[PS]Benthic Foraminiferal Carbonate Preservation from the Late Miocene - Pliocene, Northwest Svalbard Continental Shelf (ODP Hole 910C)*

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Abstract

The present study on Hole 910C from the Yermak Plateau northwest Svalbard continental shelf, elucidate the paleoceanographic changes in the Atlantic-Arctic gateway during the late Cenozoic. New biostratigraphic data indicate an early late Miocene age (~11 Ma) for the base of Hole 910C and the remaining upper part of the investigated interval is of Pliocene age. The foraminiferal analysis shows very few Arctic planktic foraminifera, and an Arctic benthic foraminiferal fauna characteristic of an outer shelf-upper slope environment. During the Pliocene the benthic foraminiferal fauna show relative changes of the inflow of warm surface-water masses into the generally cold waters of the Fram Strait. A relatively continuous stable $\delta^{18}O$ and $\delta^{13}C$ isotope record has been derived from benthic foraminifera Cassidulina teretis. The stable isotope record show heavier peaks at 2.32 and 2.45 Ma indicating interglacials. Lighter stable isotopic values indicate higher freshwater inputs and weaker ventilation in the Arctic during glacial periods. The carbonate preservation was studied under scanning electron microscope (SEM) on benthic foraminiferal tests of Cassidulina reniforme and Melonis barleeanus. Four progressive stages of dissolution were distinguished ranging from tests unaffected by dissolution to strongly dissolved tests. A semi quantitative scale describing the preservation was established with 0 as the best preservation and 3 as the poorest preservation. Maximum carbonate dissolution were found at 2.32, 2.48, 2.6, 2.63, 2.72 and 2.77-2.8 Ma and correlated well with peaks of ice-rafted debris (IRD) and heavy $\delta^{18}O$ values. This may represent episodes of severe glaciations (periods of production of carbonate-corrosive dense brines due to sea-ice formation). These events occurred immediately before distinct $CaCO_3$ maxima. This indicates that the $CaCO_3$ maxima occur close to major deglaciations when deepwater reorganizations occur. The reorganizations are also indicated by carbon isotope excursions.

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Benthic foraminiferal carbonate preservation from the Late Miocene - Pliocene northwest Svalbard continental shelf (ODP Hole 910C)

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Introduction

The present study on Hole 910C from the Yermak Plateau northwest Svalbard continental shelf, elucidate the paleoceanographic changes in the Atlantic-Arctic gateway during the late Cenozoic.

Oceanography

Hole 910C is situated at the top of the Yermak Plateau at ca. 560 m water depth. The site is situated under modern day inflow of Atlantic Water to the Arctic Ocean. The main water currents in the region are the northward-flowing, relatively warmer West Spitsbergen Current and the colder, lower-salinity, southward-flowing waters of the East Greenland Current.

Age

A new improved chronostratigraphic framework is established through continuous paleomagnetic and biostratigraphic data as well as selected intervals with stable $\delta^{18}O$ and $\delta^{13}C$ data derived from benthic foraminifera *Cassidulina teretis*. The biostratigraphic data indicate an early late Miocene age (~9 Ma) for the base of Hole 910C and the remaining upper part of the investigated interval is of Pliocene age.

Materials and Methods

New high resolution sampling was carried out, and the samples were analyzed with regard to the planktic and benthic foraminifers using the larger than 100 µm size fractions. The carbonate preservation was studied under scanning electron microscope (SEM) on benthic foraminiferal tests. Four progressive stages of dissolution were distinguished ranging from tests unaffected by dissolution to strongly dissolved tests. A semi quantitative scale describing the preservation was established with 1 as the best preservation and 4 as the poorest preservation.

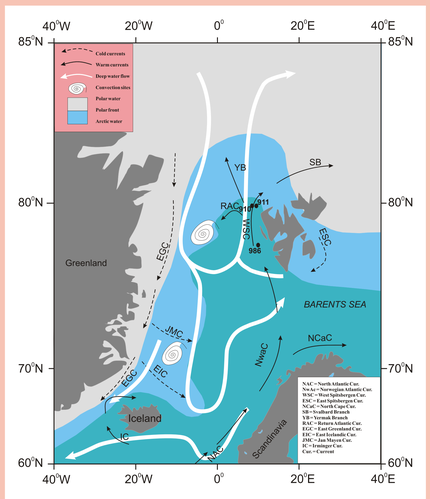


Figure 1. Map showing the location of ODP Hole 910C and the main oceanographic features; redrawn from Risebrobakken et al., 2006 and Ślubowska-Woldengen et al., 2007.

