6. MESOZOIC CALCAREOUS NANNOFOSSILS FROM LEG 130¹

Shaozhi Mao² and Sherwood W. Wise, Jr.²

ABSTRACT

The distribution of Mesozoic calcareous nannofossils are tabulated for Holes 807C and 803D drilled on the Ontong Java Plateau in the western equatorial Pacific. Nannofossils were abundant but poorly preserved in Hole 803D and range from early Albian to Maastrichtian in age. A possibly complete and expanded K/T boundary interval yielded few diagnostic taxa because of the dissolution of Tertiary forms. The only nannofossil-bearing sample examined from Hole 803D contained the uppermost Maastrichtian zonal indicator *Micula prinsii*.

INTRODUCTION

Mesozoic calcareous nannofossils were recovered at two Ocean Drilling Program (ODP) sites drilled on the Ontong Java Plateau in the western equatorial Pacific (Fig. 1). At both sites preservation was poor because of deposition close to the calcite compensation depth and postdepositional diagenesis. Species diversity of the assemblages and stratigraphic resolution were consequently low. As a result, a formal zonation was only applied to the Upper Cretaceous section. Nevertheless, even there it was impossible to delineate all of the zones, subzones, or datums recognized by Sissingh (1977), Roth (1978), or Perch-Nielsen (1979). Instead, broader intervals were delimited based on a restricted number of marker species; the less detailed sequences of datums suggested by Thierstein (1976) and subsequently incorporated into zones by Verbeek (1977) proved to be the most applicable.

The sequences were closely examined by the shipboard nannofossil specialists (J. Backman and T. Takayama), and their reports are given in Kroenke, Berger, Janecek, et al. (1991). Over certain key intervals, their reports are more detailed than ours because of closer sample spacing, and their observations are reported herein where applicable. The main purpose of the present study is to provide details of the assemblages through distribution charts and photomicrographs.

The nannofossils were observed in the light microscope at a magnification of 1560 $\times$ using simple smear slide preparations. Their distributions were plotted on range charts in order of their first occurrences (FOs). Relative individual species abundance estimates follow the procedure of Hay (1970) and are indicated in the following manner: V = very abundant (>10 specimens/field of view); A = abundant (1–10 specimens/field of view); C = common (1 specimen/2–10 fields of view); F = few (1 specimen/11–100 fields of view); and R = rare (1 specimen/101–1000 fields of view). Qualitative estimates of overall nannofossil abundance were given the following letter codes: V = very abundant, A = abundant, C = common, and F = few.

The average state of preservation of nannofossils per sample was designated as follows: G = good (little or no etching or overgrowth); M = moderate (some etching and/or overgrowth, identification of species is not generally impaired); and P = poor (strong etching and/or overgrowth, identification of species is impaired but often still possible). Taxa considered are given in the Appendix, and corresponding bibliographic references for these taxa are provided in Perch-Nielsen (1985a, 1985b).

SITE DESCRIPTIONS

Hole 807C

Hole 807C was drilled at 3°36.4'N, 156°37.5'E in a water depth of 2797 m. Abundant but poorly preserved nannofossils were recovered from 84 samples taken from limestones in Cores 130-807C-54R through -80R (Table 1). Seven samples were barren as a result of the complete dissolution of nannofossils. The nannofossil assemblages consist of only 28 species represented mainly by such dissolution-resistant taxa as *Watznaueria barnesae* and *Micula decussata*.

Cretaceous/Tertiary Boundary

The Cretaceous/Tertiary boundary cannot be placed reliably using calcareous nannofossils because of poor preservation of the material and the usual reworking of nannofossils across this boundary (e.g., see Pospichal and Wise, 1990). As noted by the shipboard nannofossil specialists (Kroenke, Berger, Janecek, et al., 1991, p. 400):

The wealth of small Tertiary placolith taxa (i.e., *Biscutum*, *Cruciplacolithus*, and *Toweius*) emerging immediately after the mass extinction of Cretaceous forms . . . essentially have been dissolved in the nearest 8 m above the assigned K/T boundary horizon at Site 807. Trace amounts of such Danian placoliths, however, are consistently present from 1.1 m above the boundary horizon.

