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Pleistocene agglutinated foraminifera from the Lomonosov Ridge and Amundsen Basin, Arctic Basin. Initial report on piston cores 2177-5 (KAL) and 2176-3 (KAL)

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Abstract

Noncalcareous Pleistocene sediments of the Central Arctic Ocean contain sparse benthic foraminiferal assemblages consisting entirely of agglutinated taxa. Deep water agglutinated foraminifera are studied from two piston cores collected from the Lomonosov Ridge and Amundsen Basin [Cores PS 2177-5 (KAL) and 2176-3 (KAL)]. Core PS 2177-5 (KAL) contains an assemblage of 10 species, dominated by *Cyclammina pusilla* Brady, and is interpreted to reflect a bathyal environment with variable organic flux and nutrition levels. Core PS 2176-3 (KAL) in the Amundsen Basin yielded a very depauperate benthic foraminiferal assemblage. It is assumed that the environment was inhospitable for agglutinated foraminifera.

1. Introduction

At present our knowledge of Cenozoic polar deep sea benthic foraminifera is significantly biased towards the Southern Hemisphere. Although the Antarctic region has been studied in detail since the beginning of the Deep Sea Drilling Project, the Arctic record consists entirely of short gravity and piston cores. Previous studies of Central Arctic benthic foraminifera have been confined largely to the thin veneer of calcareous Lower Pliocene to Upper Pleistocene sediments (e.g. Scott et al., 1989). The Pleistocene sediments of the central Arctic have not been systematically studied for benthic foraminifera.

The benthic foraminifera of the Central Arctic undoubtedly responded to environmental and palaeoceanographic changes associated with Cenozoic climatic cooling and the onset of northern hemisphere glaciation. The ultimate goal of our research is to develop a biostratigraphic zonation for the Neogene of the Central Arctic based on deep-water agglutinated foraminifera (DWAF) and interpret their palaeoecological significance. This report forms part of the "site survey" for anticipated deep sea drilling in the central Arctic under the Nansen Arctic Drilling Initiative.

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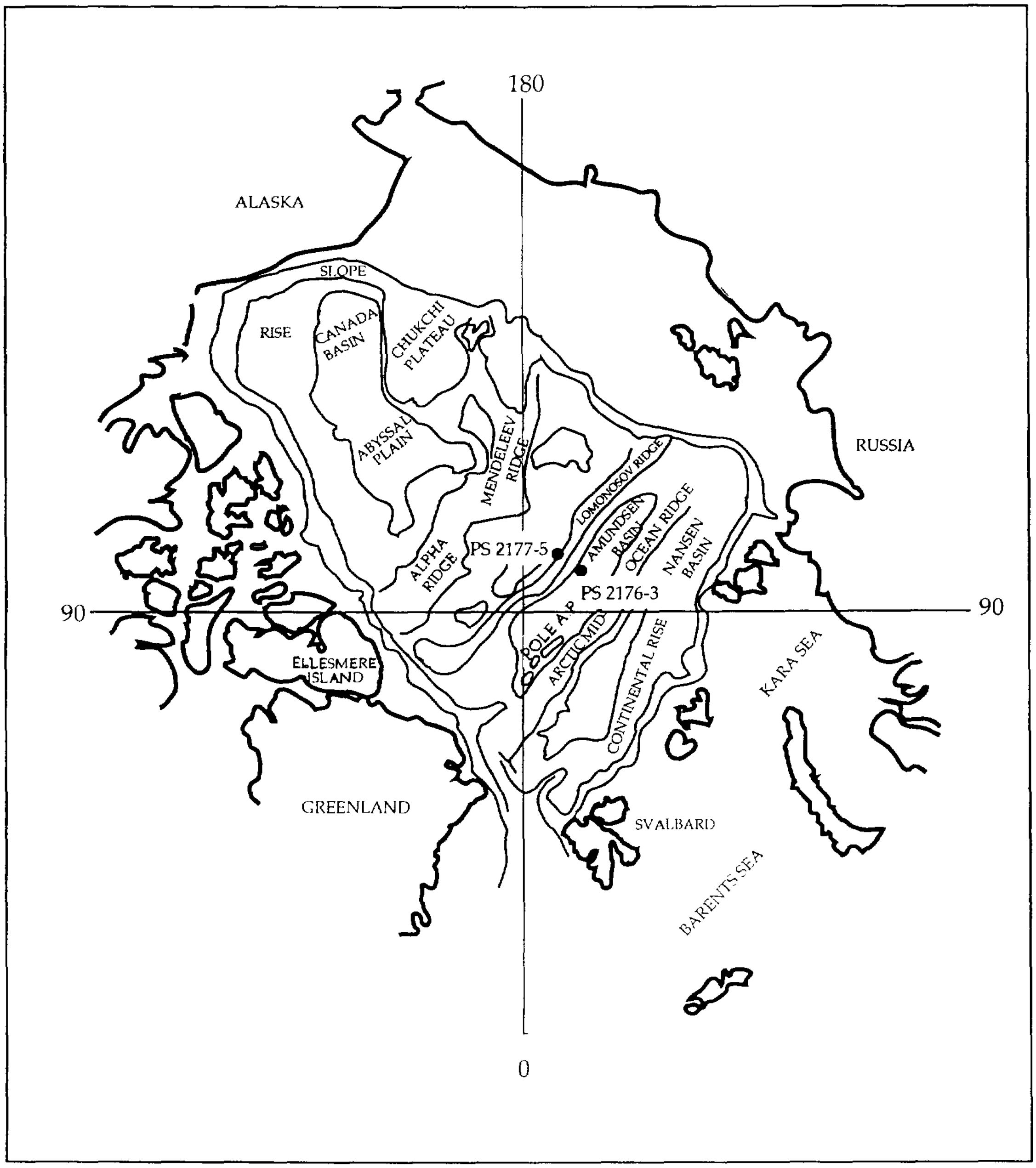

