34. COCCOLITHS IN CORES FROM THE BELLINGSHAUSEN ABYSSAL PLAIN AND ANTARCTIC CONTINENTAL RISE (DSDP LEG 35)

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INTRODUCTION

During Leg 35 of the Deep Sea Drilling Project four sites were drilled, two on the Bellingshausen Abyssal Plain (332, 323) and two on the Antarctic Continental Rise (324, 325) (Figure 1). Due to delays caused by a number of weather and mechanical problems, only 55 cores spanning 515 meters were taken. Sediment recovery was a poor 37.5% (about 193 m). Most of the sediments consist of terrigenous detritus derived from Antarctica and transported by bottom and turbidity currents and by ice-rafting. Some pelagic claystones were recovered in the bottom of Holes 322 and 323 (Bellingshausen Abyssal Plain). In the upper parts of all cores locally diatomaceous-rich layers yielded poor to moderately well preserved siliceous microfossils. Recovery of calcareous sediments was very poor (less than 3 m at Site 323 and a few thin layers at Site 325). These calcareous intervals contain poor to moderately well preserved planktonic foraminifera and calcareous nannofossils.

A summary of the site locations, coring data, and recovery of calcareous microfossils is given in Table 1.

COCCOLITHS OF LEG 35

Site 323

Coccoliths were recovered at Site 323 only in certain levels of Cores 18, Section 4, through Core 15, Section 6. Most coccolith specimens are highly fragmented and show signs of calcite dissolution and recrystallization when observed under the scanning electron microscope. Light microscope examination revealed the following species in samples from this site.

Sample 18-4, 149-150 cm: Only very rare specimens of *Ericsonia* ? *subpertusa* and *Zygodiscus sigmoides* were seen. Also observed were Maestrichtian species, such as: *Cribrosphaerella ehrenbergi*, *Micula* sp., *Cretarhabdus* ? *splendens*, and a small coccolith, possibly *Biscutum* sp. The presence of only a few Paleocene species and more common occurrence of the Maestrichtian forms in this sample suggests possible contamination rather than reworking, in which case this level can be assigned to the late Maestrichtian age.

Samples 18-4, 120-121 cm, 18-4, 70-71 cm, 18-4, 62-64 cm, 18-4, 20-21 cm: Barren. All samples examined from Core 18, Sections 3, 2, and 1 were also barren of coccoliths.

Sample 17, CC: Only rare occurrences of fragmented *Cribrosphaerella ehrenbergi* and *Watznaueria barnesae* were seen.

Samples 17-1, 20-21 cm, 17-1, 50-52 cm, 17-1, 80-82 cm, 16, CC, 16-4, 120-121 cm, 16-4, 80-81 cm, 16-4, 53-55 cm: Barren.

Sample 16-4, 20-21 cm: Fragments of small-sized *Cruciplacolithus tenuis* present.

Sample 16-4, 0-2 cm: Fragments of *C. tenuis* and *Coccolithus cavus* present.

Samples 16-3, 130-131 cm, 16-3, 92-94 cm, 16-3, 80-81 cm, 16-3, 20-21 cm: Barren.

Sample 16 2, 140-141 cm: Barren; Sample 16-2, 90-91 cm: *Coccolithus cavus* (few), *Cruciplacolithus tenuis* (common), *Ericsonia subpertusa* (rare), *Prinsius martinii* and *P.* aff. *martinii* (rare), *Thoracosphaera* spp. (few), and *Zygodiscus sigmoides* (rare).

Sample 16-2, 83-85 cm: Flora similar to Sample 16-2, 90-91 cm plus a few reworked Maestrichtian species.

Sample 16-2, 50-51 cm: Flora essentially dominated by a single species, *Cruciplacolithus tenuis*. Rare specimens of *Chiasmolithus* aff. *danicus*, *Coccolithus cavus*, *Ericsonia subpertusa*, *Prinsius martinii* and *P.* aff. *martinii*, *Thoracosphaera* spp., and *Zygodiscus sigmoides*.

Sample 16-2, 37-39 cm: *Chiasmolithus danicus* (R), *Coccolithus cavus* (R), *Cruciplacolithus tenuis* (C), *Markalius astroporus* (F), *Prinsius martinii* (R), and *Zygodiscus sigmoides* (F).

Sample 16-2, 14-16 cm: Flora similar to Sample 16-2, 37-39 cm with the addition of *Ericsonia subpertusa* (R) and reworked Maestrichtian species (R).

Sample 16-2, 10-11 cm: Fragmentary but very rich in coccoliths. *Chiasmolithus danicus* (R), *Coccolithus cavus* (F), *Cruciplacolithus tenuis* (C), *Ericsonia subpertusa* (R), *Hornibrookina* aff. *teuriensis* (R), *Markalius astroporus* (R), *Prinsius* aff. *bisulcus* (R), *P. martinii* and *P.* aff. *martinii* (R), *Thoracosphaera deflandrei* (F), *T. saxea* (R) and *Zygodiscus sigmoides* (F), and reworked Maestrichtian species (R).

Sample 16-1, 140-141 cm: *Chiasmolithus danicus* (R), *Coccolithus cavus* (F), *Cruciplacolithus tenuis* (C), *Ericsonia subpertusa* (F), *Hornibrookina* aff. *teuriensis* (R), *Markalius astroporus* (F), *Prinsius martinii* (R), *Thoracosphaera deflandrei* (F), *T. saxea* (R), *Zygodiscus sigmoides* (F), and reworked Maestrichtian species (R).