This indeed was essentially the case as we noted only specimens of the Tertiary *Coccolithus pelagicus* down to Sample 130-807C-54R-3, 88 cm (1192.7 mbsf), and all other such taxa were absent except for the expected admixture of Cretaceous forms. Most of the material in the remainder of Core 130-807C-54R and in the top of Core 130-807C-55R was micrite that was essentially barren of nannofossils other than the most dissolution-resistant Cretaceous forms.

On board ship, the nannofossil K/T boundary was placed within a 16-cm interval immediately below Sample 130-807B-54R-3, 127 cm (1192.9–1193.1 mbsf), which contained the only abundant occurrence of the calcareous dinoflagellate *Thoracosphaera* (Kroenke, Berger, Janecek, et al., 1991, p. 403, table 6). Corfield and Cartledge (this volume), however, place it much lower, between Sections 130-807B-55R-3 and -4 based on $\delta^{13}\text{C}$ signatures. Specifically, they note the initiation of a rapid decline in $\delta^{13}\text{C}$ values at 1202.25 mbsf (Sample 130-807C-55R-4, 85–89 cm). Based on planktonic foraminifers viewed in thin sections of impregnated sediment, Premoli Silva (this volume) and Sliter and Leckie (this volume) place the K/T boundary near the top of Core 55R, at 1197.2 mbsf (Sample 130-807C-55R-1, 30–31 cm).

The presence of common *Coccolithus pelagicus* at 1192.7 mbsf places an upper limit on what is designated as the "K/T boundary interval" in Table 1. The FO of this taxon falls within Subzone CP1b, the base of which is marked by the FO of *Cruciplacolithus tenuis*.

¹ Berger, W.H., Kroenke, L.W., Mayer, L.A., et al., 1993. *Proc. ODP, Sci. Results*, 130: College Station, TX (Ocean Drilling Program).

² Department of Geology, Florida State University, Tallahassee, FL 32306, U.S.A.

Table 1. Distribution of calcareous nannofossils in Hole 807C.