Fig. 1. Map showing location of Lomonosov Ridge and Amundsen Basin (Not to scale).

2. Materials and methods

Two cores were studied from among the piston cores collected by the RV *Polarstern* on the ARK VIII/3 (*Arctic* '91) cruise in the Arctic Ocean (Fütterer, 1992). The cores studied are Core PS 2177-5 (KAL) from a site on the Lomonosov Ridge situated at 88°2.1′N, 134°36.7′E and Core PS 2176-3 (KAL) from the Amundsen Basin situated at 87°46.3′N, 108°23.6′E (Fig. 1). The cores were collected from depths of 1400 m and 4363 m, with 6.94 m and 9.76 m of sediment recovered respectively.

Sixty-seven samples from Core 2177-5 and forty samples from Core 2176-3 were washed over a 63 μm sieve, dried, and residues were picked for foraminifera. These have a range of weights from 20 to 95 g, with an average weight of 50 g. Specimens were mounted in cardboard microscope slides, and are housed in the micropalaeontology collections of University College London. Although all foraminifera were picked from each sample, it was not possible to obtain 300 specimens, with 182 individuals being the highest value in Sample 2177-5, 545 cm weighing 60 g.

2.1. Core PS 2177-5 (KAL)

Core PS 2177-5 (KAL) has not been formally subdivided into lithological units and is therefore described as an entity. The lithology consists of very fine-grained sediment showing little variation throughout the core (Fig. 2). Clay is dominant with thin bands of silty sand/mud and clayey mud at different horizons through the core. The sediment is fine grained between Samples 2177-5, 690 cm and 415 cm, which then changes to a very sandy mud, becoming increasingly coarser above 300 cm. A large number of pyrite (FeS_2) nodules and fragments are present within the sandy mud. As a result of this, samples appear to be darker overall, with the sediment varying from light olive brown, through dark grey/brown and back to light olive green. The sediment lithology remains constant with an increasing number of silty sand bands towards the top (10 cm). At the top of the core, there is a calcareous interval which extends down to 30 cm.

