Paleocene and Maastrichtian calcareous nannofossils from clasts in Pleistocene glaciomarine muds from the northern James Ross Basin, western Weddell Sea, Antarctica

D.K. Kulhanek

Department of Geological Sciences, Florida State University, 108 Carraway Building, Tallahassee, FL 32306-4100, USA (kulhanek@gly.fsu.edu)

Abstract Site NBP0602A-9, drilled during the SHALDRIL II cruise of the RV/IB *Nathaniel B. Palmer*, includes two holes located in the northern James Ross Basin in the western Weddell Sea, very close to the eastern margin of the Antarctic Peninsula. Sediment from both holes consists of very dark grey, pebbly, sandy mud, grading to very dark greenish grey, pebbly, silty mud in the lower 2.5 m of the second hole. In addition to abundant pebbles found throughout the cores, both holes contain numerous sedimentary clasts. Biostratigraphic analysis of diatom assemblages from the glaciomarine muds yields rare to few, poorly preserved diatoms. The mixed assemblage consists mostly of extant species, but also includes reworked taxa that range to the Miocene. The absence of *Rouxia* spp., however, suggests the sediment is late Pleistocene in age. The sedimentary clasts, on the other hand, are nearly barren of diatoms, but contain rare, moderately to well-preserved calcareous nannofossils. The clasts contain three distinct assemblages. Two clasts are assigned an early Maastrichtian age based on the presence of *Biscutum magnum* and *Nephrolithus corystus*, while one clast yields a late Maastrichtian age based on the presence of *Nephrolithus frequens*. These samples also contain other characteristic Late Cretaceous species, including *Biscutum notaculum*, *Cribrosphaerella daniae*, *Eiffellithus gorkae*, *Kamptnerius magnificus*, and *Prediscosphaera bukryi*. Two samples yield an early Paleocene assemblage dominated by *Hornibrookina teuriensis*. The Maastrichtian assemblages are similar to those found in the López de Bertodano Formation on Seymour and Snow Hill Islands, making it the likely source area for the Cretaceous clast material. Although no calcareous nannofossils have been reported from Paleocene formations on these islands, the occurrence of calcareous foraminifers suggests other calcareous plankton may be present; thus the Paleocene clasts likely also originated from the Seymour Island area.

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Introduction

The SHALDRIL II Cruise NBP0602A was the second cruise to the Antarctic margin on which a drilling rig was installed on the RV/IB *Nathaniel B. Palmer* to allow penetration of glacial overburden. This cruise drilled 12 sites in the James Ross Basin in the western Weddell Sea, very close to the Antarctic Peninsula (Fig. 1), with the objective of obtaining cores from key intervals during the evolution of the Antarctic cryosphere, including the upper Eocene/lower Oligocene, upper Oligocene, and Miocene. Although a particularly difficult ice year precluded drilling at any one site for extended periods of time, the cruise was a success, obtaining cores from each of the targeted intervals. With multiyear sea-ice coverage approaching 100% near the proposed sites, several attempts yielded core, but did not reach the targeted interval.

Site NBP0602A-9 targeted lower Oligocene sediments at a location just east of James Ross Island (Fig. 1). Two holes were attempted at Site 9, but both had to be abandoned due to approaching ice prior to reaching the target interval situated some 20 meters below the seafloor (mbsf). Hole 9A reached 4.23 mbsf, recovering approximately 2 m of core, whereas Hole 9B penetrated to 10 mbsf, recovering 5.6 m of core. Although neither hole reached the intended target, both yielded numerous sedimentary clasts that, upon shipboard examination, contain well-preserved calcareous nannofossils.

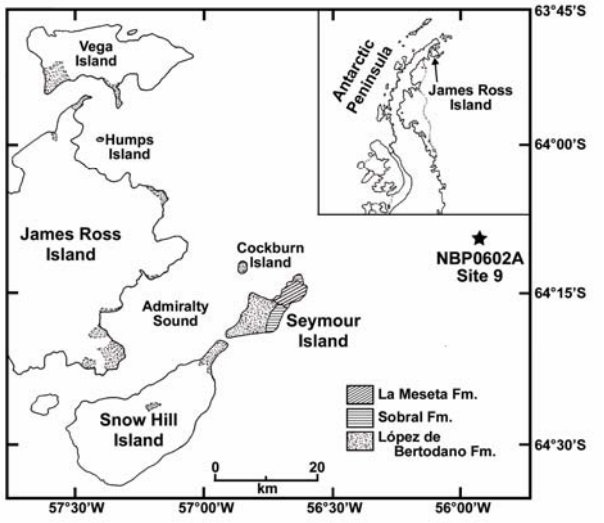

Figure 1. Locality map for the western Weddell Sea and James Ross Island region of the Antarctic Peninsula. Site NBP0602A-9 is indicated with a star. Outcrops of the Maastrichtian-Paleocene López de Bertodano Formation, Paleocene Sobral Formation, and Eocene La Meseta Formation in the James Ross Island region are shown. The inset figure shows the location of James Ross Island on the Antarctic Peninsula. (Modified from Pirrie et al., 1997.)