Age	Zonation Tertiary: Okada and Bukry (1980) Cretaceous: Thierstein (1967) and Verbeek (1977)	Lithostratigraphic unit	Core, section, interval (cm)	Depth (mbsf)	Abundance	Preservation	<i>Watznaueria barnesae</i>	<i>Boarudosphæra</i> sp.	<i>Parahalolithus embergeri</i>	<i>Lithophidites carinulensis</i>	<i>Quadrum gartneri</i>
early Paleocene	<i>Cruciplacolithus tenuis</i> Subzone (CP1b)	II B	54R-1, 125 54R-2, 117 54R-3, 88	1190.0 1191.5 1192.7	A C C	M P P	A C C	+	+	+	+
K/T	Boundary interval		54R-4, 93 54R-CC 55R-1, 142 55R-2, 38 55R-3, 78	1194.2 1194.8 1198.3 1198.8 1200.7	C F C A A	P P M M M	C F C A A	+	+	+	+
late late Maastrichtian	<i>Micula murus</i> Zone		55R-4, 135 55R-CC 56R-1, 23 56R-2, 23 56R-3, 23 56R-CC 57R-1, 66 57R-2, 66 57R-CC 58R-1, 7 58R-CC 59R-1, 66 59R-2, 118 59R-CC 60R-CC 61R-1, 56 61R-2, 91 61R-CC 62R-1, 112	1202.7 1203.0 1206.8 1208.3 1209.8 1210.3 1217.0 1218.5 1219.1 1222.6 1223.0 1232.9 1234.9 1235.5 1242.0 1252.1 1253.9 1254.2 1262.3	A A A A C A A A A A A A A A A A A A A	M M P P M M P P M M M P P P P P P P	A C A A C A A A A A A A A A A A A A	+	R	+	R
early late Maastrichtian	<i>Lithraphidites quadratus</i> Zone		62R-2, 67 62R-3, 123 62R-4, 7 62R-CC 63R-1, 37 63R-2, 60 63R-3, 56 63R-4, 46 63R-CC 64R-1, 111 64R-2, 107 64R-3, 16 64R-CC 65R-1, 75 65R-2, 78 65R-CC 66R-1, 6 66R-2, 6 66R-3, 6 66R-CC 67R-1, 45 67R-2, 43 67R-3, 16 67R-4, 124	1263.4 1265.4 1265.8 1266.0 1271.2 1272.9 1274.4 1275.8 1276.2 1281.6 1283.1 1283.7 1284.2 1290.8 1292.4 1293.3 1299.9 1301.4 1302.9 1304.2 1309.9 1311.4 1312.7 1315.2	A A	P A P P P M A P P P P P P P P P P P M M P P P P	A A	+	R	+	C
early Maastrichtian-late late Campanian	<i>Quadrum gothicum</i> Zone?		67R-5, 48 67R-CC 68R-1, 54 68R-2, 82 68R-3, 41 68R-CC 69R-1, 133 69R-2, 105 69R-3, 60 69R-4, 65 69R-5, 69 69R-CC 70R-1, 96 70R-2, 38 70R-3, 99	1316.0 1316.4 1319.6 1321.4 1322.5 1322.7 1330.1 1331.3 1332.4 1333.9 1335.5 1335.7 1339.4 1340.3 1342.4	A A A A A A A A A A A A A A A	P P P P P P P P P P P P P P P	A A A A A A A A A A A A A A A	+	+	+	C
early late Campanian	<i>Quadrum trifidum</i> Zone		70R-4, 64 70R-CC 71R-1, 116 71R-2, 106 71R-3, 95	1343.5 1344.7 1349.2 1350.6 1351.9	A C A C R	P P P P P	A C P C P	+	+	+	C
?	?	IIIA	72R-1, 95 72R-2, 99 72R-3, 2	1358.6 1360.2 1360.7	R R R	P P P	R P R	+	+	+	R
early Aptian (Sliter, this volume)	?	IIIB	73R-2, 90 74R, top 80R-1, 77 80R-3, 75	1369.8 1375.4 1424.7 1427.6	C A C R	P P P P	C A C R	R	F	F	+

Note: For abundance and preservation: A = abundant, C = common, F = few, R = rare, M = moderate, and P = poor.

Because of the poor preservation, we were not able to distinguish *C. tenuis* in our samples. At a number of ODP sites studied recently by J. Pospichal, the first common *C. pelagicus* (referred to by Pospichal as *C. cavus*) occurs about 1 m above the FAD of *C. tenuis* (e.g., ODP Site 752, Pospichal, 1991, table 1; ODP Site 738, J. Pospichal, pers. comm., 1992; DSDP Site 738, J. Pospichal, pers. comm., 1992).

According to the time scale of Berggren et al. (1985), the FAD of *Cruciplacolithus tenuis* is dated at 65.9 Ma, 500 k.y. above the K/T boundary at 66.4 Ma. The *Thoracosphaera* acme noted aboard ship occurs about 40 cm below the FO of *Coccolithus pelagicus*, but well above the K/T boundary indicated by planktonic foraminifers (Sample 130-807C-55R-1, 30–31 cm; 1197.2 mbsf) and carbon isotopes (Sample 130-807C-55R-4, 85–89 cm; 1202.2 mbsf) (Sliter and Leckie, this volume; Corfield and Cartlidge (this volume). The level of the *Thoracosphaera* acme is consistent with its position at several other (but not all) ODP sites studied by Pospichal (e.g., ODP Site 690, where it is distinctly above the K/T boundary [Pospichal and Wise, 1990]).

