

24. PRELIMINARY PALYNOLOGICAL RESULTS: SITE 361, LEG 40, DEEP SEA DRILLING PROJECT

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ABSTRACT

Site 361 lies about 180 miles west-southwest of Cape Town. A single hole drilled to 1314 meters (subbottom) intersected a nearly continuous sequence of sediments ranging in age from Aptian to Eocene. Palynological studies were undertaken on 48 samples from the Cretaceous interval (Cores 12 to 48) and palynomorphs were recovered from nearly all the cores treated. The age indications generally support those based on foraminifers and coccoliths. Further information is provided on depositional environments, sediment provenance, and climate. The sapropelic lower lithological interval was probably deposited in a near-shore situation. The climate is interpreted as having been dry and the organic material was derived from a *Classopollis*-dominated local plant community. A benthic microfauna did exist, but the calcareous shells were mostly destroyed during early burial by acid interstitial fluids associated with the carbonaceous sediment. A diverse assemblage of dinoflagellate cysts with many cosmopolitan species indicates a free circulation of the surface water and a connection with the oceanic seas. The basin was probably silled, with restricted circulation of bottom water. The phytoplankton ratio increases markedly in the Upper Cretaceous as a result of the diminished supply of terrigenous spores and pollen, but species diversities remain constant. Bottom waters were generally well oxygenated. There is a suggestion of shallowing or a closer sediment source at three intervals within the Upper Cretaceous, where the delicate nature of the cuticular material suggests minimal transport of the plant debris. The climate at this time was probably wet and floras were dominated by ferns and angiosperms. Striated bisaccate pollen characteristic of the Permian and Triassic is persistently present in the Upper Cretaceous and points to a provenance in the south-western Cape in South Africa. The sapropelic basal lithological unit has the appearance of a good petroleum source rock and is interpreted to be near the upper limit of thermal maturity necessary for the generation of hydrocarbons.

INTRODUCTION

This study was carried out as part of a shore-based palynological investigation. Samples were provided by Dr. W. Siesser of the University of Cape Town from all Cretaceous cores except Cores 26, 29, 38, 44, and 49. These were later supplied by Professor Bolli. Sample details are shown in Table 1 and the position of Site 361 is shown in Figure 1. Cores 12-27 are from lithologic Unit 6 of Site 361 (Chapter 2, this volume) and Cores 28-49 are from Unit 7.

Before palynological processing the samples were soaked in water to disaggregate them and washed onto a 150 mesh screen to remove any megaspores or microfaunal shells which might have been present. The minus 150 mesh sludge was then subjected to standard palynological processing. Slides were prepared of both unoxidized and stained oxidized organic residues.

Because the time available for study initially was short, this report was first prepared without taxonomic

notes or photographic illustration, concentrating on providing information relevant to the geology of Site 361. To this end, comments were made where possible on the ideas presented by the shipboard party in the Leg 40 Hole Summary Book-material subsequently incorporated into Chapters 1 and 2 of this volume, and the initial report of the shipboard party. An extension of time allowed the inclusion, as an addendum, of taxonomic and descriptive notes and illustrations of the spores and pollen only. The dinoflagellates and acritarchs are described and illustrated by Davey (this volume).

The most important results and conclusions are displayed in Figure 2.

PALYNOLOGICAL RESULTS

Spores and Pollen

The main results are shown in Table 1, and in Figures 2 and 3. Miospore preservation is generally good,

TABLE I
Details of Samples Processed, Site 361, Leg 40

SOEKOR Palynology Sample Number	Sample (Interval in cm)	Miospores	Phyto- plankton	Micro- foramin- ifera	Mega- spores Forams
4977	12-3, 90-92	-	-	-	F
4978	13-1, 123-125	++	+++	+	M
4979	14-2, 55-57	-	-	-	
4980	15-2, 19-21	-	-	-	
4981	15, CC	-	-	-	F
4982	16-1, 33-35	+	-	-	
4983	17-2, 51-33	++	++	-	
4984	18-2, 140-141	++	+	+	
4985	19-2, 143-145	++	++	+	
4986	19-4, 91-92	+	++	-	
4987	20-2, 144-146	+++	++	+	
4988	21-2, 131-133	+++	++	+	
4989	22-2, 92-94	+++	+++	+	
4990	23-2, 61-64	++	+++	+	
4991	24-2, 96-98	++	+++	+	
4992	25-3, 94-97	-	-	-	
-	26-2, 26-28)	-	-	
-	26-3, 59-61)	-	-	
-	26-4, 58-60)	-	-	
-	26-5, 58-60)	-	-	
-	26-6, 60-62)	-	-	
4993	27-2, 119-121	+++	++	+	
4994	28-4, 61-63	+	-	-	
4995	28-6, 115-117	++	++	+	
-	29-3, 48-50	++	++	+	
4996	30-1, 55-57	+	-	-	
4997	31-4, 129-131	++	++	-	F
4998	32-2, 117-119	++	+++	+	F
4999	33-2, 27-28	++	-	-	
5000	33-3, 117-118	++	++	+	
5001	34-2, 60-62	++	++	+	
5002	35-2, 130-132	++	+	+	
5003	35-3, 50-52	++	+	-	M
5004	36-1, 103-105	+	+	-	M
5005	36-2, 136-138	++	+	+	
5006	36-3, 77-79	++	+	-	M
5007	37-2, 129-131	++	+	+	
-	38-2, 38-40	++	++	+	
5008	39-1, 117-119	+	-	-	
5009	39-2, 46-48	+	-	-	
5010	40-2, 87-89	+	+	-	
5011	40-3, 99-101	++	++	+	
5012	41-1, 90-92	++	+	-	
5013	41-2, 86-88	++	-	-	
5014	41-3, 53-55	+	++	+	
5015	42-1, 75-77	++	-	-	
5016	43-1, 128-130	++	-	-	
5017	43-2, 116-118	++	++	+	
5018	43-3, 12-13	++	++	+	
-	44-2, 111-113	++	++	+	
5019	45-1, 134-136	++	+	-	M
5020	45-2, 93-95	+	-	+	
5021	45-3, 104-105	++	-	-	
5022	46-2, 124-125	+	+	+	
5023	47-1, 128-130	+++	+++	+	
5024	48-2, 134-136	++	++	+	

Foraminifera recovered by pretreatment wet screening

Core 12, Section 3	1 <i>Haplophragmoides</i> sp.	(A)
	2 <i>Ammodiscus</i> cf. <i>incertus</i> .	(A)
Core 15, core catcher	2 <i>Dentalina</i> spp.	(C)
	1 <i>Dorothia bulletta</i>	(A)
	1 ? <i>Cibicides</i> sp. (? <i>Oridorsalis</i> sp.)	(C)
	1 <i>Globigerinelloides</i> cf. <i>aspera</i>	(P)
	1 <i>Globotruncana</i> cf. <i>coronata</i>	(P)
Core 31, Section 4	1 <i>Hedbergella</i> sp.	(P)
	5 <i>Astacolus</i> sp.	(C)
	5 <i>Lenticulina</i> sp.	(C)
Core 33, Section 2	1 <i>Globulina</i> sp.	(C)
	3 <i>Lenticulina</i> spp.	(C)

(Identification by I. K. McMillan of Soekor)

(A) = Agglutinated, benthic; (C) = Calcareous, benthic; (P) = Calcareous, planktonic.

Note: - = Barren, + = Very poor to poor, ++ = Moderate, +++ = Good, F = Foraminifer, M = Megaspores. (Recovered by wet screening before processing.)

abundances and the floral composition graph were based on counts of 200 specimens per slide, except in Core 17, Section 2, and Core 36, Section 1, where yields were extremely low. Full assemblages were gained by scanning up to three slides in all, covering up to 5,000 specimens. Where results were available from more than one section of a core, they were combined for graphic display.

A total of 194 species has been distinguished. From Figure 2 it can be seen that there is a profound difference between the Upper and Lower Cretaceous floras. Species diversities are low in the Lower Cretaceous with no sample yielding more than 30 species. In contrast, the Upper Cretaceous samples are much richer, with a maximum of 82 species in Core 19. This marked difference requires some explanation. The species diversity curve reflects the interaction of a number of elements such as climate, provenance, miospore preservation, sample yield, and so forth. However, we believe that climate and provenance are probably the most important. The low diversities could then be interpreted to reflect a harsh climate of some sort (cold or low rainfall) and/or a supply of spores and pollen from a restricted area or plant community. The low proportion of fern and fungal spores may indicate a dry climate, but may also simply reflect dilution by pollen from the dominant *Classopollis* vegetation or a variety of other ecological factors. The Upper Cretaceous assemblages, on the other hand, with their much higher diversities, indicate a less harsh climate (warmer, and wetter?) and a source of spores and pollen from a much wider area including more diverse plant communities. These interpretations find support in the floral composition graph (Figure 2). A restricted provenance and a local plant community which supplied organic material to unit 7 are compatible with the great dominance of *Classopollis* in Cores 27 to 48: Harsh environments are characterized by adaptable species, which achieve dominance through lack of competition. Hughes (1973, p. 190) concluded that the plants producing *Classopollis* pollen were presumably coniferophytes and grew on the seaward margin of deltas, as mangrove plants do in the present time. There is some correlation between the species-diversity and the composition-of-organic-material graphs. Species diversities are highest in Cores 18, 19, and 20, where the detrital organic material is finest and most abraded, suggesting relatively long transport; it drops in Cores 17 and 13, and in Cores 21 and 24, where coarser material and more cuticular remains suggest closer source areas.

The dominance of *Classopollis* declines sharply within the Upper Cretaceous, and it becomes a minor element above the middle of the interval. *Classopollis classoides* types predominate in Unit 7, but in Unit 6 forms comparable with *C. meyeriana*, but bigger, become more important. An echinate-granulate form (*Classopollis* VI) similar to *C. perplexus* Boltenhagen, 1973, of the Cenomanian in Gabon is also present in Unit 6. Compared to the situation in the Agulhas bank wells, where *Inaperturopollenites* and *Araucariacites* pollen grains are common throughout the Lower Cretaceous (unpublished SOEKOR information), these

