

II. EARLY CRETACEOUS PALYNOmorphs OF THE WESTERN PACIFIC OCEAN¹

Gabi Ogg²

ABSTRACT

Lower Cretaceous and Jurassic sediments from Ocean Drilling Program Leg 129 (Sites 800, 801, and 802) and Deep Sea Drilling Project Sites 167, 195, 196, and 463 were analyzed for palynomorphs. In contrast to Atlantic occurrences, all Cretaceous pelagic sediments at these sites in the Pacific are barren of preserved palynomorphs. This absence of palynomorphs appears to be independent of facies, sedimentation rate, paleodepth, and paleolatitude. Except for one sample, the dinocyst-bearing sediments also contain spores and pollen grains. The only palynomorphs observed were in redeposited material having sources near former emergent seamounts.

Among the dinoflagellate cysts at Site 802, *Dingodinium cerviculum*, *Odontochitina operculata*, *Canninginopsis colliveri*, and *Oligosphaeridium complex* are the most important species. Based on the presence of these species and their known biostratigraphic ranges, this basal interval of Site 802 is considered to be Aptian/earliest Albian in age.

The lack of dinocysts within the Pacific pelagic sediments may be the result of ubiquitous oxygenated bottom waters throughout the Cretaceous or may indicate that open-marine dinoflagellate populations in this ocean did not produce cysts.

INTRODUCTION

Sporopollenic palynomorphs (dinoflagellate cysts, spores, pollen grains) are important microfossils used for biostratigraphy and paleoecology in marine and terrestrial environments. Dinocysts are especially important for biostratigraphic studies in Mesozoic and Tertiary epicontinental seas and in the Atlantic.

Palynomorphs from the Pacific are mainly described from the Tertiary (Balog and Malloy, 1978; Koreneva, 1980) and Quaternary (Wiseman, 1976). Investigations of Jurassic/Cretaceous palynomorphs in the Pacific Ocean region are very rare. The only well studied areas are Australia (e.g., Cookson and Eisenack, 1958, 1960, 1962; Burger, 1980; Jell (ed.), 1987), Papua New Guinea (e.g., Davey, 1988) and New Zealand (e.g., Helby et al., 1988).

Ocean Drilling Program (ODP) Leg 129 in the western Pacific offered an opportunity to investigate dinocysts of an open ocean environment.

The objective of this study was to investigate the palynomorph content of the three sites drilled during Leg 129 and to compare the results with other Deep Sea Drilling Project (DSDP) sites in the Pacific.

METHODS

A suite of 344 samples from Leg 129 and a total of 44 samples from Leg 17 (Site 167), Leg 20 (Sites 195 and 196), and Leg 62 (Site 463) were analyzed for palynomorphs.

All samples were processed using standard palynological preparation techniques. Hydrochloric and hydrofluoric acid were used to remove carbonates and silicates. Half of the remaining residue from each sample was oxidized with nitric acid to remove fine organic detritus to facilitate identification of the palynomorphs. Two slides were prepared from the nonoxidized residue and four from the oxidized residue. When palynomorphs were present, 500 specimens were determined in each oxidized sample, and in addition one slide with nonoxidized organic residue was examined to obtain the complete palynomorph assemblage. Acritarchs and most of the sporomorphs were determined only to generic level.

Age assignments were made by comparison with the Australian palynological zonation scheme by Helby et al. (1987).

The slides are deposited at the Institut und Museum für Geologie und Paläontologie of the University of Tübingen.

PALYNOmORPH OCCURRENCES

Site 167

Site 167 is located on the Magellan Rise (Fig. 1). Eighteen samples (167-66-1, 135–136 cm, through 167-94-1, 93–94 cm) were taken from Tithonian/Berriasian to Turonian light-colored limestone and chert (Shipboard Scientific Party, 1973a).

Only the lowest sample (167-94-1, 93–94 cm) yielded a few poorly preserved dinoflagellate cysts. The assemblage did not allow an age assignment, *Wallodinium krutzschii* is known to occur from the lower Tithonian to Aptian. Core 167-94 is dated by nannofossils as Tithonian/Berriasian (Roth, 1973).

Site 195 and Site 196

Sites 195 and 196 are located on the abyssal floor east of Izu-Bonin Trench (Fig. 1). Two samples were collected at Site 195 (195B-2-CC and 195B-3-1, 112–113 cm) from cherts of Valanginian to Hauterivian age (Shipboard Scientific Party, 1973b).

At Site 196 two samples (196-3-1, 123–125 cm, and 196-4-1, 106–107 cm) were taken from gray siliceous limestone and reddish chert of Jurassic to Hauterivian age (Shipboard Scientific Party, 1973c).

None of the samples from Sites 195 and 196 yielded any palynomorphs.