Sample 16-1, 100-101 cm: *Chiasmolithus danicus* (R), *Coccolithus cavus* (F), *Cruciplacolithus tenuis* (F), *Ericsonia subpertusa* (C), *Hornibrookina* aff. *teuriensis* (R), *Prinsius martinii* and *P.* aff. *martinii* (F), *Thoracosphaera* spp. (R), *Zygodiscus sigmoides* (F).

Sample 16-1, 50-51 cm: Flora similar to Sample 16-1, 100-101 cm except *Chiasmolithus danicus* and *Zygodiscus sigmoides* more common.

Sample 16-1, 39-41 cm: Flora similar to the above but *Chiasmolithus danicus* and *Zygodiscus sigmoides* are less common and *Coccolithus cavus* is more common. An additional species, *Zygodiscus adamas*, is also found in low numbers.

Sample 16-1, 10-11 cm: Specimens highly fragmented. *Chiasmolithus danicus* (F), *Cruciplacolithus tenuis* (C),

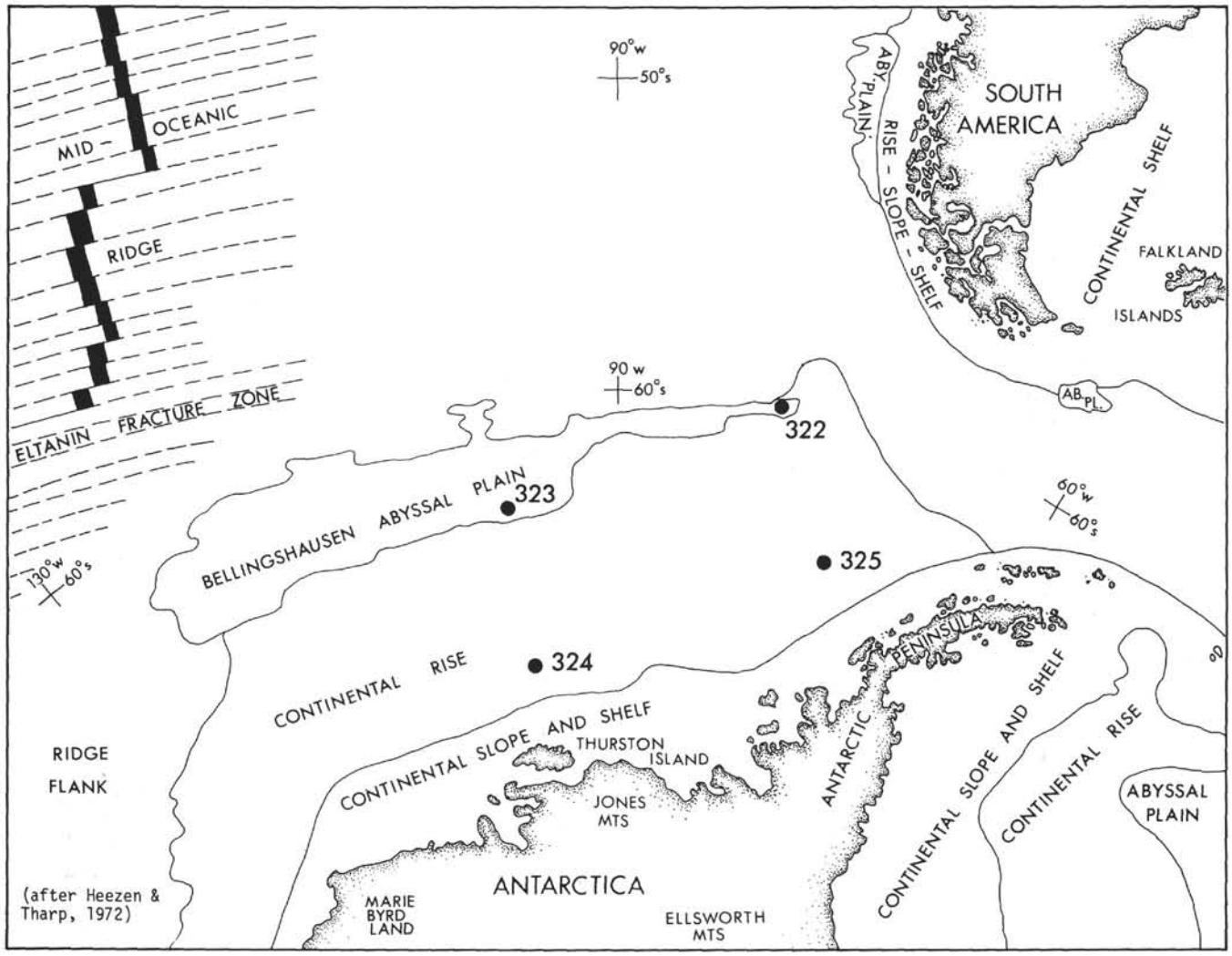

Figure 1. *Location of drill sites of DSDP Leg 35.*

TABLE 1
Core Locations and Recovery Data for DSDP Leg 35

Site	Latitude Longitude	Water Depth (m)	Penetration (m)	No. of Cores	Meters Cored	Meters Recovered	Oldest Sediments	Calcareous Microfossils Recovered (Core-Section)
322	60°01.45′S, 79°25.49′W	5026	544	14	125.5	34.2	Miocene	None
323	63°40.84′S, 97°59.69′W	4993	731	21	199.5	76.7	Upper Cretaceous	15-6, 15, CC, 16-1, 16-2, 16-4, 17, CC, 18-4
324	69°03.21′S 98°47.20′W	4449	218	10	95.0	48.1	Pliocene	None
325	65°02.79′S, 73°40.40′W	3745	718	10	95.0	34.4	Upper Oligocene/ Miocene	7-2, 7, CC, 8-2, 8, CC

Ericsonia subpertusa (C), *Markalius astroporus* (F), *Prinsius martinii* and *P.* aff. *martinii* (R), *Thoracosphaera* aff. *saxea* (R), *Zygodiscus sigmoides* (R).

