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# MODERN AGGLUTINATED FORAMINIFERA FROM THE HOVGÅRD RIDGE, FRAM STRAIT, WEST OF SPITSBERGEN: EVIDENCE FOR A DEEP BOTTOM CURRENT

**Michael A. KAMINSKI[1,2,3] & Frank NIESSEN[4] and the PS87 Shipboard Geoscience Party[5]**

[1] *Earth Sciences Department, King Fahd University of Petroleum & Minerals, PO Box 701, Dhahran, 31261, Saudi Arabia*
[2] *AGH University of Science & Technology, Faculty of Geology, Geophysics and Environmental Protection, Mickiewicza Ave 30, 30-059 Kraków, Poland*
[3] *Department of Earth Sciences, University College London, Gower Street, London WCIE 6BT, U.K.; e-mail: kaminski@kfupm.edu.sa*
[4] *Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, Am Alten Hafen 26, 27568 Bremerhaven, Germany; e-mail: frank.niessen@awi.de*
[5] *See Appendix 2*

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**Abstract:** Deep-water agglutinated foraminifera on the crest of the Hovgård Ridge, west of Spitsbergen, consist mostly of large tubular astrorhizids. At a boxcore station collected from the crest of Hovgård Ridge at a water depth of 1169 m, the sediment surface was covered with patches of large (1 mm diameter) tubular forms, belonging mostly to the species *Astrorhiza crassatina* Brady, with smaller numbers of *Saccorhiza, Hyperammina*, and *Psammosiphonella*. Non-tubular species consisted mainly of opportunistic forms, such as *Psammosphaera* and *Reophax*. The presence of large suspension-feeding tubular genera as well as opportunistic forms point to the presence of deep currents at this locality that are strong enough to disturb the benthic fauna. This is confirmed by data obtained from sediment echosounding, which exhibit lateral variation in relative sedimentation rates within the Pleistocene sedimentary drape covering the ridge, indicative of winnowing in a south-easterly direction.

**Key words:** Foraminifera, PARASOUND, Hovgård Ridge, Fram Strait, Spitsbergen, Deep Current.

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## INTRODUCTION

The Hovgård Ridge is situated in the Fram Strait, west of Spitsbergen. The ridge either represents a submerged fragment of continental crust or an upwarped fragment of ocean crust within the Fram Strait. Its crest rises to a water depth of approximately 1170 m (Eldholm and Myhre, 1977). The Fram Strait represents the only deep passageway for the exchange of deep waters between the Arctic and Atlantic oceans. This deep passage has been an active conduit for the exchange of water masses since at least the Early Miocene (Jakobsson *et al.*, 2007; Engen *et al.*, 2008; Kaminski *et al.*, 2009). The occurrence of widespread residual and well sorted sediments in the Fram Strait area has been interpreted as resulting from deposition by contour currents (Eiken and Hinz, 1993). Recently, deep furrows discovered on the crest of the Hovgård Ridge have been interpreted as plow marks, caused by mega-icebergs passing through the Fram Strait during the Late Pleistocene (Arndt *et al.*, 2014).

During the ARK XXVIII/4 Expedition to the Arctic Ocean, a sediment-echosounding profile was recorded and a boxcore station was collected from the crest of the Hovgård Ridge. Although the main purpose behind collecting the core was to study the ice-rafted detritus at this locality, upon recovery of the core, it became apparent that the surface of the box core was covered with patches of large tubular agglutinated foraminifera. The purpose of this study is to describe the composition of the benthic foraminiferal assemblage present at the crest of the Hovgård Ridge and interpret its ecological significance.

## STUDY AREA

The Hovgård Ridge (Fig. 1) has been interpreted as a submerged continental fragment that separated from the western Barents Sea margin as a result of the opening of the Fram Strait (Myhre *et al.*, 1982). However, a more recent free-air gravity survey (Engen *et al.*, 2008) indicates that the

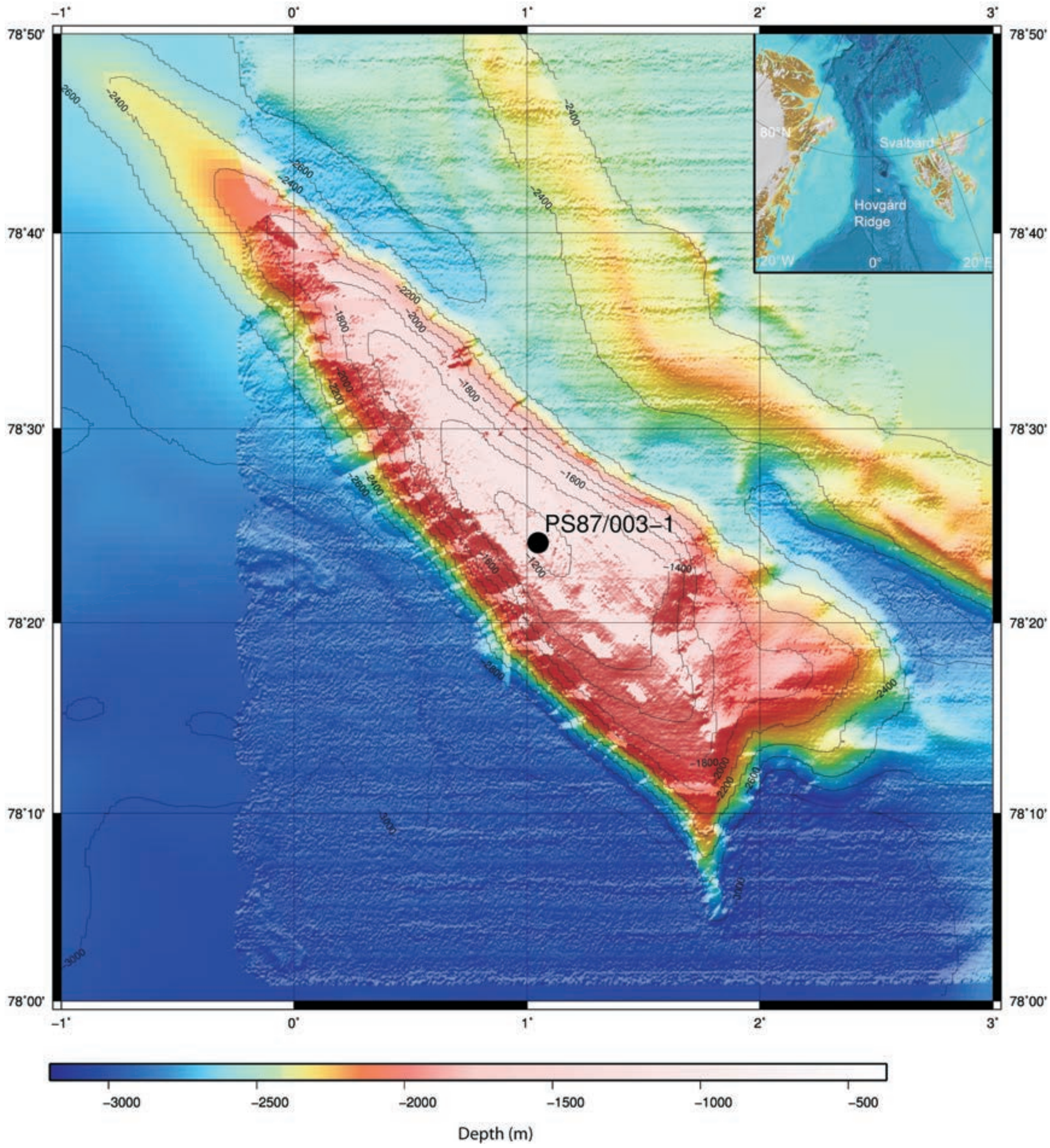


**Fig. 1.** Coring site PS87/003-1 on the Hovgård Ridge. Base map courtesy of Laura Jensen, based on the International Bathymetric Chart of the Arctic Ocean (Jakobsson *et al.*, 2004) enhanced by multibeam data collected during the ARK-VII/3a Expedition in August 1990.

ridge may be an upwarped fragment of ocean crust. The ridge was drilled during ODP Expedition 151 with the purpose of understanding its post-rift sedimentary history after the opening of the Fram Strait. At ODP Site 908, drilled at a water depth of 1267 m on the Hovgård Ridge, a 185-m-thick section of clastic Pliocene to Holocene sediment containing dropstones was recovered.