Site 463

Site 463 is located in the northwestern region of the Mid-Pacific Mountains (Fig. 1). Twenty-two samples (463-48-2, 62–63 cm, through 463-86-1, 90–91 cm) were collected from sediments of Barremian to Albian age (Shipboard Scientific Party, 1981). The multicolored pelagic limestone and silicified limestone of early Aptian to middle Albian (Samples 463-48-2, 62–63 cm, through 463-66-1, 46–47 cm) were barren. Samples 463-67-2, 97–98 cm, through 463-86-1, 90–91 cm, mainly taken from calcareous turbidite and debris-flow deposits of Barremian to early Aptian age, yielded only a few palynomorphs. The two samples (463-69-1, 19–29 cm, and 463-76-1, 124–125 cm) taken from limestones within this interval were barren.

¹ Larson, R. L., Lancelot, Y., et al., 1992. Proc. ODP, Sci. Results, 129: College Station, TX (Ocean Drilling Program).

² Institut und Museum für Geologie und Paläontologie, Sigwartstr. 10, W-7400 Tübingen, Federal Republic of Germany. (Present address: Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, U.S.A.)

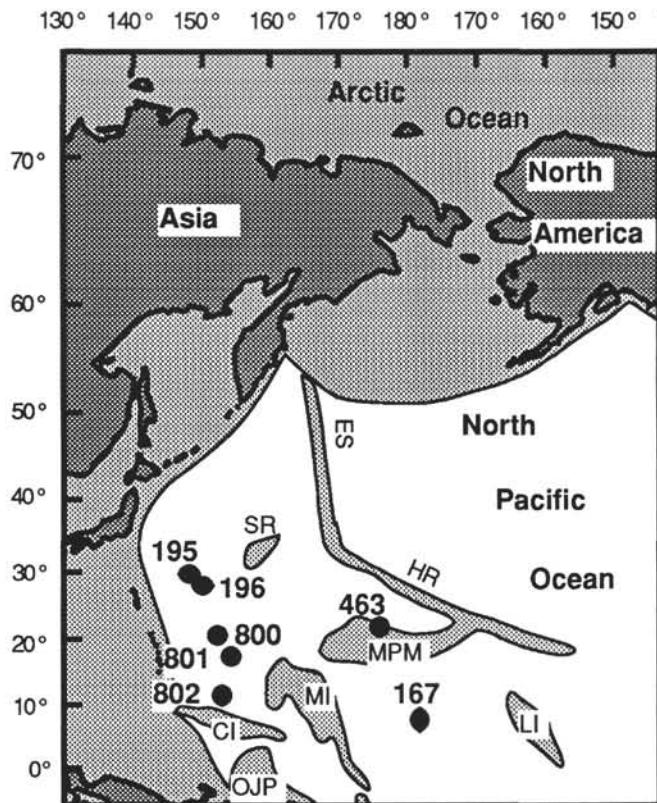


Figure 1. Location of Sites 167, 195, 196, 463, 800, 801, and 802. Shaded areas represent volcanic edifices with thickened crustal sections, as well as the younger areas beyond the Pacific subduction zones. Unshaded areas represent normal Pacific oceanic crust. (Abbreviations are as follows: CI = Caroline Islands, ES = Emperor Seamounts, HR = Hawaiian Ridge, LI = Line Islands, MI = Marshall Islands, MPM = Mid-Pacific Mountains, OJP = Ontong Java Plateau, SR = Shatsky Rise.)

Biostratigraphy of Site 463

The sampled interval of 62-463-73R-1, 124–125 cm, through 62-463-86R-1, 90–91 cm, is dated as Barremian from nannoplankton (Cepek, 1981). Magnetic polarity Chron M1r of late Barremian age (Lowrie et al., 1980) occurs in Cores 62-463-77 through 62-463-78 (Sayre, 1981). Polarity Chron M0r of basal Aptian (Ogg, 1988; Tarduno et al., 1989) is found within Core 62-463-72 (Sayre, 1981). Palynomorphs are rare and poorly preserved in this interval. The dinocyst assemblage consists mainly of *Oligosphaeridium pulcherrimum*, *O. complex*, *Wallodinium krutzschii*, and *Fromea fragilis*. The dominant sporomorphs are *Cyathidites minor* and *Callialasporites dampieri*. All these palynomorph species have a biostratigraphic range through the Early Cretaceous, and therefore a precise age assignment is not possible.

The interval of Samples 62-463-67R-2, 97–98 cm, through 62-463-71R-2, 52–53 cm, is dated as Aptian from foraminifers (Sliter, 1989). The dinocysts include *Canninginopsis colliveri*, *Odontochitina operculata*, *Spiniferites* spp., and *Fromea fragilis*. The sporomorphs are characterized by *Cyathidites minor* and *Stereisporites antiquasporites*.