Sample 15, CC: *Chiasmolithus danicus* (C), *Chiasmolithus* sp. (F), *Coccolithus cavus* (F), *Ericsonia subpertusa* (F), *Hornibrookina* aff. *teuriensis* (F), *Markalius astroporus* (F), *Prinsius martinii* and *P.* aff. *martinii* (C), *Thoracosphaera deflandrei* (F), *T. operculata* (R) and *Zygodiscus sigmoides* (R). A few reworked Maestrichtian species also observed.

Sample 15-6, 149-150 cm: Flora essentially same as Sample 15, CC with an additional species, *Thoracosphaera saxea,* present in low numbers.

Sample 15-6, 120-121 cm: *Chiasmolithus danicus* (C), *Chiasmolithus* sp. (F), *Coccolithus cavus* (F), *Cruciplacolithus tenuis* (R), *Ericsonia subpertusa* (R),

Hornibrookina aff. *teuriensis* (R), *Markalius astroporus* (F), *Prinsius martinii* and *P.* aff. *martinii* (F), *Thoracosphaera* spp. (R), *Zygodiscus sigmoides* (R).

Sample 15-6, 103-105 cm: Flora same as in Sample 15-6, 120-121 cm.

Sample 15-6, 90-91 cm: Flora same as in Sample 15-6, 120-121 cm except *Prinsius martinii* and *P.* aff. *martinii* more common.

Sample 15-6, 60-61 cm: *Chiasmolithus danicus* (C), *Chiasmolithus* sp. (F), *Coccolithus cavus* (F), *Ericsonia subpertusa* (C), *Hornibrookina* aff. *teuriensis* (R), *Markalius astroporus* (R), *Prinsius martinii* (F), *Thoracosphaera* sp. (R), *Zygodiscus sigmoides* (R).

Sample 15-6, 30-31 cm: Flora same as in Sample 15-6, 60-61 cm.

Sample 15-6, 16-18 cm: Coccoliths sparse. Only a few specimens of *Chiasmolithus danicus*, *Cruciplacolithus tenuis*, *Ericsonia subpertusa* and *Prinsius* aff. *martinii* observed.

Samples 15-5, 120-121, 90-91, 60-61 and 30-31 cm: All sections barren above Section 15-6.

Age of Coccoliths at Site 323

At the bottom of Core 18, Section 4 of Site 323, a few Maestrichtian species were encountered. After a long search only single specimens of *Zygodiscus sigmoides* and *Ericsonia subpertusa* were also seen. The extreme rarity of these Tertiary species and relatively more common occurrence of older forms points to possible contamination of Maestrichtian sediments by Paleocene species from overlying cores. In addition, Sample 17, CC yielded fragments of only late Maestrichtian species with the total exclusion of Tertiary forms. A late Maestrichtian age can thus be assigned to Section 18-4 through Sample 17, CC.

The lower parts of Core 16, Section 4 and Sample 16, CC are barren of coccoliths. However, at the 20-21 cm interval and near the top of Section 4 fragments of *Cruciplacolithus tenuis* are present. Section 3 of Core 16 is again devoid of coccoliths, but in Section 2, *C. tenuis* and additional early Danian species occur in larger numbers. *Chiasmolithus danicus* first appears at level 50-51 cm. Thus the interval from 16-4, 20-21 cm through 16-2, 83-85 cm is assigned to the *Cruciplacolithus tenuis* (NP2) Zone.

From Sample 16-2, 50-51 cm through 15-6, 16-18 cm a medium diversity nannoflora of *Chiasmolithus danicus* (NP3) Zone is encountered. The relatively common occurrence of *Coccolithus cavus* and *Ericsonia subpertusa*, both of which appear in such large numbers only in the uppermost part of NP2 or in the NP3 Zone elsewhere, also supports an assignment of late Danian age to this interval.

Site 325

Coccoliths were encountered only in thin layers of Core 8, Section 2, and Core 7, Section 2 and in Samples 8, CC and 7, CC. Their preservation is fair to poor. Most coccoliths show signs of calcite recrystallization, at times obscuring the diagnostic features of various species (see Plate 3). Species recorded in various samples are:

Sample 8, CC: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* n. sp. (abundant — making up to 90% of the total assemblage in some samples), ?*Helicopontosphaera* sp., *Pontosphaera* aff. *vadosa* (R), and *Thoracosphaera* sp. (R). The new species, *Dictyococcites antarcticus*, shows similarities to *D. scrippsae* and *Ericsonia hesslandii;* however, it is smaller in size (rarely over 7 μm in length) and shows a slightly different extinction pattern (see Taxonomic Notes).

