DAVID BUKRY

Core 7 and allow division of the *Coccolithus doronicoides* Zone into lower and upper subzones at DSDP 132.

Coccolithus doronicoides Zone

Gephyrocapsa caribbeanica Subzone

The assemblage of the upper subzone of the *C.* doronicoides Zone is similar to that of the *E. annula* Subzone, but the first appearance and common occurrence of *Gephyrocapsa caribbeanica* below the first appearance of *G. oceanica* is used to define this unit.

Gephyrocapsa oceanica Zone

This unit is defined at the base by the first occurrence of G. oceanica. Assemblages of the zone are characterized by Ceratolithus cristatus, Cyclococcolithina leptopora, Gephyrocapsa aperta, G. caribbeanica, G. oceanica, Helicopontosphaera kamptneri [H. sellii absent or rare], Rhabdo-sphaera clavigera, and Scapholithus sp. The top of this unit is based, in light-microscope study, on the occurrence above of a great abundance of Emiliania huxleyi, a small (2 to 3 micron) faint oval coccolith.

The Pleistocene zonal assemblages of DSDP 132, in this and adjacent zones, are distinguished from open-ocean assemblages by the presence throughout of *Braarudosphaera bigelowi*, a marginal-marine species, and by the absence of *Ceratolithus cristatus*, a fully marine species. *Gephyrocapsa caribbeanica*, the most temperature-tolerant species of *Gephyrocapsa*, occurs commonly through the Pleistocene cores. The warm-water species *G. oceanica* occurs most commonly at the top of Core 7, considered the lower part of the *Gephyrocapsa oceanica* Zone. Occurrences in higher cores are sparse and discontinuous.

Emiliania huxleyi Zone

This zone, the highest coccolith zone recognized, is characterized by the overwhelming dominance of *Emiliania huxleyi*. This species cannot be definitely identified by light microscopy, but dominance of small coccoliths at the top of oceanic-sediment sections in conjunction with narrowrimmed specimens of *Helicopontosphaera kamptneri* generally results in the identification of *E. huxleyi* when electron-microscope study is carried out.

Sample 132-1-1, 142 to 143 cm contains abundant ?*Emiliania huxleyi* and some small, narrow-rimmed *Helicopontosphaera kamptneri*, with *Coccolithus pelagicus*, *Cyclococcolithina leptopora*, and *Gephyrocapsa* sp. cf. *G. caribbeanica*.

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33.2. CALCAREOUS NANNOFOSSIL AGE DETERMINATIONS, DEEP SEA DRILLING PROJECT, LEG 13

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This paper contains age determinations made on a suite of samples from the cores collected during Leg 13 of the Deep Sea Drilling Project. With the exception of Site 120 in the eastern North Atlantic, all samples containing nannofossils are Neogene in age. The samples from Site 120 were dated approximately, based on meager literature available for the Jurassic and lower Cretaceous calcareous nannofossils. Inconsistency in the results obtained by the several workers who have studied this interval, lack of rigorous nomenclature, and the absence of nannoconids in the samples, make the ages assigned to Samples 13-120-2-1; 70 cm and 13-120-7-1; 33-34 cm mere estimates. The age assignments for the remaining samples, for the most part, can be considered fairly reliable despite frequent contamination of Neogene suites by older Tertiary and Cretaceous coccoliths. The zonation scheme used here for the Pliocene-Pleistocene is that proposed by Gartner (1969) and subsequently incorporated by Martini and Worsley (Figure 1). The *Discoaster pentaradiatus* Zone, which was added by Martini and Worsley (1970) and was indicated as an identifiable interval in the range chart of Gartner (1969) is not used here. The time interval represented by this zone is so short as to make it of no practical use in deep-sea sediment.

In some instances samples were not dated as to zone, instead broader age assignments are indicated. These samples generally contain a provincial nannofossil suite with key species lacking; or the assemblage is mixed over a short interval but across zonal boundaries so that mutually exclusive species may occur together.

Pleistocene	Emiliania huxleyi Gephyrocapsa oceanica Pseudoemiliania lacunosa
Pliocene	Discoaster brouweri Discoaster surculus Reticulofenestra pseudoumbilica Discoaster asymmetricus Ceratolithus rugosus
Miocene	Ceratolithus tricorniculatus Discoaster quinqueramus

Figure 1. Neogene calcareous nannofossil zones.