Canninginopsis colliveri, *Odontochitina operculata*, *Cyathidites minor*, and *Stereisporites antiquasporites* are common forms throughout the Aptian, but the known range of this assemblage extends from Barremian to Cenomanian, and therefore no precise age assignment is possible only with these palynomorphs.

The occurrence of abundant spores and pollen grains supports the hypothesis of Winterer and Metzler (1984) that the volcanoes of the

Mid-Pacific Mountains were at sea level or emergent from the Barremian through Aptian.

Sites 800, 801, and 802

Three sites were drilled during Leg 129 in the western Pacific (Fig. 1): Sites 800 and 801 in the Pigafetta Basin and Site 802 in the East Mariana Basin. The main objective of these sites was to recover the oldest oceanic crust of the Pacific Plate, which was predicted to be of Jurassic age (Abrams et al., 1988).

Sites 800 and 801

The complete sedimentary sequences at Sites 800 (100 samples) and 801 (108 samples) were sampled for palynomorphs, but all samples were barren. Samples 129-800A-7R-CC through 129-800A-9R-CC, taken from Campanian brown chert and porcellanite (Shipboard Scientific Party, 1990a), and 129-801B-16R-CC through 129-801B-32R-CC, taken from Oxfordian to Valanginian brown radiolarite (Shipboard Scientific Party, 1990b), yielded some amorphous organic matter.

Site 802

The whole sedimentary sequence at Site 802 was sampled (136 samples) for palynomorphs. Except for Cores 129-802A-25R and 129-802A-56R through 129-802A-57R, all cores from Site 802 are barren of palynomorphs. Sample 129-802A-25R-CC from lower Miocene–Pliocene volcaniclastic turbidites (Shipboard Scientific Party, 1990c) yields large amounts of wood fragments, plant cuticles, and a few spores and pollen grains of Miocene age. The terrestrial influx indicates that surrounding seamounts were above sea level during the Miocene. These volcaniclastic turbidites probably derived from the Caroline Rise, for example, the island of Truk, which is Miocene in age and is still above sea level today.

The fine-grained volcaniclastic turbidites and tuffaceous claystone (Shipboard Scientific Party, 1990c) of Samples 129-802A-56R-4, 34–36 cm, through 129-802A-57R-2, 57–61 cm (upper Aptian to Albian), yield a rich palynoflora with large amounts of plant cuticles and wood fragments. The abundance of marine and terrestrial palynomorphs is generally high, but their diversity is moderate with 28 dinocyst species and 22 sporomorph species.

Trilete spores (*Cyathidites* spp.) dominate the palynoflora, *Callialasporites dampieri* and *C. trilobatus* are rather frequent, and bisaccate pollen grains (mainly species of *Alisporites* and *Podocarpidites*) are less abundant (Fig. 2). Dinoflagellate cysts and leiosphaerid acritarchs comprise approximately 25%–40% of the total assemblage (Fig. 2). The dominance of sporomorphs and large amounts of wood fragments, and of well-preserved plant cuticles and tracheids, reflect original deposition in a nearshore area around emerged seamounts, from where they were transported to the present site by turbidity currents. Subsidence calculations on these seamounts indicate that either the oceanic crust in this region is of Early Cretaceous age or that there was widespread thermal uplift of this “Darwin Rise” associated with the pulse of mid-Cretaceous seamount building (McNutt et al., 1990).

Biostratigraphy of Site 802

Sporomorphs are very abundant in Samples 129-802A-56R-4, 34–36 cm, through 129-802A-57R-2, 57–61 cm. *Cyathidites minor*, *Callialasporites dampieri*, and *C. trilobatus* (Pl. 1, Fig. 10) are dominant (Fig. 3), but they provide little information for age assignment. An age not older than early Aptian is suggested for this sequence by the rare occurrence of *Foraminisporis asymmetricus*, on the basis of comparison with Australian palynofloras (Helby et al., 1987).