Site NBP0602A-9

Sediment from both Holes NBP0602A-9A and -9B consists of very dark grey to very dark greenish grey pebbly sandy or silty mud. Pebble lithologies in both holes include volcanics, quartzites, and poorly indurated sedimentary clasts, although they are not present in Hole 9B below 8.7 mbsf (Anderson et al., 2006). The mud matrix contains a mixed assemblage of rare to few poorly preserved diatoms. The presence of extant taxa and the absence of *Rouxia* spp. suggest a late Pleistocene age for the drilled sections, whereas the occurrence of older taxa (including *Actinocyclus ingens* and *Denticulopsis vulgaris*) is attributed to reworking (Anderson et al., 2006). Sedimentary clasts range in size from a few millimeters to two centimeters in diameter, and consist of sandy mud with only trace numbers of broken diatoms that are probably contamination for the surrounding matrix. Shipboard examination of two clasts from Hole 9A found a rare, but diverse assemblage of moderately to well-preserved Maastrichtian calcareous nannofossils.

Materials and Methods

Eight clasts from Hole NBP0602A-9B were sampled and examined for calcareous nannofossils. Samples were prepared following standard smear slide procedures, and examined on a Zeiss Axioskop microscope at 1250x. At least 800 fields of view (FOVs) were examined for each sample. Calcareous nannofossils were very rare, and therefore reported as total number of specimens found during examination.

Results

Five of the clasts contain biostratigraphically useful assemblages, two are barren or nearly so, and one contains a mixed assemblage of Cretaceous and Paleogene calcareous nannofossils (Table 1). Calcareous nannofossils are quite rare, but moderately to well preserved within the clasts. The first sample, NBP0602A-9B-2R$_a$, 12 cm, is barren of calcareous nannofossils. Sample NBP0602A-9B-2R$_a$, 21 cm contains a well-preserved Paleocene assemblage. The most abundant species in this clast is *Hornibrookina teuriensis*, a species typical of Paleocene southern high latitudes (Wei and Pospichal, 1991). Biostratigraphically useful species include *Cruciplacolithus intermedius*, *Cr. tenuis*, and *Chiasmolithus danicus*. Several specimens assigned to *Neocrepidolithus* spp. occur in the sample, as does *Braarudosphaera bigelowii* and the holococcolith *Lanternithus duocavus*. Sample NBP0602A-9B-2R$_a$, 126 cm contains a very similar Paleocene assemblage, with *H. teuriensis* the most abundant species. In addition to *B. bigelowii* and a single *Neocrepidolithus* spp., this sample contains a very small placolith assigned to *Neobiscutum* spp.

Sample NBP0602A-9B-2R$_a$, 71 cm contains a mixed assemblage of Cretaceous and Paleogene species. Calcareous nannofossils are very rare throughout the sample; only seven specimens were observed in the 800 FOVs examined. Two fragments of *Thoracosphaera* spp. and a *B. bigelowii* fragment are not biostratigraphically useful. *Biscutum notaculum* and a fragment of *Kamptnerius magnficus* are indicative of a Cretaceous age. This sample also contains a well preserved specimen of *Octolithus multiplus*, which ranges from the Maastrichtian to the Paleogene.

Sample NBP0602A-9B-2R$_a$, 79 cm contains a late Maastrichtian assemblage. The most abundant species in this sample is represented by *Prediscosphaera bukryi*, which has a range restricted to the late Campanian-Maastrichtian. Other biostratigraphically useful species present are *Nephrolithus frequens* and *Cribrosphaerella daniae*. This clast also contains *Acuturris scotus*, *B.*

Table 1. Distribution of Cretaceous and Paleogene calcareous nannofossil species in clasts from Site NBP0602A-9. K/P survivors are species that survived the Cretaceous/Paleogene boundary extinction event.

