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25. CALCAREOUS NANNOPLANKTON CHANGES ACROSS THE CRETACEOUS/PALEOCENE BOUNDARY IN THE SOUTHERN INDIAN OCEAN (SITE 750)[1]

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ABSTRACT

Changes in the composition of calcareous nannoplankton across the Cretaceous/Paleocene boundary at southern high-latitude Ocean Drilling Program Hole 750A are documented in this semiquantitative study. These changes are compared with changes described from other localities at high- and low-latitudes. This study provides additional data toward a detailed documentation of the paleontologic changes that occurred in the late Maestrichtian and the early Paleocene, despite limitations to the interpretation caused by coring gaps, drilling disturbance, and the presence of an unconformity at the boundary at this site.

INTRODUCTION

An almost complete section across the Cretaceous/Paleocene boundary was recovered from Ocean Drilling Program (ODP) Hole 750A located on the Southern Kerguelen Plateau, in the eastern part of the Raggatt Basin west of the deep Labuan Basin (57°35.54′S, 81°14.42′E; Fig. 1). Despite an unconformity at the boundary with a hiatus of about 0.3 m.y. (see also Zachos et al., this volume), a detailed study of the change in the calcareous nannoplankton across the boundary was undertaken because this is one of the first sites at southern high-latitudes in which the boundary was recovered. In this paper we document the changes in composition that the calcareous nannoplankton underwent and compare them with changes described from sections elsewhere, in particular from Hole 690C, Maud Rise, Weddell Sea (65°9.621′S, 1°12.285′E).

THE BOUNDARY AT HOLE 750A

The Cretaceous/Paleocene contact is well marked at Hole 750A (Fig. 2). A Maestrichtian white nannofossil chalk (Subunit IIIA) is overlain by a lower Paleocene, intensively bioturbated, grayish chalk that grades upward into a white chalk (Unit II) (Shipboard Scientific Party, 1989). The contact itself was strongly disturbed by drilling so that its exact nature is not known. The Maestrichtian chalk just below the contact is not homogeneously white but includes greenish gray zones with solution seams. The lower Paleocene clayey chalk just above the contact is also heterogeneous, with interfingering darker and lighter green layers. In addition, it includes clasts of Maestrichtian chalk that resulted from resedimentation rather than from bioturbation (see Fig. 2).

TECHNIQUES AND METHODS

Detailed sampling was performed on board ship using toothpicks. To identify potentially biased data resulting from drilling disturbance, strong bioturbation, resedimentation, and differential dissolution, samples were taken at close intervals on both sides of the boundary. In addition, several samples were taken from levels in which various sediment types are juxtaposed (Fig. 3). Smear slides were prepared from all samples and studied with a photomicroscope. Additional material was collected from selected levels for joint light and scanning microscope studies. The procedures described by Moshkovitz (1974) for examining the same specimen with both light microscope and scanning electron microscope were followed to establish the taxonomic framework used in this study and discussed in Aubry and Ehrendorfer (in press).

Only smear slides were used for semiquantitative analysis. For most samples over 300 specimens were counted per slide. Maestrichtian assemblages were analyzed once, but Paleocene assemblages were counted in two steps. During the first count, all nannofossils except placoliths of *Prinsius* spp. and fragments of thoracospheres were counted. The purpose of the second count was to determine roughly the proportions between all species recorded during the first count on the one hand and the placoliths (and coccospheres) of *Prinsius* spp. and fragments (and opercula) of thoracospheres on the other hand. Occasional coccospheres of *Prinsius* spp. were recorded as single placoliths, and rare opercula of thoracospheres were counted as fragments. All fragments that could be confidently assigned to *Thoracosphaera* spp. were counted. We followed this procedure because of the overwhelming dominance of *Prinsius* spp. and of fragments of thoracospheres in the Paleocene assemblages. While counting, all specimens within a view field were recorded.

Several rows were scanned so that areas with different concentrations of nannofossils were encountered, and biased results caused by differences in concentration were avoided (or minimized). The concentration of nannofossils in a preparation influences greatly the distribution of the calcareous nannofossils (Tables 1 and 2), with the less concentrated areas enriched in small forms. Biased counts resulting from lithologic differences were avoided by checking the extent to which the composition of the assemblages varied with lithology. Counts were made for samples taken at the same level, but from slightly different lithologies, in particular, colored differently.

As can be seen from Table 3, there is variability in the composition of Paleocene assemblages at selected levels. This variability is not necessarily a reflection of vertical bioturbation, as indicated by the absence of *Cruciplacolithus primus* in all samples taken at 91.5 cm in Section 120-750A-15R-3. When multiple counts were made on one slide, or on several slides prepared from different samples taken at the same stratigraphic level, the percentages of the calcareous nannofossils

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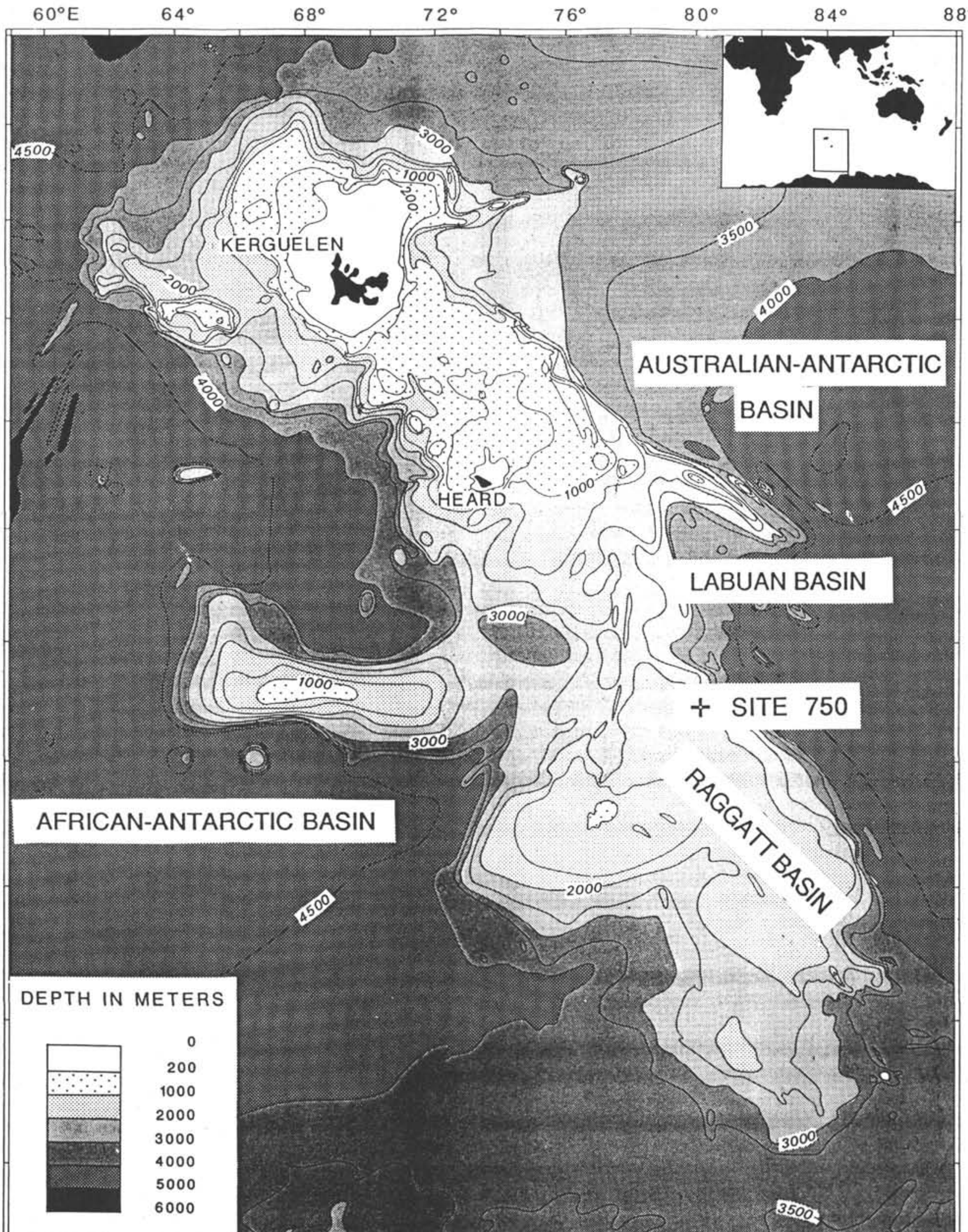

Figure 1. Location of Hole 750A in the southern Indian Ocean.