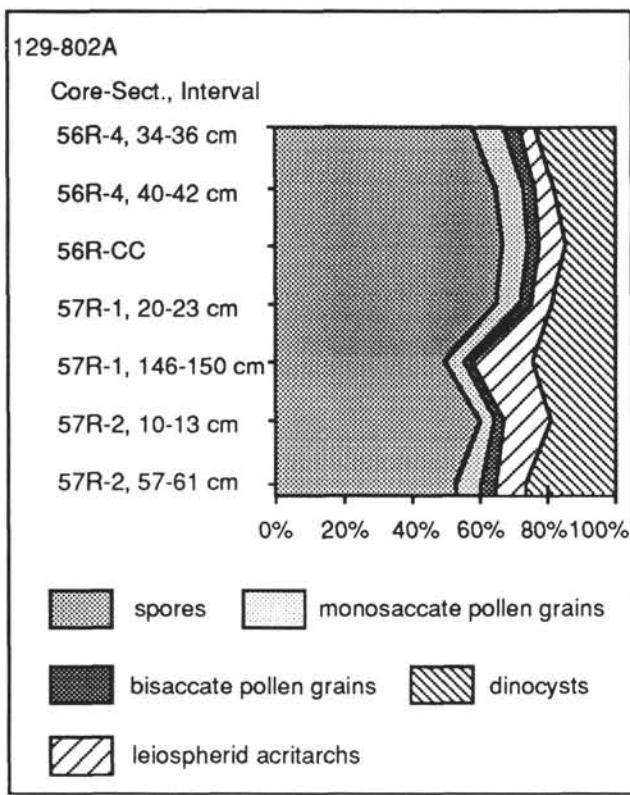


Figure 2. Palynomorph assemblage analysis of Hole 802A.

Dinoflagellate assemblages of Samples 129-802A-56R-4, 34–36 cm, through 129-802A-57R-2, 57–61 cm, are characterized by *Canninginopsis colliveri* (Pl. 1, Figs. 1, 6), *Dingodinium cervicum* (Pl. 1, Fig. 5), *Oligosphaeridium complex*, (Pl. 1, Fig. 4), and *Odontochitina operculata* (Fig. 4). In Australia, *Dingodinium cervicum* ranges from Hauterivian to earliest Albian (Helby et al., 1987). *Odontochitina operculata* occurs sporadically throughout the Barremian and consistently from Aptian to the Late Cretaceous. *Canninginopsis colliveri*, together with *Dingodinium cervicum* and *Muderongia tetricantha* (Pl. 1, Figs. 2, 3), are “significant accessory forms” of the *Diconodinium davidi* interval zone (Fig. 5). A few cysts of *Muderongia tetricantha* were found in Sample 129-802A-57R-2, 57–61 cm. Therefore, based on the presence of these species and on the absence of index species of the *Heterosphaeridium* superzone (Fig. 5), which ranges from the early Albian to earliest Santonian (Helby et al., 1987), this interval is considered to be Aptian/earliest Albian in age. Comparisons with nannofossils recovered from these sediments further constrain the age to latest Aptian/earliest Albian.

PRESERVATION

The absence of marine palynomorphs in most of the samples of the Pacific Ocean raises two intriguing questions.

First, was the open-ocean environment unfavorable for dinoflagellates that produce cysts? Studies of recent dinoflagellates show that most species do not form sporopollenin resting cysts and so they leave no fossil records (Dale, 1983). The majority of cyst-forming dinoflagellates in modern oceans are found in neritic environments on the shelf and upper slope. Open-ocean conditions seem to be less favorable for cyst-producing species, and the adaptive advantage of resting cysts that sink to the ocean floor is questionable (Loeblich and Loeblich, 1984). The dinoflagellate cysts of the studied Pacific samples occur predominantly in turbidites together with sporomorphs and plant fragments, which indicate an original deposition in a nearshore environment.

On the other hand, in the Atlantic Ocean at Sites 391 and 603, dinoflagellate cysts are found in open-ocean sediments (Habib, 1978; Habib and Drugg, 1987) of Late Jurassic and Early Cretaceous age. From the Valanginian onward, these sites were also situated within the range of turbidity currents, but no turbidite redeposition has been recognized in the reddish-colored to white limestones of Tithonian and Berriasian age that contain dinocysts.

Second, did postburial diagenetic factors destroy the palynomorphs? Organic matter is resistant to most acids but very sensitive to oxidizing conditions. The red coloration of radiolarites and claystones imply oxidizing bottom waters in the Pacific, which destroy the palynomorphs during early diagenesis. Depending on the time of exposure to oxidizing bottom waters, the destruction of configured organic matter varies. Within intervals deposited at a moderate sedimentation rate of 3 m/m.y. for Samples 129-800A-7R-CC through 129-800A-9R-CC (Campanian) and of 7–12 m/m.y. for Samples 129-801B-16-CC through 129-801B-32R-CC (Oxfordian to Valanginian) (Shipboard Scientific Party, 1990a; Molinie and Ogg, this volume), some amorphous organic matter was found, but no identifiable palynomorphs. The oxidizing bottom waters in this part of the Pacific Ocean contradict the theory of a global anoxic event (e.g., Vogt, 1989).

In addition, the recrystallization of the original matrix at a later time will destroy organic matter (Dürr, 1988). This factor further helps to explain the absence of palynomorphs in the silicified limestones at Site 800 (Core 129-800A-13R through 129-800A-22R) and at Site 463 (Sample 463-76R-1, 124–125 cm).

These possible factors of cyst production, oxidizing bottom waters, and recrystallization, operating independently or in concert, may explain the curious lack of dinoflagellate cysts in the Pacific pelagic sediments.

