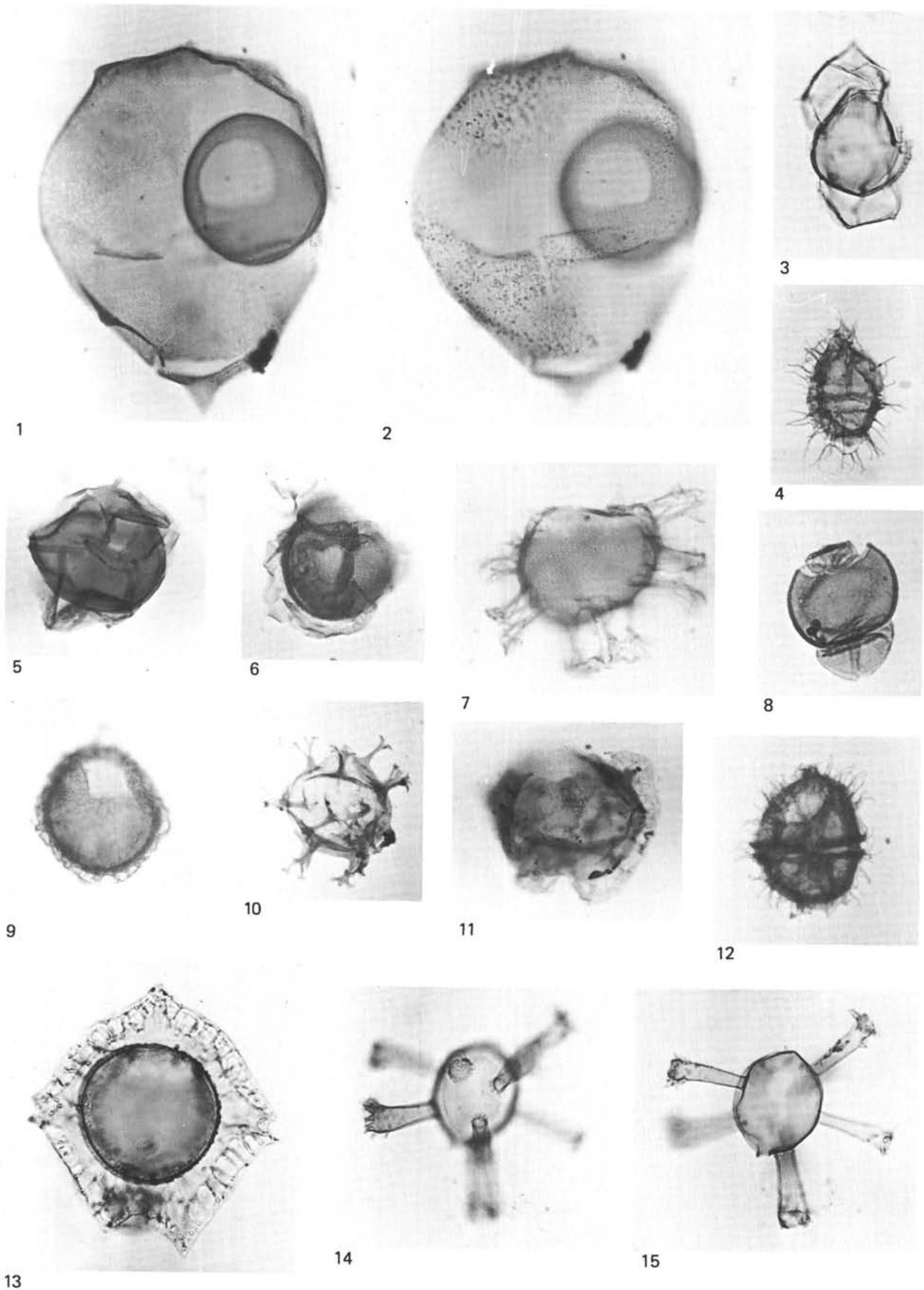


## PLATE 2

(Magnifications  $\times 500$ , unless otherwise stated.)

- Figures 1,2     *Thalassiphora* sp. A,  $\times 350$ , Sample 405-13-4, 114-116 cm.
- Figure 3        *Hystrichosphaeropsis* sp. A. Sample 406-49-1, 65-67 cm.
- Figure 4        *Phthanoperidinium* aff. *cometum* Morgenroth, 1966. Sample 406-36-1, 129-132 cm.
- Figures 5,6     *Pentadinium laticinctum* Gerlach, 1961. Sample 406-46-3, 99-101 cm.
- Figure 7        *Cyclonephelium intricatum* Eaton, 1971. Sample 406-49-1, 65-67 cm.
- Figure 8        *Duosphaeridium nudum* (Cookson) Drugg and Loeblich, 1968. Sample 406-49-1, 65-67 cm.
- Figure 9        *Samlandia chlamydophora* Eisenack, 1954. Sample 406-49-1, 65-67 cm.
- Figure 10       *Homotryblum plectilum* Sample 406-29-3, 52-55 cm.
- Figure 11       *Cyclonephelium vicinum* Eaton, 1976. Sample 406-46-3, 99-101 cm.
- Figure 12       *Phthanoperidium cometum* Morgenroth, 1966. Sample 406-48-1, 98-100 cm.
- Figure 13       *Kisselovia coleothrypta* (Williams and Downie) Lentin and Williams, 1975. Sample 405-16-1, 130-132 cm.
- Figures 14,15   *Homotryblum* sp. A. Sample 405-13-4, 114-116 cm.