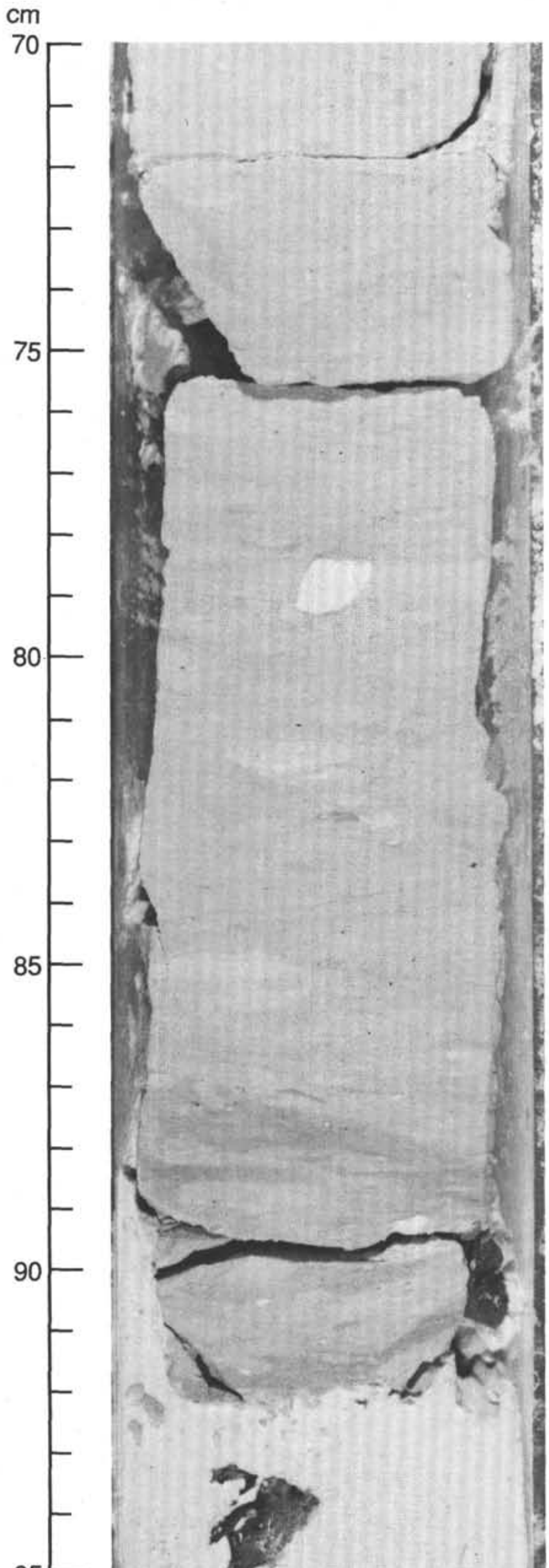

Figure 2. The lithologic contact at the Cretaceous/Paleocene boundary, Hole 750A (Section 120-750A-15R-3, 70–95 cm).

at this level were averaged between samples. Significant differences were observed between assemblages from the white and the gray Maestrichtian chalk (Tables 4 and 5). It should be emphasized that the method of sample preparation and the counting techniques used can only serve to delineate major trends.

STRATIGRAPHY

The Cretaceous/Paleocene contact was not only strongly disturbed by drilling; the sequence is also incomplete. Calcareous nannofossil Zone NP1 (Martini, 1971) is thin (see below), and planktonic foraminiferal Zone Pα (Blow, 1979) could not be confidently recognized, whereas Subzone P1a (Berggren and Miller, 1988) is well characterized (Zachos et al., this volume).

Magnetostratigraphy has yielded poor results in the upper Cretaceous-Paleocene section recovered from Site 750. Two normal polarity magnetozones, however, were identified in the lower Paleocene and tentatively assigned to Chrons C28N and C27N (Shipboard Scientific Party, 1989). The upper extent of these two magnetozones is not known because of poor recovery in Cores 120-750A-12R to -14R. Their lower boundary is well-delineated so that the levels at which the presumed C27R/C27N and C28R/C28N boundaries occur are known. Using the ages estimated by Berggren et al. (1985) for these reversal boundaries, a sedimentation rate curve can be drawn tentatively (Fig. 4 and Table 6). It suggests that, had the section been continuous, the Cretaceous/Paleocene boundary would have occurred at about 356 mbsf, and that the Paleocene section missing at this site corresponds to a hiatus of about 0.3 m.y. The curve is constrained by two points only; thus, our estimate for the duration of the lower Paleocene hiatus at this site is precarious. The lower part of Zone NP1 (i.e., below the first occurrence of *Cruciplacolithus primus*), however, has been identified, so that the hiatus is probably not longer than 0.3 m.y.

Calcareous nannofossil stratigraphy of the lower Paleocene section recovered from Site 750 does not help in evaluating the identification of Chrons C27N and C28N. Chron C27N is associated with the lower part of Zone NP4 (Berggren et al., 1985), but *Ellipsolithus macellus* does not occur at this site. The base of Chron C28N is associated with the NP2/NP3 zonal boundary (Berggren et al., 1985). The extremely rare occurrence of *Chiasmolithus danicus* in the upper 100 cm of Section 120-750A-15R-1 is possibly a result of bioturbation, and the NP2/NP3 zonal boundary cannot be drawn confidently.

Although the white Maestrichtian chalk belongs to the uppermost Cretaceous calcareous nannofossil Zone (the *Nephrolithus frequens* Zone; Čepek and Hay, 1969), it is possible that the unconformity lies in the upper part of this zone. Because of poor magnetostratigraphy and poor recovery in Cores 120-750A-15R and -16R (there is a 5.45-m coring gap between the 35 cm of Maestrichtian chalk underlying the boundary in Core 120-750A-15R and the chalk recovered in Section 120-750A-16R-1), it is not possible to determine the duration of the Cretaceous hiatus (if any) at this site.

Several toothpick samples were taken from Sample 120-750A-15R-3, 91.5 cm. Despite long search, no specimens of *Cruciplacolithus primus* were found. We believe that this level represents the lower part of Zone NP1. Counts were made on four slides (Table 7) and the percentages were averaged.

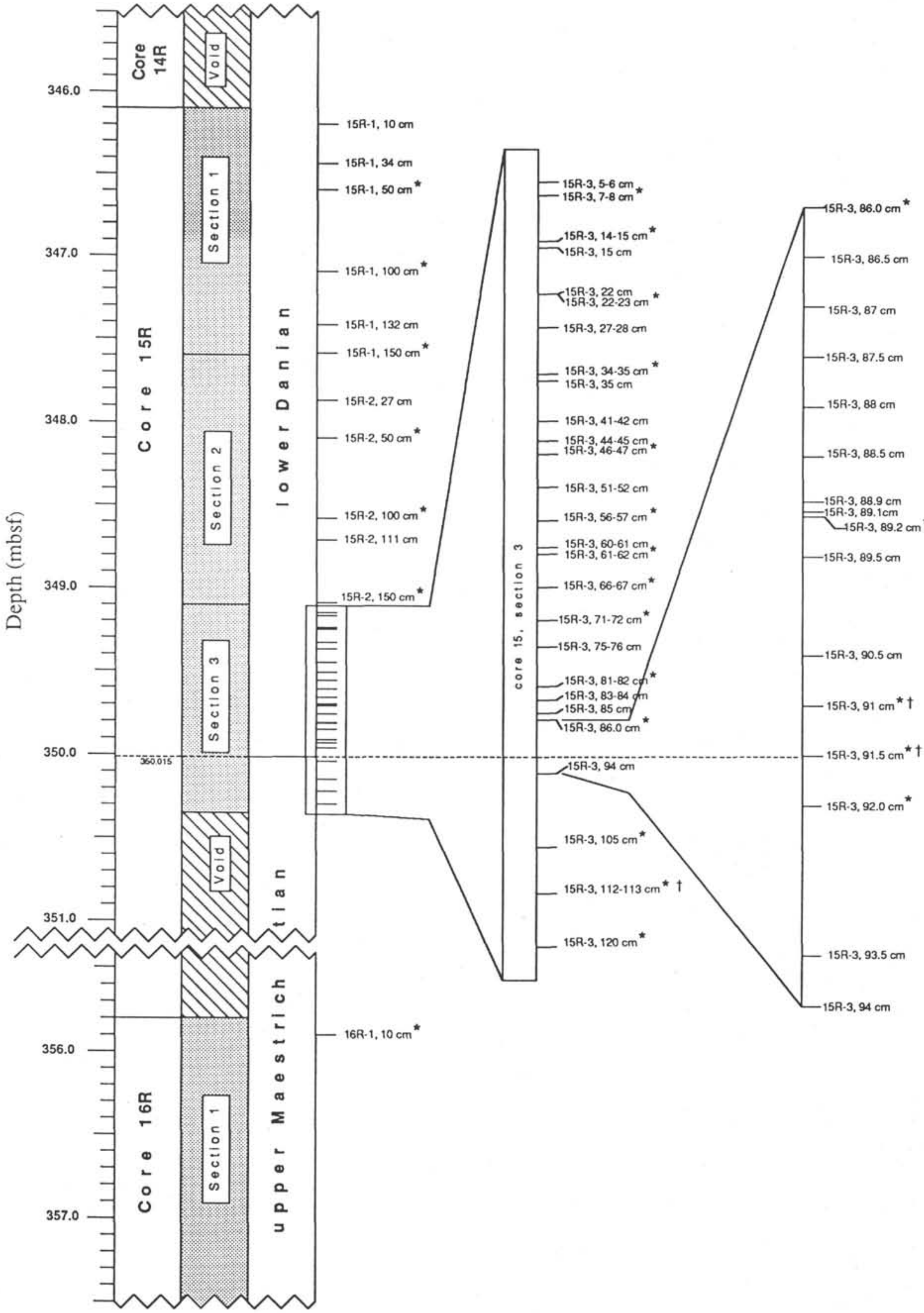

Figure 3. Stratigraphic levels sampled for this study. Dagger (†) = levels at which several samples were taken, and asterisk (*) = levels sampled for semiquantitative analysis.