The exact stratigraphic distance between the thoracosphaerid acme and the K/T boundaries determined from planktonic foraminifers or carbon isotopes cannot be ascertained because the recovery in Core 130-807C-54R was only 6.0 m or 74.1%, of the 8.1-m interval cored. Although by ODP convention all recovered material is measured from the top of the drilled interval, no way exists to know exactly where a given sample was cored as core loss could have occurred anywhere within the interval. Maximum and minimum limits can be determined, however, depending on the amount of material recovered and the position of a given sample within that recovered material. Thus, the thoracosphaerid acme in Sample 130-807C-54R-3, 127 cm, could lie as little as 2.0 m or as much as 3.3 m above the foraminiferal K/T boundary, whereas it could have come from 7.0 to 8.3 m above the carbon isotope K/T boundary.

Upper Cretaceous

Micula murus Zone

The base of this uppermost Maastrichtian zone is defined by the first occurrence of *Micula murus* in Sample 130-807C-62R-1, 112 cm, and the top of the zone by the nannofossil K/T boundary. *Watznaueria barnesae* and *Micula decussata* are dominant and continuously present whereas *Cretarhabdus crenulatus*, *Microrhabdulus decoratus*, *Quadrum gartneri*, and *Cylindralithus* sp. are common and frequently present in the assemblages. *Lithrapiidites carniolensis*, *Prediscosphaera cretacea*, *Quadrum trifidum*, and a small form (6–8 µm) of *Broinsonia* have their last occurrence (LO) in the lower part of the zone whereas *Arkhangelskiella cymbiformis*, *Cretarhabdus crenulatus*, *Cribrosphaerella ehrenbergii*, and *Parhabdololithus embergeri* disappear in the upper part of the zone. The zone corresponds to Zone NC23 of Roth (1978).

Lithrapiidites quadratus Zone

This mid-Maastrichtian zone is delimited by the FO of *Lithrapiidites quadratus* from Sample 130-807C-67R-4, 124 cm, and the FO of *Micula murus* in Sample 130-807C-62R-1, 112 cm. Specimens of *L. quadratus* are rare and were found only in two samples. Nannofossils in this zone are most abundant and also diverse with a total of 19 species, 18 of which are shared with the zone above. Fossil preservation, however, remains as poor as in the zones above and below. *Cretarhabdus crenulatus*, *C. ehrenbergii*, *Micula decussata*, and *Quadrum gartneri* are continuously present, and *Arkhangelskiella* sp., *Cylindralithus* sp., *L. carniolensis*, *M. decoratus*, *P. cretacea*, and *Q. gothicum* are common and occur frequently in the zone. This zone is equivalent to Zone NC22 of Roth (1978).

Quadrum trifidum Zone

The base of this lower Maastrichtian to uppermost Campanian Zone is delineated by the FO of *Quadrum trifidum* in Sample 130-807C-70R-3, 99 cm, and its top by the FO of *Lithrapiidites quadratus*. Heavily overgrown *Q. trifidum* with short rays are common and continuously present in the zone. In addition, *C. crenulatus* and *Quadrum gartneri* occur throughout the zone, but we did not observe *Ceratolithoides aculeus* as noted by the shipboard scientists. This zone is equivalent to Zones NC21 and NC22 of Roth (1978).

Quadrum gothicum Zone?

The presence of this upper Campanian zone is questionable as preservation in the section deteriorated further below Sample 130-807C-70R-3, 99 cm. The base of this zone was placed at Sample 130-807C-71R-3, 95 cm, based on the presence of *Quadrum gothicum* and the absence of *Q. trifidum*. Shipboard scientists, however, traced *Q. trifidum* further down into the section than we did (to Sample 130-807C-71R-1, 37–38 cm; Kroenke, Berger, Janecek, et al., 1991, p. 401).

Abundance and species diversity in this zone decreases dramatically to only nine species. Beside the most dissolution-resistant species such as *W. barnesae* and *M. decussata*, specimens of *C. crenulatus*, *C. ehrenbergii*, *L. carniolensis*, *Lucianorhabdus maleformis*, *Q. gothicum*, and *Cylindralithus* sp. are noted. The zone is recognized by Verbeek (1977) and Sissingh (1977), but not by Roth (1978).

