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The "isotopic" status of planktic foraminifers in the Arctic and their use as paleoceanographical tracers

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In the Arctic Ocean, the cold water foraminifera *Neogloboquadrina pachyderma*, left as right coiled (Np), likely forms its shell along the pycnocline between the cold, dilute, surface water and the warmer, saline North Atlantic Water (NAW), due to salinity conditions in the surface water mass below optimum values for the species ($\sim$ 35 psu; Hilbrecht, 1996). However, δ^{18}O-values in Np shell still presents negative offsets with isotopic equilibrium conditions for a calcite precipitated at mid-pycnocline depth. This offset ranges from –1 (Arctic Seas) to –3‰ (Canada Basin, East Siberian Sea), although temperature gradients along the pycnocline still result in predictable isotopic shifts from small (juvenile?) to large (mature?) shells (Hillaire-Marcel et al., 2004). The precise mechanism responsible for the ^{18}O offset is not known, but it seems linked to rates of sea-ice formation or to its seasonal duration ($e.g.$, Bauch et al., 1997). The freezing of low δ^{18}O-value sea-surface waters rejects isotopically-light brines that sink to the pycnocline. We hypothesize that Np-shell growth occurs in such high-salinity/low-δ^{18}O water droplets or thin layers sinking to the pycnocline. *In vitro* experiments by Spindler (1996) have shown that formation of new shell-chambers could still occurs in salinities of up to 58 psu, and that some specimens could survive 82 psu for at least a week. Thus, in this hypothesis, isotopic offsets in Np would relate to the rate of brine formation. In the modern Arctic Ocean, mixing of these brines into NAW and export of surface water and sea ice to the North Atlantic would contribute to maintain steady-state conditions, thus resulting in an asymptotic isotopic offset value near –2.5/-3‰ in Np. From this view, the greater offsets in the Western Arctic and East Siberian Sea areas, compared with the eastern Arctic Ocean would reflect differences in sea-ice formation rates along shelves. Such isotopic offsets maintained in the Chukchi Sea during most of the Holocene, with possibly larger offsets early on. We thus infer continuous sea-ice formation during the early Holocene than at present.

Records from this area also illustrate some decoupling between surface-water conditions, as reconstructed from dinocyst assemblages, and conditions prevailing on top of the NAW, as indicated by the size dependent ^{18}O-gradients in Np. In addition, The 9-8 ka interval depicts a large offset between small and large specimens, suggesting much warmer conditions in the NAW than in the surface water, thus enhanced inflow of a warner NAW into the Arctic (Hillaire-Marcel et al., 2004). However, between 7 and 6 ka BP, these size-dependent gradients nearly vanished, suggesting a weakening of the pycnocline. This likely resulted from a higher surface salinity and less sea ice, as also indicated by the dinocysts.