Table 1. Influence of the density of a preparation (Sample 120-750A-15R-3, 66-67 cm) on species frequency.

Species	Count 1 (%)	Count 2 (%)	Count 3 (%)
Biscutum castrorum	11.3	7.5	16.9
Cruciplacolithus spp.	3.0	9.0	4.4
Hornibrookina sp. cf. *H. teuriensis*	25.6	15.8	12.5
Markalius inversus	3.0	1.5	0.7
Neocrepidolithus cohenii	1.5	0.8	2.9
Placozygus sigmoides	46.6	49.6	50.0
Cretaceous species	6.0	9.0	8.1
Undetermined	3.0	6.8	4.4

Note: Count 1 performed on areas of low density, Count 2 performed on areas of high density, and Count 3 performed on areas of average density.

Table 2. Influence of the density of a preparation (Sample 120-750A-15R-3, 56–57 cm) on species frequency.

Species	Count 1 (%)	Count 2 (%)
Biscutum castrorum	11.2	10.5
Cruciplacolithus spp.	20.7	21.7
Hornibrookina sp. cf. *H. teuriensis*	8.8	11.7
Markalius inversus	3.6	2.8
Neocrepidolithus cohenii	6.0	3.5
Placozygus sigmoides	34.5	35.7
Cretaceous species	5.7	3.3
Undetermined	9.5	10.7

Note: Consistent results are obtained when areas of different densities are included in each count.

CALCAREOUS NANNOFOSSIL ASSEMBLAGES AROUND THE CRETACEOUS/PALEOCENE BOUNDARY

Figures 5–8 show the profound changes that calcareous nannofossil assemblages underwent across the boundary. The plot (Fig. 5) of the distribution of the calcareous nannofossil species in the samples studied is intended to provide the detailed stratigraphic ranges of taxa throughout Core 120-750A-15R, and, combined with Figures 6–8, to illustrate the frequency of these taxa. Percival and Fischer (1977) and Perch-Nielsen et al. (1982) recognized that three groups of species can be distinguished in early Paleocene calcareous nannofossil assemblages.

Percival and Fischer (1977) referred to them as "vanishing species," "persistent species," and "incoming species"; Perch-Nielsen et al. (1982) referred to them as "Cretaceous species," "survivors," and "Tertiary species." We have chosen to follow the terminology proposed by Percival and Fischer but at the genus level rather than at the species level for reasons given in Aubry (1989, 1990, and unpubl. data). She showed that, for calcareous nannofossils, the genus is a less "superficial" taxon (i.e., having a phylogenetic meaning) than the species itself (i.e., mostly restricted to a morphotype). The groups "vanishing" and "Cretaceous" species are clearly synonymous, but the groups "incoming" and "Tertiary" species, on the one hand, and "survivors" and "persistent" species, on the other, may differ slightly. Perch-Nielsen et al. (1982) regard as incoming species all forms that evolved shortly after the boundary, even those that share the same structure with the survivors (and thus represent the same genera as these latter). We do not know if Percival and Fischer (1977) would have included such taxa among the incoming species or among the persistent species because the taxonomic scheme available at the time of their study was limited. Their inclusion of *Braarudosphaera discula* among the incoming species suggests, however, that they would have made the same choice as Perch-Nielsen et al. (1982).

In the vanishing genera are included the vanishing species *sensu* Percival and Fischer (1977) and the Cretaceous species *sensu* Perch-Nielsen et al. (1982). The species assigned to genera that are represented in both the Cretaceous and the Paleocene are included among the persistent genera. This concept differs noticeably from that of survivors *sensu* Perch-Nielsen et al. (1982). The species *Biscutum castrorum,* which occurs in the Cretaceous, and the early Paleocene form *Biscutum kerguelensis,* are both assigned to the persistent genera, whereas the former would belong to the survivors, the latter to the incoming species following Perch-Nielsen et al. (1982). Likewise, the concept of incoming genera differs from that of Tertiary species. The Appendix indicates to what group the species encountered during this study are assigned. Discussions on the taxonomy and illustrations of these forms are given in Aubry and Ehrendorfer (in press).

An abrupt change in the composition of the calcareous nannoflora is seen across the Cretaceous/Paleocene boundary at Hole 750A, as a result of a dramatic decrease in the abundance of the vanishing genera and the resulting dominance of the persistent genera (Fig. 6). A second abrupt change occurs 70 cm above the boundary (between Samples 120-750A-15R-3, 34–35 and 22–23 cm). From this level upward the incoming genera become predominant, the persistent genera constitute a small fraction of the assemblages, and the frequency of the vanishing genera is extremely reduced. In the interval between these changes (between 350.0 and 349.3 mbsf), the incoming and persistent genera are about equally represented but the vanishing genera decrease rapidly in abundance.

There is no doubt that the abruptness of the change at 350.0 mbsf across the Cretaceous/Paleocene boundary is artificially enhanced because of the unconformable contact. There is no reason, however, to question the reality of the second sharp change in composition that occurs at about 349.30 mbsf. Using the tentative sedimentation rate curve (Fig. 4), this latter change occurred at about 65.9 Ma (i.e., this change is 0.5 m.y. younger than the boundary). The level at which the frequency of the incoming genera begins to increase is essentially correlative with the lowest occurrence of *Cruciplacolithus primus* (about 0.3 m.y. after the boundary).

The Vanishing Genera

The vanishing genera are represented by the same species below and above the boundary. They are extremely rare above 349.10 mbsf, except at 347.60 mbsf where *Lucianorhabdus cayeuxii* is common (Fig. 7).

The Persistent Genera

Of the persistent genera only the genus *Placozygus* is represented in the Upper Cretaceous. *Placozygus fibuliformis* constitutes up to 5% of the Late Cretaceous assemblages (Fig. 7). *Placozygus sigmoides* does not occur in the Upper Cretaceous chalk, but it is extremely common in the lower Paleocene and reaches percentages higher than 50% (Fig. 7; Tables 8–10). The frequency of *Biscutum castrorum,* which reaches almost 20% in Sample 120-750A-15R-3, 89.2 cm,

Table 3. Influence of lithology on species frequency in the Paleocene clayey chalk.

Sample 120-750A-15R-3, 91 cm	Darker green		Lighter green		Indifferent	
	Number of specimens	%	Number of specimens	%	Number of specimens	%
Incoming taxa:						
Cruciplacolithus spp.	1	0.3	8	1.9	16	5.1
Hornibrookina sp. cf. H. teuriensis	26	8.2	31	7.3	31	9.9
Persistent taxa:						
Biscutum castrorum	61	19.3	39	9.1	39	12.4
Markalius inversus	13	4.1	9	2.1	10	3.2
Neocrepidolithus cohenii	8	2.5	4	0.9	4	1.3
Placozygus fibuliformis	2	0.6				
Placozygus sigmoides	85	26.9	107	25.1	106	33.8
Vanishing taxa:						
Ahmuellerella octoradiata	2	0.6	7	1.6	1	0.3
Arkhangelskiella cymbiformis	3	0.9	9	2.1	4	1.3
Cretarhabdus spp.	1	0.3	1	0.2	3	1.0
Cribrosphaerella ehrenbergii	2	0.6	3	0.7	1	0.3
Eiffellithus turriseiffeli	1	0.3	2	0.5		
Glaukolithus fessus	1	0.3	7	1.6	3	1.0
Kamptnerius magnificus	8	2.5	19	4.4	5	1.6
Lucianorhabdus cayeuxii	15	4.7	37	8.7	15	4.8
Microrhabdulus decoratus			4	0.9		
Micula staurophora	1	0.3	1	0.2	1	0.3
Nephrolithus frequens	20	6.3	26	6.1	16	5.1
Prediscosphaera cretacea	4	1.3	15	3.5	4	1.3
Prediscosphaera spinosa			2	0.5	2	0.6
Prediscosphaera stoveri	53	16.8	86	20.1	41	13.1
Undetermined	9	2.8	10	2.3	12	3.8
Sum	316	100.0	427	100.0	314	100.0

Note: Counts were performed on preparations made from three samples taken at 91 cm in Section 120-750A-15R-3 in sediments of darker green, lighter green, and intermediate colors.

decreases progressively upward through Core 120-750A-15R. *Markalius inversus* and *Neocrepiodolithus cohenii* represent minor components of the early Paleocene assemblages (Fig. 7). Fragments of *Thoracosphaera* spp. constitute the bulk (as much as 80%) of the assemblages in the lower part of the Paleocene section.

The Incoming Genera

Hornibrookina sp. cf. *H. teuriensis* forms a high percentage (over 15%) of the calcareous nannofossil assemblages in the lowermost Paleocene (upper part of Zone NP1) recovered from Hole 750A (Fig. 7; Tables 8–10). Jiang and Gartner (1986) and Pospichal and Wise (1990) reported on the occurrence of *H. teuriensis* from the Brazos River section (Texas) and of *H. edwardsii* from Site 690 (Maud Rise, Weddell Sea), respectively, in the lowermost Paleocene. These reports and ours indicate that the frequency of *H. teuriensis* in earliest Paleocene assemblages varies with latitude, from scarce at low latitudes to abundant at high latitudes.

The increase in abundance of *Cruciplacolithus* spp. occurs in a sawtooth fashion. Because of poor preservation (obscured central area), it was not possible to distinguish consistently between different species.