Lower Cretaceous

Samples below Core 130-807C-72R yielded no diagnostic nannofossils. This sequence, which includes samples in Core 130-807C-80R taken between basalt flows, is best described by the shipboard nannofossil specialists (Kroenke, Berger, Janecek, et al., 1991, pp. 401–402). Premoli Silva (this volume) and Sliter and Leckie (this volume) assign an age of early Aptian to Sample 130-807C-74R-1, 24 cm, taken directly above basement.

Hole 803D

Hole 803D was drilled at 2°25.98'N, 160°32.46'E in a water depth of 3414.2 m. We were provided five widely spaced samples from this site across the K/T boundary (Table 2); however, assemblages in about 40 smear slides were examined by the shipboard nannofossil specialists, who provide detailed explanations and a range chart for 17 closely spaced samples across the boundary (Kroenke, Berger, Janecek, et al., 1991, p. 122, table 4). These specialists place the K/T boundary at this locality in Section 130-803C-68R-1, between 38 and 53 cm, based on an abundance increase in *Thoracosphaera* spp. We confirm in Sample 130-803D-68R-1, 54–55 cm, the presence of *Micula prinsii*, an uppermost Maastrichtian marker noted by Perch-Nielsen (1979). Below that, Cretaceous nannofossils are essentially absent in our samples.

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APPENDIX

Calcareous Nannofossils Considered in this Report in Alphabetical Order of Generic Epithets

- Arkhangelskiella cymbiformis* Vekshina, 1959
- Braarudosphaera* sp.
- Broinsonia* sp.
- Coccolithus pelagicus* (Wallich, 1877) Schiller, 1930
- Cretarhabdus conicus* Bramlette and Martini, 1964
- Cretarhabdus crenulatus* Bramlette and Martini, 1964
- Cribrosphaerella ehrenbergii* (Arkhangelsky) Deflandre in Piveteau, 1952
- Cruciplacolithus tenuis* (Stradner, 1961) Hay and Mohler in Hay et al., 1967
- Cyclagelosphaera margerelii* Noël, 1965
- Cyclagelosphaera* sp.
- Cyclicargolithus floridanus* (Roth and Hay in Hay et al. 1967) Bukry, 1971
- Cylindralithus* sp.
- Lithraphidites carniolensis* Deflandre, 1963
- Lithraphidites quadratus* Bramlette and Martini, 1964
- Lucianorhabdus maleformis* Reinhardt, 1966
- Manivitella pemmatoidea* (Deflandre in Manivit, 1965) Thierstein, 1971
- Microrhabdulus decoratus* Deflandre, 1959
- Micula decussata* Vekshina, 1959
- Micula murus* (Martini, 1961) Bukry, 1973
- Micula praemurus* (Bukry, 1973) Stradner and Steinmetz, 1984
- Nannoconus* sp.
- Parhabdololithus embergeri* (Noël, 1975) Stradner, 1963
- Prediscosphaera cretacea* (Arkhangelsky) Gartner, 1968
- Prinsius africanus* Perch-Nielsen, 1980
- Quadrum gartneri* Prins and Perch-Nielsen in Manivit et al., 1977
- Quadrum gothicum* (Deflandre, 1959) Prins and Perch-Nielsen in Manivit et al., 1977
- Quadrum trifidum* (Stradner in Stradner and Papp, 1961) Prins and Perch-Nielsen in Manivit et al., 1977
- Quadrum sissinghii* Perch-Nielsen, 1984
- Tegumentum stradneri* Thierstein in Roth and Thierstein, 1972
- Thoracosphaera* sp.
- Watznaueria barnesae* (Black) Perch-Nielsen, 1968

Figure 1. Location of Sites 803 and 807.

Table 2. Distribution of calcareous nannofossils in Hole 803D.