Near the study area, the West Spitsbergen Current transports water of Atlantic origin northward along the coast of Spitsbergen. Current metres, moored further offshore in the Fram Strait between the West Spitsbergen Current and the East Greenland Current, recorded a mean easterly flow direction at a depth of 1360 m with average current speeds of 7 cm/sec (Aagaard *et al.*, 1973). This led Aagaard and Coachman (1977) to speculate that a small, but more or less permanent, bathymetrically controlled cyclonic eddy exists in the area and extends all the way to the sea floor. This eddy with easterly transport across the Hovgård Ridge (0–233 m water depth) is clearly reproduced in the coupled ice-ocean circulation model, published by Maslowski *et al.* (2004).

The sediment-echosounding profile across the crest of the ridge (Fig. 2) was acquired, using the hull-mount parametric PARASOUND system (ATLAS HYDROGRAPHIC, Bremen, Germany; see Jokat 2009 for details). The 4 kHz pulse penetrated the upper 25 metres of the sedimentary cover. The ridge is draped by undisturbed sediments, except for at a few locations, where icebergs have grounded in the past and reworked sediments locally. It is now draped by about 8 m of pelagic mud. Polarstern boxcore station PS87/003 is located at N78°24', E01°02', in 1169 m water

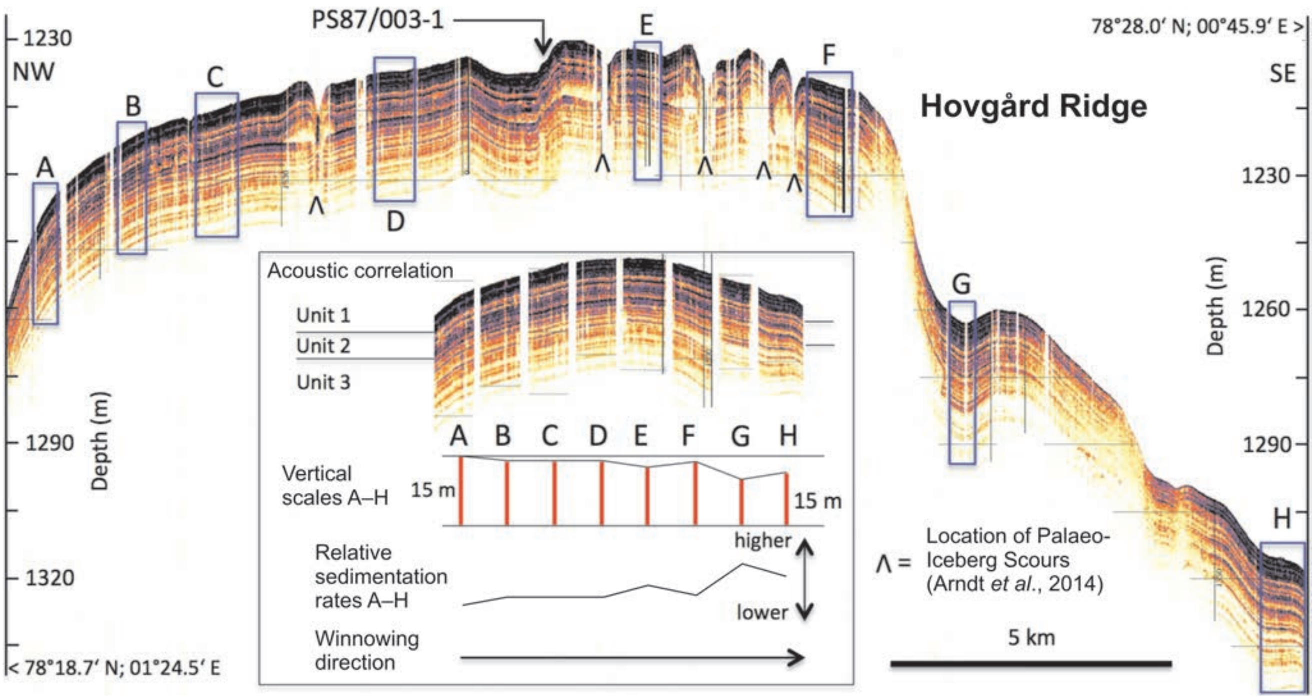


**Fig. 2.** PARASOUND profile across the crest of the Hovgård Ridge. PS87/003-1 marks the sampling location. Eight sections (A to H) highlighted in the profile were re-scaled to provide the best fit for lateral acoustic correlation, thereby indicating differences in sediment thickness. The distinction of Units 1 to 3 in the acoustic correlation is based on reflector amplitudes (yellow = weak to black = strong). The transparent wedges at locations of palaeo-iceberg scours indicate reworked sediments.

depth, at the crest of the ridge (Fig. 1). Recovery of the boxcore was good, the surficial sediment was preserved, and the supernatant water in the boxcore was clear. The surficial sediment at this station consists of dark yellowish brown pebbly-sandy mud, with a minor admixture of biogenic components in the coarse fraction. Patches of large tubular foraminifera and isolated pebbles were clearly visible on the sediment surface.

## METHODS

Sampling of the core was carried out immediately upon recovery. The supernatant water was siphoned through a 63 µm sieve, and the sediment surface was sampled, using a 12.5 cm × 12.5 cm metal frame. The upper centimetere of the sediment was scraped off into a sample jar using a spoon, and the sample was preserved in ethanol with Rose Bengal. The sample was gently agitated to disperse the sediment/ethanol mixture. An additional sample of surficial sediment was collected with the aim of providing extra material for taxonomical study. This sample was immediately washed over a 63 µm sieve, dried overnight, then split into fractions, using a microsplitter. Splits of the sample were then dry-sieved through a 125 µm sieve, and microfossils were picked out into cardboard microscope slides for permanent storage. The microscope slides are currently housed in the first author's collection at KFUPM, while splits of the unpicked residues are stored in the collections of Micropress Europe at the AGH University of Science & Technology in Kraków, Poland.

## RESULTS

A lateral correlation of PARASOUND reflectors from 8 locations (A to H; Fig. 2) along the crest, including the uppermost ends of the slope, revealed differences in sediment thickness, indicative of an increase of sedimentation rates in a south-easterly direction. Also, reflector amplitudes increased stepwise from unit 3 to 1 and are particularly strong in Unit 1 at the top of the drape (Fig. 2).