			Cretaceous													K/P Survivors			Paleogene							
Sample	Total Abundance	Preservation	*Acuturris scotus*	*Biscutum magnum*	*Biscutum notaculum*	*Cribrosphaerella daniae*	*Cyclagelosphaera reinhardtii*	*Eiffellithus gorkae*	*Kampnerius magnificus*	*Misceomarginatus pleniporus*	*Nephrolithus corystus*	*Nephrolithus frequens*	*Prediscosphaera bukryi*	*Prediscosphaera spinosa*	*Rhagodiscus splendens*	*Braarudosphaera bigelowii*	*Octolithus multiplus*	*Thoracosphaera* spp.	*Chiasmolithus danicus*	*Cruciplacolithus intermedius*	*Cruciplacolithus tenuis*	*Hornibrookina teuriensis*	*Lanternithus duocavus*	*Neobiscutum* spp.	*Neocrepidolithus* spp.	*Reticulofenestra* spp.
NBP0602A-9B-2R$_a$, 12 cm	0	-																								
NBP0602A-9B-2R$_a$, 21 cm	37	G														5		2	1	1	1	21	2		4	
NBP0602A-9B-2R$_a$, 71 cm	7	G			1				1							1	1	2								1
NBP0602A-9B-2R$_a$, 79 cm	23	M-G	1		2	3		3	3	2		2	5			2										
NBP0602A-9B-2R$_a$, 84 cm	20	G	1	4			2	1	5		3			1	?	1		2								
NBP0602A-9B-2R$_a$, 107 cm	4	M-G									1					2	1									
NBP0602A-9B-2R$_a$, 111 cm	1	G														1										
NBP0602A-9B-2R$_a$, 126 cm	13	M-G														2						9		1	1	

bigelowii, *B. notaculum*, *Eiffellithus gorkae*, *Micseomarginatus pleniporus*, and fragments of *K. magnificus*

Sample NBP0602A-9B-2R$_a$, 84 cm also contains rare Maastrichtian calcareous nannofossils. The presence of *Biscutum magnum* and *Nephrolithus corystus* indicate a somewhat older age than the previous sample. The most abundant species is *K. magnificus*, several specimens of which are whole and well preserved. The overall assemblage is generally similar to that of the previous sample, and includes *A. scotus*, *E. gorkae*, and *Prediscosphaera spinosa*. Other species present include *Thoracosphaera* spp., small *Cyclagelosphaera reinhardtii*, and a single broken specimen of what appears to be *Rhagodiscus splendens*. Sample NBP0602A-9B-2R$_a$, 107 cm contains a sparse assemblage that includes *N. corystus*, *B. bigelowii*, and *O. multiplus*. The presence of *N. corystus* suggests this clast is the same age as the clast from 84 cm. Only a single specimen of *B. bigelowii* was found in the final clast (Sample NBP0602A-9B-2R$_a$, 111 cm).

Discussion

Clast Ages

Five of the seven clasts that contain calcareous nannofossils can be assigned to a biostratigraphic zone based on the assemblages present. The Paleocene samples (NBP0602A-9B-2R$_a$, 21 cm and 126 cm) are assigned to early Paleocene Antarctic Zone NA4 (Wei and Pospichal, 1991) based on the presence of *Ch. danicus* and absence of *Prinsius martinii* in the former clast. Although the latter clast did not yield any biostratigraphic markers, the assemblage is very similar to that in the former, and thus is presumed to come from the same horizon.

Sample NBP0602A-9B-2R$_a$, 79 cm contains a late Maastrichtian assemblage assigned to the *C. daniae* Subzone of the *N. frequens* Zone of Pospichal and Wise (1990) based on the presence of these species, and the absence of *N. corystus*. Sample NBP0602A-9B-2R$_a$, 84 cm contains an early Maastrichtian assemblage assigned to the *B. magnum* Zone of Pospichal and Wise (1990) based on the presence of this species. Although Sample NBP0602A-9B-2R$_a$, 107 cm did not contain *B. magnum*, it does contain an older assemblage compared to the clast at 79 cm based on the presence of *N. corystus*, which has a last occurrence shortly after the first occurrence of *N. frequens*. The presence of *N. corystus* therefore supports an early to earliest late Maastrichtian age for this clast, potentially from the same horizon as the clast from 84 cm.

Clast Provenance

Cretaceous and Paleocene sediments occur in outcrops on Antarctic Peninsular islands along the western margin of the James Ross Basin (e.g., Rinaldi, 1982; Macellari and Huber, 1982; Macellari, 1988; Pirrie et al., 1997; Crame et al., 2004). The fossiliferous López de Bertodano Formation, which crops out on Seymour, Snow Hill, and James Ross Islands (Fig. 1) spans the upper lower Maastrichtian to the Danian based on diatom, foraminifer, and calcareous nannofossil assemblages (e.g., Huber et al., 1983; Harwood, 1988; Huber, 1988; Crame et al., 2004). The overlying Sobral Formation is also Paleocene in age based on diatoms (Harwood, 1988) and foraminifers (Huber, 1988).