Sample 8-3, 119-121 cm: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (A), and *Pontosphaera* aff. *vadosa* (R). Preservation: very poor.

Sample 8-3, 58-60 cm: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (A), *D.* aff. *scrippsae* (R), *Reticulofenestra* aff. *pseudoumbilica* (F). The last named species is similar to *R. pseudoumbilica* but has a smaller size range (6 to 8 μm in length).

Sample 8-2, 132-134 cm: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (C). Preservation: very poor.

Sample 8-2, 119-120 cm: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (A), *Thoracosphaera* sp. (R).

Sample 8-2, 33-35 cm: Barren.

Sample 8-1, 92-94 cm: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (A), *D.* aff. *scrippsae* (F), *Reticulofenestra* aff. *pseudoumbilica* (R).

Sample 8-1, 55-57 cm: Rare *Dictyococcites antarcticus.*

Samples 8, CC and 7, CC: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (A), *D.* aff. *scrippsae* (R), *Reticulofenestra* aff. *pseudoumbilica.*

Sample 7-2, 133-134 cm: Rare specimens of *Coccolithus pelagicus* and *Dictyococcites antarcticus.*

Sample 7-2, 108-110 cm: Same as Sample 7-2, 133-134 cm, but *D. antarcticus* is more common.

Sample 7-2, 54-56 cm: *Coccolithus pelagicus* (R), *Dictyococcites antarcticus* (C), *D.* aff. *scrippsae* (F), *Reticulofenestra* aff. *pseudoumbilica* (R).

Sample 7-2, 22-23 cm: Flora similar to Sample 7-2, 54-56 cm.

Sample 7-1, 105-106 cm and all other samples in this section are barren of coccoliths.

Age of Coccoliths at Site 325

The new species described here (*Dictyococcites antarcticus*) closely resembles the late Eocene-Oligocene species *D. hesslandii*. This species is common to abundant in the cooler higher latitude assemblages of Oligocene (Haq and Lohmann, in press). In addition to the abundant to common occurrence of *Dictyococcites antarcticus* in Site 325 sediments, another larger form showing close affinity to *D. scrippsae* was also found at some levels. On the basis of these species alone one is tempted to assign probable Oligocene age to these samples. However, due to the presence of the species with close affinity to *Reticulofenestra pseudoumbilica*, a form first appearing in middle Miocene, the narrowest age range we can assign the interval between 325-8, CC and 325-7-2 is late Oligocene to middle Miocene. A broader Oligocene-Miocene range would seem more appropriate.

BIOGEOGRAPHY AND PALEOCLIMATIC IMPLICATIONS

Site 323

The assemblages at Site 323 can be differentiated into two major types: (a) the *Cruciplacolithus tenuis*

dominated assemblage in the NP2 and lower part of the NP3 zones (16-4, 20-21 cm to 16-1, 140-141 cm), (b) An *Ericsonia subpertusa-Coccolithus cavus* assemblage (dominated by the first species with rare to common occurrences of the second species) with prominence of *Chiasmolithus danicus* at some levels in the upper part of the NP3 Zone.

The *Cruciplacolithus tenuis* assemblage is a relatively low diversity assemblage and is peculiar with respect to its dominance by a single species, i.e., *C. tenuis*. Elsewhere (e.g., northern Indian Ocean and mid-latitude Atlantic Ocean) the component species of the assemblages of equivalent age are essentially the same, but *C. tenuis* occurs only sparsely, the flora being dominated by *Ericsonia subpertusa* and *Coccolithus cavus* (Haq, unpublished data). The assemblages of this age (NP2 Zone) have not as yet been carefully studied from the northern higher latitudes and thus no valid biogeographic comparison can be made. In the southern high latitudes Edwards (1973) reports a similar assemblage from the Tasman Sea area (DSDP Site 208) but all species occur in very small numbers. It would seem that the dominance by *Cruciplacolithus tenuis*, of an otherwise relatively cosmopolitan assemblage, may be a local phenomenon peculiar to the Bellingshausen area.

The second *Ericsonia subpertusa* and *Coccolithus cavus* assemblage has elsewhere been observed to dominate the mid and low latitudes of the northern Indian Ocean and Tethyan region in NP3 Zone (Haq, unpublished data). In the Atlantic Basin, Haq and Lohmann (1976) report that this is the dominant middle Paleocene assemblage occurring between 30°N-30°S, recording it from Caribbean and Gulf of Mexico sites as well as the central South Atlantic (Figure 2). Very similar assemblages have been described from western Greenland (Perch-Nielsen, 1973) and the Tasman Sea (Edwards, 1973). The presence of *Hornibrookina* aff. *teuriensis* in the present material points to a close affinity between this assemblage and those from the Tasman Sea and New Zealand.

According to Haq et al. (1974) and Haq and Lohmann (1976), during the time represented by the NP3 Zone a boreal assemblage dominated by *Prinsius martinii* developed in the North Sea and Denmark (Figure 2), the mid and low latitudes being occupied by the *Ericsonia subpertusa* and *Coccolithus cavus* assemblage. The authors observed a latitudinal shift of *Prinsius martinii* towards mid latitudes during NP3-NP9 time and a return to higher latitudes and disappearance in the early Eocene (NP10 Zone). From this shift of the boreal *Prinsius martinii* assemblage they concluded that climatic conditions changed from relatively warm during NP2 time to cooler climates in the NP3-NP9 intervals and that a marked warming occurred during the period represented by the NP10 Zone. *Ericsonia subpertusa-Coccolithus cavus* assemblage is replaced in mid and low latitudes by a *Toweius craticulus-Coccolithus cavus* assemblage in the NP9 Zone. This assemblage migrates into higher latitudes during NP12 time, replacing *Prinsius martinii*.