A taxonomic survey of the agglutinated foraminiferal fauna (total assemblage) found at the sampled location yielded 32 species of agglutinated foraminifera (Appendix 1). By far the dominant taxa in terms of numbers and biomass was the group of tubular astrorhizids, dominated by large specimens of *Astrorhiza crassatina* Brady. These specimens formed patches on the surface of the boxcore (Figs 3, 4). Accessory species included large specimens of *Saccorhiza ramosa* (Brady), attached to dropstones, and some smaller specimens of *Psammosiphonella cylindrica* Glaessner, *Bathysiphon rufus* de Folin, and *Hyperammina elongata* Brady.

Among the monothalimids, the most abundant species was *Psammosphaera fusca* Schultze, which is known to be an opportunist (Kaminski *et al.*, 1988). This species was accompanied by *Lagenammina* spp., *Saccammina sphaerica* Brady, and *Thurammina papillata* Brady. Multichambered agglutinated foraminifera were less common than the monothalamids. The dominant species were coarsely-agglutinated varieties of *Reophax bradyi* Brönnimann et Whittaker and *Reophax bilocularis* Flint, followed by an enigmatic species of *Hormosinelloides* that bears closest resemblance to *H. guttifer* (Brady).


**Fig. 3.** Surface of boxcore PS87/003-1. Width of core = 50 cm. Photograph by Robert Spielhagen.

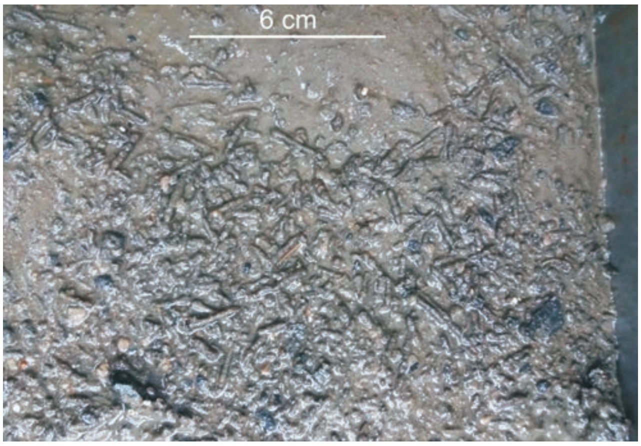


**Fig. 4.** Detail of the boxcore surface, showing the dense patch of large tubular astrorhizids, mostly *Astrorhiza crassatina*.

## DISCUSSION

The Hovgård Ridge, situated at the southern end of the Fram Strait, forms a topographic barrier to the exchange of deep water between the Arctic Ocean and northern Norwegian-Greenland Sea (Myhre and Thiede, 1995; Engen *et al.*, 2008). This positive topographic feature rises 1500 m above the depth of the Greenland-Spitsbergen sill. The thickness of Holocene and Pleistocene sediments on the Hovgård Ridge is reduced in comparison with that of basinal settings, e.g. by up to 20% compared to ODP-151 sites (Arndt *et al.*, 2014), indicating that winnowing is taking place. This is confirmed by the difference in relative sedimentation rates visible in the PARASOUND profile. As a consequence, Holocene sediments at the crest of the ridge are 30–50% thinner than in nearby basinal settings. The colour change in Boxcore PS87/003-1 indicates only 12–15 cm of Holocene are present at the study site, while Box core PS1535-3 collected approximately 30 km north of the station in the Fram Strait has ca. 30 cm of Holocene sediments (Spielhagen *et al.*, 2012, fig. 11). This interpretation is confirmed by the discovery of coarse sandy sediment in Boxcore PS87/003-1. These sandy sediments may also explain the higher reflector amplitudes towards the top of the PARASOUND profile (Fig. 2). Thus, the composition of the agglutinated foraminiferal assemblage in Boxcore PS87/003-1 is consistent with the sedimentological evidence for winnowing at the crest of the ridge.

The presence of large, suspension-feeding tubular genera as well as opportunistic forms points to the presence of deep bottom currents at this locality that are strong enough to disturb the benthic fauna. Suspension-feeding organisms rely upon the lateral transport of food particles carried by bottom currents. For example, the genus *Saccorhiza* is known to build an umbrella-like structure, from which it extends its pseudopodia to capture food (Altenbach *et al.*, 1988). Beneath the Western Boundary Undercurrent off Nova Scotia, Schröder (1986) noted the occurrence of large tubular astrorhizids including the species *Astrorhiza crassatina* in an area of current-winnowed coarse-grained sediments at a water depth of 3543 m, whereas the smaller tubular forms were found at deeper stations. On the west coast of Spitsbergen, Gooday *et al*. (2005) found dense standing crops of large *Rhabdammina*, *Hyperamina*, and *Pelosina* species at two stations collected beneath the strong West Spitsbergen Current at 313 and 504 m water depth. These authors noted that the large tubular foraminifera protruded from the surface of the boxcores, and concluded that these and other foraminifera with an erect life position are "predominately suspension feeders". The type locality of *Astrorhiza crassatina* was a station collected in the Faero-Shetland Channel, which is one of the main passageways for overflow water from the Norwegian Sea. The genus *Psammosphaera* was the dominant agglutinated foraminiferal genus at the High-Energy Benthic Boundary Layer Experiment (HEBBLE) site located off Nova Scotia, where the meandering current of the Gulf Stream is strong enough to periodically resuspend sea-floor sediment (Kaminski, 1985). Some species of the genus *Reophax* have the capability to rapidly recolonise newly deposited sediment (Kaminski, 1985; Hess and Kuhnt, 1996; Hess *et al*., 2001). The composition of the agglutinated foraminiferal assemblage at Station PS87, 3-1 on the Hovgård Ridge is therefore consistent with a scenario of deep bottom currents that can periodically disturb the benthic fauna.

## SYSTEMATIC TAXONOMY

In the section below, the species are arranged according to the classification of Kaminski (2014). For taxonomic determinations the monographs of Cushman (1948), Pfleger (1952), Vilks (1969), Schröder-Adams *et al.* (1990), Kaminski and Gradstein (2005), Wollenburg (1992, 1995) were mainly used, and direct comparisons were made with specimens preserved in the Brady collection at the Natural History Museum (London).

Subclass MONOTHALAMANA Pawlowski, Holzmann et Tyszka, 2013
Order ALLOGROMIIDA Hartog in Harmer et Shipley, 1906

Genus *Nodellum* Rhumbler, 1913

**Type species:** *Reophax membranacea* Brady, 1879.

*Nodellum membranaceum* (Brady, 1879)

**Description:** Test free, ovoid proloculus followed by an elongated, slightly curved tubular chamber, gradually enlarging, and with irregularly spaced transverse constrictions. Wall, thin, translucent, brownish, proteinaceous. Aperture rounded, at the slightly constricted end of the tube.
**Remarks:** The specimen from the Hovgård Ridge is much smaller than the type specimen.

Genus *Astrorhiza* Sandahl, 1858

**Type species:** *Astrorhiza limnicola* Sandahl, 1858.

*Astrorhiza crassatina* Brady, 1881
Fig. 5G–M

**Description:** Test free, very large, tubular or cylindrical, open only at one end, proloculus with approximately the same diameter as the tubular chamber. The tubular chamber is up to 10 mm in length and may display constrictions or taper slightly toward the aperture. Wall several grains thick, of fine sand with occasional larger sand grains, broken fragments of other agglutinated foraminifera, and broken sponge spicules with little cement, grey in colour. Exterior and interior rough, with larger sand grains protruding into the central cavity, which has a yellowish brown inner organic lining. Aperture terminal, constricted, but regular in outline, may be partially obstructed by agglutinated particles.
**Remarks:** The syntypes of *Astrorhiza crassatina* Brady, 1881 are housed in the Brady Collection in the NHM, London. These are from Porcupine sta. 64, in the Faroe Channel. These specimens are very large for an agglutinated foraminifer. The diameter of the tubular chamber is variable in our specimens, giving the impression of pseudochambers. These pseudochambers sometimes taper toward the aperture and may be up to 5 mm in length. However, the wall of the tubular chamber is continuous from one pseudochamber to the next, therefore these are not true chambers. The interior layer contains larger agglutinated grains than the outer layer, giving the interior a rough appearance.