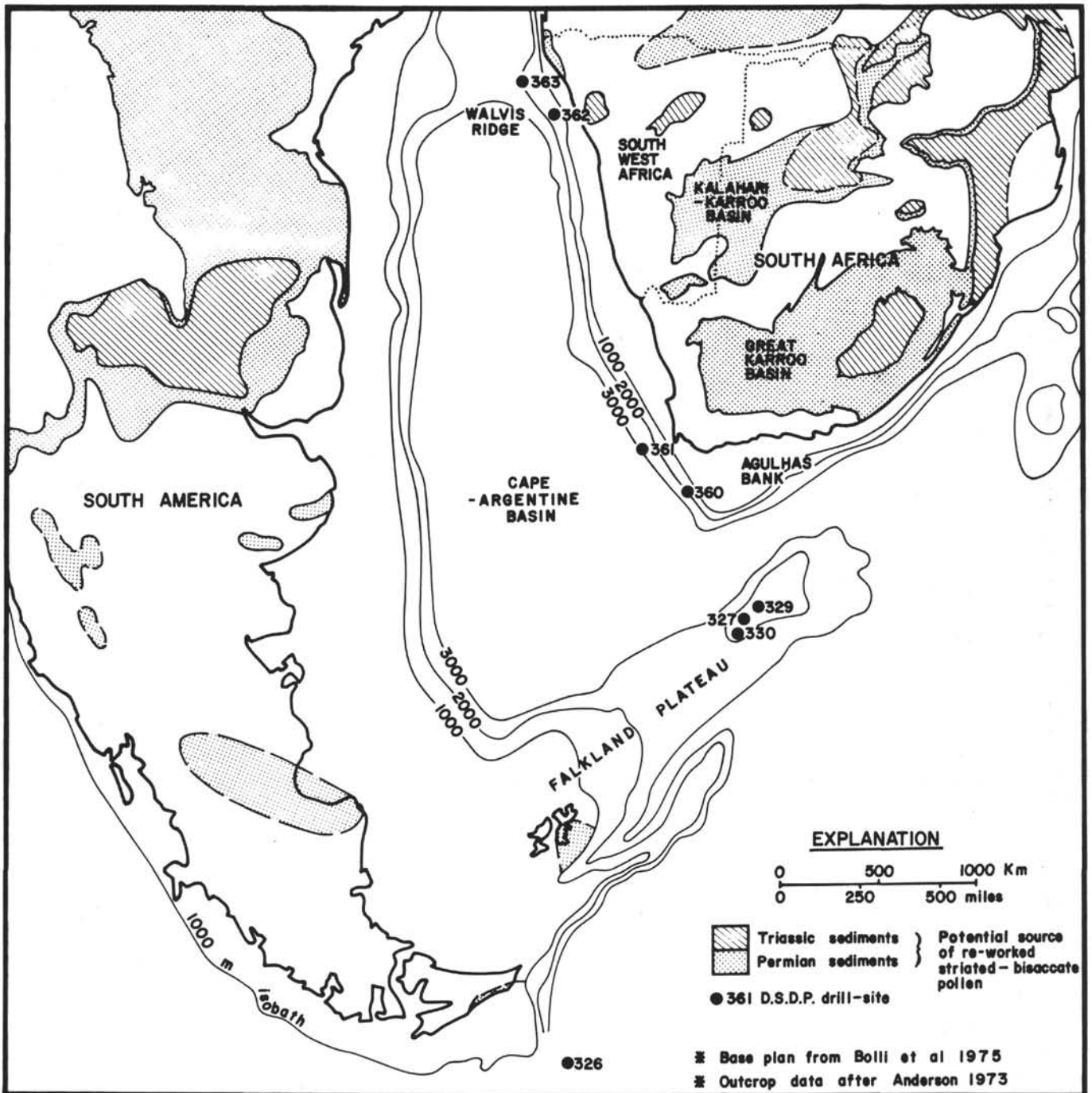


Figure 1. Plan showing the position of Site 361 in the Cape-Argentine Basin in Late Cretaceous time and the present distribution of Permian and Triassic sediments.

two genera are fairly rare at Site 361. As in described Australian floras, *I. limbatus* Balme, 1957, is restricted to the Lower Cretaceous (cf. Burger, 1973).

In the saccate flora mono- and bisaccates dominate in the Lower Cretaceous, while trisaccates become more important in the Upper Cretaceous. Many of the trilete fern spores in the Lower Cretaceous interval of Site 361 have also been recorded from Australia, but the important species on which the Australian zonation is based, are lacking. These include *Pilosporites*, *Trilobosporites*, *Contignisporites*, etc.

(Burger, 1973; Dettmann, 1963), which are present however in the Agulhas bank wells (unpublished SOEKOR information). Though few in numbers, many species of *Cicatricosisporites* and *Appendicisporites* are present at Site 361. There are few similarities with the described West African floras, but *Zlivisporites blanensis* Palct, 1961, recorded by Boltenhagen (1967) from Gabon, are present in the Senonian of Site 361.

The angiosperms appear very suddenly and in great numbers in Core 24 of lithological Unit 6. Contrary to the sequence of appearance in Australia (Dettmann,

1973) monocolpates appear earlier than tricolpates. A few *Liliacidites* and *Clavatipollenites* specimens are found in the Lower Cretaceous, but their presence is obscured by the abundance of *Classopollis*. The angiosperm flora consists mainly of tricolpates with simple reticulate ornamentation and is of little use in zoning the Upper Cretaceous, because the key species, such as *Nothofagidites* used in Australia (Dettmann and Playford, 1966), and *Rugubivesiculites* used in America (Gray and Groot, 1969), are absent. Of the more important West African pollen (Belsky et al., 1965) only *Constantisporis* and *Andreisporis* are found, though they first appear much later in the Senonian. Typical West African Upper Cretaceous pollen such as *Aquilapollenites* and *Galeacornea* were not recorded.

Phytoplankton (dinoflagellate cysts and acritarchs)

Yields of phytoplankton are consistently much lower than of spores and pollen, but the degree of preservation is generally good. The percentage phytoplankton graph in Figure 2 shows persistent low ratios in the Lower Cretaceous, but a marked increase within the Upper Cretaceous. This pattern is in line with the idea expressed in Chapter 2 of this volume, that the supply of terrigenous material—spores and pollen in this case—dwindled during the Late Cretaceous. It is probable, however, that the fall-off is due as much to the greater distance of transport to the depositional site as to reduction of relief in the provenance.

The persistent presence of phytoplankton confirms that sedimentation took place in a marine environment throughout the interval cored at Site 361; this is further supported by the presence in nearly all the samples of the acid-resistant chitinous linings of the initial chambers of benthic foraminifer (commonly referred to as "microforaminifers" after Wilson and Hoffmeister, 1952).

Acritarchs form an insignificant proportion of the assemblages. *Crassosphaera bella* Singh, 1971, is rare but quite conspicuous in Unit 7 and *Pterospermella* spp. are common in this unit but was not recorded above Core 27. It would be interesting to know whether these palynomorphs are characteristic of the Unit 7 sort of depositional environment elsewhere in the world. Species of *Cymatiosphaera* and *Micrhystridium* are both present in small numbers throughout Units 6 and 7.

The presence of the alga *Botryococcus* within the Late Cretaceous samples is interesting. It typically occurs in shallow, fresh- to brackish-water lakes and pans at the present day. It is most unlikely that it lived in the deep-water conditions of lithological Unit 6, and it was probably transported in with other land-derived organic material. For it to be so consistently represented, it must have been quite abundant in the source area. This could be tentatively taken to imply that the shores at the time were of fairly low relief and that there were extensive areas of brackish-to fresh-water marsh and shallow lakes supporting *Botryococcus*, which was periodically swept out to sea by floods. *Palambages* spp. were noted only in the Late Cretaceous (Cenomanian to Turonian?) in Cores 21 to 24. Davey (1970) has reported *Palambages* in the Albian and Cenomanian of Europe and North America.

CONCLUSIONS. HOLE SUMMARY BOOK (Bolli and Ryan 1975) and Bolli et al (1975)	CONCLUSIONS FROM THIS STUDY
DEEP - WATER SEDIMENTS	NO SAMPLES
<p>Deep-water sediments below carbonate compensation depth (abyssal).</p> <p>Terrigenous influx waned in U. Cretaceous reflecting decline in significant denudation of Africa</p> <p>Oxygenated bottom water.</p> <p>No paleontological evidence for a shallowing</p>	<p>PALEONTOLOGY</p> <p>Relatively high phytoplankton ratio but species diversity as in unit 7.</p> <p>Chitinous linings of benthic forams (microforams)</p> <p>Reworked striated bisaccate pollen from Karroo sediments.</p> <p>Dominance of fern spores</p> <p>Gymnosperms decline in importance Angiosperms appear.</p> <p>Botryococcus present</p> <p>Organic material fine and abraded Fungi more abundant</p> <p>INTERPRETATION</p> <p>Good circulation of oxygenated top and bottom water, with oceanic connection.</p> <p>Small size of organic material (O.M.) suggests long transport.</p> <p>Botryococcus suggests flat swampy shore.</p> <p>Reduced influx of terrigenous O.M. African Karroo sediment was a major source of supply.</p> <p>Climate moister than in unit 7. (High % ferns)</p> <p>Shallow water, or near-shore position for core 13 ?</p> <p>Small unconformity near core 13 ?</p> <p>Small unconformity between cores 27 and 25 ?</p>
<p>Forams only in core 28. Solution resistant coccoliths. Lack of bioturbation.</p> <p>No benthic faunas.</p> <p>Rapid sedimentation. Rivers feed into sub-marine canyons. Turbidite re-distribution to deep water.</p> <p>Totally euxinic Bottom condition hostile to benthos.</p> <p>Most calcareous plankton dissolved by acid sediments. Abundant vegetation. High rainfall ?</p>	<p>PALEONTOLOGY</p> <p>High % sapropelic O.M. Coarse O.M. Microforams present. Diverse cosmopolitan dinoflagellates</p> <p>Dominance of gymnosperm pollen, fern spores rare. Low phytoplankton ratio</p> <p>INTERPRETATION</p> <p>Silled basin. Oxygenated surface water with link to oceans. Oxygen deficient bottom water but only anaerobic below sediment surface. Sparse benthic shelly fauna largely destroyed by acidic bottom sediment.</p> <p>Short transport of O.M. Low % fern spores suggests low rainfall. Also low % fungi Dilution of phytoplankton ratio by terrigenous spores and pollen.</p>

Figure 2. Graphic display of main palynological results, Site 361.

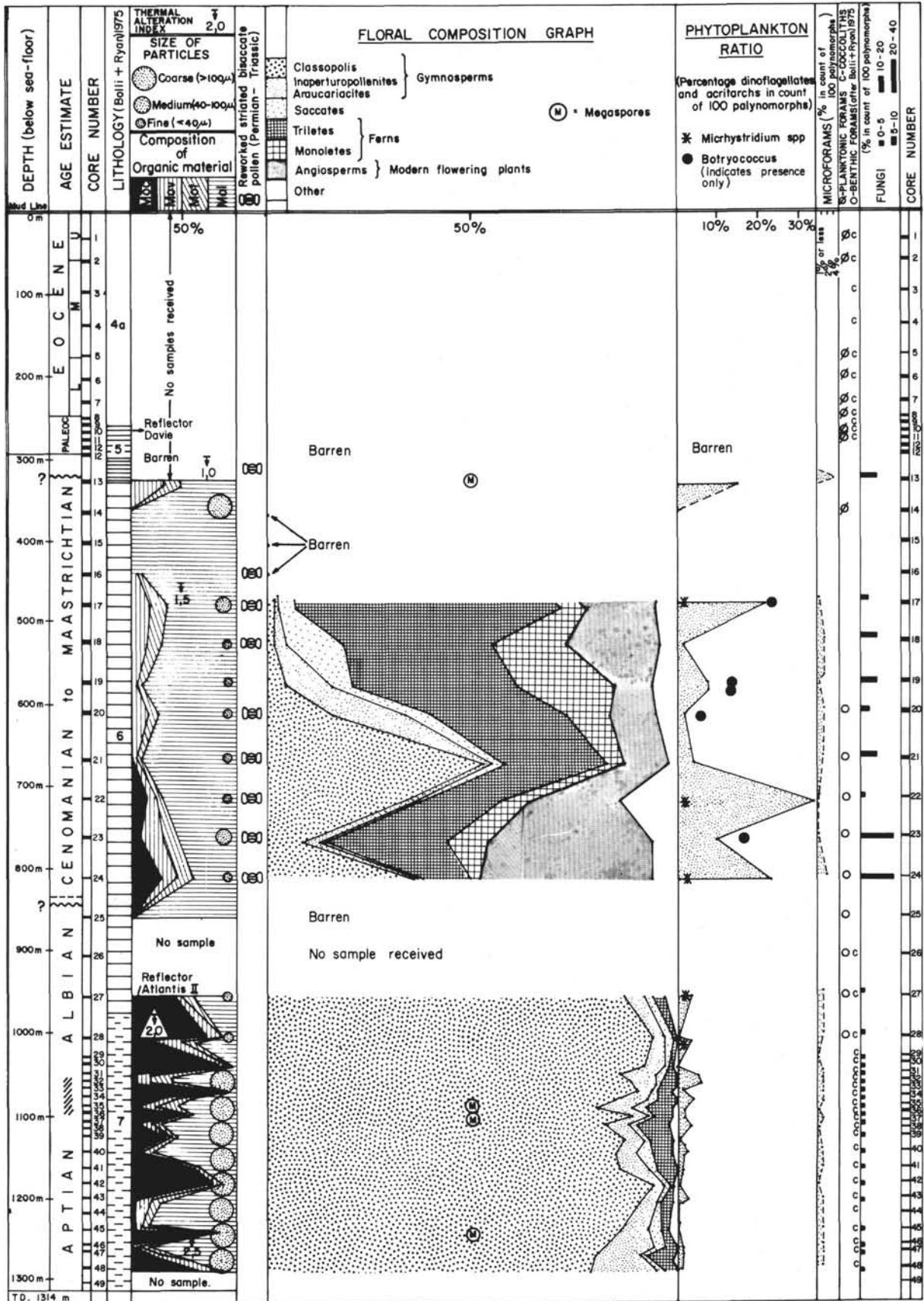


Figure 2. (Continued).