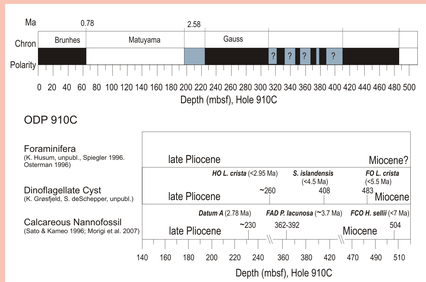


Figure 2. Age model of ODP Hole 910C.

Results and Discussion

Maximum carbonate dissolution were found at 154, 180, 185, 200, 220-222 and 235 mbsf and correlated well with peaks of ice-rafted debris (IRD). Higher $\delta^{18}O$ values do not always correspond to poor preservation. Preservation index does not have a linear relation to number of species in a sample. Dinoflagellate cyst and foraminiferal assemblages indicate a near-coastal environment.

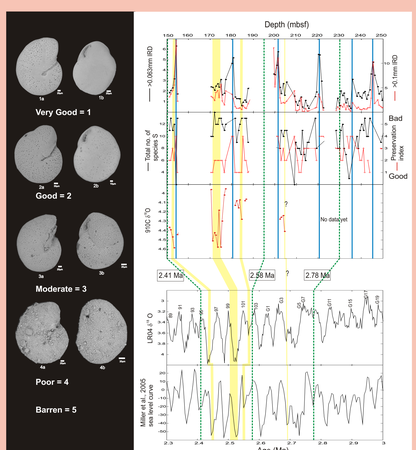


Figure 3. Benthic carbonate preservation index and total no. of species (3 - 2.3 Ma) compared with LR04 stack, Miller et al., (2005) data, stable $\delta^{18}O$ data derived from 910C benthic foraminifera *Cassidulina teretis* and IRD data (> 63µm and >100 µm). The green lines are the age datums (2.78, 2.58 and 2.41 Ma); yellow bars are depth to age correlation; blue lines are peaks of IRD.

Periods of maximum carbonate dissolution correlated well with peaks of ice-rafted debris (IRD). $\delta^{18}O$ values of *C. teretis* show short-lived changes. Thus there was periodic influx of dense brine-enriched waters or dilution by open-ocean convection.

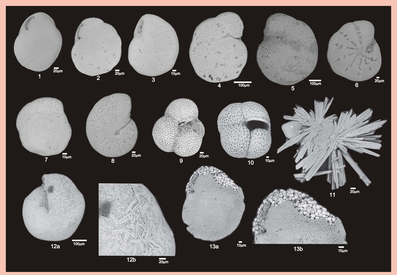


Plate I. 1. *Cassidulina reniforme* Nørvang, Sample 151-910C, 17-3, 98-102 cm. **2.** *Cassidulina teretis* Tappan, Sample 151-910C, 17-1, 98-102 cm. **3.** *Islandiella helenae/norcrossi*, Sample 151-910C, 19-1, 37-41 cm. **4.** *Cibicides lobatulus* (Walker and Jacob), Sample 151-910C, 17-1, 37-41 cm. **5.** *Cibicides grossa* (Dam and Walker), Sample 151-910C, 19-5, 37-41 cm. **6.** *Elphidium excavatum*, Sample 151-910C, 19-5, 98-102 cm. **7.** *Epistominella vitrea* Parker, Sample 151-910C, 19-1, 37-41 cm. **8.** *Melonis barleeanus* (Williamson), Sample 151-910C, 17-2, 98-102 cm. **9.** *Neogloboquadrina atlantica* (Berggren) sinistral, Sample 151-910C, 23-3, 98-102 cm. **10.** *Neogloboquadrina pachyderma* (Ehrenberg) sinistral, Sample 151-910C, 43-2, 34-38 cm. **11.** Calcite/Gypsum crystals? Sample 151-910C, 42-2, 37-41 cm. **12 a, b.** *Pullenia bulloides*, recrystallisation, Sample 151-910C, 47-4, 37-41 cm. **13 a, b.** *Cassidulina reniforme*, pyritisation, Sample 151-910C, 41-5, 98-102 cm.