The more common occurrence of *Chiasmolithus danicus* in some levels of Core 16, Section 1, and Core 15, Section 1 at Site 323 suggests even cooler temperatures during deposition of the upper part of the NP3 Zone relative to the NP2 Zone.

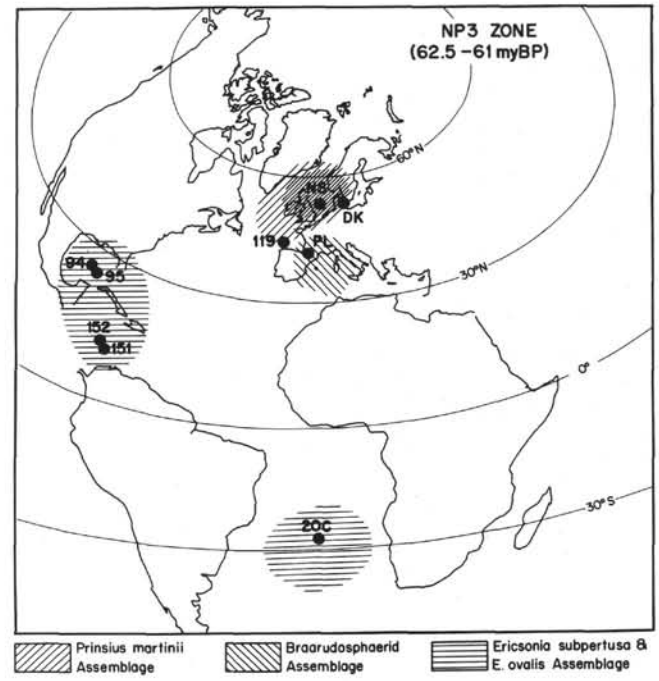

Figure 2. *Calcareous nannoplankton biogeography during* Chiasmolithus danicus *(NP3) Zone. Low and mid latitudes occupied by* Ericsonia subpertusa-Coccolithus cavus (=E. ovalis) *assemblage. Boreal assemblage developed in North Sea* (Prinsius martinii *assemblage*). *Epi-continental site PL (Pont Labau, France) dominated by hemipelagic Braarudosphaerids. (After Haq and Lohmann, 1976.)*

The present data support the earlier conclusion of Haq et al. (1974) that Danian assemblages were essentially cosmopolitan in the species composition. The differences were local and mainly in the relative dominance of component taxa. However, from the present data it would seem that the boreal *Prinsius martinii* assemblage that developed during NP3 time was confined to the northern high latitudes, since this taxon occurs in rare numbers in the material from Site 323. If the relative latitudinal position of various assemblages can be taken as the indication of their temperature preference, it is tempting to conclude that during the Danian the northern high latitudes were cooler than the southern high latitudes.

Site 325

At Site 325 the possible Oligocene-Miocene assemblage is dominated throughout by a single taxon, *Dictyococcites antarcticus* n. sp., which occurs in abundances of up to 90% of the total flora. This species shows similarities to *Dictyococcites scrippsae* and *D. hesslandii* (see Taxonomic Notes). *D. hesslandii* is a dominant form in all latitudes of the Oligocene (Haq and Lohmann, 1976) and its migrations through mid and low latitudes indicate at least two major and two minor periods of marked cooling in the Oligocene.

If morphological affinity is indicative of synthermy, it would seem that *Dictyococcites antarcticus* is a cooler water, high latitude form and that its dominance in all samples of Cores 7 and 8 at Site 325 indicates relatively low temperatures for the period during which these sediments were deposited.

TAXONOMIC NOTES

A single new coccolith taxon is described from the Oligocene-Miocene of Site 325 on the Antarctic Continental Rise.

Genus DICTYOCOCCITES Black, 1967

Dictyococcites antarcticus Haq, n. sp.

Description: Small elliptical to subcircular placoliths from 4 to 7 μm in length (rarely up to 8 μm), with a solid central area showing a long central furrow on both proximal and distal sides. Shields composed of about 60 to 80 thin rays. Under cross-polarized light the extinction lines radiate out from the tips of the central furrow and thicken and bend slightly near the periphery of the distal shield.

Remarks: This species is distinguished from *Dictyococcites scrippsae* Bukry and Percival, 1971, by its smaller size range (5 to 7 μm and rarely up to 8 μm as compared to 6 to 12 μm) its longer central furrow and slightly different extinction pattern. *D. hesslandii* Haq, 1966, also a similar species, has a subcircular central hole instead of a long furrow and only 30 to 60 rays in the distal shield.

Holotype: Plate 3, Figure 3; Paratype: Plate 3, Figure 8.

Type locality: DSDP Site 325, Core 8, Section 2, Interval 132-134 cm.

Occurrence: Occurs throughout Core 8, Section 2, 7, CC and Core 7, Section 2, mostly in abundant numbers (up to 90% of the total flora).

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PLATE 1

Bar scale on each figure represents 1 μm.
All figures are scanning electron micrographs.