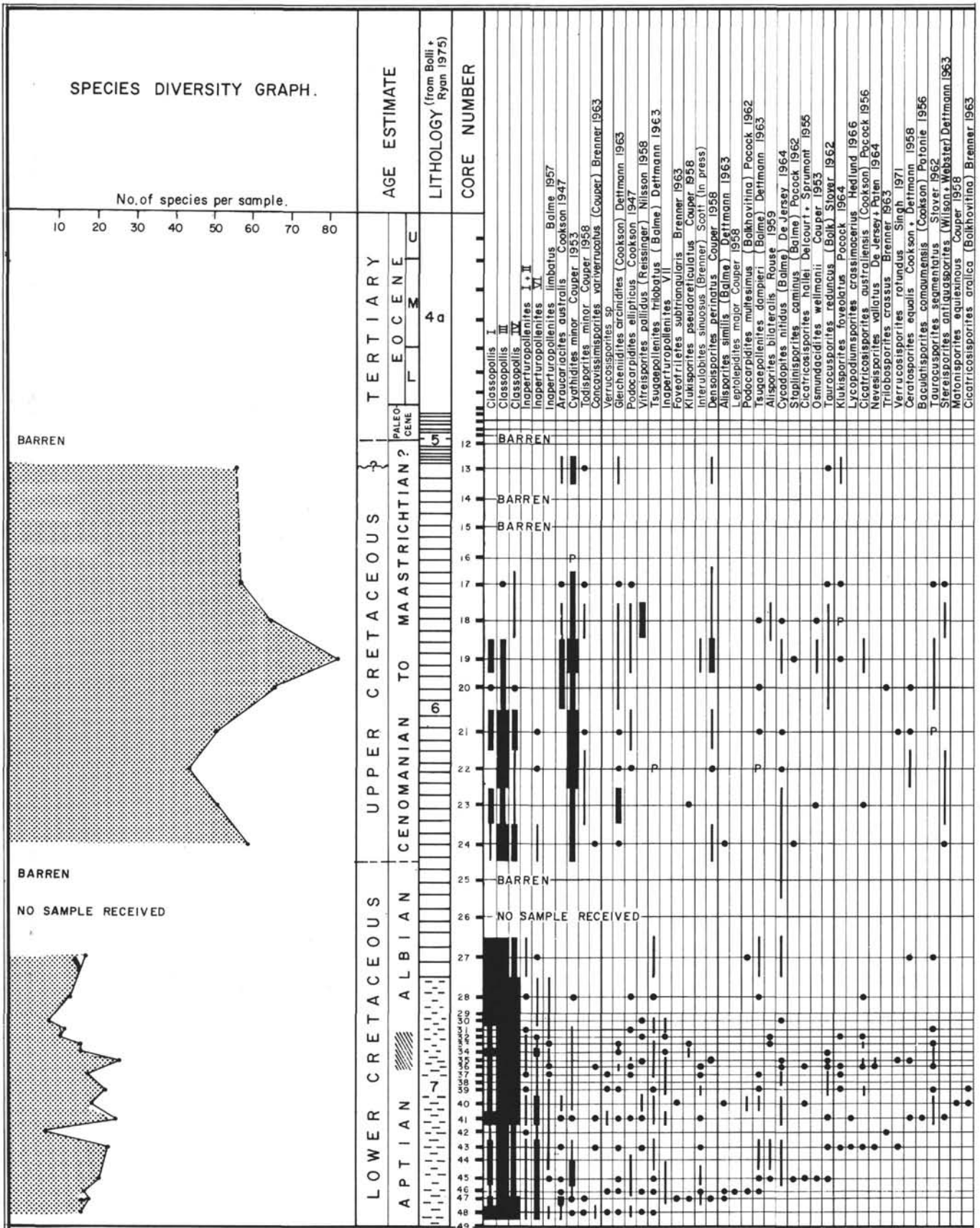


Figure 3. Spore and pollen range chart and species diversity graph, Site 361.

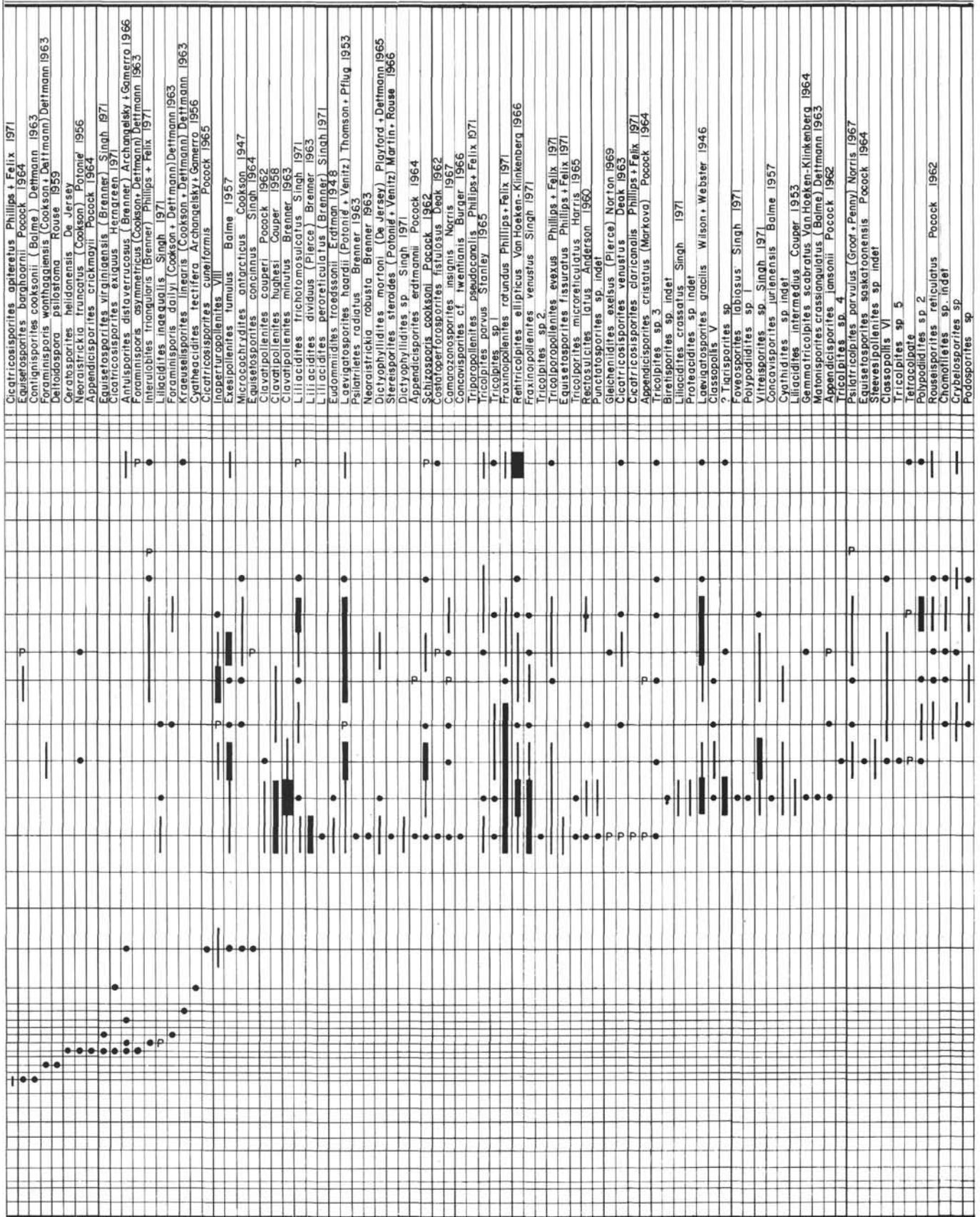


Figure 3. (Continued).

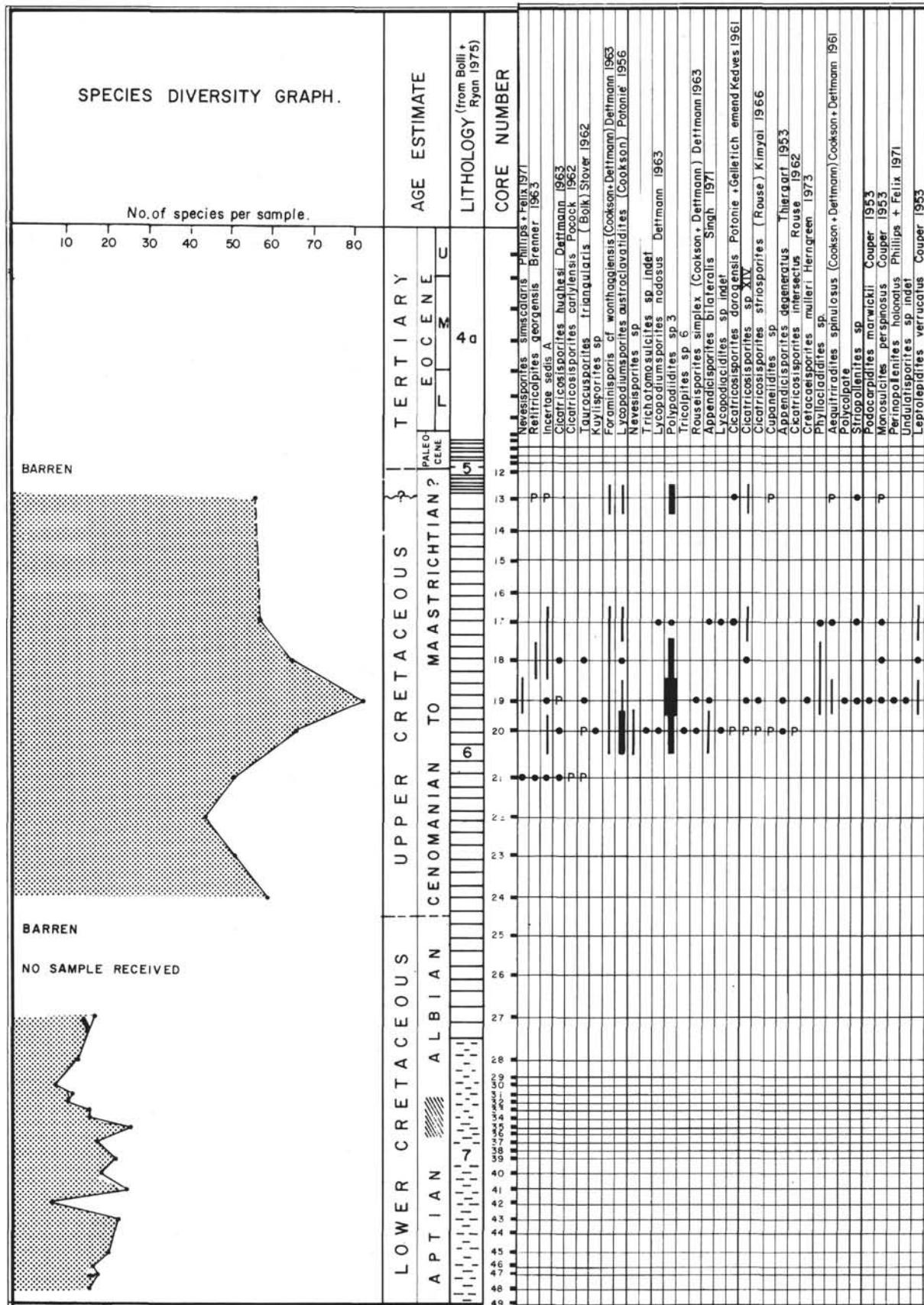


Figure 3. (Continued).