2.2. Core PS 2176-3 (KAL)

As with PS 2177-5 (KAL), this core has not been subdivided into lithological units. The lithology consists of clay which contains less coarser material than in the previous core (Fig. 2). The colour ranges from dark brown to very dark brown at the base of the core, through to a lighter olive brown clay at the top. The base of the core shows a large number of silty sand horizons, which occur at different levels in the core. These decrease in frequency towards the top of the core, and some silty sand horizons show lamination and cross-bedding. The sediment in some of the samples occurs as coagulated masses and are not broken down. However, as the sediment becomes lighter in colour, it becomes finer up core, occurring as fine flakes of sediment. These samples, such as Samples 2176-3, 390, 395 and 400 cm have a certain amount of fibrous material which appears to stick the fine flakes together. Samples 2176-3, 430 cm to 410 cm are rich or very rich in quartz fragments. The calcareous interval is present in this core at the same level.

2.3. Chronostratigraphy

Sediment cores recovered from the Lomonosov Ridge generally display brownish sediments, which is an indication of low sedimentation rates. Carbon-14 analyses from nearby cores studied by Stein et al. (1994b), show very low sedimentation rates for the uppermost centimetres, with the oxygen isotopic stage 1/2 boundary at 10 cm, and Termination 2/3 at 15 cm. Results of ^{10}Be analysis suggest sedimentation rates on the order of 0.4 cm/kyr. Extrapolation of these rates suggests that cores from the Lomonosov Ridge may have penetrated Pliocene sediments.

The chronostratigraphy of Core 2177-5 is based on studies of stable isotopes using *Neogloboquadrina pachyderma* and AMS ^{14}C derived ages from selected intervals (Stein et al., 1994a). Stein et al. identified the oxygen isotopic stage 1/2 boundary (15.7 ka) at 17 cm, which yields a sedimentation rate of 1.1 cm/kyr for the Holocene. Using the data of Stein et al., the base of the calcareous interval in Core 2177-5 is about 37 ka. Glacial sedimentation rates in the area, however, vary from 0.4 to 0.7 cm/kyr which on average is a factor of 2–3 lower compared with isotopic stage boundary 1/2. If we extrapolate these rates, the base of the core may be as old as 1 Ma (lower Pleistocene).

Sedimentation rates derived from isotopes are lower than 2.1 cm/kyr for the Holocene calculated by Gard (1993) using calcareous nannoplankton. Similarly, the rates from the Lomonosov Ridge are much lower than values of 2 to 4 cm/kyr calculated by Nowaczyk and Baumann (1992) based on correlation of magneto- and calcareous nannofossil stratigraphy for Core PS 1533-3 SL on the Yermak Plateau.

There is even less chronostratigraphic information available from Core 2176-3. Carbonate content in this basinal core is low ($<1\%$) and patchy, however it has a high Total Organic Carbon (TOC) value of 0.5 to 1.5%. Stein et al. were not able to derive an oxygen isotope curve. At neighbouring Site 2175 on the abyssal