There have been very few studies that report Cretaceous calcareous nannofossils from outcrops on Seymour Island (Huber et al., 1983; Concheyro et al., 1991; and Concheyro et al., 1995) and Snow Hill Island (Concheyro et al., 1995 and Robles Hurtado and Concheyro, 1995). Huber et al. (1983) reported well-preserved calcareous nannofossils from the López de Bertodano Formation on Seymour Island. The assemblage consists of Maastrichtian taxa, with the exception of *N. corystus* (latest Campanian to middle Maastrichtian), and is dominated by *B. bigelowii*. Concheyro et al. (1991) also report a well-preserved Maastrichtian flora from this formation on Seymour Island. Robles Hurtado and Concheyro (1995) find a similar, but poorly preserved Maastrichtian assemblage from the López de Bertodano Formation of Snow Hill Island. Species composition is similar to those reported from the Cretaceous clasts in this study. This, coupled with the proximity of Seymour and Snow Hill Islands, suggests the López de Bertodano Formation in those locations is the likely source for the Maastrichtian clasts.

No calcareous nannofossils have been reported from Paleocene sequences in this area, although calcareous foraminifers do occur above a dissolution facies in the lowermost Paleocene López de Bertodano Formation and in the lowermost unit of the overlying Sobral Formation on Seymour Island (Huber, 1988). Despite a dearth of reported nannofossils from the area, the Paleocene rocks of Seymour Island are the most likely provenance for the two Paleocene clasts found in this study.

Summary

Clasts found in Pleistocene glaciomarine muds of Site NBP0602A-9 contain diverse Maastrichtian and Paleocene calcareous nannofossil assemblages. These assemblages represent three distinct ages: early Maastrichtian, late Maastrichtian, and early Paleocene. The Maastrichtian assemblages are similar to those found in the López de Bertodano Formation on neighboring Seymour and Snow Hill Islands, making it the likely source area for the clast material. Although no calcareous nannofossils have been reported from Paleocene formations in the area, the occurrence of calcareous foraminifers suggests other calcareous plankton may be present; thus the Paleocene clasts likely also originated from the Seymour Island area.

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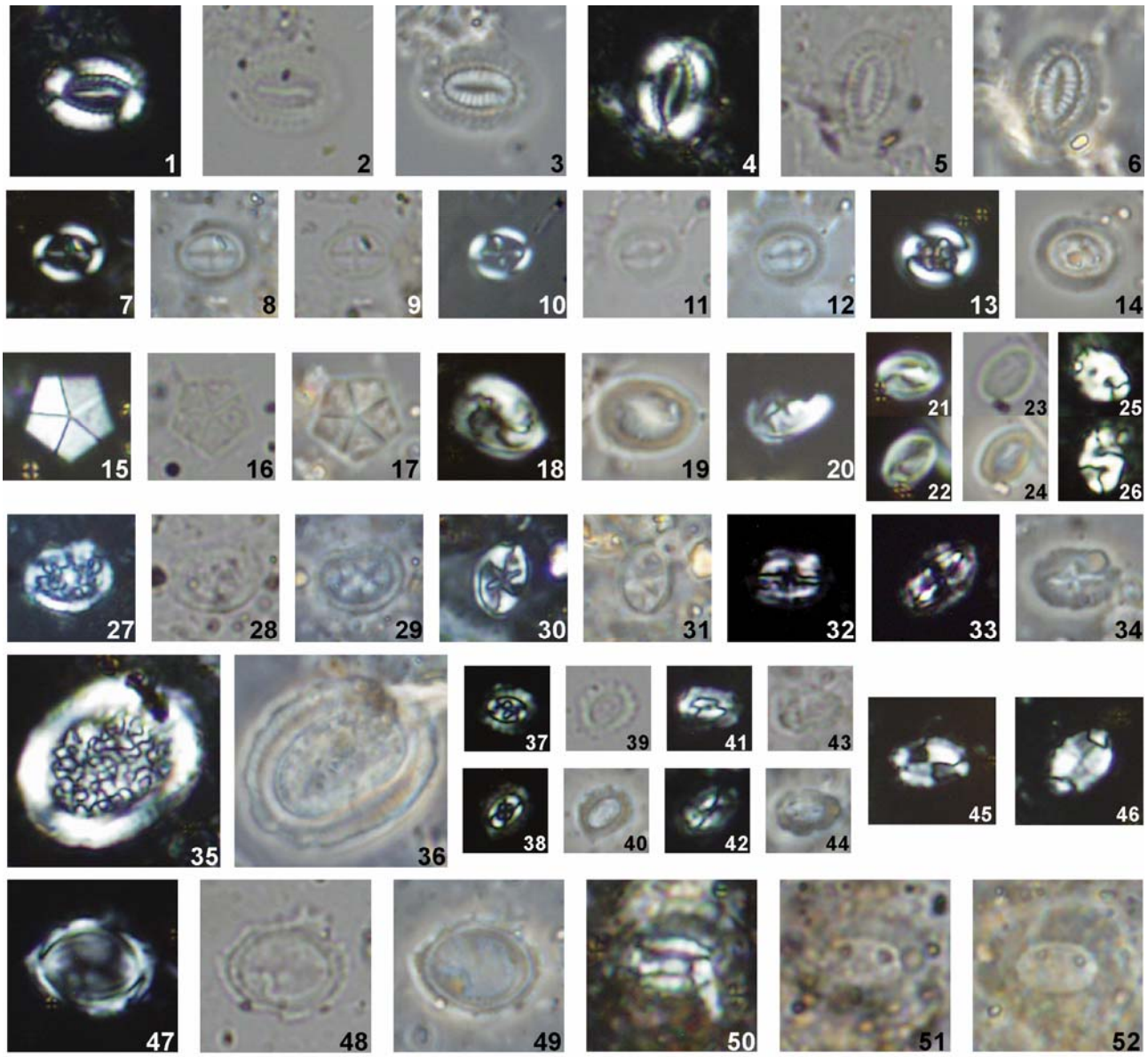