13-120-2-1, 70 cm:

Maslovella barnesae, Cretarhabdus, sp., Lithraphidites carniolensis (no Prediscosphaera; no Eiffellithus), Cyclagelosphera margerelli, Staurolithites sp., Markalius circumradiatus, Micrantholithus hochschulzi cf. Calcicalathina oblonga, Rucinolithus irregularis Corollithion exiguum, cf. Cretaturbella rothii, Cruciellipsis cuvillieri. Age: Late Valanginian to early Hauterivian.

13-120-7-1, 33-44 cm:

Diazomatolithus lehmani, Cretarhabdus conicus, Cruciellipsis cuvillieri, Coccolithus britannicus, Stephanolithion laffittei, Podorhabdus sp.

Age: ? Portlandian – Purbeckian.

13-121-1-1, 17-18 cm: Coccolithus pelagicus, Gephyrocapsa oceanica Age: Gephyrocapsa oceanica Zone.

13-121-1-5, 0-1 cm: Age: As above.

13-121-2-1, 4-5 cm: Age: As above.

13-121-2-6, 3-4 cm: Age: As above.

13-121-3-1, 102-103 cm: Gephyrocapsa oceanica, Pseudoemiliania lacunosa. Age: Pseudoemiliania lacunosa Zone.

13-121-3-4, 9-10 cm: Age: As above. 13-121-4-1, 2-3 cm: Age: As above.

13-121-4-6, 3-4 cm: Age: As above.

13-121-7-1, 105-106 cm: Age: As below.

13-121-8-1:

Pseudoemiliania lacunosa, Cyclococcolithina macintyrei (no discoasters).

Age: Probably Discoaster brouweri Zone, late Pliocene.

13-121-9-1, 95-96 cm:

Discoaster sp. (6 rays, possibly indigenous). Age: As above.

13-121-10-1, 74-75 cm:

Discoaster brouweri, cf. Discoaster surculus, Pseudoemiliania lacunosa.

Age: Discoaster surculus Zone.

13-121-10-2, 12-13 cm: Age: As above.

13-121-13-1, 133-134 cm: Age: As above.

13-121-14-1, 120-121 cm: *Reticulofenestra pseudoumbilica, Pseudoemiliania lacunosa*. Age: Probably as above.

13-121-15-1, pieces: Calcareous detritus; no nannofossils.

13-121-19-1, 120-122 cm: Discoaster variabilis, Reticulofenestra pseudoumbilica. Age: Probably pre-Reticulofenestra pseudoumbilica Zone.

13-121-22-CC, 116-117 cm: Sphenolithus abies; Reticulofenestra pseudoumbilica. Age: Late Neogene.

13-121-23-2, 87-88 cm: Age: As above.

13-121-24-1, 114-117 cm: Discoaster variabilis, Discoaster exilis, Sphenolithus abies, Reticulofenestra pseudoumbilica. Age: Neogene, late Miocene to early Pliocene.

13-121-24-2, 93-94 cm: Discoaster exilis, Reticulofenestra pseudoumbilica, Sphenolithus abies, Discoaster variabilis, cf. Discoaster surculus. Age: Late Miocene to early Pliocene.

13-122-1-1, 107-108 cm: Emiliania huxleyi, Gephyrocapsa spp. Age: Emiliania huxleyi Zone.

13-122-1-2, 3-4 cm: Gephyrocapsa spp. Age: Gephyrocapsa oceanica Zone.

13-122-CC, 2-3 cm: *Reticulofenestra pseudoumbilica, Sphenolithus abies.* Age: Pre-mid Pliocene.

13-122-2-2, 9-10 cm: Age: Probably as above.

STEFAN GARTNER, JR.

13-122-3-CC, 1-2 cm: Calcareous detritus, no nannofossils.

13-123-1-2, 2-3 cm: Emiliania huxleyi. Age: Emiliania huxleyi Zone.

13-123-1-3, 2-3 cm: Calcareous detritus; no nannofossils.

13-123-2-1, 77-78 cm: Pseudoemiliania lacunosa, Gephyrocapsa oceanica. Age: Pseudoemiliania lacunosa Zone.

13-123-3-1, 88-89 cm: Pseudoemiliania lacunosa, Discoaster pentaradiatus, Coccolithus pelagicus. Age: Late Pliocene.

13-123-4-2, 17-20 cm: Age: As above.

13-123-4-3, 15-16 cm: Age: As above.

13-123-5-1, 97-98 cm: Discoaster tamalis, Discoaster asymmetricus, Sphenolithus abies, Reticulofenestra pseudoumbilica. Age: Early to mid Pliocene.

13-123-5-2, 1-2 cm: Age: As above.

13-123-6-1, 83-84 cm: Age: As above.