At 349.35 mbsf, assemblages are flooded with the tiny placoliths and coccospheres of *Prinsius tenuiculum* and possibly *P. dimorphosus* (Fig. 8). In the counts these two forms were not distinguished. The abundance of *P. tenuiculum* is generally high above this level, but it is not clear whether abrupt, strong fluctuations are related to changes in preservation, or whether they can be regarded as a primary indicator of unstable paleoceanographic conditions. Other incoming taxa such as *Biantholithus sparsus, Coccolithus pelagicus,* and *Ericsonia subpertusa* remain scarce.

DISCUSSION

In recent years, semiquantitative studies documenting the changes that the calcareous nannoplankton underwent across the Cretaceous/Paleocene boundary have become available (Percival and Fischer, 1977; Romein, 1977; Monechi, 1979; Perch-Nielsen, 1979a, 1979b; Herm et al., 1981; Romein and Smit, 1981; Thierstein, 1981; Jiang and Gartner, 1986; Pospichal and Wise, 1990). Most of them, however, concern sections geo-

Table 4. Influence of lithology on species frequency in the Maestrichtian chalk.

Sample 120-750A-15R-3, 112-113 cm	White chalk		Grey chalk	
	Number of specimens	%	Number of specimens	%
Persistent taxa:				
Neocrepidolithus cohenii	7	2.0	3	0.9
Vanishing taxa:				
Ahmuellerella octoradiata	6	1.7	2	0.6
Arkhangelskiella cymbiformis	37	10.6	31	9.6
Cretarhabdus spp.	5	1.4	2	0.6
Cribrosphaerella ehrenbergii	1	0.3	1	0.3
Eiffellithus turriseiffeli	1	0.3		
Glaukolithus fessus	17	4.9	2	0.6
Kamptnerius magnificus	21	6.0	28	8.7
Lucianorhabdus cayeuxii	53	15.2	61	18.9
Microrhabdulus decoratus	2	0.6		
Micula staurophora	10	2.9	26	8.1
Nephrolithus frequens	43	12.3	35	10.9
Prediscosphaera cretacea	23	6.6	18	5.6
Prediscosphaera spinosa	1	0.3	4	1.2
Prediscosphaera stoveri	105	30.1	91	28.3
Watznaueria barnesae			3	0.9
Undetermined	17	4.9	15	4.7
Sum	349	100.0	322	100.0
Fields examined	48		102	

Notes: Counts were performed on two samples taken at 112–113 cm in Section 120-750A-15R-3: one in the white chalk, one in the greenish chalk. In this experiment, only unbroken nannofossils were counted. Species frequencies are comparable except for a decrease in "*G. fessus*" and an enrichment (slight) in *L. cayeuxii* and (strong) in *M. staurophora* in the gray chalk. However, twice as many fields were counted in the gray chalk to obtain a comparable number of unbroken coccoliths from both samples.

graphically distant but all from low latitudes. There are only a few reports dealing with high-latitude sections (Perch-Nielsen, 1979b; Perch-Nielsen et al., 1982) and only one study of a southern high-latitude site (Pospichal and Wise, 1990).

Perch-Nielsen et al. (1982) pointed out some of the differences observed in the calcareous nannofossil assemblages between low and high latitudes. As at other high-latitude localities (e.g., Stevens Klint section, Denmark: Perch-Nielsen, 1979b; DSDP Site 524: Perch-Nielsen et al., 1982; ODP Sites 690 and 752: Pospichal, 1989) and in contrast with low-latitude sections, no *Thoracosphaera* occurs in the Maestrichtian assemblages from Hole 750A. As in other high-latitude sites (e.g., Denmark: Perch-Nielsen, 1979b; ODP Site 690: Pospichal and Wise, 1990), *Placozygus sigmoides* is common above the boundary. This species is rare in early Paleocene assemblages from low-latitude regions (e.g., Biarritz: Perch-Nielsen, 1979c; Gubbio: Monechi, 1979; Zumaya: Percival and Fischer, 1977). *Braarudosphaera bigelowii* is absent at Hole 750A, although it is particularly abundant in the lower Paleocene of the Brazos River section (Texas: Jiang and Gartner, 1986), the Braggs section (Alabama: Thierstein, 1981), in the Rio Urola and Punta de San Telmo sections (Spain: Percival and Fischer, 1977), and at DSDP Sites 356 (South Atlantic; paleolatitude of 31° to 32°S at the end of the Cretaceous; Thierstein 1981) and 384 (North Atlantic; paleolatitude of about 33°N at the end of the Cretaceous; Thierstein, 1981).

Although successive species dominance was observed at low-latitude sites (particularly well illustrated by Monechi [1979] for Gubbio [Italy], by Romein [1977] for the Gredero section [Caravaca, southeast Spain], and by Thierstein [1981] for the Braggs section [Alabama]), no clear successive dominances are seen at Site 750, possibly the result of the incompleteness of this Cretaceous/Paleocene sequence. *Hornibrookina* sp. cf. *H. teuriensis* is common at the base of the lower Paleocene part of the section and is replaced upward by *Cruciplacolithus* spp., which reaches 80% of the assemblages (exclusive of *Thoracosphaera* and *Prinsius*). A similar pattern was observed at Hole 690C (Pospichal and Wise, 1990), where a peak in abundance of *Hornibrookina edwardsii* (= *Hornibrookina* sp. cf. *H. teuriensis* herein) precedes a frequency increase in *Cruciplacolithus primus/tenuis*. Because Site 690 is located in the Atlantic sector (1°12.285′E) and Site 750 in the Indian Ocean sector (81°14.42′E) of the Southern Ocean, this succession appears to have a regional significance; and the frequency peak in *Hornibrookina* sp. cf. *H. teuriensis* at both sites may be correlative. It should be noted, however, that before the abundance increase in *Hornibrookina* sp. cf. *H. teuriensis*, there is no successive dominance of the persistent species at Site 690 (Pospichal and Wise 1990). As at Site 690, *Prediscosphaera stoveri* is very common in the Upper Cretaceous assemblages described in this study.

Table 5. Influence of lithology on species frequency in the Maestrichtian chalk.

Sample 120-750A-15R-3, 112-113 cm

	Numbers of specimens	
	White chalk	Grey chalk
Nannofossils:		
Whole	178	104
Fragments	72	57
Lucianorhabdus cayeuxii:		
Whole	66	78
Fragments	94	195

Fragmentation ratio

	White chalk	Grey chalk
Nannofossils		
Fragments/whole	0.4	1.8
L. cayeuxii		
Fragments/whole	1.4	2.5

Notes: Counts were performed on two samples taken at 112–113 cm in Section 120-750A-15R-3: one in the white chalk, one in the greenish chalk. In this experiment, broken nannofossils were recorded as well. These counts reveal an artificial enrichment in *L. cayeuxii* in the gray chalk as a result of intensive dissolution. A comparison of the results in Tables 4 and 5 call for cautious sampling before proceeding to semiquantitative analyses.

CONCLUSIONS

Interpretation of the data presented here is restricted because of drilling disturbance, coring gaps, and an unconformity at the Cretaceous/Paleocene boundary at Site 750. As a result, this study does not bring new evidence for the ongoing discussion about the abruptness of the extinction at the Cretaceous/Paleocene boundary. The distribution pattern of the nannofossil species at this site is similar to that described from the high-latitude Cretaceous/Paleocene boundary section at Hole 690C (Pospichal and Wise, 1990). In addition, the changes seen across the boundary at this southern high-latitude site (57°35.54′S) are similar to those described for northern high-latitude localities.

Despite its restricted character, this study brings additional data toward a much needed detailed analysis of the changes that the calcareous nannoplankton underwent across the Cretaceous/Paleocene boundary.

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APPENDIX

Taxonomy and Species Assignments to the Incoming, Persistent, and Vanishing Genera for This Study

Incoming Genera

Biantholithus sparsus Bramlette and Martini, 1964
Chiasmolithus danicus (Brotzen, 1959) Hay and Mohler, 1967
Coccolithus pelagicus (Wallich, 1877) Schiller, 1930
Cruciplacolithus primus Perch-Nielsen, 1977
Cruciplacolithus tenuis (Stradner, 1961) Hay and Mohler in Hay et al., 1967
Cruciplacolithus Hay and Mohler in Hay et al., 1967, spp. indet.
Ericsonia cava (Hay and Mohler, 1967) Perch-Nielsen, 1969
Ericsonia subpertusa Hay and Mohler, 1967
Hornibrookina Edwards, 1973, cf. *H. teuriensis* Edwards, 1973
Prinsius martinii (Perch-Nielsen, 1969) Haq, 1971
Prinsius tenuiculum (Okada and Thierstein, 1979) Perch-Nielsen, 1984
Prinsius dimorphosus (Perch-Nielsen, 1969) Perch-Nielsen, 1977