The species is very common at this locality. Patches of the species were observed covering the surface of the box core. Gooday *et al.* (2005) noted mass occurrences of the species at deep stations (2000 m and 2472 m) collected on the western continental slope of Spitsbergen.

Genus *Bathysiphon* G.O. et M. Sars, 1872

**Type species:** *Bathysiphon filiformis* G.O. et M. Sars, 1872.

*Bathysiphon rufus* de Folin, 1886
Fig. 5R, S

**Description:** Test a curved unbranched elongate tube, open at both ends, gradually enlarging in size with growth, without any visible constrictions. Wall comprised of equidimensional quartz grains, with yellowish brown organic cement. Aperture at the open end of the tube.
**Remarks:** The specimens from the Hovgård Ridge agree with the description of the species given by Wollenburg (1995), except that they are yellowish brown in colour instead of reddish. Lukina (2001, fig. 16) illustrated a specimen from the Laptev Sea as *H. elongata*. The species in the northeast Atlantic can be much larger, up to 14 mm in length (Gooday, 1988). Gooday (1988) designated a lectotype of *B. rufus* from the de Folin collection, but the type locality is unknown.

*Bathysiphon* sp.

**Description:** Test tiny, only found as broken fragments. Wall very finely agglutinated, surface smooth, whitish grey, with a silvery reflection.
**Remarks:** This form may be the same as the "tiny *Bathysiphon*", reported from offshore Svalbard by Gooday *et al.* (2005). This species was reported from the deeper part of a depth transect (2472–1532 m), collected on the continental slope off western Svalbard.

Genus *Psammosiphonella* Avnimelech, 1952

**Type species:** *Bathysiphon arenaceus* Cushman, 1927.

*Psammosiphonella cylindrica* (Glaessner, 1937)

**Description:** Test tubular, round in cross-section, straight, of even diameter. The inner surface of the tube is even, not constricted. Wall thick, composed of equidimensional mineral grains, mostly quartz, with organic cement. Apertures at the open ends of the tube.
**Remarks:** The recovered specimens compare well with the specimens from the Upper Cretaceous and Palaeogene of the Carpathian flysch.

*Psammosiphonella* sp. 1

**Description:** Test tubular, round in cross-section, straight or slightly bent, of uneven diameter, but generally larger than that of *P. cylindrica*. Wall thinner than that of *P. cylindrica*, composed of equidimensional quartz grains with yellowish brown organic cement.

Genus *Rhizammina* Brady, 1879

**Type species:** *Rhizammina algaeformis* Brady, 1879.

*Rhizammina algaeformis* Brady, 1879
Fig. 5P

**Description:** Test elongate, tubular, branching not observed. Wall thin and flexible, with large amount of organic material and with fine sand grains, juvenile tests of *Neogloboquadryina pachyderma*, and a few fragments of sponge spicules loosely attached to the outer surface. Aperture at the ends of the tubes.

*Rhizammina* sp. 1 (clay wall)

**Description:** Test elongate, tubular, unbranched, collapsed when dry. Wall thin and flexible, comprised entirely of clay particles. Aperture at the ends of the tubes.

Genus *Lagenammina* Rhumbler, 1911

**Type species:** *Lagenammina laguncula* Rhumbler, 1911.

*Lagenammina atlantica* (Cushman, 1944)

**Description:** Test small, flask shaped, tapering gently towards the neck. Wall composed of unidimensional clear quartz grains. Aperture terminal, produced on an elongate neck.

### *Lagenammina arenulata* (Skinner, 1961)

**Remarks:** Test larger than that of *L. atlantica,* comprised of agglutinated grains of varying size. The specimens of the authors are similar to the specimens from the Nansen Basin, illustrated by Wollenburg (1992) as *Lagenammina difflugiformis* (Brady) subsp. *arenulata* (Skinner).

### *Lagenammina* sp 1.

**Remarks:** This species differs from the above in its smaller dimensions and in possessing a long, tapered neck. It resembles *Saccammina tubulata* Rhumbler, but the neck is more tapered.

### Genus *Saccammina* Carpenter, 1869

**Type species:** *Saccammina sphaerica* Brady, 1871.

### *Saccammina sphaerica* Brady, 1871

**Remarks:** Only a few broken specimens were observed at the study site. They closely resemble the type specimens from the Hardanger Fjord, Norway from the Sars collection, preserved in the Natural History Museum, London.

### Genus *Thurammina* Brady, 1879

**Type species:** *Thurammina papillata* Brady, 1879.

### *Thurammina papillata* Brady, 1879

**Description:** Test subglobular, with many short conical protuberances. Wall agglutinated, very thin, of a single layer of fine quartz grains, yellowish brown in colour. Aperture a small opening at the summit of each protuberance.

### Genus *Psammosphaera* Schulze, 1875

**Type species:** *Psammosphaera fusca* Schulze, 1875.

### *Psammosphaera fusca* Schulze, 1875
Fig. 6A–C

**Description:** Test free or attached to a single large sand grain, varying in size, consisting of a single spherical chamber. Wall agglutinated, of a single layer of coarse sand grains, cemented together in a matrix of finer agglutinated particles, without any inner organic layer. Small pores between the loosely agglutinated sand grains serve as apertures.
**Remarks:** The species *P. fusca* uses a combination of larger and smaller agglutinated particles, sometimes selecting a single larger grain that may serve as an attachment surface. Although the style of agglutination is often described as irregular, the larger agglutinated grains selected by the specimens recovered at this locality show some degree of orientation. The organism orients the flat surface of the larger grains toward the interior of the test, and as a result the rounded or angular surface of the grain points to the exterior. The space between grains is filled in by a matrix of much finer agglutinated particles. This behavior in *P. fusca* has not been previously noted. At the station studied, the available ice-rafted sand grains are angular and therefore presented with the opportunity to use such grains the organism orients the grains to take advantage of flat surfaces. The size of the specimens recovered is variable. Smaller specimens build their test out of only a few (<10) grains. Already Cushman (1948) noted "All the Arctic specimens I have seen are small with rather large, angular quartz grains, and quite different from some of the specimens that are figured and referred to this species".

### Genus *Sorosphaera* Brady, 1879

**Type species:** *Sorosphaera confusa* Brady, 1879.

### *Sorosphaera* sp.

**Description:** Test pseudocolonial, attached, a series of low subglobular chambers without definite arrangement. Wall agglutinated, made of fine quartz particles with a reddish brown cement. No distinct aperture.
**Remarks:** Wollenburg (1992) reported *Sorosphaera* consociate living attached to a sponge spicule. The specimen from the Hovgård Ridge station was attached to a flat substrate that is no longer present. The specimen consists of five chambers, which are clearly visible when viewed from the attached side of the test. No apertures are visible.

## Subclass TUBOTHALAMANA Pawlowski, Holzmann et Tyszka, 2013
## Order AMMODISCIDA Mikhalevich, 1980

### Genus *Ammodiscus* Reuss, 1862

**Type species:** *Ammodiscus infimus* L. G. Bornemann, 1874.

### *Ammodiscus gullmarensis* Höglund, 1948

**Description:** Test very small, resembling an *Ammodiscus* with sligh-tly irregular coiling. Wall finely agglutinated, smooth surface, brown in colour.
**Remarks:** The specimen from the Hovgård Ridge is similar to the one illustrated by Lukina (2001) from the Laptev Sea.