13-124-1-1, 2-3 cm: Pseudoemiliania lacunosa, Gephyrocapsa oceanica. Age: Pseudoemiliania lacunosa Zone.

13-124-1-6, 1-2 cm: Age: As above.

13-124-2-1, 26-27 cm: Pseudoemiliania lacunosa, Cyclococcolithina macintyrei, Coccolithus pelagicus (no Gephyrocapsa). Age: Probably latest Pliocene.

13-124-2-4, 1-2 cm: Age: As above.

13-124-3-1, 105-106 cm: Reticulofenestra pseudoumbilica, Discoaster asymmetricus, Discoaster brouweri. Age: Early to mid Pliocene.

13-124-3-2, 5-6 cm: Age: As above.

13-124-4-1, 81-82 cm: Age: Probably as above.

13-124-4-4, 1-2 cm: Discoaster surculus, Reticulofenestra pseudoumbilica, Discoaster pentaradiatus, Sphenolithus abies. Age: Probably late Miocene.

13-124-5-1, 102-104 cm: Age: As above.

13-124-5-2, 8-9 cm: Age: As above. 13-124-7-1, 1-2 cm: Mostly detritus, insufficient material, poor preservation.

13-124-10-2, 99-100 cm: No calcareous nannofossils.

13-125-1-1, 10 cm: Gephyrocapsa spp. Age: Gephyrocapsa oceanica Zone.

13-125-1-5, 15 cm: Age: As above.

13-125-2-1, 120 cm: Pseudoemiliania lacunosa, Gephyrocapsa spp. Age: Pseudoemiliania lacunosa Zone.

13-125-2-5, 70 cm: Age: As above.

13-125-3-1, 44-45 cm: Age: As above.

13-125-3-6, 3-4 cm: Age: As above.

13-125-4-1, 10-11 cm: Age: As above.

13-125-4-6, 10-11 cm: *Pseudoemiliania lacunosa* (no *Gephyrocapsa*, no *Discoaster*). Age: Probably latest Pliocene.

13-125-5-1, 10-11 cm: Age: As above.

13-125-5-CC, 70-71 cm: Discoaster pentaradiatus, Pseudoemiliania lacunosa, Coccolithus pelagicus, Cyclococcolithina leptopora, Discoaster surculus. Age: Discoaster surculus Zone.

13-125-6-1, 10-11 cm: Age: As above.

13-125-6-3, 13-14 cm: Age: As above. 13-125-7-2, 10-11 cm:

Age: As above.

13-125-7-5, 10-11 cm: Age: As above.

13-125A-1-1, 74-75 cm: Cyclococcolithina macintyrei, Pseudoemiliania lacunosa. Age: Probably late Pliocene.

13-125A-1-2, 10-11 cm: Discoaster brouweri, Pseudoemiliania lacunosa. Age: Discoaster brouweri Zone.

13-125A-1-2, 2-3 cm: Reticulofenestra pseudoumbilica, Pseudoemiliania lacunosa; mixed assemblage.

13-125A-2-1, 70-71 cm: Pseudoemiliania lacunosa, Cyclococcolithina macintyrei. Age: Late Pliocene.

13-125A-3-1, 30-31 cm: Age: As above. 13-125A-4-1, 7-8 cm: Discoaster tamalis (no Pseudoemiliania lacunosa, no Reticulofenestra pseudoumbilica). Age: Mid Pliocene.

13-125A-4-2, 86-87 cm: Age: As above.

13-125A-5-1, 101-102 cm: Age: Probably as above.

13-125A-5-4, 4-5 cm: Sphenolithus abies, Discoaster surculus, Reticulofenestra pseudoumbilica, Discoaster pentaradiatus. Age: Early Pliocene.

13-126-1-2: Gephyrocapsa spp. Age: Probably Gephyrocapsa oceanica Zone.

13-126-1-6, 11-12 cm: Gephyrocapsa spp., Pseudoemiliania lacunosa. Age: Pseudoemiliania lacunosa Zone.

13-126-2-1, 16-17 cm: Age: As above.

13-126-2-5, 113-114 cm: Age: As above.

13-126-3-1, 134 cm: Age: As above.

13-126-3-2, 10-11 cm: Age: As above.

13-126-6-1, 100 cm: Reticulofenestra pseudoumbilica. Age: Mid-Miocene to mid-Pliocene (inadequate assemblage).

13-126A-1-1, 125-126 cm: Discoaster variabilis, Reticulofenestra pseudoumbilica, Discoaster aff. D. bollii. Age: Probably late middle Miocene.