Persistent Genera

Biscutum castrorum Black in Black and Barnes, 1959
Biscutum kerguelensis Aubry, 1991
Cyclagelosphaera margerelii Nol, 1965
Ellipsagelosphaera Noël, 1965, sp. indet.
Goniolithus fluckigeri Deflandre, 1957
Lapideacassis blackii Perch-Nielsen in Perch-Nielsen and Franz, 1977
Markalius inversus (Deflandre in Deflandre and Fert, 1954) Bramlette and Martini, 1964
Neocrepidolithus cohenii (Perch-Nielsen, 1968) Perch-Nielsen, 1984
Placozygus fibuliformis (Reinhardt, 1964) Hoffmann, 1970
Placozygus sigmoides (Bramlette and Sullivan, 1961) Romein, 1979
Scampanella asymmetrica Perch-Nielsen, 1977
Scampanella bispinosa Perch-Nielsen, 1977
Scampanella wisei Perch-Nielsen in Perch-Nielsen and Franz, 1977
Scampanella Forchheimer and Stradner, 1973 emend. Perch-Nielsen and Franz, 1977, sp. indet.
Thoracosphaera operculata Bramlette and Martini, 1964
Thoracosphaera sp. cf. *T. imperforata* Kamptner, 1927

Vanishing Genera

Ahmuellerella octoradiata (Gorka, 1957) Reinhardt, 1964
Arkhangelskiella cymbiformis Vekshina, 1959
Cretarhabdus conicus Bramlette and Martini, 1964
Cretarhabdus crenulatus Bramlette and Martini, 1964
Cretarhabdus Bramlette and Martini, 1964, spp. indet.
Cribrosphaerella ehrenbergii (Arkhangelsky, 1912) Deflandre in Piveteau, 1952
Eiffellithus turriseiffeli (Deflandre in Deflandre and Fert, 1954) Reinhardt, 1965
Glaukolithus fessus (Stover, 1966) Perch-Nielsen, 1968
Kamptnerius magnificus Deflandre, 1959
Lithastrinus floralis Stradner, 1962
Lucianorhabdus cayeuxii Deflandre, 1959
Microrhabdulus decoratus Deflandre, 1959
Micula staurophora (Gardet, 1955) Stradner, 1963
Nephrolithus frequens Gorka, 1957
Prediscosphaera cretacea (Arkhangelsky, 1912) Gartner, 1968
Prediscosphaera spinosa (Bramlette and Martini, 1964) Gartner, 1968
Prediscosphaera stoveri (Perch-Nielsen, 1968) Shafik and Stradner, 1971
Reinhardtites anthophorus (Deflandre, 1959) Perch-Nielsen, 1968
Reinhardtites levis Prins and Sissingh in Sissingh, 1977
Rhagodiscus Reinhardt, 1967, spp. indet.
Watznaueria barnesae (Black in Black and Barnes, 1959) Perch-Nielsen, 1968

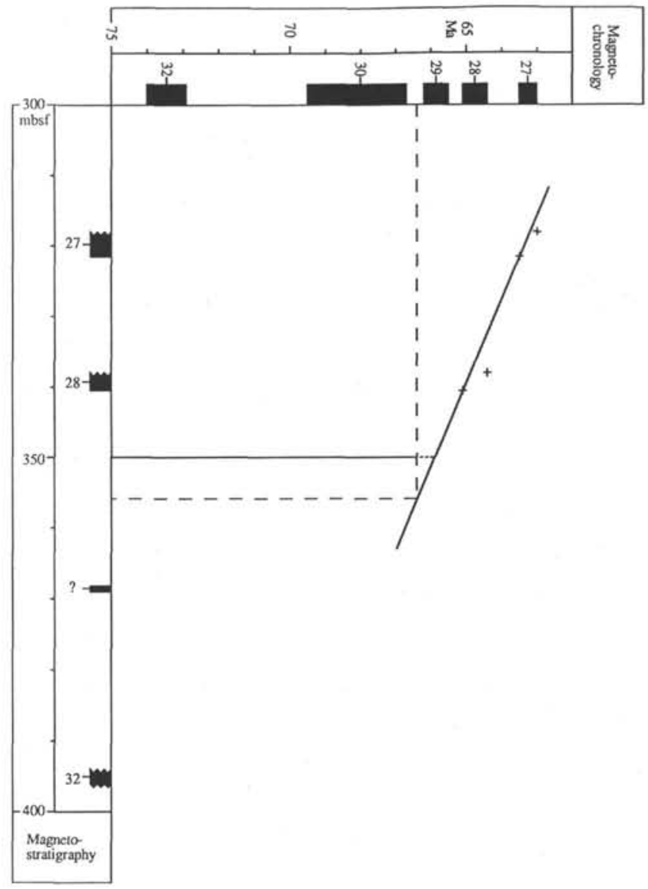

Figure 4. Tentative sedimentation rate curve for the lower Paleocene sequence recovered at Hole 750A. Magnetobiochronology from Berggren et al. (1985) and Kent and Gradstein (1985). Magnetostratigaphy from Heider (this volume).

Table 6.

Chron		Age (Ma)	Depth in core (mbsf)
27N	y	63	318.25 (+)
	o	63.5	321.82
28N	y	64.4	337.86 (+)
	o	65.1	340.52
29N	y	65.5	
	o	66.2	
30N	y	66.7	
	o	69.5	
32N	y	73	394.10 (+)
	o	74	396.20 (+)

Note: Age estimates are from Berggren et al. (1985) and Kent and Gradstein (1985). Depth in core is from Heider et al. (this volume). y = younger boundary and o = older boundary.

Table 7. Species frequencies in sediments assigned to the lower part of Zone NP1 at Hole 750A.

Sample 120-750A-15R-3, 91.5 cm	A		B		C		D	
	Number of specimens	%	Number of specimens	%	Number of specimens	%	Number of specimens	%
Incoming taxa:								
Hornibrookina sp. cf. H. teuriensis	29	10.1	26	7.8	19	6.4	12	3.8
Persistent taxa:								
Biscutum castrorum	44	15.4	52	15.7	28	9.4	34	10.9
Markalius inversus	18	6.3	21	6.3	26	8.7	20	6.4
Neocrepidolithus cohenii	8	2.8	11	3.3	10	3.3	5	1.6
Placozygus fibuliformis	2	0.7	2	0.6	1	0.3		
Placozygus sigmoides	34	11.9	82	24.7	46	15.4	60	19.2
Vanishing taxa:								
Ahmuellerella octoradiata	1	0.3	2	0.6	3	1.0	4	1.3
Arkhangelskiella cymbiformis	9	3.1	6	1.8	5	1.7	10	3.2
Cretarhabdus spp.	1	0.3	2	0.6	1	0.0	1	0.3
Cribrosphaerella ehrenbergii	2	0.7	2	0.6	5	1.7	2	0.6
Eiffellithus turriseiffeli	1	0.3			1	0.0	1	0.3
Glaukolithus fessus	5	1.7	1	0.3	4	1.3	6	1.9
Kamptnerius magnificus	8	2.8	5	1.5	12	4.0	10	3.2
Lucianorhabdus cayeuxii	24	8.4	34	10.2	20	6.7	31	9.9
Microrhabdulus decoratus							1	0.3
Micula staurophora	3	1.0	1	0.3	2	0.7	4	1.3
Nephrolithus frequens	18	6.3	8	2.4	30	10.0	27	8.6
Prediscosphaera cretacea	6	2.1	8	2.4	13	4.3	15	4.8
Prediscosphaera spinosa			1	0.3	3	1.0	4	1.3
Prediscosphaera stoveri	62	21.7	46	13.9	61	20.4	53	16.9
Undetermined	11	3.8	22	6.6	9	3.0	13	4.2
Sum	286	100.0	332	100.0	299	99.3	313	100.0