PLATE 2



## PLATE 3

(Magnifications  $\times 500$ , unless otherwise stated.)

- Figure 1 *Heteraulacacysta* sp. A. Sample 406-29-3, 52-55 cm.
- Figure 2 *Batiacasphaera* cf. *compta* Drugg, 1970b,  $\times 1000$ . Sample 406-29-3, 52-55 cm.
- Figures 3,6 *Apteodinium spiridioides* Benedek, 1972. Sample 406-36-1, 129-132 cm.
- Figure 4 *Spiniferites mirabilis* (Rossignol) Sarjeant, 1970. Sample 406-29-3, 52-55 cm.
- Figure 5 *Homotryblium oceanicum* Eaton, 1976. Sample 406-48-1, 98-100 cm.
- Figures 7,10 *Pentadinium taeniagerum* subsp. *imaginatum* Benedek, 1972. Sample 406-36-1, 129-132 cm.
- Figure 8 *Impletosphaeridium* sp. I, Manum, 1976. Sample 406-29-3, 52-44 cm.
- Figure 9 Forma A (= "*Thalassiphora delicata*"). Sample 406-29-3, 52-55 cm.
- Figure 11 *Batiacasphaera* sp.A,  $\times 1000$ . Sample 406-29-3, 52-55 cm.
- Figure 12 *Distatodinium craterum* Eaton, 1976. Sample 406-36-1, 129-132 cm.
- Figure 13 *Distatodinium paradoxum* (Brosius) Eaton, 1976. Sample 406-36-1, 129-132 cm.

PLATE 3



1



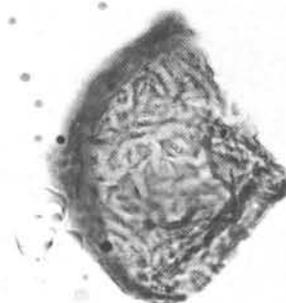
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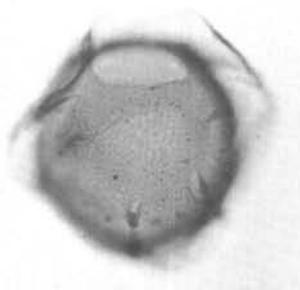
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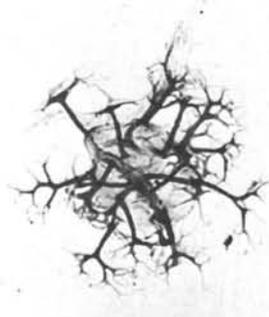
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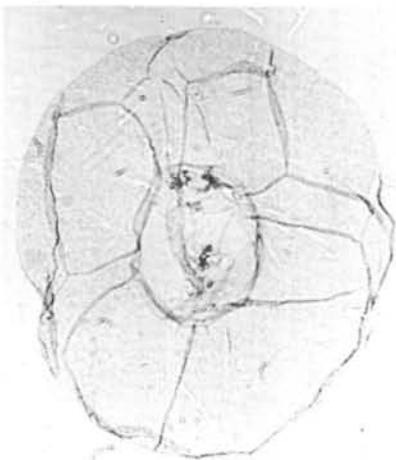
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7



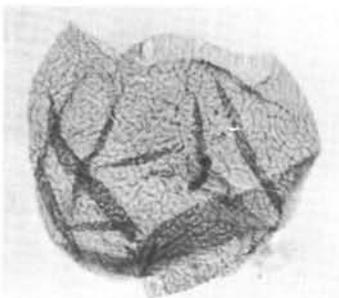
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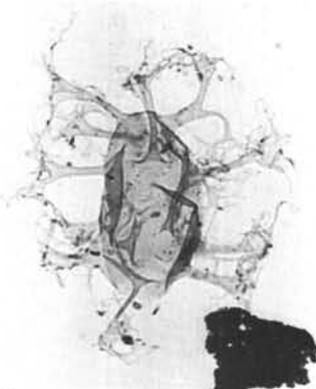
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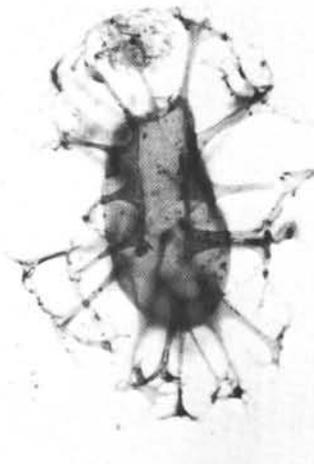
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