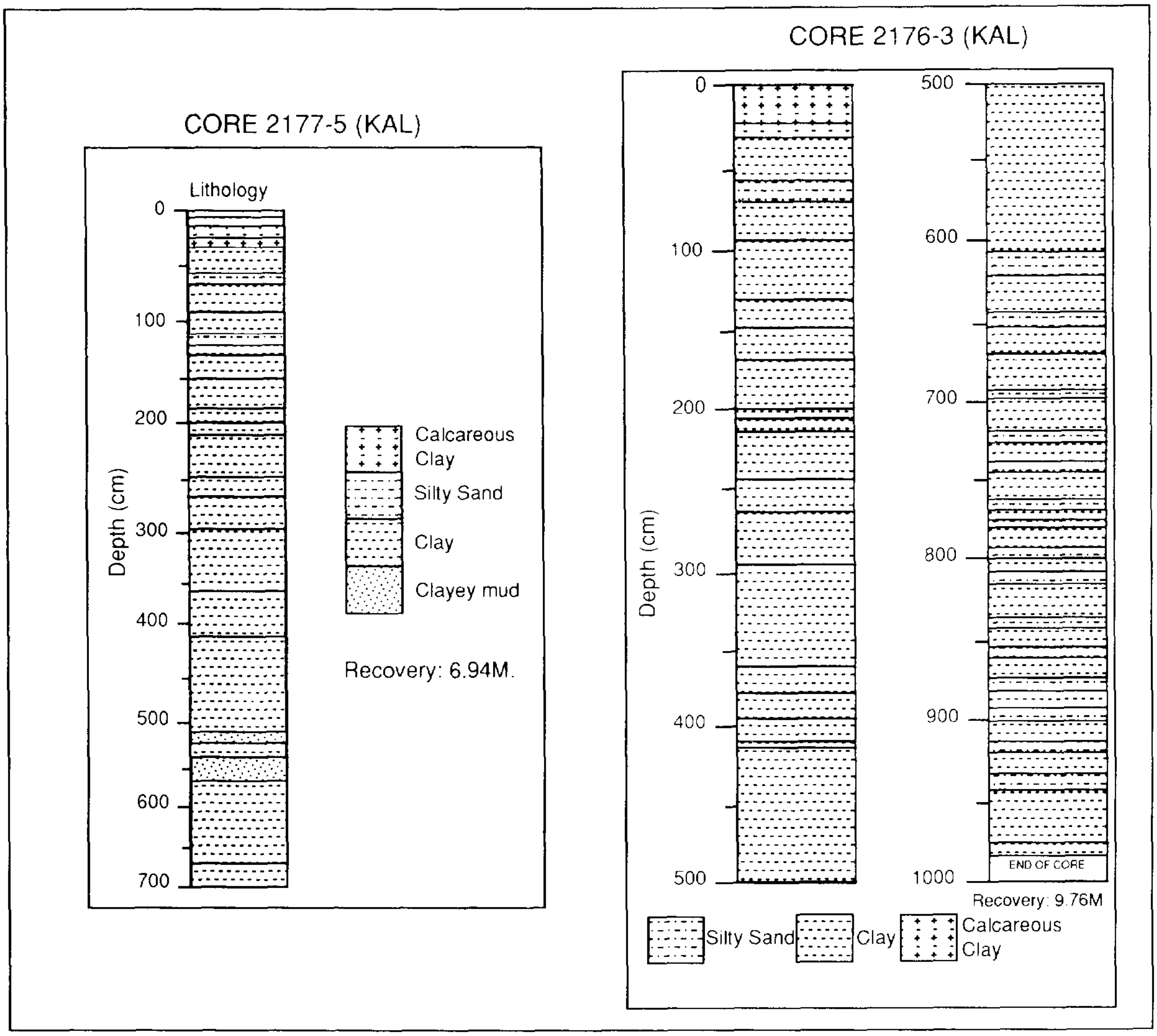

Fig. 2. Lithological logs of PS 2177-5 (KAL) and PS 2176-3 (KAL).

plain, the Holocene sedimentation rate was determined to be at least 0.9 cm/kyr. Core 2176-3 has a high sediment recovery (9.76 m). If the uppermost calcareous layer is ignored, approximately 9.3 m of sediment remains. In addition, Core 2176-3, contains turbidite sequences which complicate the age determinations. However, if the sedimentation rate for Core 2175 is considered, its geographical proximity and similar depth suggest that Core 2176-3 will have a comparable sedimentation rate. By extrapolating these rates an age of 1 Ma (lower Pleistocene) is derived for Core 2176-3, which is similar to Core 2177-5.

3. Previous work

There have been no previously published studies of the Neogene and Quaternary agglutinated foraminifera from the central Arctic to date. However, a large number of studies have conducted research on the Pleistocene and modern calcareous benthic and planktic foraminifera of the Arctic Ocean and surrounding area. The taxonomic determinations in this study are based mainly on the monographs of deep-sea benthic foraminifera by Brady (1881, Brady 1884), Brönnimann and Whittaker (1988), Cole (1981), Thomas et al.