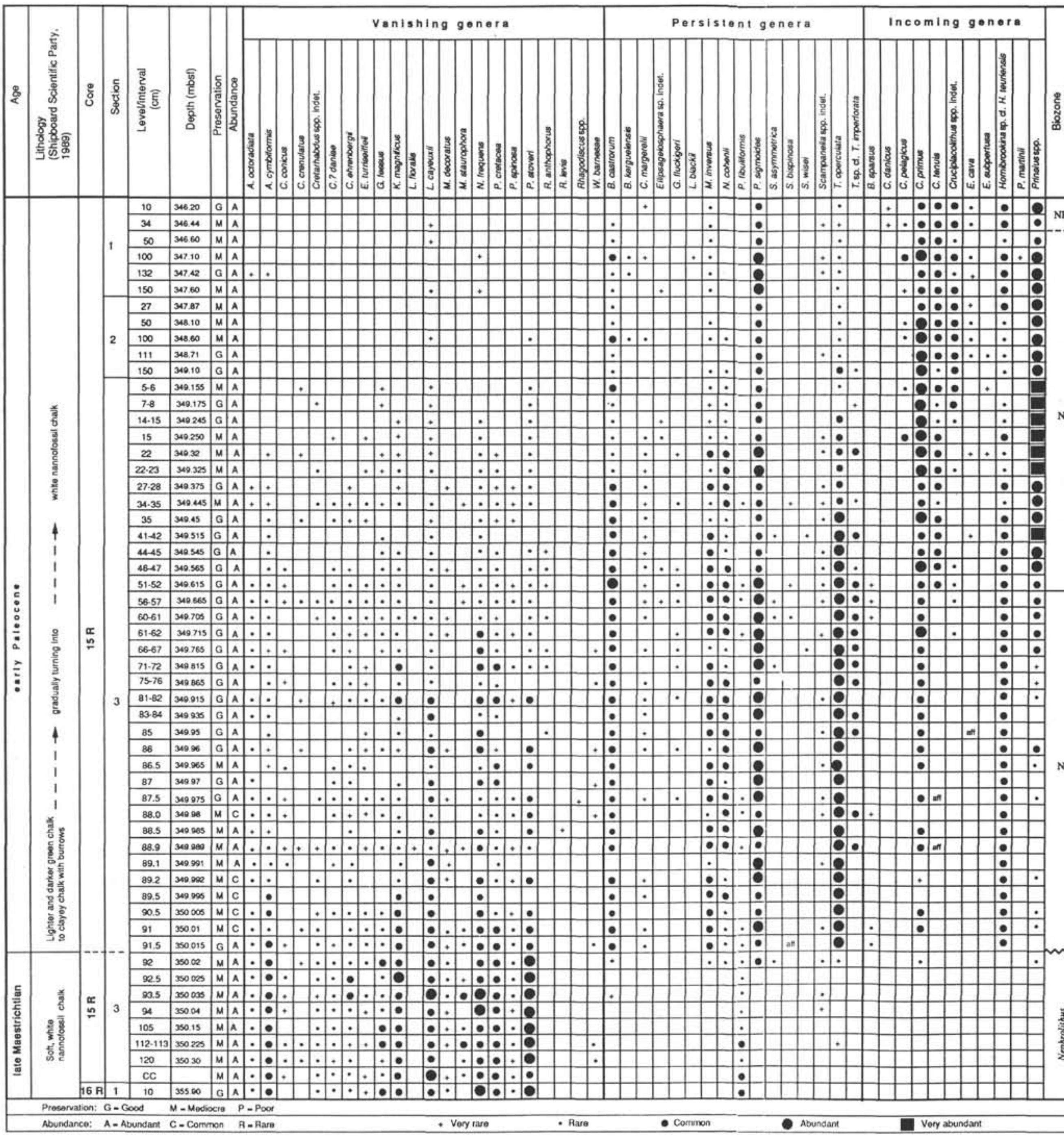

Figure 5. Distribution and frequency of calcareous nannofossil species across the Cretaceous/Paleocene boundary at Hole 750A.

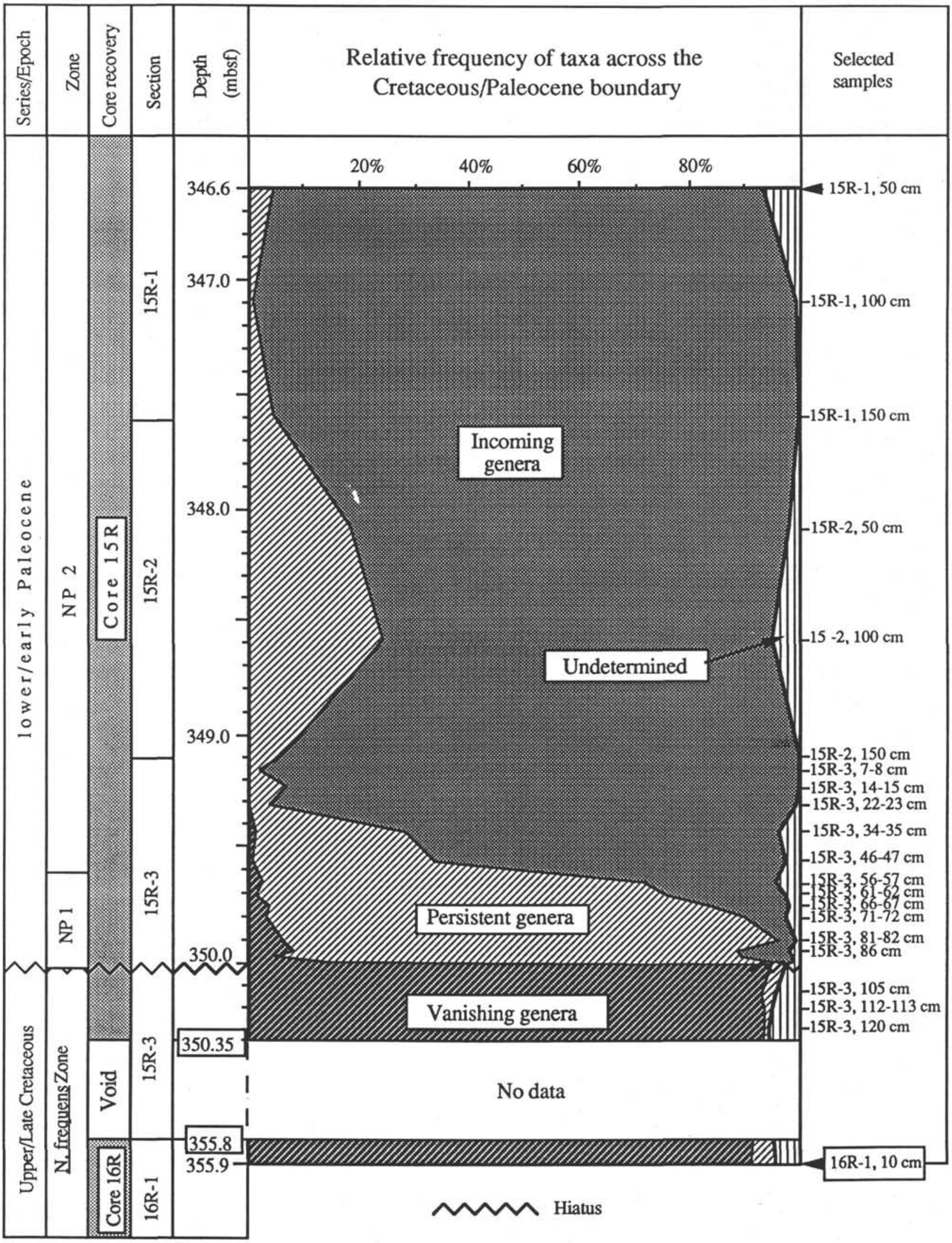

Figure 6. Percentage frequency of vanishing, persistent, and incoming genera at Hole 750A. Note the unconformity at 350.0 mbsf (at the Cretaceous/Paleocene boundary), and the 5.45 m coring gap between Cores 120-750A-15R and -16R.

Table 8. Abundance counts of calcareous nannofossils, except for *Thoracosphaera* and *Prinsius* spp., in the Maestrichtian and Paleocene chalks at Hole 750A.

Core, Section	16R-1	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3
Interval (cm)	10cm	120cm	12-113cn	105cm	92cm	91.5cm	91cm	89.2cm	86cm	81-82cm	71-72cm
Depth (mbsf)	355.9	350.3	350.225	350.15	350.02	350.015	350.01	349.992	349.96	349.915	349.815
Incoming taxa:											
Coccolithus pelagicus											
Cruciplacolithus spp.							25	2	8		74
Ericsonia subpertusa											
Hornibrookina sp. cf. H. teuriensis						86	88	50	39	35	61
Persistent taxa:											
Biscutum castrorum					3	158	139	56	31	36	51
Cyclagelosphaera margerelii								1	1	1	
Ellipsagelosphaera sp. indet.											
Goniolithus fluckigeri									2	1	
Markalius inversus						85	32	16	5	15	13
Neocrepidolithus cohenii					1	34	16	5	11	18	7
Placozygus fibuliformis	17	2	10	8	3	5	2				
Placozygus sigmoides					11	222	298	97	118	142	145
Scampanella spp.					1						
Vanishing taxa:											
Ahmuellerella octoradiata	3	1	8	3	11	10	10	4	3	2	3
Arkhangelskiella cymbiformis	13	22	68	23	51	30	16	3	1	5	2
Cretarhabdus spp.	2	7	7	7	6	5	5		1	1	
Cribrosphaerella ehrenbergii	3		2	4	10	11	6	3	2	6	4
Eiffellithus turriseiffeli	1		1		4	3	3		1	4	1
Glaukolithus fessus	12		19	11	15	16	11		2	5	
Kamptnerius magnificus	33	36	49	18	47	35	32	5	1	9	9
Lucianorhabdus cayeuxii	12	46	114	47	93	109	67	12	8	13	5
Microrhabdulus decoratus	2		2	1	6	1	4	2	2		
Micula staurophora		5	36	2		10	3				
Nephrolithus frequens	85	27	78	48	80	83	62	14	22	25	16
Prediscosphaera cretacea	54	15	41	35	59	42	23	3	1	10	11
Prediscosphaera spinosa			5		1	8	4	1		1	1
Prediscosphaera stoveri	114	90	196	93	236	222	180	10	34	13	
Watznaueria barnesae		2	3								
Undetermined	15	15	32	13	14	55	31	13	20	9	42
Total sum	366	268	671	313	652	1230	1057	297	313	351	445

Table 8 (continued).

15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-2	15R-2	15R-2	15R-1	15R-1	15R-1
66-67cm	61-62cm	56-57cm	46-47cm	34-35cm	22-23cm	14-15cm	7-8cm	150cm	100cm	50cm	150cm	100cm	50cm
349.765	349.715	349.665	349.565	349.445	349.325	349.245	349.175	349.1	348.6	348.1	347.6	347.1	346.6
		1				11	3	5	5	1	1	20	97
22	66	87	139	227	191	226	239	246	195	252	88	104	58
													6
72	47	37	10	2		1			2	5	18	12	2
48	47	47	34	17	6	6	8	6	15	4	9	16	2
				1	1	1							
		1	1			1					1		
7	12	15	6	6	8	1	1			1	3	5	3
7	6	25	14	9	17	1	3	4	1				
196	232	145	93	54	83	53	48	45	63	68	152	100	33
5													
2	3	3	1										
		2		3	2		1						
3		2	2	1									
		1											
1	1	2			1		1						
3	1	2	1		2	1							
4	1	1		1	1	1	1		1		11		1
	1		1										
9	7	10	6	4	3	3					1	1	
4	1		1		2								
				1									
						4	1		1				2
1													
19	28	40	32	39	29	10	7	5	33	30	29	42	91
403	453	421	341	365	346	320	313	311	316	361	313	300	295

Table 9. Relative frequency (percentages) of taxa, except for *Thoracosphaera* and *Prinsius* spp., in the Maestrichtian and Paleocene chalks at Hole 750A.