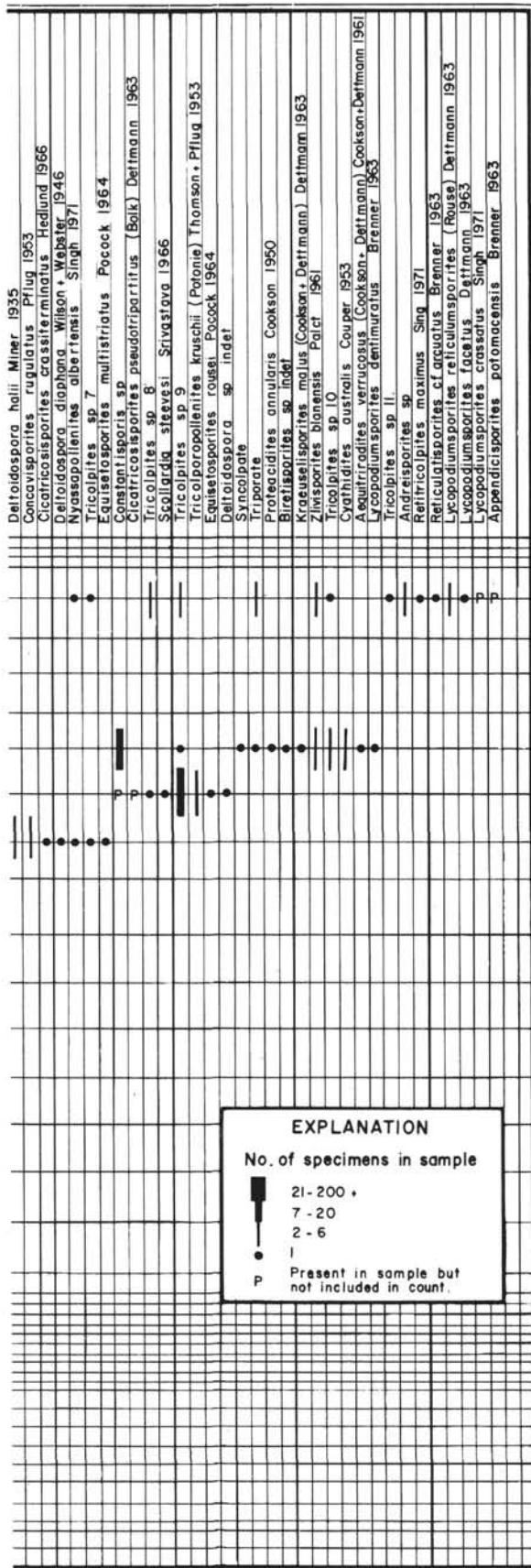


Figure 3. (Continued).

Only the more prominent dinoflagellate cyst species are shown on the accompanying range chart (Figure 4). They indicate clearly that the assemblages of both Upper and Lower Cretaceous are of a cosmopolitan nature and contain species which are familiar in Europe, Australia, and elsewhere in the world. This implies that the surface water of Units 6 and 7 was able to circulate freely and had an effective communication with the oceanic seas. Furthermore, the dinoflagellate species diversity graph (Figure 4) shows that many of the samples from the Lower Cretaceous interval have diversities equivalent to those of the Upper Cretaceous, which adds support to the idea of freely circulating surface water during the time Unit 7 was deposited.

As noted above, microforaminifers are present in most cores. The most common forms show a simple coiled or trochoid chamber arrangement. Uniserial and biserial specimens were noted but are quite rare. Generic and specific identifications of the parent foraminifers are not possible. They are especially significant in those intervals where foraminifers were not reported in the shipboard record (Bolli and Ryan, 1975); it is likely that their original calcareous shells or carbonate-cemented shells were dissolved during early burial. We know of no record of microforaminifers from planktonic species. If this is correct then in Unit 7 they indicate the presence of a benthic microfauna, which in turn implies that the bottom environment was not "totally euxinic" as proposed in Chapter 2. The calcareous benthic foraminifers recovered by us from Cores 31 and 32 (see Table 1) confirm that a shelled benthos is present in at least some of the cores. This interpretation may have a bearing on the origin and deposition of the sediments: we are not entirely convinced that Unit 7 was deposited in particularly deep water. Within Unit 6 the microforaminifers simply record the wider presence of a deep-water microfauna presumably similar to that noted in the shipboard report for Cores 20 to 28.

Age

It has not been possible to arrive at an age subdivision that is consistent with the indications of the more important species of Site 361. The placing of many of the boundaries has therefore been rather arbitrary. Because of the paucity of reliable index spores and pollen, we have relied more heavily on the dinoflagellates to derive the breakdown shown in Figure 2. The dinoflagellate ranges shown in Figure 5 were obtained mainly from Williams (1974), Wiseman and Williams (1974), Davey and Verdier (1971, 1973, 1974) and Verdier (1975). The dinoflagellates were plotted against these ranges in the same order of appearance as detailed in Figure 4. By comparing Figures 4 and 5, it can be seen that the age indications of the species in any particular core sample are commonly in conflict. Nevertheless, although this makes the selection of stage boundaries arbitrary, it can be seen that the dinoflagellates support the age bracket given in the shipboard report and indicate sediments ranging in age from Aptian to Senonian. It has also been possible to make a broad correlation with the

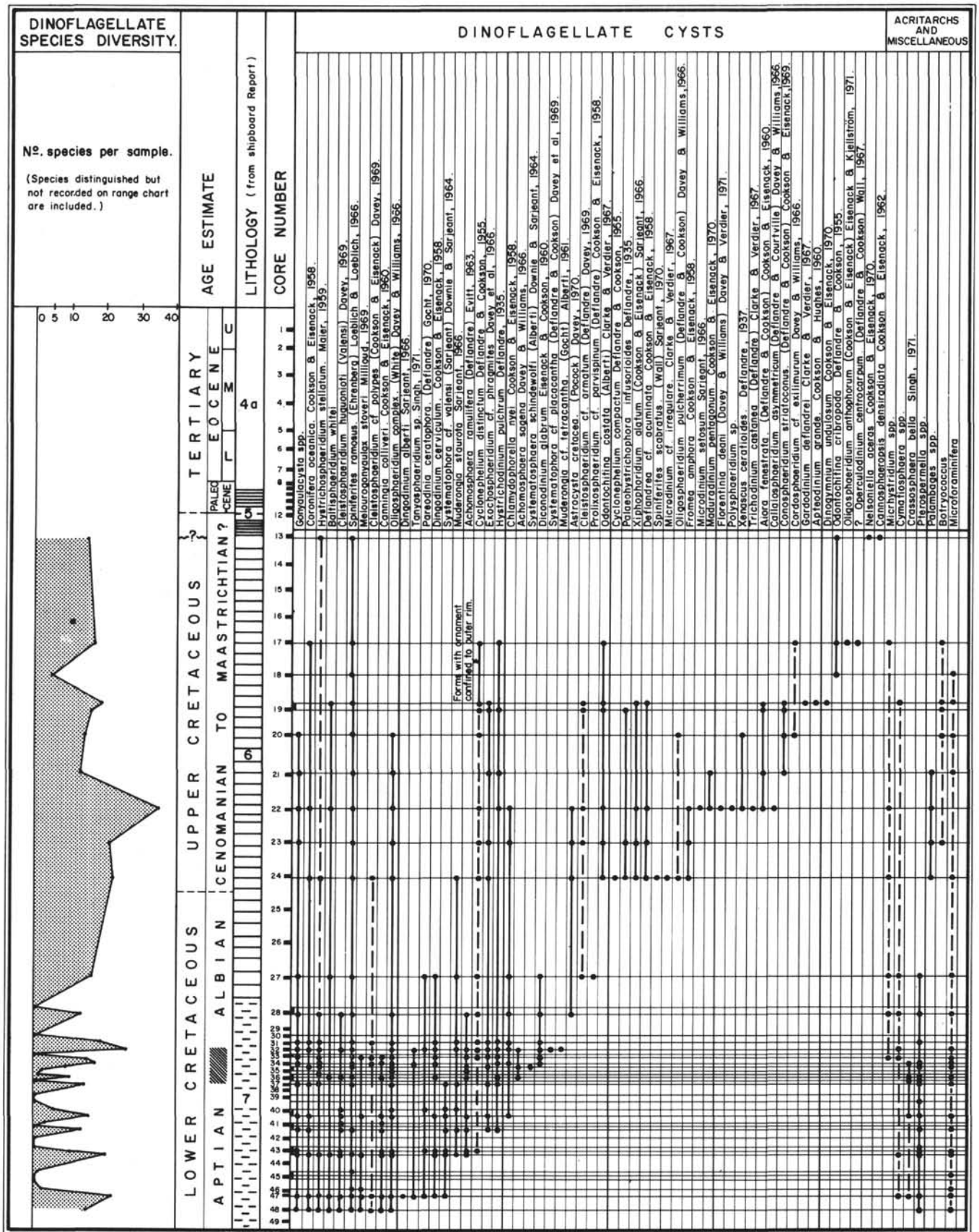


Figure 4. Phytoplankton range chart and species diversity graph, Site 361.

dinoflagellates *Odontochitina costata*, *Cyclonephelium compactum*, *Palaeohystrichophora infusorioides*, *Xiphophoridium alatum* is upper Albian but at Site 361 where they appear in Core 24 it can be assumed that the lack of information from Cores 25 and 26 (upper Albian?) explains their late record. It does not seem practicable to attempt to distinguish stage boundaries within the Upper Cretaceous interval on the information available. There is no suggestion of any erosional or depositional gap in the record and the palynomorphs provide support for the Cenomanian to Maestrichtian allocation of Bolli et al. (1975). It is possible that a part of the Maestrichtian is missing. In wells drilled on the Agulhas bank, microfossil information suggests a widespread regression within the upper Maestrichtian, and there seems to be a distinct but minor unconformity at the top of the stage (McLachlan et al., in press). The depositional environment of Core 13 is interpreted here as being significantly nearer source and perhaps shallower than that of the rest of Unit 6, so the same situation may apply at Site 361.

Assessment of Organic Residue

For this study only slides of unoxidized unstained residue were used. Results are shown in Figure 2. The organic residue of each sample has been examined and the components classified according to the categories used by Correia (1971, p. 610), with slight modification viz:

MOC—Amorphous or colloidal sapropelic material.

MOV—Cuticular plant tissue, including spores, pollen, fungi, phytoplankton.

MOT—Plant tracheid or other dense structured land plant material, usually of a dark orange or brown color.