Plate 1. Micrographs taken with an Olympus DP11 digital camera on a Zeiss Axioskop 2, using a 100x objective and 1.25 optivar. All figures from Core NBP0602A-9B-2R$_a$; clast depth listed after each species. Light micrography; XP = cross-polarized light, PL = plain-transmitted light, PH = phase-contrast light. **Fig. 1-6.** *Hornibrookina teuriensis* Edwards, 1973, 21 cm, 1 (XP), 2 (PL), 3 (PH), 4 (different specimen, XP), 5 (PL), 6 (PH). **Figs. 7-9.** *Cruicplacolithus intermedius* van Heck and Prins, 1987, 21 cm, 7 (XP), 8 (PH), 9 (PL). **Figs. 10-12.** *Cruciplacolithus tenuis* (Stradner, 1961) Hay and Mohler in Hay et al., 1967, 21 cm, 10 (XP), 11 (PL), 12 (PH). **Figs. 13 and 14.** *Chiasmolithus danicus* (Brotzen, 1959) van Heck and Perch-Nielsen, 1987, 21 cm, 13 (XP), 14 (PH). **Figs. 15-17.** *Braarudosphaera bigelowii* (Gran and Braarud, 1935) Deflandre, 1947, 21 cm, 15 (XP), 16 (PL), 17 (PH). **Figs. 18-24.** *Neocrepidolithus* spp., 21 cm, 18 (XP), 19 (PH), 20 (different specimen, XP), 21, 22 (different specimen, XP), 23 (PL), 24 (PH). **Figs. 25 and 26.** *Lanternithus duocavus* Locker, 1967, 21 cm, 25, 26 (XP). **Figs. 27-29.** *Nephrolithus frequens* Górka, 1957, 79 cm, 27 (XP), 28 (PL), 29 (PH). **Figs. 30 and 31.** *Eiffellithus gorkae* Reinhardt, 1965, 79 cm, 30 (XP), 31 (PH). **Figs. 32-34.** *Misceomarginatus pleniporus* Wind and Wise in Wise and Wind, 1977, 79 cm, 32, 33 (XP), 34 (PH). **Figs. 35 and 36.** *Cribrosphaerella daniae* Perch-Nielsen, 1973, 79 cm, 35 (XP), 36 (PH). **Figs. 37-40.** *Prediscosphaera bukryi* Perch-Nielsen, 1973, 79 cm, 37, 38 (XP), 39 (PH), 40 (PH). **Figs. 41-44.** *Biscutum notaculum* Wind and Wise in Wise and Wind, 1977, 79 cm, 41, 42 (XP), 43 (PL), 44 (PH). **Figs. 45 and 46.** *Octolithus multiplus* (Perch-Nielsen, 1973) Romein, 1979, 71 cm, 45, 46 (XP). **Figs. 47-49.** *Kamptnerius magnificus* Deflandre, 1959, 79 cm, 47 (XP), 48 (PL), 49 (PH). **Figs. 50-52.** *Biscutum magnum* Wind and Wise in Wise and Wind, 1977, 84 cm, 50 (XP), 51, 52 (PH).

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