CONCLUSIONS

Dinoflagellate cysts throughout the Pacific are rarely present in Jurassic or Cretaceous pelagic sediments. This absence of cysts may be due either to rarity of preservation because of destruction of the organic matter at the sediment surface or during diagenesis, or to an original lack of cyst-producing dinoflagellates in the open-ocean environment. Well-preserved palynomorphs are mainly found in turbidites derived from shallow-marine environments where conditions for cyst-forming dinoflagellates are favorable. The occurrence of sporomorphs, wood fragments, and plant cuticles at Site 802 and Site 463 give evidence for the existence of islands with dense vegetation during the Early Cretaceous.

Precise age assignment of Site 463 is not possible using palynomorphs. Volcaniclastic turbidites that directly overlie the basalts at Site 802 are dated as late Aptian/earliest Albian.

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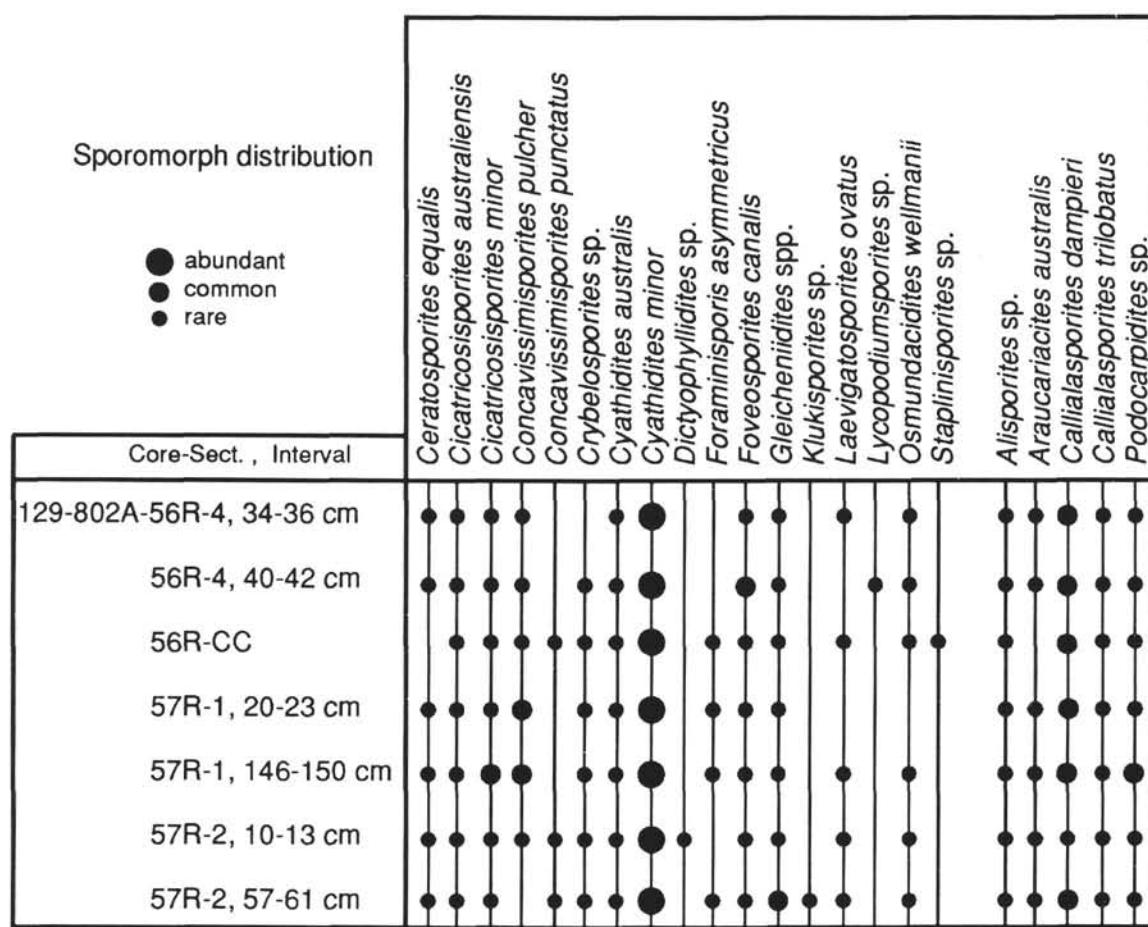


Figure 3. Distribution of spores and pollen grains in Hole 802A.