Figures 1, 2 — *Markalius astroporus* (Stradner) Mohler and Hay. Specimens partly corroded. Sample 323-16-2, 137-139 cm.
1. Distal view.
2. Proximal view.

Figures 3, 4 — *Zygodiscus sigmoides* Bramlette and Sullivan. Distal views. Sample 323-16-2, 137-139 cm.

Figure 5 — *Coccolithus cavus* Hay and Mohler. Distal view with recrystallized central area. Sample 323-16-1, 39-40 cm.

Figure 6 — *Ericsonia subpertusa* Hay and Mohler. Distal view. Specimen partly dissolved. Sample 323-16-2, 137-139 cm.

PLATE 1

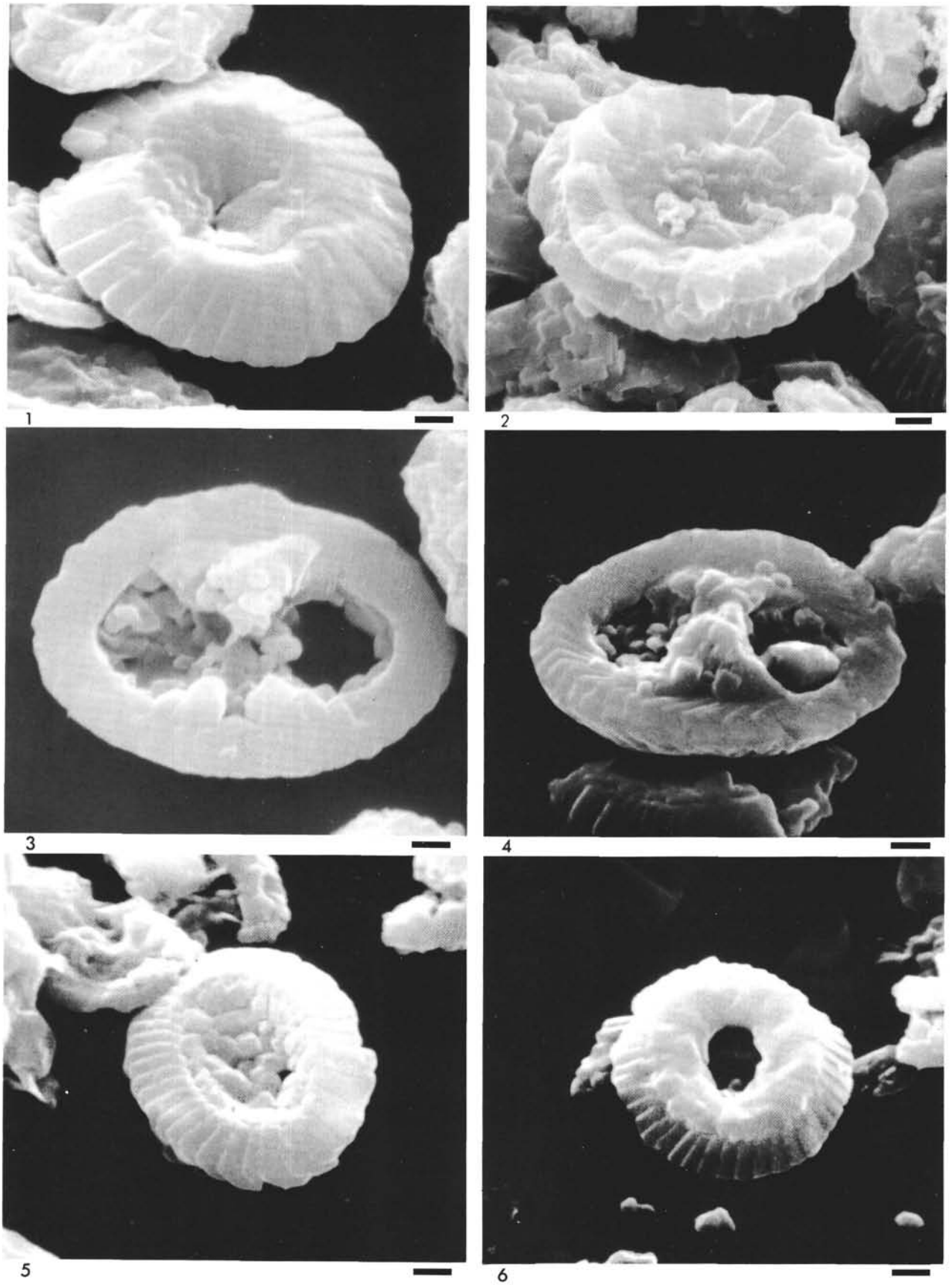

PLATE 2

Bar scale on each figure represents 1 μm.
All figures are scanning electron micrographs.

Figures 1-3 — *Cruciplacolithus tenuis* (Stradner) Hay and Mohler. Distal views of partly corroded specimens. Sample 323-16-2, 137-139 cm.

Figure 4 — Partly dissolved specimen of a large placolith. Proximal view. Sample 323-16-2, 137-139 cm.

Figure 5 — *Hornibrookina* aff. *teuriensis* Edwards. Distal view. Sample 323-16-2, 137-139 cm.

Figure 6 — *Ericsonia subpertusa* Hay and Mohler. Distal view of a corroded specimen. Sample 323-16-1, 39-40 cm.