Core, Section	16R-1	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3
Interval (cm)	10cm	120cm	112-113cm	105cm	92cm	91.5cm	91cm	89.2cm	86cm	81-82cm	71-72cm
Depth (mbsf)	355.9	350.3	350.225	350.15	350.02	350.015	350.01	349.992	349.96	349.915	349.815
Incoming taxa:											
Coccolithus pelagicus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cruciplacolithus spp.	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.7	2.6	0.0	16.6
Ericsonia subpertusa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Hornibrookina sp. cf. H. teuriensis	0.0	0.0	0.0	0.0	0.0	7.0	8.3	16.8	12.5	10.0	13.7
Persistent taxa:											
Biscutum castrorum	0.0	0.0	0.0	0.0	0.5	12.8	13.2	18.9	9.9	10.3	11.5
Cyclagelosphaera margerelii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.0
Ellipsagelosphaera sp. indet.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Goniolithus fluckigeri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.0
Markalius inversus	0.0	0.0	0.0	0.0	0.0	6.9	3.0	5.4	1.6	4.3	2.9
Neocrepidolithus cohenii	0.0	0.0	0.0	0.0	0.2	2.8	1.5	1.7	3.5	5.1	1.6
Placozygus fibuliformis	4.6	0.7	1.5	2.6	0.5	0.4	0.2	0.0	0.0	0.0	0.0
Placozygus sigmoides	0.0	0.0	0.0	0.0	1.7	18.0	28.2	32.7	37.7	40.5	32.6
Scampanella spp.	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Vanishing taxa:											
Ahmuellerella octoradiata	0.8	0.4	1.2	1.0	1.7	0.8	0.9	1.3	1.0	0.6	0.7
Arkhangelskiella cymbiformis	3.6	8.2	10.1	7.3	7.8	2.4	1.5	1.0	0.3	1.4	0.4
Cretarhabdus spp.	0.5	2.6	1.0	2.2	0.9	0.4	0.5	0.0	0.3	0.3	0.0
Cribrosphaerella ehrenbergii	0.8	0.0	0.3	1.3	1.5	0.9	0.6	1.0	0.6	1.7	0.9
Eiffellithus turriseiffeli	0.3	0.0	0.1	0.0	0.6	0.2	0.3	0.0	0.3	1.1	0.2
Glaukolithus fessus	3.3	0.0	2.8	3.5	2.3	1.3	1.0	0.0	0.6	1.4	0.0
Kamptnerius magnificus	9.0	13.4	7.3	5.8	7.2	2.8	3.0	1.7	0.3	2.6	2.0
Lucianorhabdus cayeuxii	3.3	17.2	17.0	15.0	14.3	8.9	6.3	4.0	2.6	3.7	1.1
Microrhabdulus decoratus	0.5	0.0	0.3	0.3	0.9	0.1	0.4	0.7	0.6	0.0	0.0
Micula staurophora	0.0	1.9	5.4	0.6	0.0	0.8	0.3	0.0	0.0	0.0	0.0
Nephrolithus frequens	23.2	10.1	11.6	15.3	12.3	6.7	5.9	4.7	7.0	7.1	3.6
Prediscosphaera cretacea	14.8	5.6	6.1	11.2	9.0	3.4	2.2	1.0	0.3	2.8	2.5
Prediscosphaera spinosa	0.0	0.0	0.7	0.0	0.2	0.7	0.4	0.3	0.0	0.3	0.2
Prediscosphaera stoveri	31.1	33.6	29.2	29.7	36.2	18.0	17.0	3.4	10.9	3.7	0.0
Watznaueria barnesae	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Undetermined	4.1	5.6	4.8	4.2	2.1	4.5	2.9	4.4	6.4	2.6	9.4
Total sum	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 9 (continued).

15R-3 66-67cm 349.765	15R-3 61-62cm 349.715	15R-3 56-57cm 349.665	15R-3 46-47cm 349.565	15R-3 34-35cm 349.445	15R-3 22-23cm 349.325	15R-3 14-15cm 349.245	15R-3 7-8cm 349.175	15R-2 150cm 349.1	15R-2 100cm 348.6	15R-2 50cm 348.1	15R-1 150cm 347.6	15R-1 100cm 347.1	15R-1 50cm 346.6
0.0	0.0	0.2	0.0	0.0	0.0	3.4	1.0	1.6	1.6	0.3	0.3	6.7	32.9
5.5	14.6	20.7	40.8	62.2	55.2	70.6	76.4	79.1	61.7	69.8	28.1	34.7	19.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
17.9	10.4	8.8	2.9	0.5	0.0	0.3	0.0	0.0	0.6	1.4	5.8	4.0	0.7
11.9	10.4	11.2	10.0	4.7	1.7	1.9	2.6	1.9	4.7	1.1	2.9	5.3	0.7
0.0	0.0	0.0	0.0	0.3	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.2	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.7	2.6	3.6	1.8	1.6	2.3	0.3	0.3	0.0	0.0	0.3	1.0	1.7	1.0
1.7	1.3	5.9	4.1	2.5	4.9	0.3	1.0	1.3	0.3	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
48.6	51.2	34.4	27.3	14.8	24.0	16.6	15.3	14.5	19.9	18.8	48.6	33.3	11.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	0.7	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.5	0.0	0.8	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
0.7	0.0	0.5	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.2	0.2	0.5	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
0.7	0.2	0.5	0.3	0.0	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.2	0.2	0.0	0.3	0.3	0.3	0.3	0.0	0.3	0.0	3.5	0.0	0.3
0.0	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.2	1.5	2.4	1.8	1.1	0.9	0.9	0.0	0.0	0.0	0.0	0.3	0.3	0.0
1.0	0.2	0.0	0.3	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.3	0.0	0.3	0.0	0.0	0.0	0.7
0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.7	6.2	9.5	9.4	10.7	8.4	3.1	2.2	1.6	10.4	8.3	9.3	14.0	30.8
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

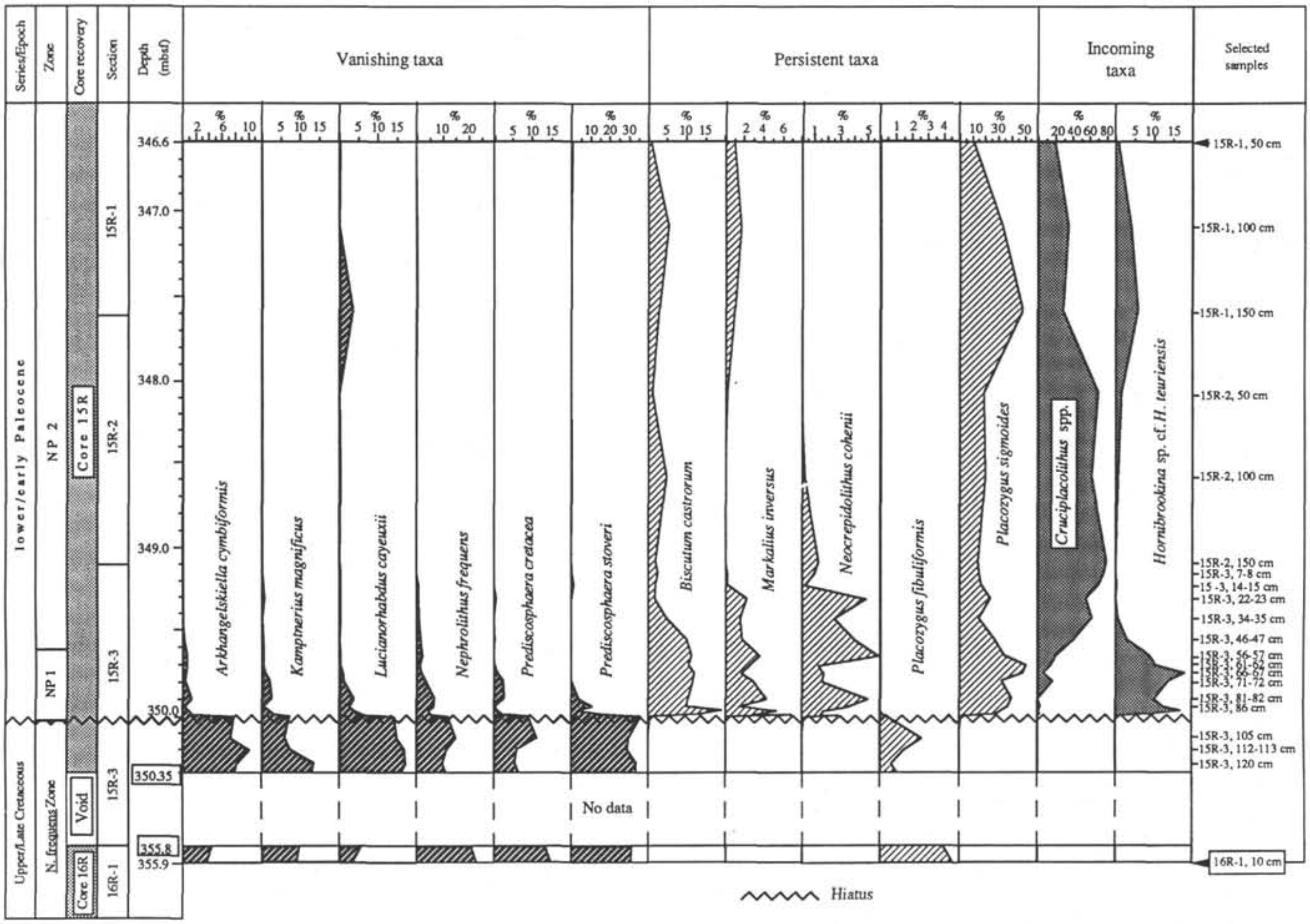

Figure 7. Percentage frequency of selected species of the vanishing, persistent, and incoming genera at Hole 750A.