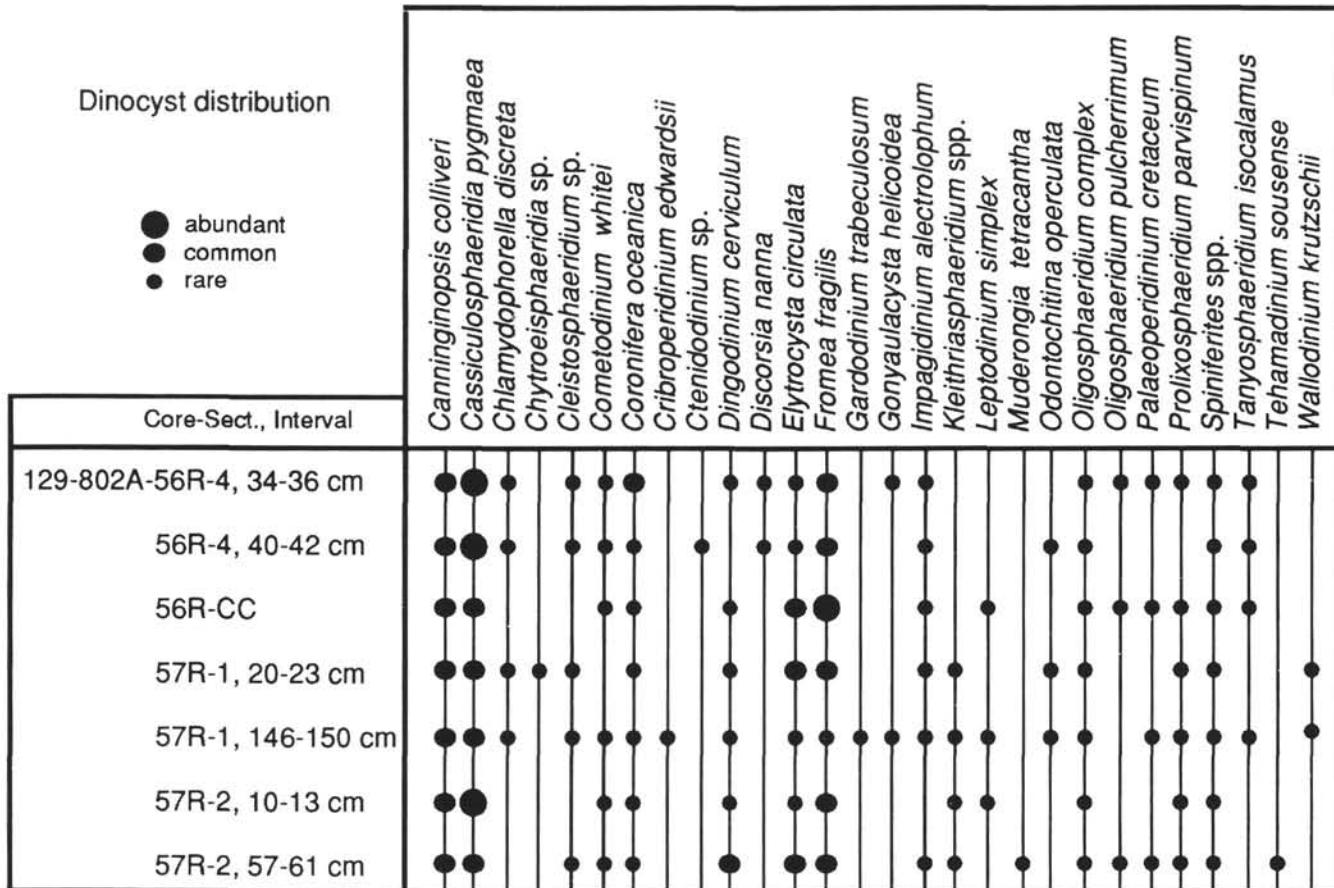


Figure 4. Distribution of dinoflagellate cysts in Hole 802A.

Age	SZ	Dinocyst zones		SZ	Sporomorph zones		
		Heterosphaeridium	Xenascus asperatus		Phimopollenites pannosus	Coptospora paradoxa	
Aptian	Muderongia	Pseudoceratium ludbrookiae		Microchaitydites			
		Canningtonopsis denticulata					
		Muderongia tetracantha					
		Diconodinium davidi					
		Odontochitina operculata					
Albian		Hoegsporis		Hoegsporis			
				Crybelosporites striatus			
				Cyclosporites hughesii			

SZ = Superzone

Figure 5. Aptian/Albian dinoflagellate cyst and sporomorph zonation scheme of Australia (Helby et al., 1987).