MOL—Apparently structureless lignitic material; this includes micrinite, fusainite, and mineral charcoal.

The shaly samples of lithological Unit 7 yielded very high proportions of sapropelic organic material, indicating strongly reducing bottom sediment conditions; the siltier or sandier—and presumably better oxygenated—samples contained much less sapropel and relatively high proportions of lignite. The reducing bottom conditions seem to have persisted through into Unit 6, as Cores 27, 24, 23, and 22 all contain small proportions of sapropel. The floral composition of Core 27 suggests a greater similarity with the Unit 7 samples than with those of Unit 6. The increase in lignitic material upward into Unit 6, indicates increasingly oxygenated conditions, since lignite resists destruction by oxidation more effectively than any of the other types of organic material.

The average size of the detrital particles of organic material shows some interesting trends (Figure 2). Within lithological Unit 7 the material is relatively coarse ($>100 \mu\text{m}$), implying that it has not been subjected to much breakage or abrasion during transport; it probably accumulated fairly near source. On the other hand, the particle size is generally fine within Unit 6 ($<40 \mu\text{m}$); tracheid and lignitic fragments are usually quite well rounded and are interpreted to have been abraded during transport. This is compatible with the deep-water distal depositional environment postulated in the shipboard report. There are

exceptions to this pattern. Core 23 has relatively coarser detrital organic material and a reduced phytoplankton content, *Botryococcus* is present, and the content of fungal spores is relatively high. We interpret this to record a regression with a (?) shallower water depth and a reduction in transport distance. A similar situation is indicated by the sample from Core 17. Results from Core 13 are even more striking: the residue contains a relatively large proportion of plant cuticle, and sporangia with numbers of spores still in place are conspicuous, together with a variety of other delicate cuticular material. It is difficult to reconcile these features and the information given in the section above dealing with age, with the deep-water depositional environment suggested in the shipboard report and in Bolli et al. (1975); we prefer to visualize a quiet, shallow-water, near-shore environment.

A further application of this study is the assessment of the potential of the sediments as petroleum source rocks, using the techniques outlined by Correia (1971) and others. Assuming a correspondingly high total organic content, which seems reasonable from the shipboard report, the high sapropel (MOC) content of the 300-meter-thick shales of Unit 7 indicates a good oil-generating potential. The color of the organic material can be used to estimate the maximum temperature to which the sediments have been subjected and hence the "maturity" of the source rocks (Correia, 1971); with increasing temperatures, volatile components are progressively lost, resulting in an increase in the carbon content of the material and a corresponding darkening of color. We have used the five-step scale of Correia (1971, table III), which follows the changing color of spores, pollen, and other organic material from pale translucent yellow, through orange and brown to black. The scale units are referred to here as "thermal alteration indices" or TAIs. The results for Site 361 are shown in Figure 2. The highest sample (Core 13) is barely altered; spores, pollen, and phytoplankton remain generally pale yellow to yellow and translucent down to the top of Unit 7, where some darkening becomes apparent. Only the last 50 meters of the unit is approaching the upper limit at which oil might have been generated (TAI 2.5). This lithological unit is said in the shipboard report to thicken shorewards. Where it is more deeply buried ($\pm 500 \text{ m}$ more) and thicker, it could have acted as a significant petroleum source rock.

An interesting feature concerning the color of the miospores is the presence in Unit 7 of darkened spores and pollen with TAIs ranging from 2.5 (orange) to 4 (brown-black). Identifiable specimens belong to the same species as their pale in situ equivalents in the same slides. No darkened phytoplankton was observed, so the possibility of carboniation by accidental overheating during laboratory processing can be discounted. The fact that the darkened miospores belong to the same species as the paler material in the same slides also refutes the possibility of it being reworked older Cretaceous material. It is tentatively suggested that the darker miospores are the result of forest fires. This would account for the variable darkening, the common speciation, and the lack of

darkened phytoplankton. Dark, opaque yellow-orange (TAI 3.00-3.5) generally distinctly marked, striated bisaccate pollen grains were detected within Unit 6 samples (Figure 2); they probably derive from the sediments in the Karoo basin in South Africa (Figure 1). The organic material in the lower Permian Dwyka and Ecca Groups in the southern half of the basin has everywhere been strongly carbonized (brown-black to black, TAI 4a-5) and the same situation holds for the southwestern part of the Kalahari Karoo basin (personal observation). The color of the striated bisaccates in the Site 361 sediments indicates that they originated from sediments that were not strongly heated as a result of dolerite intrusion or deep burial. They are equivalent in color to pollen from the northern part of the Karoo basin which is estimated to have been buried not deeper than 1500 to 2000 meters. The source of the bisaccates was probably carbonaceous facies of Permian to Triassic age in the southwestern Cape.

It is surprising that no reworked Karoo palynomorphs were seen in the Unit 7 residues, but their absence perhaps can be explained by the suggested very local source for the sediments of this unit. It would be interesting to know what climatic and physical conditions are necessary to allow the weathering, erosion, transport, and deposition without destruction, of reworked palynomorphs. Palynomorphs and cuticle are usually absent from even apparently fresh outcrop samples of both Paleozoic and Mesozoic sediments in South Africa.

ADDENDUM

Notes on spores and pollen

A list of the spores and pollen recorded can be found in the range chart on Figure 3. The absence of adequately preserved specimens for photography prevented the illustration of some species. Descriptive or taxonomic notes are only given in a few cases as the majority of the species accord well with the descriptions in the literature.

Classopollis spp.

Because of the difficulties involved, no attempt was made to speciate *Classopollis*, though several species are represented. For convenience the following broad grouping was used.

Classopollis I *C. meyeriana*-type. Smooth, solid appearance with no or only minor infrastructure. 23-38 μm diameter.

Classopollis III *C. classoides*-type. With conspicuous infrastructure and prominent striae near the equator. 25-35 μm diameter.

Classopollis IV Much like *C. III* but with less clear structure and generally smaller. 22-32 μm diameter.

Classopollis V Very fine infrastructure with radial folds round the periphery giving it a frill-like appearance. 28-30 μm diameter.

Classopollis VI Echinolate-granulate form comparable to *C. perplexus*, Boltenhagen 1973.

Inaperturopollenites spp.

The genus *Inaperturopollenites* was not speciated, but the following grouping based on a few outstanding characteristics, was used:

Inaperturopollenites I & II Thin to medium wall with a thinned or thickened area in the center; smooth.

Inaperturopollenites VI Subequatorial fold; smooth.

Inaperturopollenites VII Very thick wall; smooth.

Inaperturopollenites VIII Granulate.

Densoisporites

There may be more than one species of *Densoisporites*, but because it is impossible to find sharp distinctions, all were retained under *D. perinatus*.

Trilobosporites and Contignisporites

Only a few specimens (one *Contignisporites* and two *Trilobosporites*) were found and thus were not regarded as stratigraphically significant.

?Tigrisporites

Although the specimen resembles *Tigrisporites*, no distal polar thickening can be seen as is required in the generic diagnosis.

Cyathidites sp.

This specimen possesses fine spines both proximally and distally. 24 μm in diameter.

Zlivisporites

Zlivisporites differs from *Lycopodiumsporites* in having a flange and a distal reticulum that does not continue onto the flange (Boltenhagen, 1967).

Cicatricosisporites

C. apiteretus differs from *C. australiensis* only by having a solid area at the corners, whereas *C. australiensis* has a notched appearance.

Cicatricosisporites XIV

Amb triangular with rounded corners. Laesurae straight, with membranous lips and reaching $\pm 3/4$ of spore radius. Distal face with ribs parallel to sides of amb, forming a triangle in the center. Proximally the ribs run subparallel to one laesura and oblique to the other one in each contact face, leaving a very small, smooth area next to the laesurae. The ribs are not straight but curve round the spore at the equator. At the corners the ribs fuse to form solid areas. Ribs 3 μm wide, canals 0.8 μm wide. A narrow groove runs down the center of each rib.

Dimensions: 56 (65) 80 μm (6 specimens).

Remarks: No fossil spore with the characteristic narrow groove in the center of the ribs could be found in the available literature, but a similar feature is seen in recent *Mohria* spp. (Welman, 1970).

Incertae sedis A

Outline circular. Porate. Inner body with scattered spines on proximal side. No stratification distinguishable in wall. Distal side psilate with heavy,

raised ornamentation. This consists of muri $\sim 2\mu\text{m}$ in diameter forming an irregular curvilinear reticulum or terminating freely to form a maze. Round the equator it forms a perfect circle. The ornamentation is connected to the inner body by pillars of $\sim 1\mu\text{m}$ diameter. The muri are chagrinata and opaque light yellow.

Dimensions: 32 (34) 36 μm (5 specimens).

Angiosperms

The pollen grains were, where possible, given names of species already described in the literature, although the latter does not form a coherent system. Those that could not be identified were grouped together under *Tricolpites* spp. 1-11.

ACKNOWLEDGMENTS

We are indebted to Dr. W. Siesser who encouraged the study, provided the samples, and made available early results of the shipboard report and also to Professor H. Bolli who has been most generous with his assistance and advice. Material was processed in the SOEKOR laboratories, which are maintained at the Bernard Price Institute for Palaeontological Research. Dr. H. Winter, Dr. A. de Swardt, and Mr. S. van Wyk of Soekor and Dr. Ann Anderson of the Bernard Price Institute discussed various aspects of the work and critically reviewed the manuscript. Mr. I.K. McMillan of SOEKOR made identifications of foraminifers and microforaminifers.

The Management of SOEKOR is thanked for providing the time and facilities which were devoted to the study.

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PLATE 1

All figures are magnified $\times 500$. Additional information in following order: Negative Number; Core Number; Sample Number; Coordinates on Zeiss photomicroscope mechanical stage.