PLATE 2

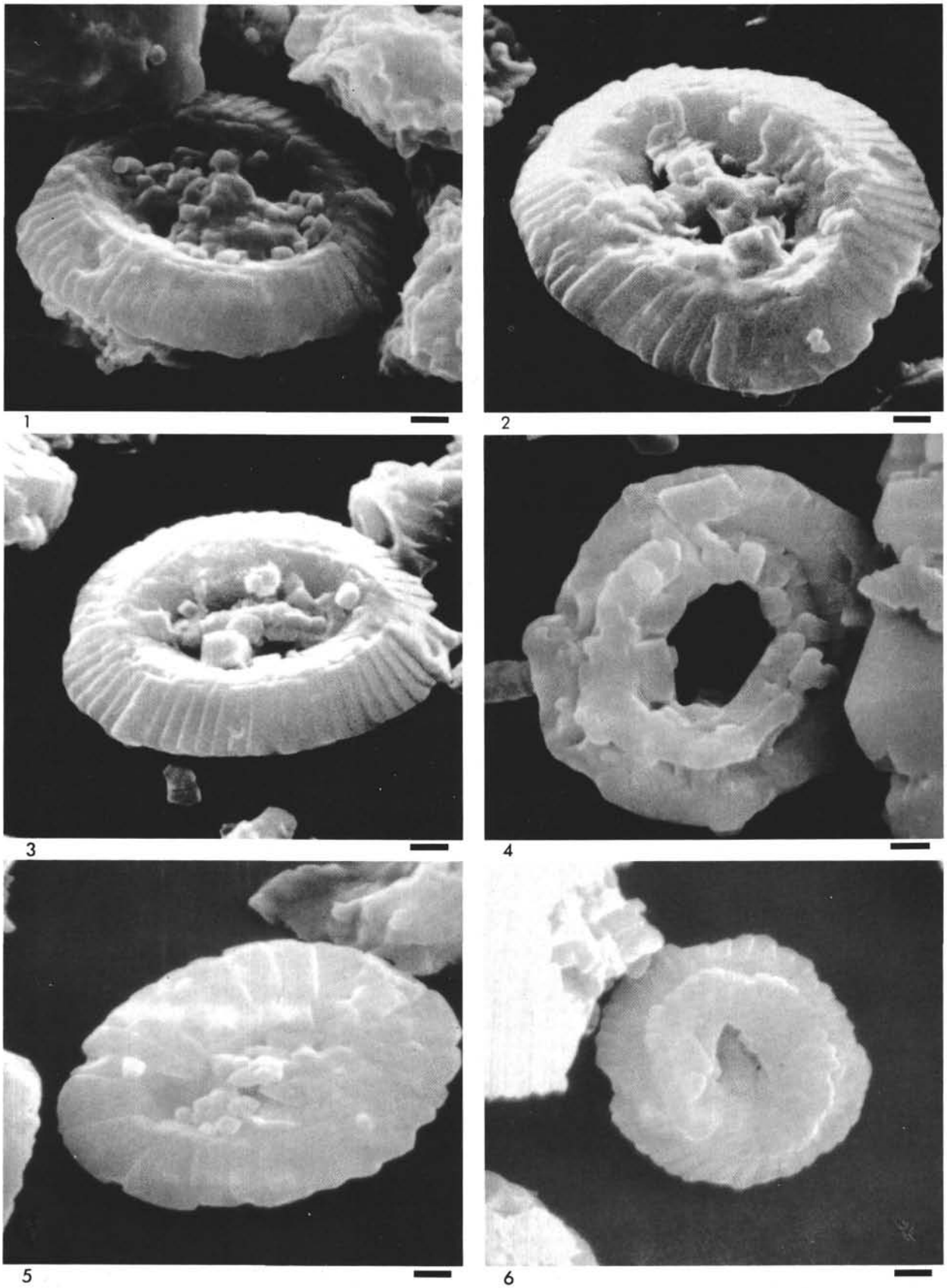

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PLATE 3

Bar scale on each figure represents 1 μm. Figures 4 and 5 are light micrographs, all others are scanning electron micrographs.

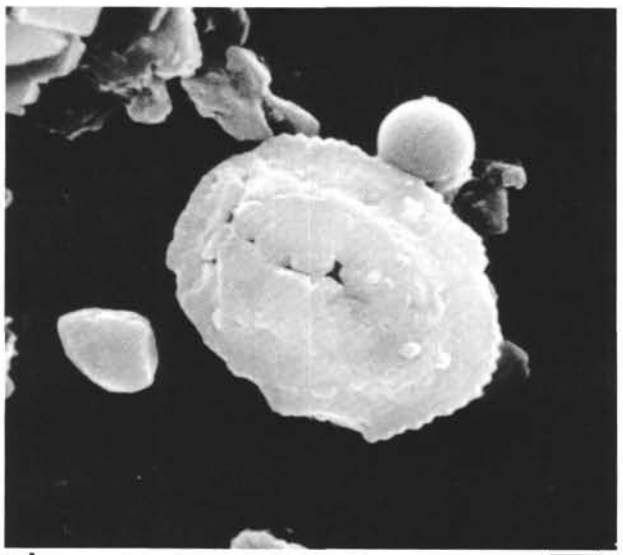
Figures 1, 2, 3 — *Dictyococcites antarcticus* Haq, n. sp. Distal views. Sample 325-8-2, 132-134 cm.
3. Holotype.