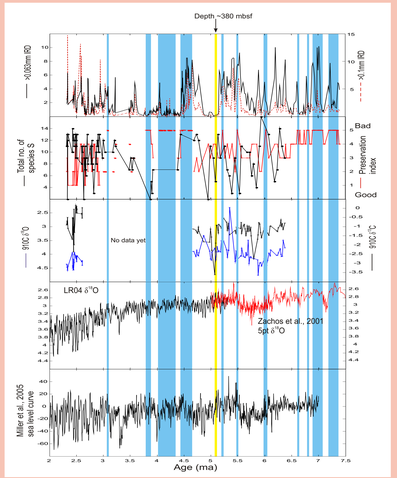
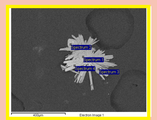
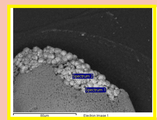


Figure 4. 910C benthic carbonate preservation index, total number of species, stable $\delta^{18}O$ and $\delta^{13}C$ data (*Cassidulina teretis*) and IRD data compared with $\delta^{18}O$ (LR04 stack and Zachos et al., 2001), sea level curve (Miller et al., 2005).



Spectrum	In stats.	O	Al	Si	S	K	Ca	Total
Spectrum 1	Yes	42.50	21.71	26.99		8.80		100.00
Spectrum 2	Yes	46.68	20.06	25.78		7.48		100.00
Spectrum 3	Yes	17.23			33.21		49.56	100.00
Spectrum 4	Yes	63.66			16.81		19.53	100.00
Max.		63.66	21.71	26.99	33.21	8.80	49.56	
Min.		17.23	20.06	25.78	16.81	7.48	19.53	



Spectrum	In stats.	C	O	Si	S	Ca	Fe	Total
Spectrum 1	Yes	36.79	5.06		16.99	5.17	35.99	100.00
Spectrum 2	Yes	32.69	8.14	0.82	16.62	2.82	38.91	100.00
Max.		36.79	8.14	0.82	16.99	5.17	38.91	
Min.		32.69	5.06	0.82	16.62	2.82	35.99	

All results in weight %

Figure 5. SEM spectrum analyses of microcrystalline (gypsum?) grains and pyrite impregnated shell of *Cassidulina teretis*; Sample 151-910C, 42-2, 37-41 cm and 41-5, 98-102 cm found around 380 mbsf (~5.1 Ma).

The dissolution spikes occured immediately before distinct $CaCO_3$ maxima. Better preservation show correlation with higher oxygen isotopic values indicating better preservation in the Arctic during glacial periods. Thus $CaCO_3$ minima occur close to major deglaciations when deepwater reorganizations occur. The reorganizations are also indicated by carbon isotope excursions (low $\delta^{13}C$ indicating reduced ventilation). In addition, a negative $\delta^{13}C$ excursion may also represent the influx of methane in the system.

Interestingly at the interval around 380 mbsf (~5.1 Ma) in Hole 910C there is evidence of extensive diagenesis with sulphide (greigite?) filled shells of foraminifera and recrystallised calcite (gypsum?) grains with nearly barren samples immediately above and below this depth. The primary SEM spectrum on the sulphide filled shells confirms it to be iron sulphide, but detailed analysis can reveal if it is greigite. Authigenic greigite (Fe_3S_4) can be formed as a byproduct of microbially-mediated diagenetic reactions in the sulphate, the anaerobic oxidation of methane and the methanic/gas hydrate zones (Larrasoaña et al., 2007). Greigite is preserved in the sediments, but gas hydrate eventually dissociates, thus any occurrence of greigite below the gas hydrate stability zone (GHSZ) can be a useful marker for the past presence of gas hydrates (Larrasoaña et al., 2007).

Conclusions

Samples that are barren or have a poor preservation may represent episodes of deglaciations.
Barren samples can also be an artifact of dissolution of shells and/or dilution by detrital material and IRD.
Observed dissolution peaks may represent very strong, short term meltwater events.
Presence of sulphide (greigite?) may be a useful marker for the former presence of gas hydrates.
Transition from Miocene into the Pliocene was associated with a prolonged period of barren samples with preservation improved in Late Pliocene.
Preservation of planktic foraminifera is better in Miocene compared to Pliocene.

Acknowledgements

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