- Figure 1 *Cyathidites minor* Couper, 1953, -22982; 24; 4991b.1; 116.5/16.5
 Figure 2 *Cyathidites sp.*, -23048; 23; 4990b; 122/15.
 Figure 3 *Deltoidospora sp.*, -22995; 18; 4984b; 120.6/20.
 Figure 4 *Deltoidospora hallii* Miner, 1935, -23001; 19; 4986b; 103.5/10.5.
 Figure 5 *Biretisporites sp.*, -23058; 23; 4990b; 115/22.3.
 Figure 6 *Psilatrilletes radiatus* Brenner, 1963, -23075; 24; 4991b; 78/20.5.
 Figure 7 *Concavisporites juriensis* Balme, 1957, -23049; 23; 4990b; 76/15.
 Figure 8 *Stereisporites steroides* (Potonié and Venitz) Martin and Rouse, 1966, -23072; 24; 4991b; 97/18.7.
 Figure 9 *Stereisporites antiquasporites* (Wilson and Webster) Dettmann, 1963, -23055; 23; 4990b; 96/16.5.
 Figure 10 *Matonisporites equixinous* Couper, 1958, -23097; 40; 5011b; 117/21.
 Figure 11 *Todisporites minor* Couper, 1958, -23054; 23; 4990b; 75/17.6.
 Figure 12 *Dictyophyllidites sp.*, -23070; 24; 4991b; 78/16.7.
 Figure 13 *Dictyophyllidites mortoni* (De Jersey) Playford and Dettmann, 1965, -23073; 19; 4986b; 98.3/17.5.
 Figure 14 *Undulatisporites sp.*, -23005; 19; 4985b; 115.3/9.5.
 Figure 15 *Leptolepidites verrucatus* Couper, 1953, -23003; 19; 4985b; 113.4/7.7.
 Figure 16 *Leptolepidites major* Couper, 1958, -22976; 47; 5023b; 87/5.
 Figure 17 *Osmundacidites wellmanii* Couper, 1958, -23114; 45; 5020a; 100/21.
 Figure 18 *Baculatisporites comaumensis* (Cookson) Potonié, 1956, -23102; 41; 5014b; 115/9.5.
 Figure 19 *Conavissimisporites variverrucatus* (Couper) Brenner, 1963, -23122; 48; 5024b.1; 124/18.3.
 Figure 20 *Verrucosisporites rotundus* Singh, 1964, -23104; 43; 5016b; 90.5/14.
 Figure 21 *Verrucosisporites sp.*, -22977; 41; 5012b; 92.8/14.
 Figure 22 *Ceratosporites equalis* Cookson and Dettman, 1958, -23103; 41; 5014b; 95.4/20.5.
 Figure 23 *Ceratosporites helidonensis* De Jersey, -23090; 35; 5002b; 106/19.
 Figure 24 *Neoraistrickia robusta* Brenner, 1963, -23074; 24; 4991b; 85/18.
 Figure 25 *Neoraistrickia truncatus* (Cookson) Potonié, 1956, -23089; 22; 4989b; 96.4/20.9.
 Figure 26 *Antulsporites distaverrucosus* (Brenner) Archangelsky and Gamarro, 1966, -23085; 31; 4997b; 79/22.7.
 Figure 27 *Foraminisporis asymmetricus* (Cookson and Dettman) Dettman, 1963, -23084; 13; 4978a; 124/11.
 Figure 28 *Foraminisporis wonthaggiensis* (Cookson and Dettman) Dettmann, 1963, -23029; 20; 4987b; 98/21.
 Figure 29 *Foraminisporis dailyi* (Cookson and Dettmann) Dettmann, 1963, -23082; 18; 4984b; 119.3/20.3.
 Figure 30 *Nevesisporites vallatus* De Jersey and Paten, 1964, -23107; 43; 5017b; 103/10.
 Figure 31 *Nevesisporites sp.* proximal view, -23026; 20; 4987b; 122/22.
 Figure 32 *Nevesisporites sp.* median view, -23027; 20; 4987b; 122/22.
 Figure 33 *Nevesisporites simiscalaris* Phillips and Felix, 1971, -23040; 19; 4985b 120/9.
 Figure 34 *Interulobites sinuosus* (Brenner) Scott (in press) -23117; 43; 5018b; 82/9.4.
 Figure 35 *Interulobites triangularis* (Brenner) Phillips and Felix, 1971, -23083; 34; 5001b; 122.4/19.6.
 Figure 36 *Taurocusporites triangularis* (Bolk) Stover, 1962, -23031; 18; 4984b; 79.4/16.
 Figure 37 *Taurocusporites reduncus* (Bolk) Stover, 1962, -23113; 35; 5002b; 120/8.4.
 Figure 38 *Taurocusporites segmentatus* Stover, 1962, -23101; 39; 5009b; 102.7/21.8.
 Figure 39 *Kuylisporites sp.* -23030; 20; 4987b; 99/17.7.
 Figure 40 *Gleicheniidites exelsus* (Pierce) Norton, 1969, -23062; 19; 4985b; 81/20.
 Figure 41 *Gleicheniidites circinidites* (Cookson) Dettmann, 1963, -23059; 23; 4990b; 89/21.4.
 Figure 42 *Camaronosporites insignis* Norris, 1967, -23067; 21; 4988b; 116/21.
 Figure 43 *Lycopodiacidites sp.*, -23014; 20; 4987b; 101/17.8.
 Figure 44 *Crybelosporites sp.*, -23043; 21; 4988b; 103/22.
 Figure 45 *Staplinisporites caminus* (Balme) Pocock, 1962, -23071; 24; 4991b; 99/18.5.

PLATE 1

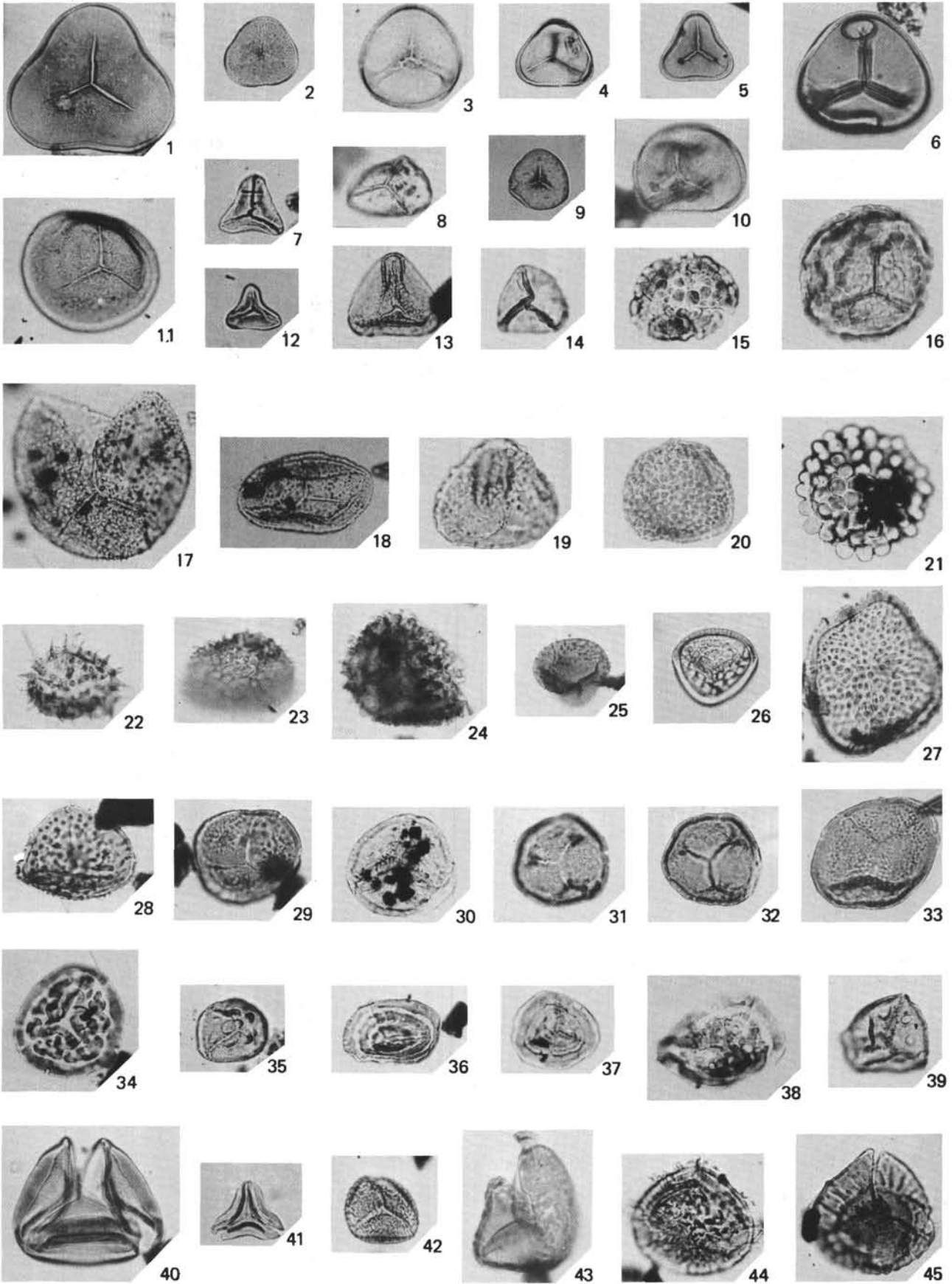


PLATE 2

All figures are magnified $\times 500$. Additional information in following order: Negative Number; Core Number; Sample Number; Coordinates on Zeiss photomicroscope mechanical stage.

- Figure 1 *Lycopodiumsporites facetus* Dettmann, 1963, -22989; 13; 4978b; 112/3.
 Figure 2 *Lycopodiumsporites reticulumsporites* (Rouse) Dettmann, 1963, -22990; 13; 4978b; 122.5/7.7.
 Figure 3 *Lycopodiumsporites austroclavitudites* (Cookson) Potonié, 1956, -23028; 20; 4987b; 120.4/22.4.
 Figure 4 *Lycopodiumsporites nodosus* Dettmann, 1963, -23017; 20; 4987b; 113/20.8.
 Figure 5 *Lycopodiumsporites crassatus* Singh, 1971, -22988; 13; 4978a.1; 110.1/20.3.
 Figure 6 *Lycopodiumsporites crassimacerius* Hedlund, 1966, -23110; 41; 5014b; 82/12.7.
 Figure 7 *Klukisporites foveolatus* Pocock, 1964, -23111; 36; 5006b.1; 88.7/9.7.
 Figure 8 *Zlivisporites blanensis* Palct, 1961, -22993; 13; 4978b; 79.3/14.
 Figure 9 ?*Tigrisporites* sp., -23052; 23; 4990b; 94/17.7.
 Figure 10 *Cicatricosisporites dorogensis* Potonié and Gelletich emend Kedves, 1961, -23013; 13; 4978b; 116.7/19.
 Figure 11 *Cicatricosisporites intersectus* Rouse, 1962, -23012; 20; 4987b.1; 90/14.
 Figure 12 *Cicatricosisporites pseudotripartitus* (Bolk) Dettmann, 1963, -22997; 18; 4984b.1; 121.2/11.6.
 Figure 13 *Cicatricosisporites claricanalis* Phillips and Felix, 1971, -23061; 24; 4991b; 85/4.3.
 Figure 14 *Cicatricosisporites striosporites* (Rouse) Kimyai, 1966, -23002; 19; 4986b; 92/10.5.
 Figure 15 *Cicatricosisporites australiensis* (Cookson) Pocock, 1956, -23109; 19; 4986b; 88.5/22.
 Figure 16 *Cicatricosisporites venustus* Deak, 1963, proximal view, -22999; 19; 4985b; 100.4/16.7.
 Figure 17 *Cicatricosisporites venustus* Deak, 1963, distal view, -22998; 19; 4985b; 100.4/16.7.
 Figure 18 *Cicatricosisporites aralica* (Bolkhovitina) Brenner, 1963, -23095; 39; 5008b; 90/19.8.
 Figure 19 *Cicatricosisporites exiguus* Hengreen, 1971, -23086; 35; 5002b.1; 94.6/22.6.
 Figure 20 *Cicatricosisporites apiteretus* Phillips and Felix, 1971, -23094; 39; 5008b; 87/15.
 Figure 21 *Cicatricosisporites cuneiformis* Pocock, 1965, -23080; 27; 4993b; 111.5/23.
 Figure 22 *Cicatricosisporites hughesi* Dettman, 1963, -22986; 27; 4993b.1; 90/3.
 Figure 23 *Cicatricosisporites hallei* Delcourt and Sprumont, 1955, -23108; 40; 5011b; 119/9.5.
 Figure 24 *Cicatricosisporites carlylensis* Pocock, 1962, proximal view, -23033; 21; 4988a; 81.4/18.7.
 Figure 25 *Cicatricosisporites carlylensis* Pocock, 1962, distal view, -23032; 21; 4988a; 81.4/18.7.
 Figure 26 *Cicatricosisporites* XIV, -23020; 17; 4983a; 117/15.7.
 Figure 27 *Cicatricosisporites* XIV, -23023; 13; 4978b; 88.5/12.6.
 Figure 28 *Appendicisporites degeneratus* Thiergart, 1953, proximal view, -22984; 20; 4987b; 77.7/21.
 Figure 29 *Appendicisporites degeneratus* Thiergart, 1953, distal view, -22983; 20; 4987b; 77.7/21.