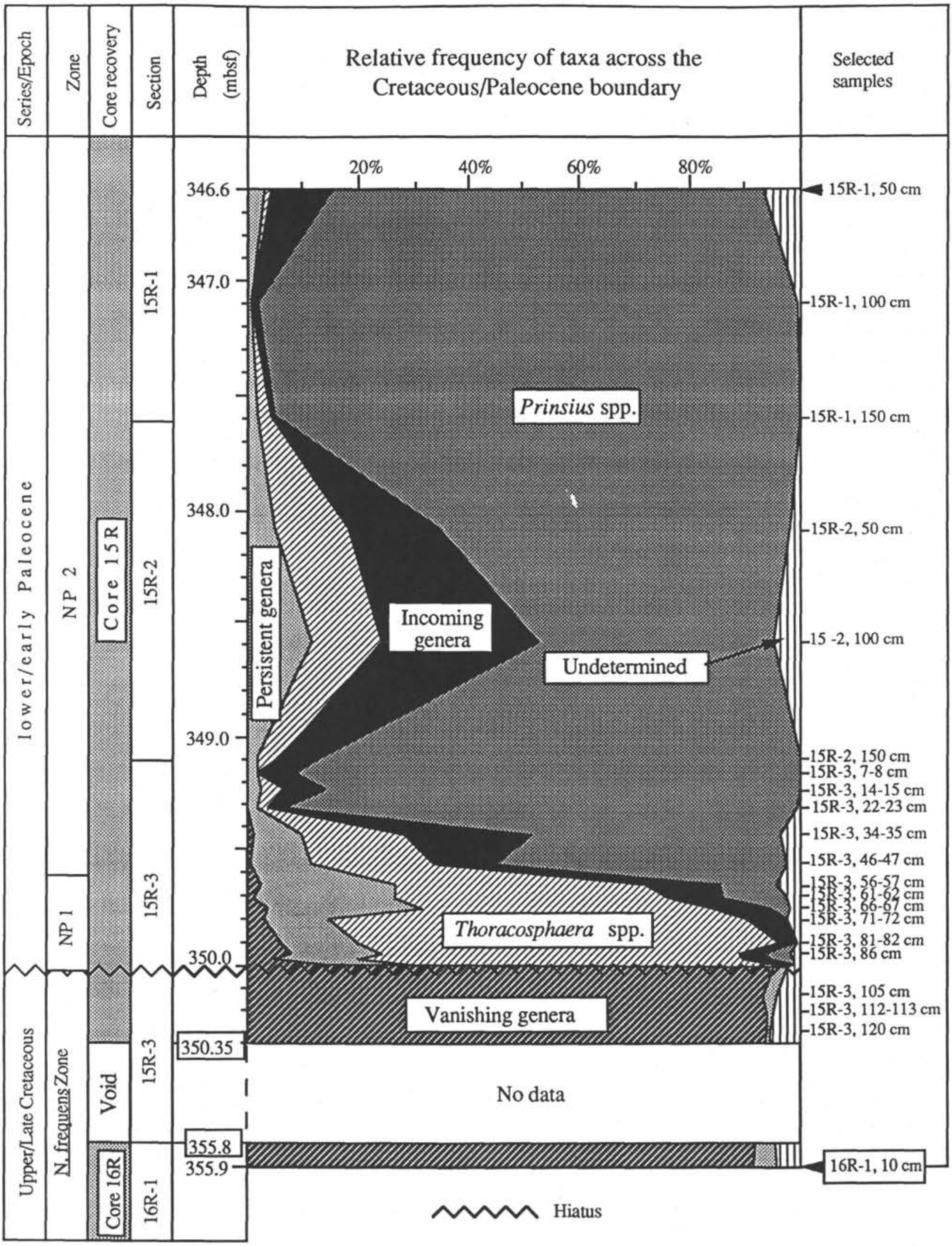

Figure 8. Percentage frequency of vanishing, persistent, and incoming genera at Hole 750A, with emphasis on the frequency of *Thoracosphaera* (a persistent genus) and *Prinsius* (a representative of the incoming genera). Note the unconformity at 350.0 mbsf (at the Cretaceous/Paleocene boundary), and the 5.45-m coring gap between Cores 120-750A-15R and -16R.

Table 10. Abundance counts (number of specimens) and relative frequency (percentages) of *Thoracosphaera* and *Prinsius* spp., in the Maestrichtian and Paleocene chalks at Hole 750A.

Core, Section	16R-1	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3
Interval (cm)	10cm	120cm	112-113cm	105cm	92cm	91.5cm	91cm	89.2cm	86cm	81-82cm
Depth (mbsf)	355.9	350.3	350.225	350.15	350.02	350.015	350.01	349.992	349.96	349.915
Thoracosphaera spp.	0	0	0	0	0	205	187	30	59	91
All other Nannofossils						105	97	11	28	27
Prinsius spp.	0	0	0	0	0	0	0	2	4	1
Number of specimens:										
Vanishing taxa	334	251	629	292	619	585	426	57	78	94
Persistent taxa (excl. Thoracosphaera)	17	2	10	8	19	504	487	175	168	213
Thoracosphaera spp.	0	0	0	0	0	2401	2038	810	660	1183
Incoming taxa (excl. Prinsius spp.)	0	0	0	0	0	86	113	52	47	35
Prinsius spp.	0	0	0	0	0	0	0	54	45	13
Undetermined	15	15	32	13	14	55	31	13	20	9
Sum	366	268	671	313	652	3631	3095	1161	1017	1547
Percentage of taxa:										
Vanishing taxa	91.3	93.7	93.7	93.3	94.9	16.1	13.8	4.9	7.7	6.1
Persistent taxa (excl. Thoracosphaera)	4.6	0.7	1.5	2.6	2.9	13.9	15.7	15.1	16.5	13.8
Thoracosphaera spp.	0.0	0.0	0.0	0.0	0.0	66.1	65.8	69.8	64.8	76.5
Incoming taxa (excl. Prinsius spp.)	0.0	0.0	0.0	0.0	0.0	2.4	3.7	4.5	4.6	2.3
Prinsius spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	4.4	0.8
Undetermined	4.1	5.6	4.8	4.2	2.1	1.5	1.0	1.1	2.0	0.6
Sum	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 10 (continued).

15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-3	15R-2	15R-2	15R-2	15R-1	15R-1	15R-1
71-72cm	66-67cm	61-62cm	56-57cm	46-47cm	34-35cm	22-23cm	14-15cm	7-8cm	150cm	100cm	50cm	150cm	100cm	50cm
349.815	349.765	349.715	349.665	349.565	349.445	349.325	349.245	349.175	349.1	348.6	348.1	347.6	347.1	346.6
75	46	38	39	19	16	2	6	0	3	5	8	2	0	1
24	38	30	37	21	31	6	13	8	6	18	14	3	3	16
0	3	9	9	45	38	109	118	84	58	17	38	88	143	61
52	32	15	23	12	10	11	9	4	0	2	0	12	1	3
216	258	297	233	148	87	115	63	60	55	79	73	165	121	38
1391	488	574	444	309	188	115	148	0	156	88	206	209	0	18
135	94	113	125	149	229	191	238	242	251	202	258	107	136	163
0	32	136	102	731	447	6286	2905	3287	3006	298	980	9181	14300	1125
42	19	28	40	32	39	29	10	7	5	33	30	29	42	91
1836	923	1163	967	1380	1001	6747	3372	3600	3473	702	1547	9703	14600	1438
2.8	3.5	1.3	2.4	0.9	1.0	0.2	0.3	0.1	0.0	0.3	0.0	0.1	0.0	0.2
11.8	28.0	25.5	24.1	10.7	8.7	1.7	1.9	1.7	1.6	11.3	4.7	1.7	0.8	2.6
75.8	52.9	49.4	45.9	22.4	18.8	1.7	4.4	0.0	4.5	12.5	13.3	2.2	0.0	1.3
7.4	10.2	9.7	12.9	10.8	22.9	2.8	7.1	6.7	7.2	28.8	16.7	1.1	0.9	11.3
0.0	3.4	11.7	10.6	52.9	44.7	93.2	86.1	91.3	86.6	42.5	63.3	94.6	97.9	78.2
2.3	2.1	2.4	4.1	2.3	3.9	0.4	0.3	0.2	0.1	4.7	1.9	0.3	0.3	6.3
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0