### Genus *Glomospira* Rzehak, 1885

**Type species:** *Trochammina squamata* Jones et Parker var. *gordialis* Jones et Parker, 1860.

### *Glomospira irregularis* (Grzybowski, 1896)

**Remarks:** The specimen from the Hovgård Ridge conforms well to the modern specimen from the North Atlantic, illustrated by Kaminski and Gradstein (2005, pl. 26, fig. 6).

### Genus *Hyperammina* Brady, 1878

**Type species:** *Hyperammina elongata* Brady, 1878.

### *Hyperammina elongata* Brady, 1878
Fig. 5N, O

**Description:** Test free, elongate, large proloculus, followed by undivided tubular chamber of unequal diameter. Aperture rounded, at the end of the tube. Wall of agglutinated medium-sized equidimensional quartz particles, firmly cemented with a brownish yellow organic cement.
**Remarks:** The specimens from the Hovgård Ridge are very similar to those, illustrated as *H. elongata* from the western North Atlantic by Schröder (1986), and as *H. cylindrica* Parr from Lancaster Sound by Schröder-Adams *et al.* (1990).


**Fig. 5.** Agglutinated Foraminifera from the Hovgård Ridge, Fram Strait, west of Spitsbergen. Scale bars = 1 mm. **A**–**F**. *Saccorhiza ramosa* (Brady, 1879). **G**–**M**. *Astrorhiza crassatina* Brady, 1881. **N**, **O**. *Hyperammina elongata* Brady, 1879.

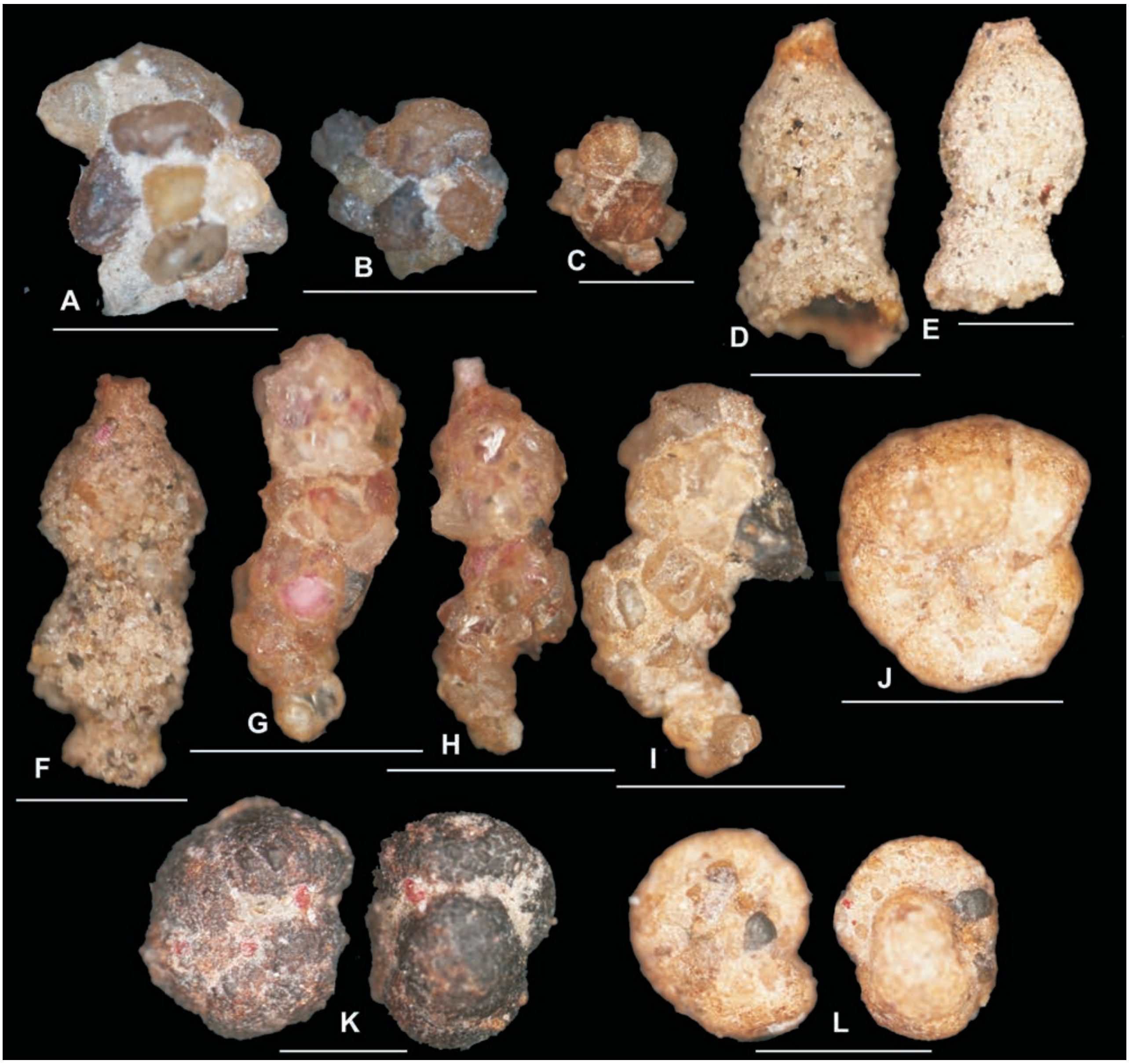


**Fig. 6.** Agglutinated Foraminifera from the Hovgård Ridge, Fram Strait, west of Spitsbergen. Scale bars = 1 mm. **A**–**C**. *Psammosphaera fusca* Schulze, 1875. **D**–**F**. *Archimerismus subnodosus* (Brady, 1884). **G**–**I**. *Reophax bradyi* Brönnimann et Whittaker, 1980. **J**–**L**. *Cribrostomoides subglobosus* (Cushman, 1910).

*Hyperammina rugosa* Verdenius et Van Hinte, 1983
Fig. 5Q

**Description:** Test tubular, extremely coarsely agglutinated, containing sand grains of various composition and even some small planktonic and agglutinated foraminiferal tests. Proloculus not observed.
**Remarks:** This species was first described from the Eocene of the Norwegian-Greenland Sea (Verdenius and Van Hinte, 1983), and is also known from Cenozoic and Upper Cretaceous deposits (Kaminski and Gradstein, 2005).

Genus *Saccorhiza* Eimer et Fickert, 1899

**Type species:** *Hyperammina ramosa* Brady, 1879.

*Saccorhiza ramosa* (Brady, 1879)
Fig. 5A–F

**Description:** Test large, attached to ice-rafted pebbles. Proloculus followed by tubular chamber that branches dichotomously or shows very irregular growth, with terminal stoloniferous projections. Wall predominantly of agglutinated quartz grains with some mafic minerals, with yellowish brown organic cement, with a large component of outwardly projecting sponge spicules that give the surface a hirsute appearance. Aperture rounded, at the open ends of the stolon-like branches.
**Remarks:** The specimens from the Hovgård Ridge select individual sand grains varying in size that likely serve as bases for attachment.