PLATE 2

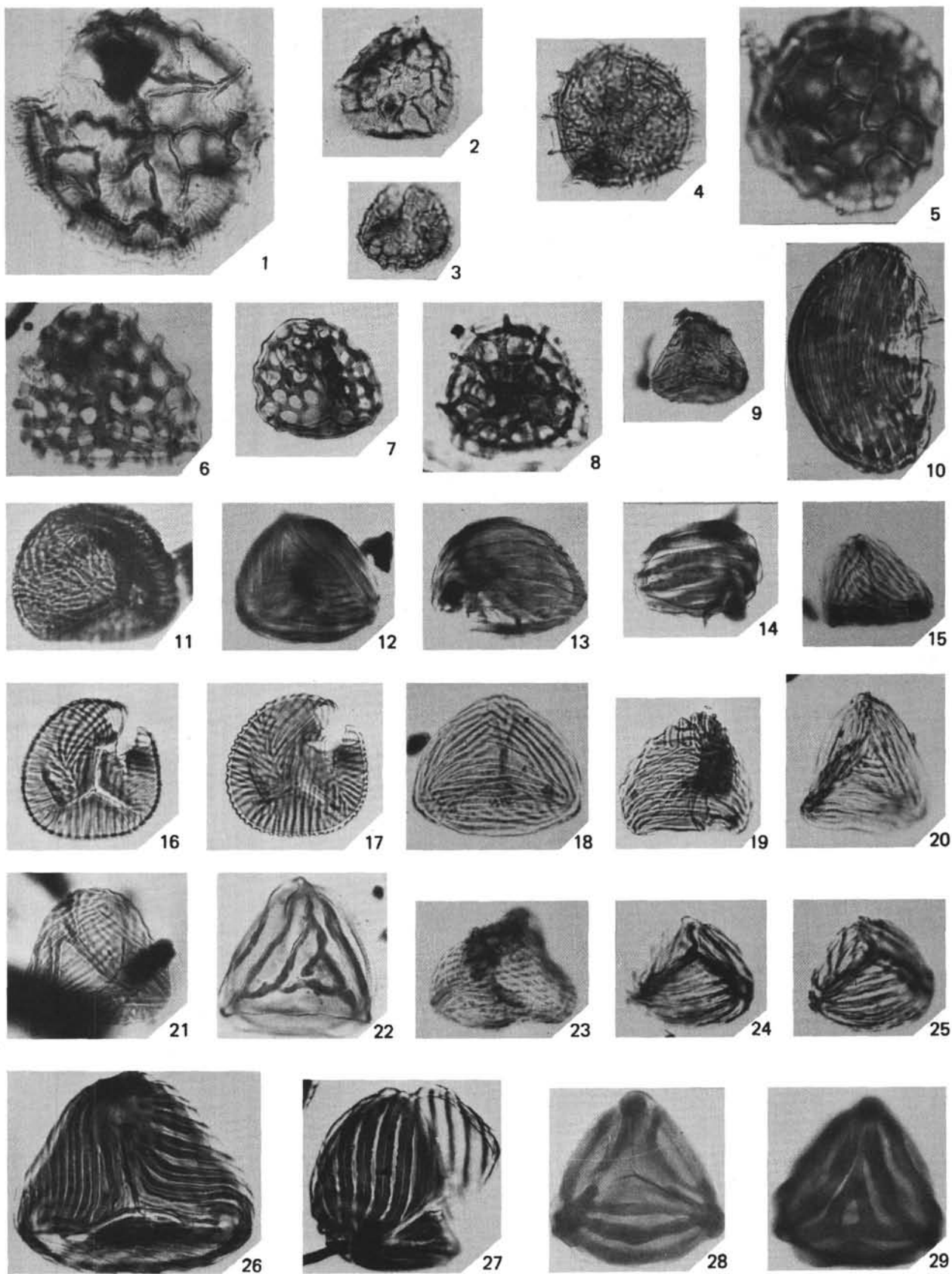


PLATE 3

All figures are magnified $\times 500$. Additional information in following order: Negative Number; Core Number; Sample Number; Coordinates on Zeiss photomicroscope mechanical stage.

- Figure 1 *Appendicisporites bilateralis* Singh, 1971, -23015; 19; 4986b; 110.5/3.5.
 Figure 2 *Appendicisporites erdtmanii* Pocock, 1964, -23069; 24; 4991b; 121/14.
 Figure 3 *Appendicisporites cristatus* (Markova) Pocock, 1964, -23060; 24; 4991a; 93/16.
 Figure 4 *Appendicisporites jansonii* Pocock, 1962, -23047; 21; 4988b; 103/22.3.
 Figure 5 *Appendicisporites crickmayii* Pocock, 1964, -23088; 35; 5002b; 114/8.5.
 Figure 6 *Costatoperforosporites fistulosus* Deak, 1962, -23068; 24; 4991b; 110/14.2.
 Figure 7 *Contignisporites cooksonii* (Balme) Dettmann, 1963, -23093; 39; 5008b; 105/15.
 Figure 8 *Chomotriletes* sp. -23044; 19; 4986b; 89/3.
 Figure 9 *Rouseisporites simplex* (Cookson and Dettmann) Dettmann, 1963, -23016; 19; 4986b; 120/3.4.
 Figure 10 *Rouseisporites reticulatus* Pocock, 1962, -23045; 19; 4985b; 115/10.4.
 Figure 11 *Kraeuselisporites majus* (Cookson and Dettmann) Dettmann, 1963, -22994; 17; 4983b; 100.4/11.2.
 Figure 12 *Aequitriradites verrucosus* (Cookson and Dettmann) Cookson and Dettmann, 1961, -22992; 13; 4978a; 99/3.5.
 Figure 13 *Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann, 1961, -23010; 19; 4985b; 96/20.6.
 Figure 14 *Cyatheacidites tectifera* Archangelsky and Gamarro, 1956, -23081; 28; 4995b; 96.3/22.
 Figure 15 *Densoisporites perinatus* Couper, 1958, -23123; 17; 4983b; 101/18.
 Figure 16 *Polypodiisporites* sp. 2, -23018; 20; 4987b; 106.5/21.
 Figure 17 *Polypodiisporites* sp. 3, -23019; 20; 4987b; 93/21.
 Figure 18 *Punctatosporites* sp., -23063; 24; 4991b; 76/15.8.
 Figure 19 *Laevigatosporites haardtii* (Potonié and Venitz) Thomson and Pflug, 1953, -23057; 23; 4990b; 98/19.8.
 Figure 20 *Laevigatosporites gracilis* Wilson and Webster, 1946, -23056; 23; 4990b; 85/11.4.
 Figure 21 *Classopollis* I, -22980; 48; 5024b; 82/20.7.
 Figure 22 *Classopollis* IV, -22975; 47; 5023b; 103.7/7.8.
 Figure 23 *Classopollis* V, -22978; 22; 4989b; 121.6/21.4.
 Figure 24 *Classopollis* VI, -22979; 20; 4987b; 87.5/21.3.
 Figure 25 *Classopollis* III, -23126; 27; 4993b.1; 100.5/18.8.
 Figure 26 *Araucariacites australis* Cookson, 1947, -23100; 40; 5010b.1; 78/3.
 Figure 27 *Inaperturopollenites* I+II, -23105; 43; 5016b; 122.5/8.6.
 Figure 28 *Inaperturopollenites limbatus* Balme, 1957, -23120; 47; 5023b.1; 90.7/15.4.
 Figure 29 *Inaperturopollenites* VI, -22971; 47; 5023b; 93/21.6.
 Figure 30 *Inaperturopollenites* VII, -23125; 27; 4993b.1; 80/21.4.
 Figure 31 *Inaperturopollenites* VIII, -23130; 20; 4987b; 92.4/21.4.
 Figure 32 *Tsugaepollenites trilobatus* (Balme) Dettmann, 1963, -23119; 48; 5024b.1; 124/6.8.
 Figure 33 *Tsugaepollenites dampieri* (Balme) Dettmann, 1963, -23127; 18; 4984b; 80/10.3.
 Figure 34 *Vitreisporites pallidus* (Reissinger) Nilsson, 1958, -23128; 18; 4984b; 88/21.
 Figure 35 *Vitreisporites* sp. Singh, 1971, -23050; 22; 4989b; 111.4/22.5.

PLATE 3

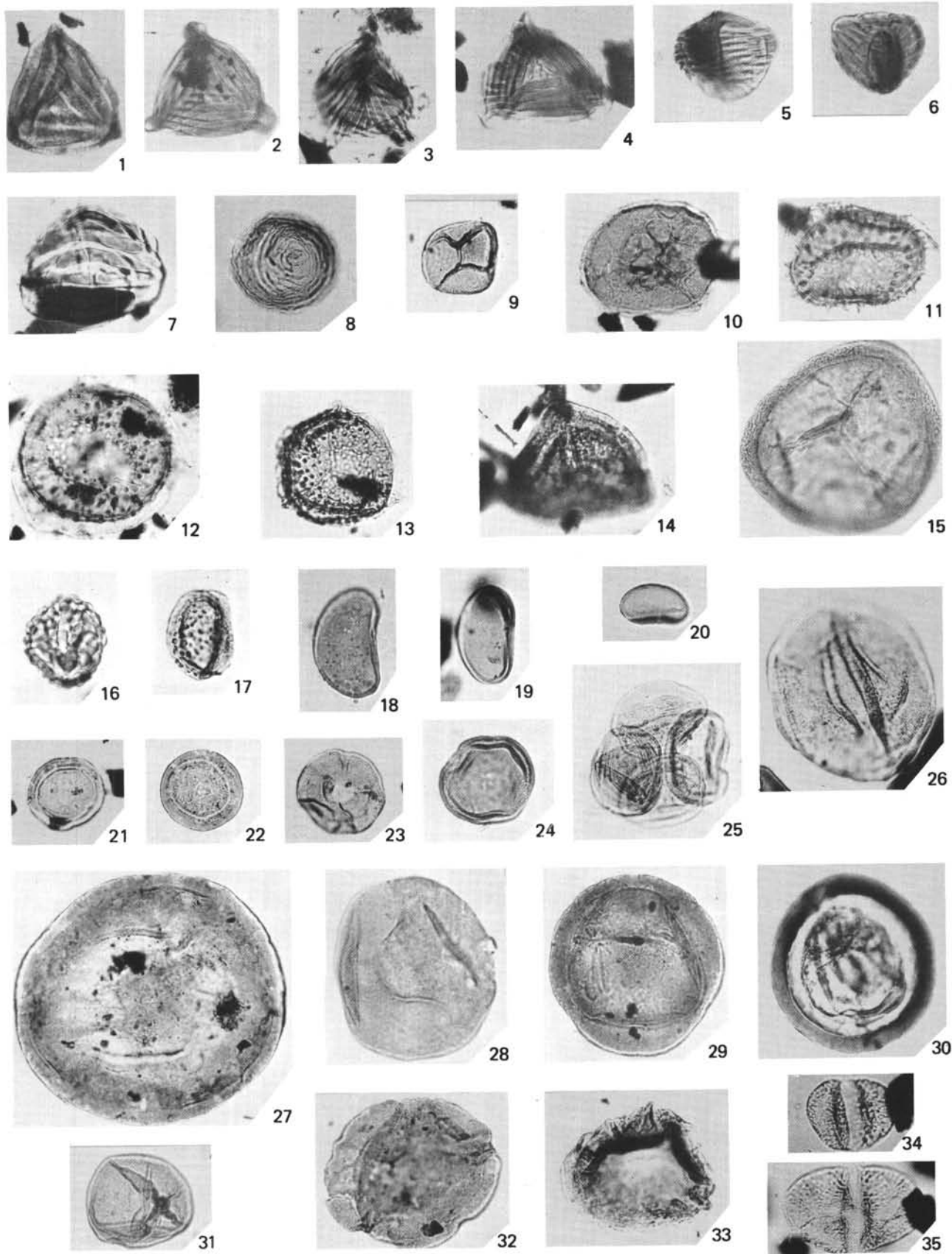


PLATE 4

Figures 1-18 are magnified $\times 500$; Figures 19-33 $\times 1000$. Additional information in following order: Negative Number; Core Number; Sample Number; Coordinates on Zeiss photomicroscope mechanical stage.