Figures 4, 5 — *Dictyococcites antarcticus* Haq, n. sp. Sample 325-7-2, 54-56 cm.
4. Phase-contrast light micrograph of a distal view of relatively well preserved specimen.
5. Under cross-polarized light.

Figure 6 — *Dictyococcites* aff. *scrippsae* Bukry and Percival. Proximal view. Sample 325-8-2, 132-134 cm.

Figures 7, 8 — *Dictyococcites antarcticus* Haq, n. sp. Sample 325-8-2, 132-134 cm.
7. Distal view of a partly dissolved specimen.
8. Proximal view of paratype, a partly corroded specimen.

PLATE 3



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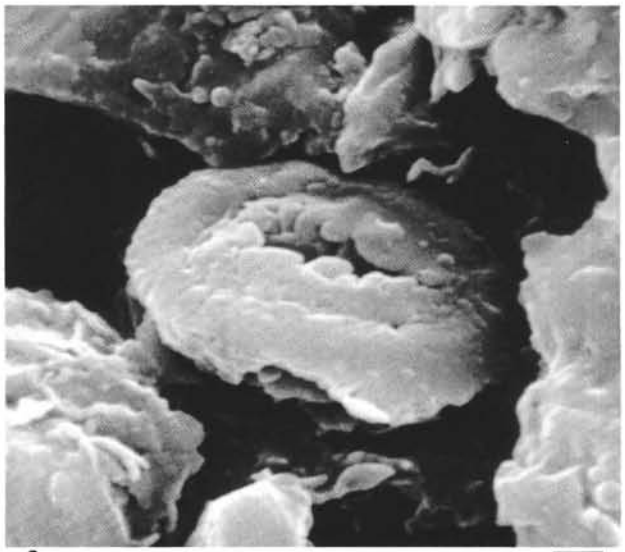

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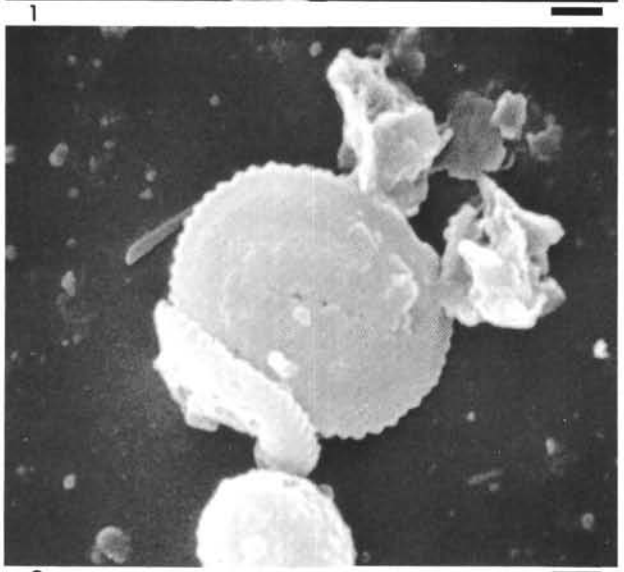

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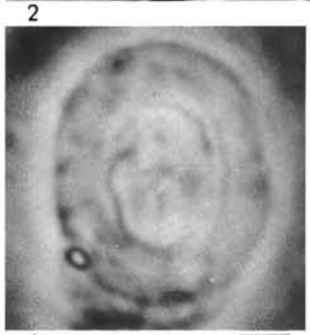

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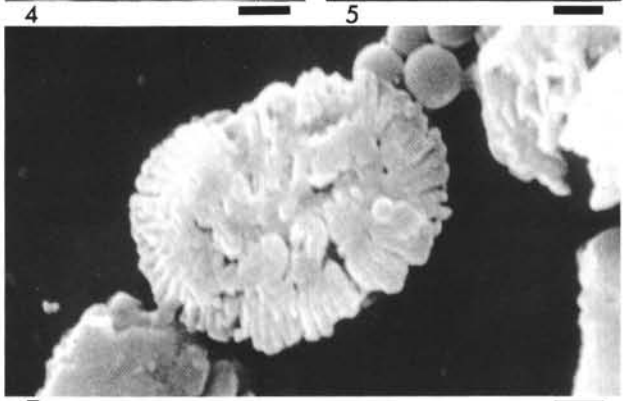

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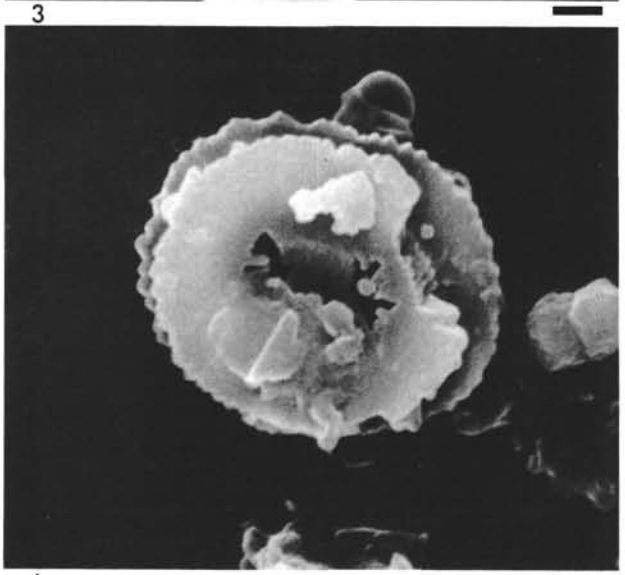

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