Genus *Archimerismus* Loeblich et Tappan, 1984

**Type species:** *Hyperammina subnodosa* Brady, 1884.

*Archimerismus subnodosus* (Brady, 1884)
Fig. 6D–F

**Description:** Test free, very large, tubular or cylindrical, open

only at one end, proloculus with approximately the same diameter as the tubular chamber. The fragments of the tubular chamber are several mm in length and may display constrictions or taper slightly toward the aperture. Wall is several grains thick, of fine sand with occasional larger sand grains, occasional diatom frustules and dark mafic grains, with little cement, grey in colour. The test appears to be comprised of two layers: the interior layer is much thinner, with smaller sand grains lining the central cavity, which has a yellowish brown inner organic lining. Aperture terminal, constricted, round in outline, may be partially obstructed by agglutinated particles.
**Remarks:** Three slides of type specimens of *Hyperammina subnodosa* are preserved in the Carpenter Collection in the NHM, London, all from VALOROUS sta. 2, 100 fathoms. The lectotype, designated by Kaminski and Cetean (2011), is the specimen illustrated by Brady (1884) in pl. 23, fig. 11, and is preserved in slide BMNH 1886.4.16.94. These specimens are very large for an agglutinated foraminifer. The diameter of the tubular chamber is variable in specimens of the authors, giving the impression of pseudochambers. These pseudochambers sometimes taper toward the aperture and may be several mm in length. However, the wall of the tubular chamber is continuous from one pseudochamber to the next, therefore these are not true chambers. This is the type species of the genus *Archimerismus* Loeblich et Tappan, 1984, which differs from *Hyperammina* in the partial subdivision of the test to form pseudochambers.

### Genus *Subreophax* Saidova, 1975

**Type species:** *Reophax aduncus* Brady, in Tizard et Murray, 1882.

### *Subreophax aduncus* (Brady in Tizard et Murray, 1882)

**Description:** Test consists of an irregular series of very slowly enlarging ovoid to subpyriform pseudochambers separated only by constrictions of the wall, but without distinct internal septa. Wall thin, finely agglutinated, with a brownish yellow cement.

## Subclass GLOBOTHALAMANA Pawlowski, Holzmann et Tyszka, 2013
## Order LITUOLIDA Lankester, 1885

### Genus *Hormosinelloides* Zheng, 2001

**Type species:** *Reophax guttifera* Brady, 1881.

### *Hormosinelloides* sp. aff. *H. guttifer* (Brady, 1881)

**Description:** Test free, uniserial, straight to slightly curved. Chambers globular to pyriform, the first two appressed together, the following chamber is separated from the preceding one by a short stolon-like neck. Chambers overlap, with each succeeding chamber attached near the base of the apertural neck of the preceding one. Wall thin, consisting of fine quartz particles. Cement organic, yellowish in colour. Aperture terminal, at the end of the terminal neck.
**Remarks:** The specimens from the Hovgård Ridge are consistently made up of only two to four chambers, while the type specimens of *H. guttifer* from Challenger Station 323, South Atlantic, east of Buenos Aires are much larger and consist of 8 or more chambers. Additionally, the chambers of the type specimens are more pyriform and they incorporate small planktonic foraminifera into their wall. Likewise, the specimen illustrated by Vilks (1969) from Hecla Bay, NWT is only a two-chambered individual. The differences between the specimens from the Hovgård Ridge and the type specimens from Challenger sta. 323 are probably enough to warrant erecting a new species.

### Genus *Reophax* de Montfort, 1808

**Type species:** *Reophax scorpiurus* de Montfort, 1808.

### *Reophax bilocularis* Flint, 1899

**Description:** Test free, uniserial, comprised of two chambers, with the second one much larger than the first. Wall very coarsely agglutinated, comprised of angular and rounded quartz grains with an admixture of some dark minerals, cemented with a matrix of much finer agglutinated grains. Aperture on a produced neck that consists of much finer agglutinated grains than the chamber wall.
**Remarks:** In the North Atlantic, *Reophax bilocularis* has a habit of incorporating small planktonic foraminiferal tests in addition to mineral grains. This feature is not observed in the specimens from the Hovgård Ridge.

### *Reophax bradyi* Brönnimann et Whittaker, 1980
Fig. 6G–I

**Description:** Test free, uniserial, arched or slightly meandering, consisting of up to 5 chambers. Chambers are poorly discernable, but when visible appear to be round or slightly elongated. Wall very coarsely agglutinated, Aperture terminal, without a neck.
**Remarks:** The species resembles *Reophax excentricus* Cushman, but the test wall is more coarsely agglutinated. The specimens from the Hovgård Ridge correspond well to the illustration given by Lukina (2001). The specimens illustrated by Pfleger (1952) as *Reophax* sp. cf. *R. scorpiurus* Montfort and by Schröder-Adams *et al.* (1990) as *R. scorpiurus* likely belongs in this species.

### Genus *Hormosina* Brady, 1879

**Type species:** *Hormosina globulifera* Brady, 1879.

### *Hormosina* sp.

**Description:** Test large, uniserial, rectilinear to very slightly arcuate, with large subglobular chambers increasing gradually in size. Wall agglutinated of unidimensional quartz grains, of two to three layers, with the occasional larger grain, outer coarser material restricted to the chambers and not continuing onto the neck, which thus shows a sharply decreased grain size and a greater amount of orange brown cement. Aperture terminal at the end of a short tapering neck.
**Remarks:** Differs from the type species *Hormosina globulifera* Brady in possessing chambers that increase in size more slowly, and in having a short, stout, tapering neck. The species is also larger than the types of *H. globulifera* – the final chamber can be over 1 mm in length. Lukina (2001) illustrated a broken specimen as *Reophax sabulosus* Brady from Laptev Sea station PS95/69 (984 m water depth), which closely resembles this species.

### Genus *Cribrostomoides* Cushman, 1910

**Type species:** *Cribrostomoides bradyi* Cushman, 1910.

### *Cribrostomoides bradyi* Cushman, 1910

**Description:** Test free, involute, 6 chambers in the last whorl, early stage slightly streptospiral in growth, later becoming planispiral and symmetrical. Wall agglutinated, with some larger agglutinated grains embedded in a matrix of finer grains, surface smoothly finished, cement yellowish brown in colour. Aperture above the base of the final chamber face, with a narrow lip of finer sand present on both margins, a simple slit in the early chambers, later becoming irregular and crenulated in the adult form.
**Remarks:** This species is rare on the Hovgård Ridge.

*Cribrostomoides subglobosus* (Cushman, 1910)
Fig. 6J–L

**Description:** Test free involute, 6–7 chambers in the last whorl, early stage slightly streptospiral in growth, later becoming planispiral and symmetrical. Wall medium to coarsely agglutinated. Aperture single, oval, above the base of the final chamber face.
**Remarks:** The differences between *Cribrostomoides subglobosus* and *Cribrostomoides bradyi* are distinct in Cushman's material from the North Pacific, and this is the case in the material from Hovgård Ridge. The primary difference between the two species is the aperture, which becomes crenulated and eventually multiple in *C. bradyi*. Also the test wall in *C. bradyi* is more finely finished. Kaminski and Gradstein (2005) discussed the validity of the species designation *C. subglobosus. Cribrostomoides subglobosus* widely distributed (from 200 to 3800 m) in the Norwegian Sea, where it displays a maximum (80% of the living foraminiferal fauna) between 960 and 1970 m in the Vøring Plateau region, while on the Greenland side of the basin the maximum was somewhat deeper, between 2500 and 3200 m (Thies, 1991).