13-126A-1-1, 135 cm: Age: As above.

13-127-1-1, 13-14 cm: Gephyrocapsa spp.-mixed assemblage. Age: Pleistocene, probably late Pleistocene.

13-127-1-5, 13-14 cm: Age: As above.

13-127-2-1, 70-71 cm: *?Emiliania huxleyi, Gephyrocapsa* spp. Age: Probably as above.

13-127-2-5, 10-11 cm: Gephyrocapsa spp. Age: Probably Gephyrocapsa oceanica Zone. 13-127-4-2, 14-15 cm:

Age: As above.

13-127-5-2, 10-11 cm: Age: As above.

13-127-6-2, 10-11 cm: Pseudoemiliania lacunosa, Gephyrocapsa spp. Age: Pseudoemiliania lacunosa Zone. 13-127-7-2, 10-11 cm: Age: As above. 13-127-8-2, 10-11 cm: Age: As above. 13-127-9-1, 30-31 cm: Age: As above. 13-127-10-2, 10-11 cm: Age: As above. 13-127-11-1, 85-86 cm: Age: As above. 13-127-12-3, 10-11 cm: Age: As above. 13-127-13-1, 49-50 cm: Age: As above. 13-127-14-1, 10-11 cm: Age: As above. 13-127-14-6, 11-12 cm: Age: As above.

13-127-15-2, 10-11 cm: Age: As above.

13-127-18-1, 79-80 cm: Pseudoemiliania lacunosa, Discoaster brouweri. Age: Discoaster brouweri Zone.

13-127A-2-2, 10-11 cm: Pseudoemiliania lacunosa, Gephyrocapsa spp., Emiliania huxleyi. Age: Mixed Pleistocene assemblage.

13-127A-2-3, 10-11 cm: Gephyrocapsa spp., Pseudoemiliania lacunosa. Age: Pseudoemiliania lacunosa Zone.

13-127A-3-1, 125-126 cm: Age: As above.

13-127A-3-6, 10-11 cm: Age: As above. 13-127A-4-2, 10-11 cm:

Age: As above.

13-127A-4-5, 6-7 cm: Age: As above.

13-128-1-1, 140-141 cm: Emiliania huxleyi. Age: Emiliania huxleyi Zone.

13-128-1-3, 37 cm: Age: *Gephyrocapsa oceanica* Zone.

13-128-2-2, 10-11 cm: Pseudoemiliania lacunosa, Gephyrocapsa spp. Age: Pseudoemiliania lacunosa Zone.

13-128-3-3, 59-60 cm: Age: As above. 13-128-4-2, 10-11 cm: Age: As above. 13-128-5-2, 10-11 cm: Age: As above.

STEFAN GARTNER, JR.

13-128-6-2, 10 cm: Age: As above. 13-128-7-2, 13-14 cm: Age: As above. 13-128-8-2, 10 cm: Age: As above. 13-128-10-2, 25 cm: Age: As above. 13-128-11-2, 13-14 cm: Age: As above. 13-129-2-1, 87-89 cm: Calcareous detritus with mixed Neogene nannofossil assemblage. 13-129-3-1, 15-16 cm: Reticulofenestra pseudoumbilica, Sphenolithus abies, Discoaster cf. D. exilis (contaminated). Age: Probably late middle Miocene. 13-129A-3-1, 15 cm: Reticulofenestra pseudoumbilica, Sphenolithus belemnos, Sphenolithus abies (mixed assemblage). Age: Possibly somewhere in the middle Miocene. 13-130-1-1, 100 cm: Pseudoemiliania lacunosa, Gephyrocapsa spp. Age: Pseudoemiliania lacunosa Zone. 13-130-1-2, 5 cm: Age: As above. 13-130-1-4, 12-13 cm: Age: As above. 13-130-2-1, 46 cm: Age: As above. 13-130-2-3, 10 cm: Age: As above. 13-130-3-2, 28 cm: Age: As above. 13-130-4-2, 7 cm: Age: As above. 13-130-5-2, 15 cm: Pseudoemiliania lacunosa (sparse assemblage). Age: Mid Pliocene to Pleistocene. 13-130-5-3, 11-12 cm: Pseudoemiliania lacunosa, Gephyrocapsa spp. Age: Pseudoemiliania lacunosa Zone. 13-130-6-2, 74 cm: Pseudoemiliania lacunosa, Discoaster brouweri. Age: Discoaster brouweri Zone. 13-130-6-4, 50-51 cm: Age: As above. 13-131-1-1, 10-11 cm: Gephyrocapsa spp. Age: Probably Gephyrocapsa oceanica Zone. 13-131A-1-1, 137 cm: Pseudoemiliania lacunosa, ? Gephyrocapsa spp. Age: Probably Pseudoemiliania lacunosa Zone.