(1990), and Saidova (1975) who all documented modern benthic foraminifer taxa from various parts of the world ocean. The comprehensive monograph of Recent benthic foraminifera from the Nansen Basin by Wollenburg (1992) provides a modern taxonomic data base for the Arctic Ocean. In addition to the above, Scott et al. (1989) presented the biostratigraphy of Pleistocene calcareous benthic foraminifera from the Alpha Ridge. These authors documented the benthic foraminiferal assemblages in CESAR Core 14, a magnetostratigraphically dated piston core that recovered lower Pliocene to Recent sediments.

4. Results

4.1. PS 2177-5 (KAL)

Agglutinated foraminifera were found in twenty nine of the samples from the core. The recovered assemblage consists of six genera and eleven species. The dominant genera present are *Cyclammina, Paratrochammina, Psammosphaera, Glomospira, Rhabdammina,* and *Buzasina.* The most abundant genus is *Cyclammina* with 705 specimens present in the samples, which is 71.5% of the total foraminiferal assemblage. This is represented by *Cyclammina pusilla* Brady only. The genus *Paratrochammina* sensu lato is represented by two unnamed species. This taxonomic group represents 10.3% of the assemblage. *Psammosphaera fusca* Schulze is the only species representing its genus and consists 6.5% of the assemblage. The least common genera are *Rhabdammina, Glomospira,* and *Buzasina. Rhabdammina* is represented by *R. antarctica* Saidova, *R. discreta* Brady and *Rhabdammina* sp. 1, which comprises only 4.65% of the assemblage. This is followed by *Glomospira* which is represented by two species, *G. gordialis* (Jones and Parker), (3.65%) and *G. charoides* (Jones and Parker), (2.33% = 23 specimens). Six specimens of *Buzasina* were found, all of which are fragments. These have not been identified to the species level. The abundance of most the above taxa, are illustrated in Fig. 3. Foraminifera increase in abundance from the base of the recovered interval, reaching a maximum near 400–500 cm. There is a sharp decrease in abundance between 415 cm and 300 cm. This is attributed to the very sandy sediment present in this interval. Foraminiferal abundance is variable but generally low between 300 and 30 cm. Samples above 30 cm yielded no agglutinated foraminifera but, are very rich in planktic and calcareous benthic foraminifera.

The assemblages at the base of the core are characterised by the presence of *Rhabdammina* sp. 1, which as yet is without denomination and *Rhabdammina antarctica* Saidova (Fig. 3). This species shows a similar distribution pattern to *R. discreta* Brady. It is possible that it is present in the same samples as *R. antarctica* Saidova and *R. discreta* Brady, but the tests were fragmented to such a degree that they were not identifiable to the species level. The genus *Rhabdammina* is believed to be epifaunal, belonging to the suspension-feeding group according to the morphogroup classification of Jones and Charnock (1985). Suspension feeding benthic foraminifera dominate the assemblages of the oligotrophic abyssal plains. The presence of *Rhabdammina* at the base of the studied section and its subsequent decline above 2177-5, 545 cm may be related to a change in trophic conditions.

The dominant species in the core is *Cyclammina pusilla* Brady, which is present in all of the samples up to Sample 2177-5, 285 cm (Fig. 3). Its abundance increases from the base of the core and peaks at Sample 2177-5, 545 cm, coinciding with the peak in total abundance. The presence of this species in Sample 300 cm indicates that it is able to withstand an environment with a slightly coarser sediment compared with the other species present in the assemblage. Murray (1991) suggested that the genus *Cyclammina* is epifaunal and lives free on mud or sand on the outer shelf to abyssal plain. This can be further refined, indicating that *Cyclammina* is present on the lower slope = lower bathyal (2000–4000 m) and also on the abyssal plain (>4000 m). While this statement may hold true for the type species *C. cancellata* Brady, the species *C. pusilla* has a different shape. This species very strongly resembles *Reticulophragmium amplectens* (Grzybowski), which is symmetrical in shape and has a circular outline. This species was probably a mobile infaunal detritivore, because its shape is similar to that of the modern calcareous benthic species *Melonis barleeanum.* In the Paleogene Talaa Lakrah flysch assemblage from Northern Morocco, Kaminski et al. (in press) observed that *R. amplectens* increases in abundance from reddish to greenish claystones which reflect more productive and/or less well oxygenated condi-