Genus *Deuterammina* Brönnimann, 1976

**Type species:** *Trochammina glabra* Heron-Allen et Earland, 1932.

*Deuterammina grisea* (Earland, 1934)

**Description:** Test small, low trochspiral, circular in outline, with 5 chambers in the final whorl. Primary aperture interiomarginal and extraumbilical, secondary apertures at the tips of the chambers in the umbilicus.
**Remarks:** Specimens from the Hovgård Ridge are very similar to those, illustrated by Wollenburg (1992) from the Nansen Basin and Lukina (2001) from the Laptev Sea. It may be the same form that Schröder-Adams *et al.* (1990) referred to as *Trochammina* cf. *inflata*.

Genus *Earlandammina* Brönnimann et Whittaker, 1988

**Type species:** *Trochammina inconspicua* Earland, 1934.

*Earlandammina inconspicua* (Earland, 1934)

**Description:** Test free, high trochospiral, with subglobular appressed chambers. Axial depression closed. Wall agglutinated, imperforate, single-layered, made of fine quartz particles with an orange brown cement. Aperture simple, slit-like to oval, areal, in lower part of the apertural face parallel to the base of the last chamber.
**Remarks:** Specimens from the Hovgård Ridge are very similar to those, illustrated by Wollenburg (1992) from the Nansen Basin.

Order TEXTULARIIDA Delage et Hérouard, 1896

Genus *Textularia* Defrance, 1824

**Type species:** *Textularia sagittula* Defrance in de Blainville, 1824.

*Textularia earlandi* Parker, 1952

**Description:** Test slender, with chambers biserially arranged, with as many as 10 pairs of chambers. Test finely agglutinated, cement yellowish brown in colour.
**Remarks:** This species is rare on the Hovgård Ridge, but it is one of the most common species found in the East Greenland fjords and shelf (Jennings and Helgadottir, 1994). Because of its organic cement, this species most likely belongs in the genus *Palustrella*, but detailed studies are needed to resolve the arrangement of the initial chambers.

## CONCLUSIONS

The authors report the occurrence of a modern agglutinated foraminiferal assemblage dominated by large tubular astrorhizids at 1169 m water depth on crest of the Hovgård Ridge in Fram Strait. Altogether, 32 species of deep-water agglutinated foraminifera are documented from this locality. The presence of this suspension-feeding community is consistent with reports of current-winnowed sediments (Eiken and Hinz, 1993) and deep currents (Aagaard *et al.*, 1973), observed in the vicinity of the Hovgård Ridge. Lateral correlation of PARASOUND reflectors along the crest, including the uppermost ends of the slope, reveals differences in sediment thickness indicative of an increase of sedimentation rates in a south-easterly direction. Therefore, the composition of the agglutinated foraminiferal assemblage in Boxcore PS87/003-1 is consistent with the sedimentological and geophysical evidence for winnowing at the crest of the Hovgård Ridge.

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## REFERENCES

Aagaard, K. & Coachman, L. K., 1977. Recent studies on Arctic currents. In: Dunbar, M. J. (ed.), *Polar Oceans*. Arctic Institute of North America, Calgary, pp. 87–98.
Aagaard, K., Darnall, C. & Greisman, P., 1973. Year-long current measurements in the Greenland–Spitsbergen Passage. *Deep-Sea Research*, 20: 743–746.
Altenbach, A., Unsöld, G. & Walger, E., 1988. The hydrodynamic environment of *Saccorhiza ramosa* (Brady). *Meyniana*, 40: 119–132.
Arndt, J. E., Niessen, F., Jokat, W. & Dorschel, B., 2014. Deep water paleo-iceberg scouring on top of Hovgaard Ridge – Arctic Ocean. *Geophysical Research Letters*, 41: 5068–5074.
Brady, H. B., 1884. Report on the foraminifera dredged by H.M.S. CHALLENGER during the years 1873–1876. In: Murray, J. (ed.), *Reports of the scientific results of the voyage of the H.M.S. Challenger. Zoology,* 9: 1–814.
Cushman, J. A., 1948. Arctic Foraminifera. *Contributions to the Cushman Laboratory for Foraminiferal Research Special Publication*, 23: 79 pp + 8 pls.
Eiken, O. & Hinz, K., 1993. Contourites in the Fram Strait. *Sedimentary Geology*, 82: 15–32.
Eldholm, O. & Myhre, A. M., 1977. *Hovgaard Fracture Zone, Årbok 1976*. Norsk Polarinstitutt, Oslo, pp. 195–208.
Engen, Ø., Faleide, J. I. & Dyreng, T. K., 2008. Opening of the Fram Strait gateway: a review of plate tectonic constraints. *Tectonophysics*, 450: 51–69.

Gooday, A. J., 1988. The genus *Bathysiphon* (Protista, Foraminiferida) in the NE Atlantic: revision of some species described by de Folin (1886). *Journal of Natural History*, 22: 71–93.

Gooday, A. J., Bowser, S. S., Cedhagen, T., Cornelius, N., Hald, M., Korsun, S. & Pawlowski, J., 2005. Monothalamous foraminiferans and gromiids (Protista) from western Svalbard: a preliminary survey. *Marine Biology Research*, 1: 290–312.

Hess, S. & Kuhnt, W., 1996. Deep-sea benthic foraminiferal recolonization of the 1991 Mt. Pinatubo ash layer in the South China Sea. *Marine Micropaleontology*, 28: 171–197.

Hess, S., Kuhnt, W., Hill, S., Kaminski, M. A., Holbourn, A. E. & de Leon, M., 2001. Monitoring the recolonization of the Mt. Pinatubo 1991 ash layer by benthic Foraminifera. *Marine Micropaleontology*, 43: 119–142.

Jakobsson, M., Backman, J., Rudels, B., Nycander, J., Frank, M., Mayer, L., Jokat, W., Sangiorgi, F., O'Regan, M., Brinkhuis, H., King, J. & Moran, K., 2007. The Early Miocene onset of a ventilated circulation regime in the Arctic Ocean. *Nature*, 447: 986–990

Jakobsson, M., Macnab, R., Cherkis, N. & Schenke, H.-W., 2004. *International Bathymetric Chart of the Arctic Ocean. Research Publication RP-2*. National Geophysical Data Centre, Boulder, Colorado.

Jennings, A. E. & Helgadottir, G. 1994. Foraminiferal assemblages from the fjords and shelf of eastern Greenland. *Journal of Foraminiferal Research*, 24: 123–144.

Jokat, W. (ed.), 2009. The Expedition ARK-XXIII/3 of RV Polarstern in 2008. *Reports on Polar and Marine Research*, 597: 1–221.

Kaminski, M. A., 1985. Evidence for control of abyssal agglutinated foraminiferal community structure by substrate disturbance. *Marine Geology*, 66: 113–131.

Kaminski, M. A., 2014. The year 2010 classification of the agglutinated foraminifera. *Micropaleontology*, 61: 89–108.

Kaminski, M. A. & Cetean, C.G. 2011. Lectotypes of type species of Agglutinated Foraminiferal Genera in the Collections of the Natural History Museum, London. Part 2. Hippocrepinina and Hormosinina. In: Kaminski, M.A. & Filipescu, S. (eds), *Proceedings of the Eighth International Workshop on Agglutinated Foraminifera. Grzybowski Foundation Special Publications*, 16: 61–69.

Kaminski, M. A. & Gradstein, F. M., 2005. Cenozoic cosmopolitan deep-water agglutinated foraminifera. *Grzybowski Foundation Special Publication*, 10: 547 pp.