Age	Zonation Thierstein (1967) and Verbeek (1977)	Abundance	Preservation	Core, section, interval (cm)	<i>Quadrum trifidum</i>	<i>Watznaueria barnesae</i>	<i>Arkhangelskiella cymbiformis</i>	<i>Cretarhabdus crenulatus</i>	<i>Cribrosphaerella ehrenbergii</i>	<i>Cylindralithus</i> sp.	<i>Micula decussata</i>	<i>Micula murus</i>	<i>Micula prinsii</i>	<i>Quadrum gothicum</i>	<i>Quadrum sissinghii</i>	<i>Quadrum</i> sp.
Eocene				67R-1, 26–27 67R-2, 26–27	• •	• •	• •	• •	• •	• •	• •	• •	• •	• •	• •	• •
late late Maastrichtian	<i>Micula murus</i> Zone	A C R	P P P	68R-1, 54–55 68R-2, 82–83 68R-3, 56–61	F • R	A C R	F • •	C • •	F • •	F • •	C • •	C • •	R • •	F • •	F • •	R • •

Plate 1. Note: All figures are light photomicrographs, $\times 2100$. PH = phase contrast light; all other figures in cross-polarized light. 1. *Micula decussata*, Sample 130-807C-56R-2, 23–25 cm. 2, 4. *Quadrum gartneri*; (2) Sample 130-807C-56R-3, 23–25 cm; (4) Section 130-807C-56R-CC. 3. *Micula praemurus*, Sample 130-807C-56R-3, 23–25 cm. 5. *Quadrum gothicum*, Sample 130-803D-68R-1, 54–55 cm. 6. *Micula murus*, Sample 130-803D-68R-1, 54–55 cm. 7, 8. *Lucianorhabdus maleformis*, Sample 130-807C-70R-3, 99–100 cm; (8) PH. 9, 18. *Lithraphidites quadratus*; (9) Sample 130-807C-59R-1, 66–68 cm; (18) Sample 130-807C-62R-4, 7–8 cm. 10. *Arkhangelskiella cymbiformis*, Section 130-807C-57R-CC. 11. *Broinsonia* sp., Sample 130-807C-59R-1, 66–68 cm. 12. *Micula murus*, Sample 130-807C-56R-2, 23–25 cm. 13. *Quadrum sissinghii*, Sample 130-803D-68R-1, 54–55 cm. 14. *Microhabdulus decoratus*, Sample 130-807C-62R-4, 7–8 cm, PH. 15, 16. *Quadrum trifidum*, (15) Sample 130-807C-67R-3, 16–18 cm; (16) Sample 130-803D-68R-1, 54–55 cm. 17, 28, 29. *Lithraphidites carniolensis*; (17) Section 130-807C-62R-CC, PH; (28) Sample 130-807C-63R-4, 46–48 cm, (29) Sample 130-807C-63R-4, 46–48 cm. 19. *Cretarhabdus crenulatus*, Section 130-807C-61R-CC. 20. *Cretarhabdus conicus*, Sample 130-807C-59R-1, 66–68 cm. 21. *Cribrosphaerella ehrenbergii*, Section 130-807C-61R-CC. 22. *Watznaueria barnesae*, Sample 130-807C-55R-3, 78–80 cm. 23, 27, 31, 34–36. *Quadrum gothicum*; (23) Sample 130-807C-66R-3, 6–8 cm; (27) Sample 130-807C-70R-4, 64–66 cm; (31) Sample 130-807C-69R-2, 105–106 cm; (34) Sample 130-807C-66R-3, 6–8 cm; (35) Sample 130-807C-69R-5, 69–70 cm; (36) Sample 130-807C-65R-1, 75–76 cm, PH. 24. *Micula* sp., Sample 130-807C-62R-1, 112–113 cm. 25. *Cylindralithus* sp., Sample 130-807C-55R-1, 142–143 cm. 26. *Ceratolithoides aculeus*?, Sample 130-807C-69R-5, 69–70 cm. 30. *Thoracosphaera* sp., Sample 130-807C-67R-1, 45–46 cm. 32. *Parhabdolithus embergeri*, Section 130-807C-60R-CC. 33. *Prediscosphaera cretacea*, Sample 130-807C-62R-1, 112–114 cm.