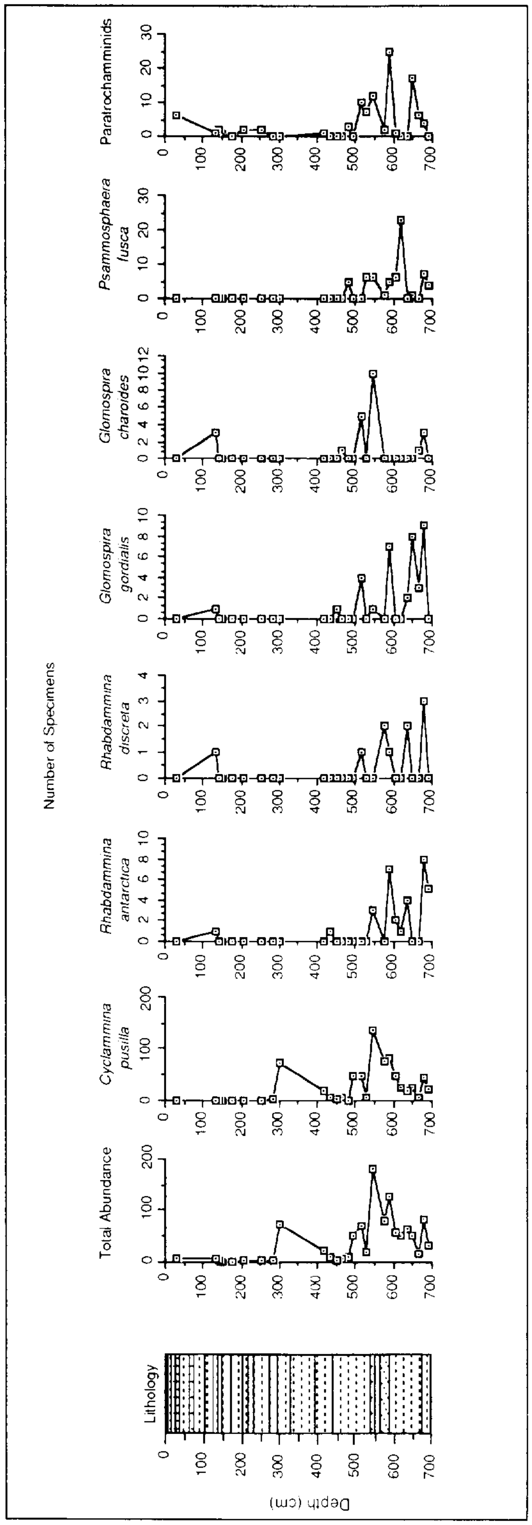

Fig. 3. Graph showing abundance of main specimens down core.

tions. This may also explain the dominance of *C. pusilla* in the Arctic cores, since the common shape of the two species suggests an ecological link. Assuming a constant sedimentation rate, the increase in total foraminiferal abundance from the base of the section to 2177-5, 545 cm may reflect a higher amount of total organic flux to the sea floor (e.g. Herguera and Berger, 1991). Therefore, this may explain the dominance of *C. pusilla* and its high abundance at 2177-5, 545 cm. Increasing organic flux would affect the oxygen values of sediment pore waters as well as the nutrition available for the foraminifera. We speculate that *Cyclammina pusilla* may be able to adapt to the low oxygen conditions within sediments. The two species of the paratrochammids show a similar distribution to *C. pusilla*, but is slightly deeper in the core.

Psammosphaera fusca Schulze is present in small numbers (Fig. 3), and not found above Sample 2177-5, 450 cm. Modern *P. fusca* is probably an opportunistic species (Kaminski et al., 1989), suggesting that the species is able to survive in a disturbed environment.