Kaminski, M. A., Grassle, J. F. & Whitlatch, R. D., 1988. Life history and recolonization among agglutinated foraminifera in the Panama Basin. *Abhandlungen der geologischen Bundesanstalt, Wien*, 41: 228–244.

Kaminski, M. A., Silye, L. & Kender, S., 2009. Miocene deep-water agglutinated foraminifera from IODP Hole M0002a, Lomonosov Ridge: faunal constraints for the timing of the opening of the Fram Strait. *Micropaleontology*, 55: 117–135.

Lukina, T., 2001. Foraminifera of the Laptev Sea. *Protistology*, 2: 105–122.

Maslowski, W., Marble, D., Walczowski, W., Schauer, U., Clement, J. L. & Semtner, A. J., 2004. On climatological mass, heat, and salt transports through the Barents Sea and Fram Strait from a pan-Arctic coupled ice-ocean model simulation. *Journal of Geophysical Research*, 109: C03032, doi:10.1029/2001JC001039.

Myhre, A. M., Eldholm, O. & Sundvor, E., 1982. The margin between Senja and Spitsbergen fracture zones: implications from plate tectonics. *Tectonophysics*, 89: 33–50.

Myhre, A. M. & Thiede, J., 1995. North Atlantic–Arctic gateways. *Proceedings of the Ocean Drilling Program, Initial Reports*, 151: 5–26.

Pfleger, F. B. 1952. Foraminifera distribution in some sediment samples from the Canadian and Greenland Arctic. *Contributions from the Cushman Foundation for Foraminiferal Research*, 3: 80–89.

Schröder, C. J., 1986. Deep-water arenaceous foraminifera in the northwest Atlantic Ocean. *Canadian Technical Report of Hydrography and Ocean Sciences*, 71: 191 pp.

Schroder-Adams, C. J., Cole, F. E., Medioli, F. S., Mudie, P. J., Scott, D. B. & Dobbin, L., 1990. Recent Arctic shelf foraminifera: seasonally ice covered vs. perennially ice covered areas. *Journal of Foraminiferal Research*, 20: 8–36.

Spielhagen, R., 2012. History of Atlantic water advection to the Arctic Ocean: review of 20 years of progress since the "Oden"-"Polarstern" Expedition ARCTIC 91. *Polarforschung,* 82: 19–36.

Thies, A., 1991. Die Benthos-Foraminiferen im Europäischen Nordmeer. *Berichte aus dem Sonderforschungsbereich 313*, 31: 97 pp.

Verdenius, J. G. & Van Hinte, J. E., 1983. Central Norwegian-Greenland Sea: Tertiary arenaceous foraminifera, biostratigraphy and environment. In: Verdenius, J. G., Van Hinte, J. E. & Fortuin, A. R. (eds), *Proceedings of the First Workshop Arenenaceous Foraminifera, 7–9 Sept. 1981. Continental Shelf Institute Publication,* 108: 173–224.

Vilks, G., 1969. Recent Foraminifera in the Canadian Arctic. *Micropaleontology*, 15: 35–60.

Wollenburg, J., 1992. Zur Taxonomie von rezenten bentischen Foraminiferen aus dem Nansen Becken, Arktischer Ozean. *Berichte der Polarforschung*, 112: 137 pp.

Wollenburg, J., 1995. Benthische Foraminiferenfaunen als Wassermass-, Produktions- und Eisdriftanzeiger im Arktischen Ozean. *Berichte zur Polarforschung*, 179: 1–227.

## Appendix 1

Species of Agglutinated Foraminifera
recorded from Station PS87/3-1

Tubular forms:
*Nodellum membranaceum* (Brady, 1879) = *Reophax membranacea* Brady, 1879
*Astrorhiza crassatina* Brady, 1881
*Bathysiphon rufus* de Folin, 1886
*Bathysiphon* sp.
*Psammosiphonella cylindrica* (Glaessner, 1937) = *Rhabdammina cylindrica* Glaessner, 1937
*Psammosiphonella* sp. 1
*Rhizammina algaeformis* Brady, 1879
*Rhizammina* sp. 1 (clay wall)

Monoloculids:
*Lagenammina atlantica* (Cushman, 1944) = *Proteonina atlantica* Cushman, 1944
*Lagenammina arenulata* (Skinner, 1961) = *Reophax difflugiformis* Brady subsp. *arenulata* Skinner, 1961
*Lagenammina* sp. 1 (long tapered neck)
*Psammosphaera fusca* Schulze, 1875
*Saccammina sphaerica* Brady, 1871
*Sorosphaera* sp.
*Thurammina papillata* Brady 1879

Tubothalamids:
*Ammodiscus gullmarensis* Höglund
*Archimerismus subnodosus* (Brady, 1884) = *Hyperammina subnodosa* Brady, 1884

*Glomospira irregularis* (Grzybowski, 1896) = *Ammodiscus irregularis* Grzybowski, 1896
*Hyperammina elongata* Brady, 1878
*Hyperammina rugosa* Verdenius et Van Hinte, 1983
*Saccorhiza ramosa* (Brady, 1879) = *Hyperammina ramosa* Brady, 1879
*Subreophax aduncus* (Brady in Tizard and Murray, 1882) = *Reophax aduncus* Brady in Tizard et Murray, 1882

Globothalamids:
*Cribrostomoides bradyi* Cushman, 1910
*Cribrostomoides subglobosus* (Cushman, 1910) = *Haplophragmoides subglobosum* (Sars) Cushman, 1910
*Deuterammina grisea* (Earland, 1934) = *Trochammina grisea* Earland, 1934
*Earlandammina inconspicua* (Earland, 1934) = *Trochammina inconspicua* Earland, 1934
*Hormosina* sp.
*Hormosinelloides* sp. aff. *H. guttifer* (Brady, 1881) = aff. *Reophax guttifera* Brady, 1881
*Reophax bilocularis* Flint, 1899
*Reophax bradyi* Brönnimann et Whittaker, 1980
*Textularia earlandi* Parker, 1952

## Appendix 2
Affiliations of the PS87 Shipboard Geoscience Party

Evgenia BAZHENOVA (University of St. Petersburg)
Laura CASTRO DE LA GUARDIA (University of Alberta Edmonton)
Bernard COAKLEY (University of Alaska Fairbanks)
Anne DE VERNAL (GEOTOP, Département des Sciences de la Terre, Université du Québec à Montreal)
Graeme EAGLES (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Hannes EISERMANN (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Mattias FORWICK (University of Tromsø)
Catalina GEBHARDT (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Wolfram GEISSLER (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Tanja HÖRNER (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Laura JENSEN (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Haiyan JIN (Second Institute of Oceanography, State Oceanic Administration)
Wilfried JOKAT (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Stefanie KABOTH (University of Utrecht)
Bastian KIMMEL (University of Hamburg)
Henriette KOLLING (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Conrad KOPSCH (ESYS GmbH - Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Anna KUDRIAVTSEVA (University of St. Petersburg)
Jens MATTHIESSEN (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Seung-il NAM (Korea Polar Research Institute)
Florian PETERSEN (University of Kiel)
Anna Katharina PRIM (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Florian RIEFSTAHL (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Isabel SAUERMILCH (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Michael SCHRECK (Korea Polar Research Institute)
Robert SPIELHAGEN (Heimholtz-Zentrum für Ozeanforschung (GEOMAR))
Ruediger STEIN (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Clara STOLLE (Alfred-Wegener-Institut Helmholz-Zentrum für Polar und Meeresforschung)
Mike ZWICK (University of Bremen)