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Deep-water agglutinated foraminifer from the Fram Strait and Lomonosov Ridge: Implications for the opening of the Fram Strait

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Deep-water agglutinated foraminifera (DWAf) are investigated from Miocene deposits recovered from the IODP Arctic Drilling Expedition (IODP Leg 302) cores and from ODP Hole 909C (ODP Leg 151) in the Fram Strait, Greenland Sea. We studied 90 samples from the Miocene of Hole M004 drilled on the Lomonosov Ridge in 2004, as well as 125 samples from Cores 909C-50R to -103R drilled on the Fram Strait.

At the Fram Strait site, we identified over 60 species of DWAf. The faunal succession in Hole 909C is subdivided into three assemblages based on the stratigraphic ranges of characteristic cosmopolitan taxa. These are:

- 1) a diverse *Reticulophragmium amplexens* – *Reophanus berggreni* Assemblage in Cores 909C-100R-2 to -91R-1 (1040.71–952.78 mbsf);
- 2) a *Reticulophragmium amplexens* Assemblage in Cores 909C-87R-2, to -71R-3 (915.7–762.68 mbsf);
- 3) a low-diversity *Reticulophragmium rotundidorsatum* Assemblage in Cores 909C-71R-1 to -55R-1 (759.68-605.52 mbsf).

The DWAf assemblages are correlated to the standard chronostratigraphy using dinoflagellate cysts and magnetostratigraphy. The stratigraphic ranges of some well-known Paleogene DWAf species extend far into the Miocene at this locality, confirming the hypothesis that the Arctic and northern Norwegian Sea basins served as a refuge for these species long after they disappeared from the North Atlantic stratigraphic record. The taxonomic affinity of the Miocene assemblages from Hole 909C with Norwegian Sea assemblages supports the idea that an estuarine circulation pattern has been in place between the Arctic Ocean and Greenland Sea basins since at least the early Miocene. Changes in the benthic foraminiferal morphogroups within Hole 909C correlate with an increase in total organic carbon, indicating an increase in oceanic productivity in the Fram Strait region during the late Miocene.

Comparison with agglutinated foraminiferal assemblages recovered from Hole M004 suggest to us that the opening of the Fram Strait and the onset of the current fully-marine conditions in the Arctic took place during the early Miocene. Eocene sediments from the Lomonosov Ridge are largely biosiliceous with indicators of brackish and fresh-water conditions, and are barren of Foraminifera. A hiatus or extremely condensed interval separates these sediments from overlying marine sediments. The oldest fully marine sediments with cosmopolitan DWAF present on the Lomonosov Ridge are dated to the earliest middle Miocene (approx 15.2 Ma based on magnetostratigraphy). Since at least the mid-Miocene, the Arctic experienced open connections with the Norwegian-Greenland Sea to the south. The Arctic foraminiferal record from the mid-Miocene to Pliocene marine deposits consists entirely of agglutinated benthic species, largely sparse assemblages containing *Cyclammina pusilla*, *Ammolagena clavata*, and *Alveolophragmium polarensis*. By comparing the foraminiferal record of the new IODP Arctic Drilling holes with the record from ODP Hole 909C in the Fram Strait, we now have better constraints on the timing of the opening of the Fram Strait, and the establishment of the Arctic – Atlantic faunal connections.