APPENDIX

Dinoflagellate Cysts

Site 802

- Canninginopsis colliveri* (Cookson and Eisenack, 1960) Backhouse, 1988
Cassiculospaeridium pygmaea Stevens, 1987
Cleistosphaeridium spp.
Chamydophorella discreta Clarke and Verdier, 1967
Chytröeisphaeridium sp.
Cometodinium ?whitei (Deflandre and Courteville, 1939) Stover and Evitt, 1978
Coronifera oceanica Cookson and Eisenack, 1958, emend. May 1980
Cribroperidinium edwardsii (Cookson and Eisenack, 1958) Davey, 1969
Ctenidodinium sp.
Dingodinium cerviculum Cookson and Eisenack, 1958 emend. Mehrotra and Sarjeant, 1984
Discorsia nanna (Davey, 1974) Duxbury, 1977
Elytrocysta circulata (Clarke and Verdier, 1967), Stover and Helby, 1987
Fromea fragilis (Cookson and Eisenack, 1962) Stover and Evitt, 1978
Gardodinium trabeculosum (Gocht, 1959) Alberti, 1961
Gonyaulacysta helicoidea (Eisenack and Cookson, 1960) Sarjeant, 1966
Impagidinium alectrolophum (Sarjeant, 1966) Stover and Evitt, 1978
Kleithriaspaeridium spp.
Leptodinium simplex Burger 1980
Muderongia tetricantha (Gocht, 1957) Alberti, 1961
Odontochitina operculata (Wetzel, 1933) Deflandre and Cookson, 1955
Oligosphaeridium complex (White, 1842) Davey and Williams, 1966
Oligosphaeridium pulcherrimum (Deflandre and Cookson, 1955) Davey and Williams, 1966
Palaeoperidinium cretaceum Pocock, 1962, emend. Davey, 1970
Prolixospaeridium parvispinum (Deflandre, 1937) Davey et al., 1969
Spiniferites spp.
Tanyosphaeridium isocalamus (Deflandre and Cookson, 1955) Davey and Williams, 1969
Tehamadinium souseense (Below, 1981) Jan du Chêne et al., 1986
Wallodinium krutzschii (Alberti, 1961) Habib, 1972
- Site 167
- Cleistosphaeridium* spp.
Wallodinium krutzschii (Alberti, 1961) Habib, 1972
- Site 463
- Canninginopsis colliveri* (Cookson and Eisenack, 1960) Backhouse, 1988
Chytröeisphaeridium sp.
Fromea fragilis (Cookson and Eisenack, 1962) Stover and Evitt, 1978
Impagidinium alectrolophum (Sarjeant, 1966) Stover and Evitt, 1978
Leptodinium simplex Burger 1980
Oligosphaeridium complex (White, 1842) Davey and Williams, 1966
Oligosphaeridium pulcherrimum (Deflandre and Cookson, 1955) Davey and Williams, 1966
Spiniferites spp.
Tanyosphaeridium isocalamus (Deflandre and Cookson, 1955) Davey and Williams, 1969
Wallodinium krutzschii (Alberti, 1961) Habib, 1972

Acaritarchs

Site 802

- Leiosphaeridia* spp.
Micrhystridium spp.
Pterospermella sp.

Site 167

- Micrhystridium* spp.

Site 463

- Leiosphaeridia* spp.
Micrhystridium spp.
Pterospermella sp.

Sporomorphs

Site 802

- Alisporites* sp.
Araucariacites australis Cookson, 1947
Callialasporites dampieri (Balme 1957), Dev, 1961
Callialasporites trilobatus (Balme 1957), Dev, 1961
Ceratosporites equalis Cookson and Dettmann, 1958
Cicatricosporites australiensis (Cookson 1953) Potonié, 1956
Cicatricosporites minor (Bolchovitina 1961) Pocock, 1964
Concavissimopores punctatus (Delcourt and Sprumont, 1955) Brenner, 1963
Crybelosporites sp.
Cyathidites australis Couper, 1953
Cyathidites minor Couper, 1953
Dictyophyllidites sp.
Foraminisporis asymmetricus (Cookson and Dettmann, 1958) Dettmann, 1963
Foveosporites canalis Balme, 1957
Gleicheniidites spp.
Klukisporites sp.
Laevigatosporites ovatus Wilson and Webster, 1946
Lycopodiumsporites sp.
Osmundacidites wellmanii Couper, 1953
Podocarpidites sp.
Staplinisporites sp.

Site 463

- Callialasporites dampieri* (Balme 1957), Dev, 1961
Cicatricosporites australiensis (Cookson 1953) Potonié, 1956
Cicatricosporites minor (Bolchovitina 1961) Pocock, 1964
Cyathidites australis Couper, 1953
Cyathidites minor Couper, 1953
Gleicheniidites spp.
Leptolepidites sp.
Osmundacidites wellmanii Couper, 1953
Podocarpidites sp.
Stereisporites antiquasporites (Wilson and Webster, 1946) Dettmann, 1963