The two species of *Glomospira*, *G. gordialis* (Jones and Parker) and *G. charoides* (Jones and Parker), are common below 450 cm. In the Palaeogene and Createaceous high numbers of *Glomospira* reflect high organic productivity, (Kuhnt and Kaminski, 1989; Kaminski et al., 1989).

4.2. PS 2176-3 (KAL)

Core PS 2176-3 (KAL), only two of which contain agglutinated foraminifera. The other samples were either barren or contained calcareous benthic and/or planktic foraminifera. Two genera, *Saccammina* and *Hemisphaerammina*, are observed in Samples 360 cm and 300 cm. There are two broken specimens of *Saccammina* and two of *Hemisphaerammina* in Sample 360 cm. Sample 300 cm contains two specimens of *Hemisphaerammina*. These are broken and therefore difficult to identify to the species level.

The presence of only two genera, *Saccammina* and *Hemisphaearammina* in the assemblage suggests that the environment was not suitable for the growth and/or preservation of DWAF. The low foraminiferal number suggests early diagenetic destruction of the organically cemented test.

5. Discussion

The values for the total abundance of the samples, suggest that the most productive stage during the deposition of the sampled sediments was at Sample 2177-5, 545 cm. This would have occurred during a period of a higher availability of nutrition and organic matter flux compared with the rest of the core. Higher in the core the abundance values indicate that the environment became less hospitable to DWAF as the sediment was deposited, therefore, resulting in an overall decrease in abundance. DWAF were not found in the calcareous sediments at the top of the core (above 30 cm). This agrees with the general trend observed by Scott et al. (1989) at the Alpha Ridge, where a decrease of agglutinated and calcareous benthic foraminifera occurs in Lithologic Unit L (45–25 cm) in CESAR Core 14.

Overall, the above assemblage reflects a deep water environment with a low sedimentation rate that was corrosive with respect to calcium carbonate, therefore, leaving a residual assemblage enriched in DWAF. The area may have been affected by gentle bottom water currents, which may be assumed from the presence of *Rhabdammina* and *Psammosphaera*. However, it should be noted that the initial environmental conditions were probably also adverse for the preservation of agglutinated foraminifera as well, because the diversity of the assemblage is much lower than modern DWAF faunas from the Central Arctic. Scott et al. (1989) speculated that the finely laminated sediments of Unit L reflect periodic strong bottom turbulence and vertical mixing of the water column. If this mixing occurred upwards into corrosive deep water, the calcareous component would dissolve. These authors also attributed the lack of DWAF to unstable bottom conditions. The change from non-calcareous to calcareous sedimentation in the early Pleistocene was attributed to the establishment of perennial sea ice cover in the Arctic Ocean.

5.1. Comparison of Core PS 2177-5 (KAL) with other localities

The two studied cores have very few similarities, with no species or genus in common. The difference in depth between the two cores may have contributed to the large difference in the composition and abundance of the assemblages. As a result there is little or no basis to compare the two cores. However, the assemblages of PS 2177-5 (KAL), with dominant *C. pusilla* compare remarkably well with the foraminiferal record from CESAR Core 14 from the Alpha Ridge (Scott et al., 1989). The CESAR core has been magnetostratigraphically dated and shows a similar pattern for the distribution of *C. pusilla*. Together with other DWAF, *C. pusilla* increases from the base of the core and then decreases with the appearance of the calcareous benthic foraminifera. However, Core PS 2177-5 (KAL) does not show the marked peak of calcareous benthic foraminifera that was found at 230 cm in CESAR Core 14.

Cyclammina pusilla and associated *Glomospira* species have also been reported from ODP Hole 646B from the Eirik Ridge in the Labrador Sea (Kaminski et al., 1989). This site is in the direct pathway of water that originated in the Arctic, flowing through the Fram and Denmark Straits to the Labrador Sea. Although the assemblages at Site 646 are of late Miocene age, the composition of the DWAF assemblage resembles that of PS 2177-5 (KAL), suggesting similar ecological characteristics. However, the DWAF assemblages disappeared during the early Pliocene in the Labrador Sea, but are present to the Pleistocene in the Central Arctic.

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