- Figure 1 *Podocarpidites multesimus* (Bolkhovitina) Pocock, 1962, -23116; 46; 5022b; 115/4.
 Figure 2 *Podocarpidites marwickii* Couper, 1953, -22981; 19; 4985b; 107.3/15.
 Figure 3 *Podocarpidites ellipticus* Cookson, 1947, -23129; 19; 4985b.1; 76/22.
 Figure 4 *Microcachrydites antarcticus* Cookson, 1947, -23078; 19; 4985b; 90.5/21.
 Figure 5 *Phyllocladidites* sp., -23011; 17; 4983b; 122.3/8.
 Figure 6 *Alisporites bilateralis* Rouse, 1959, -23115; 45; 5021b; 114/16.7.
 Figure 7 *Alisporites similis* (Balme) Dettmann, 1963, -23118; 40; 5010b.1; 109/20.3.
 Figure 8 *Podosporites* sp., -23042; 17; 4983b; 111.5/21.
 Figure 9 *Perinopollenites halonatus* Phillips and Felix, 1971, -23053; 23; 4990b; 95.2/22.
 Figure 10 *Schizosporis cooksonii* Pocock, 1962, -23064; 24; 4991b; 115/14.3.
 Figure 11 *Monosulcites perspinosus* Couper, 1953, -23009; 19; 4985b; 89/11.6.
 Figure 12 *Cycadopites nitidus* (Balme) de Jersey, 1964, -23098; 41; 5013b; 89.3/19.5.
 Figure 13 *Equisetosporites multistriatus* Pocock, 1964, -23000; 19; 4986b; 96.5/10.5.
 Figure 14 *Equisetosporites fissuratus* Phillips and Felix, 1971, -23065; 24; 4991b; 105/19.7.
 Figure 15 *Equisetosporites virginiaensis* (Brenner) Singh, 1971, -23087; 35; 5002b; 116/2.3
 Figure 16 *Equisetosporites rousei* Pocock, 1964, -22996; 18; 4984b; 107/11.
 Figure 17 *Equisetosporites barghoornii* Pocock, 1964, -22987; 39; 5008b.1; 85.3/16.
 Figure 18 *Equisetosporites concinnus* Singh, 1964, -23077; 19; 4985a; 112/12.
 Figure 19 *Steevesipollenites* sp., -23151; 22; 4989b; 87.6/22.
 Figure 20 *Liliacidites intermedius* Couper, 1953, -23131; 24; 4991b; 101/14.9.
 Figure 21 *Liliacidites crassatus* Singh, 1971, -23143; 23; 49906; 120/22.2.
 Figure 22 *Liliacidites peroreticulatus* (Brenner) Singh, 1971, -23139; 24; 4991b; 120.7/15.8.
 Figure 23 *Liliacidites trichotomosulcatus* Singh, 1971, -23135; 24; 4991b; 80.3/21.2.
 Figure 24 *Liliacidites dividius* (Pierce) Brenner, 1963, -23133; 24; 4991b; 111/20.
 Figure 25 *Liliacidites inaequalis* Singh, 1971, -23148; 23; 4990b; 124/13.6.
 Figure 26 *Clavatipollenites couperi* Pocock, 1962, -23134; 24; 4991b; 107/23.
 Figure 27 *Clavatipollenites hughesi* Couper, 1958, -23132; 24; 4991b; 92/20.3.
 Figure 28 *Clavatipollenites minutus* Brenner, 1963, -23146; 23; 4990b; 91/21.
 Figure 29 *Tricolpites parvus* Stanley, 1965, -23137; 24; 4991b; 122/20.
 Figure 30 *Tricolpites* sp. 1 -23147; 23; 4990b; 82/15.
 Figure 31 *Tricolpites* sp. 2 -23154; 24; 4991b; 81.3/14.5.
 Figure 32 *Tricolpites* sp. 3 -23153; 22; 4989b; 106/20.9.
 Figure 33 *Tricolpites* sp. 4 -23150; 22; 4989b; 115/23.
 Figure 34 *Poro-trichotomosculcus* sp. Phillips, 1971.

PLATE 4

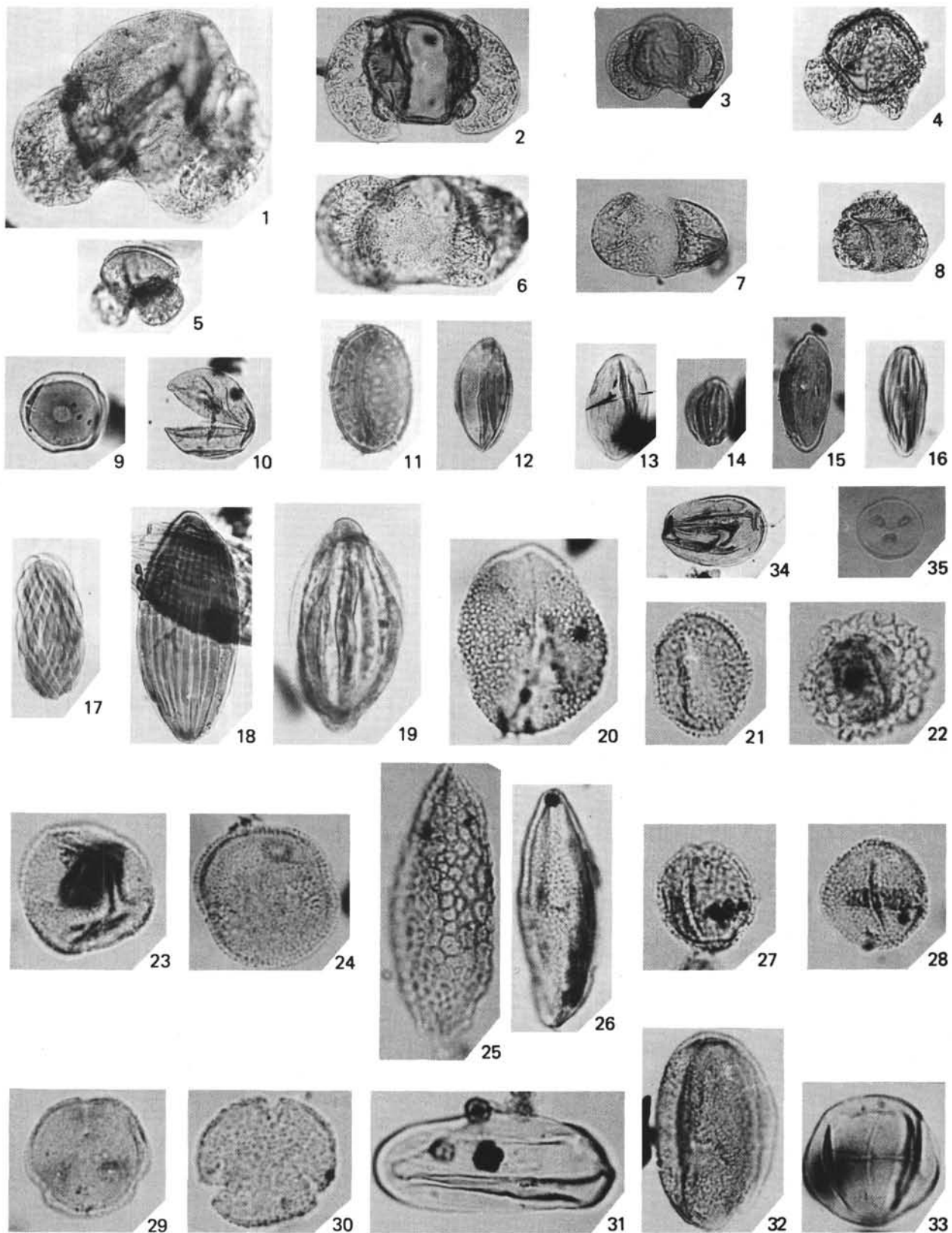


PLATE 5

All figures are magnified $\times 1000$; excepting figures 21-23 $\times 500$. Additional information in following order: Negative Number; Core Number; Sample Number; Coordinates on Zeiss photomicroscope mechanical stage.

- Figure 1 *Tricolpites* sp. 7, -23160; 19; 4986a; 77/5.
 Figure 2 *Tricolpites* sp. 9, -23168; 13; 4978b; 123/21.
 Figure 3 *Tricolpites* sp. 10, -23166; 17; 4983b.1; 99/14.
 Figure 4 *Tricolpites* sp. 6, -23156; 20; 4987b; 101.4/19.7.
 Figure 5 *Tricolpites* sp. 5, -23151; 22; 4989b; 101.4/19.7.
 Figure 6 *Retitricolpites georgensis* Brenner, 1963, -23155; 21; 4988b; 118/21.5.
 Figure 7 *Retitricolpites maximus* Singh, 1971, -23169; 13; 4978b; 79/17.
 Figure 8 *Retitricolpites ellipticus* Van Hoeken Klinkenberg, 1966, -23142; 24; 4991b; 98.5/13.7.
 Figure 9 *Psilatricolpites parvulus* (Groat and Penny) Norris, 1967, -23141; 24; 4991b; 115.6/14.4.
 Figure 10 *Striopollenites* sp., -23159; 19; 4985b; 111/16.
 Figure 11 *Scollardia steevesi* Srivastava, 1966, -23163; 18; 4984b; 76/20.5.
 Figure 12 *Tetracolpate*, -23162; 19; 4985b; 106/7.
 Figure 13 *Fraxinopollenites venustus* Singh, 1971, -23144; 23; 4990b; 120/22.2.
 Figure 14 *Fraxinopollenites rotundus* Phillips and Felix, 1971, -23140; 24; 4991b; 80/20.
 Figure 15 Polycolpate -23158; 19; 4985b; 86/16.7.
 Figure 16 *Gemmatricolpites scabratus* Van Hoeken-Klinkenberg, 1964, -23149; 23; 4990b; 123/14.3.
 Figure 17 *Tripoporollenites pseudocanalisis* Phillips and Felix, 1971, -23136; 24; 4991b; 76/20.3.
 Figure 18 *Nyassapollenites albertensis* Singh, 1971, -23161; 19; 4986b; 76/6.8.
 Figure 19 Syncolpate, -23164; 17; 4983b; 110/17.6.
 Figure 20 *Tricolporopollenites kruschii* (Potonié) Thomson and Pflug, 1953, -23138; 24; 4991b; 118.5/17.6.
 Figure 21 Incertae sedis A, -23037; 17; 4983b; 118/6.5.
 Figure 22 Incertae sedis A, -23035; 19; 4985b; 105/16.
 Figure 23 Incertae sedis A, -23039; 18; 4984b; 104/15.7.
 Figure 24 *Cretacaesporites mulleri* Hengreen, 1973, -49157; 19; 4985b; 78/22.
 Figure 25 Triporate, -23170; 13; 4978b; 124/12.
 Figure 26 *Proteacidites* sp., -23145; 23; 4990b; 119/21.
 Figure 27 *Proteacidites annularis* Cookson, 1950, -23165; 17; 4983b; 101.4/16.7.
 Figure 28 *Cupaneidites* sp., -23167; 13; 4978a.1; 110/15.4

PLATE 5