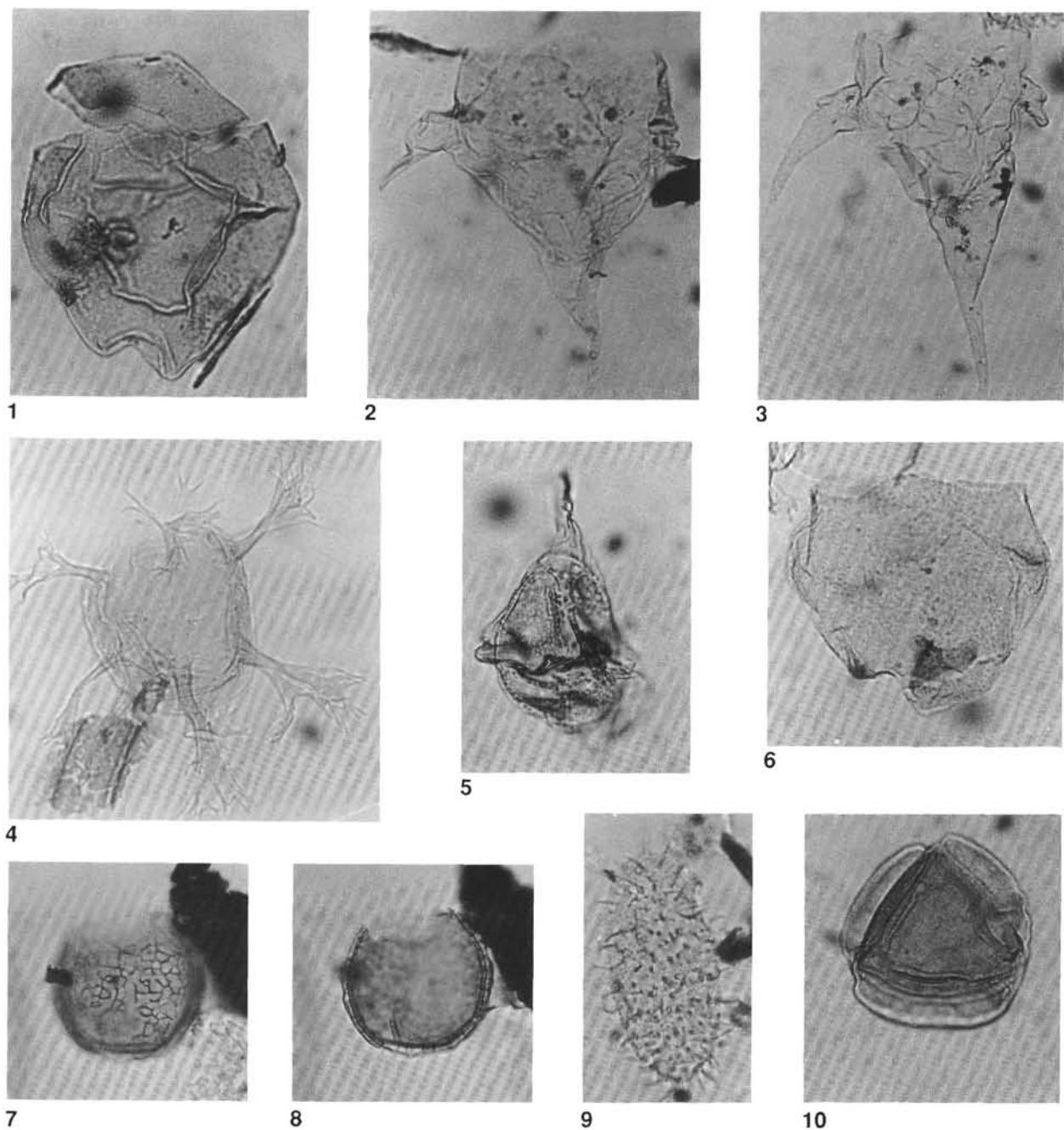


Plate 1. Photomicrographs of palynomorphs. Magnification 600 \times . **1.** *Canninginopsis colliveri*, Sample 129-802A-57R-2, 57–61 cm, slide e. **2.** *Muderongia tetracantha*, Sample 129-802A-57R-2, 57–61 cm, slide e. **3.** *Muderongia tetracantha*, Sample 129-802A-57R-2, 57–61 cm, slide e. **4.** *Oligosphaeridium complex*, Sample 129-802A-56R-4, 40–42 cm, slide b. **5.** *Dingodinium cerviculum*, Sample 129-802A-57R-2, 57–61 cm, slide e. **6.** *Canninginopsis colliveri*, Sample 129-802A-57R-2, 57–61 cm, slide e. **7, 8.** *Elytrrocysta circulata*, Sample 129-802A-57R-1, 20–23 cm, slide a. **9.** *Prolixosphaeridium parvispinosum*, Sample 129-802A-57R-2, 10–13 cm, slide a. **10.** *Callialasporites trilobatus*, Sample 129-802A-56R-4, 40–42 cm, slide d.