13-131A-1-2, 10-11 cm: Age: Probably as above. 13-131A-3-1, 118-119 cm: Pseudoemiliania lacunosa Zone. 13-131A-4-1, 110 cm: Age: Probably as above. 13-131A-5-2, 4-5 cm: Age: Probably as above. 13-132-1-1, 25-26 cm: Gephyrocapsa spp., ?Emiliania huxleyi. Age: Emiliania huxleyi Zone. 13-132-1-6, 6-7 cm: Gephyrocapsa spp. Age: Gephyrocapsa oceanica Zone. 13-132-2-1, 90 cm: Age: As above. 13-132-2-4, 14-15 cm: Age: As above. 13-132-3-1, 79-80 cm: Age: As above. 13-132-3-4, 15-16 cm: Pseudoemiliania lacunosa, Gephyrocapsa spp. Age: Pseudoemiliania lacunosa Zone. 13-132-4-1, 119-120 cm: Age: As above. 13-132-4-6, 20-21 cm: Age: As above. 13-132-5-1, 10 cm: Age: As above. 13-132-5-3, 10-11 cm: Age: As above. 13-132-6-1, 16 cm: Age: As above. 13-132-6-6, 30-32 cm: Age: As above. 13-132-7-1, 9 cm: Age: As above. 13-132-7-6, 5 cm: Age: As above. 13-132-8-1, 15 cm: Age: As above. 13-132-8-6, 5-6 cm: Age: As above. 13-132-9-1, 10-11 cm: Age: Probably oldest Pleistocene. 13-132-9-6, 10 cm: Age: Pseudoemiliania lacunosa Zone. 13-132-10-1, 10 cm: Age: As above. 13-132-10-6, 10 cm: Discoaster brouweri; Discoaster pentaradiatus, Pseudoemiliania lacunosa. Age: Discoaster brouweri Zone.

13-132-11-1, 10 cm: Age: As above.

13-132-11-4, 10 cm: Discoaster variabilis, Discoaster surculus, Pseudoemiliania lacunosa.

Age: Discoaster surculus Zone.

13-132-12-1, 5 cm: Age: As above.

13-132-12-2, 5 cm: Age: As above.

13-132-13-1, 5 cm: Discoaster asymmetricus, Discoaster tamalis, Discoaster surculus. Age: Mid-Pliocene.

13-132-14-2, 10 cm: Age: As above.

13-132-16-1, 5 cm: Reticulofenestra pseudoumbilica, Sphenolithus abies, Discoaster pentaradiatus. Age: Early Pliocene.

13-132-17-1, 5 cm:

Age: Probably as above (very poor preservation).

13-132-18-1, 5 cm: *Reticulofenestra pseudoumbilica, Discoaster brouweri.* Age: Late Miocene or early Pliocene.

13-132-19-2, 10 cm: Discoaster brouweri, Discoaster pentaradiatus, cf. Discoaster brouweri rutellus, Reticulofenestra pseudoumbilica, Discoaster variabilis. Age: Probably late Miocene.

13-132-20-2, 10 cm: Age: As above.

13-132-21-2, 5 cm: Age: As above. 13-132-22-1, 100 cm: Age: Probably as above.

13-132-25-1, 05 cm: Barren of nannofossils.

13-132-26-1, 13-14 cm: Barren of nannofossils.

13-133-1-1, 130 cm: Gephyrocapsa spp. Age: Gephyrocapsa oceanica Zone.

13-133-1-2, 70 cm: Age: As above.

13-133-5-1, 35 cm: Barren of nannofossils.

13-134-3-1, 20 cm: Discoaster variabilis, Pseudoemiliania lacunosa, Discoaster brouweri, Discoaster pentradiatus. Age: Discoaster surculus Zone.

13-134-5-2, 31 cm: Age: As above.

13-134-6-1, 20 cm: Reticulofenestra pseudoumbilica, Sphenolithus abies, Discoaster brouweri, Discoaster asymmetricus. Age: Early Pliocene.

13-134-7-1, 105 cm: Age: As above.

13-134-7-5, 49-50 cm: Age: Probably as above.

13-134A-1-1, 139 cm: Gephyrocapsa spp. Age: Gephyrocapsa oceanica Zone.

13-134A-1-2, 15 cm: Age: As above.