Water column structure of the Eocene Arctic Ocean from Nd-Sr isotope proxies in fossil fish debris

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Nd-Sr isotopic compositions of Eocene fish debris (teeth, bones, scales) and reduced organic coatings reveal details of Arctic Ocean Basin water column structure at Lomonosov Ridge. Nd in marine fossil fish debris is acquired post-mortem at the sediment-water interface, recording bottom water composition; Sr is metabolized by fish (in this case a variety of smelt) living in equilibrium with their surroundings, recording the $^{87}Sr/^{86}Sr$ of the photic zone. Samples from IODP Expedition 302 all record isotopic values consistent with a brackish-to-fresh water surface environment ($^{87}Sr/^{86}Sr$ = ~0.7079-0.7087) that was poorly mixed with Eocene global seawater (~0.7077-0.7078). Leaching experiments show reduced organic coatings to be consistently more radiogenic (~0.7090-0.7094) than cleaned ichthyolith phosphate. Ichthyolith Sr isotopic variations likely reflect changes in localized river input as a function of shifts in the Arctic hydrologic cycle. We suggest that $^{87}Sr/^{86}Sr$ might be used as a proxy for salinity of surface waters. Model mixing calculations indicate salinities of ~5 to ~20 per mil, close to but lower than estimates based on O isotopes. Significant salinity drops (*i.e.*, 55 Ma PETM and 48.5 Ma Azolla event) do not show large excursions in $^{87}Sr/^{86}Sr$. Epsilon Nd in cleaned ichthyoliths (-5.7 to -7.8) overlaps Neogene Arctic Intermediate Water (B. Haley, pers. comm.), distinct from modern AIW (-10.5) and North Atlantic Deep Water. Eocene ichthyolith Nd may record some deep-water exchange with Pacific/Tethyan water masses, but inputs from local sources are also permissible. The Sr-Nd isotopic record is consistent with highly restricted basin-wide circulation in the Eocene, indicative of a poorly mixed ocean and highly stratified water column with anoxic bottom waters. A stable, "fresh" water upper layer was likely a pervasive feature of the Eocene Arctic Ocean, recording enhanced continental runoff during an unprecedented warm interval lasting from the 55 Ma PETM to the first appearance of ice rafted debris at ~45 Ma.

Trace element zonation of plagioclase from the Kunene Intrusive Complex (NW Namibia)

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The Mesoproterozoic Kunene Intrusive Complex (NW Namibia) consists of two main anorthosite bodies. A pale coloured so-called *white anorthosite* is intruded by the *dark anorthosite* which comprises leucogabbronorites, anorthosites and leucotroctolites.

Anhedral cumulus plagioclase of the *white anorthosite* is often turbid due to post-emplacement alteration. The An contents range from 40 to 50 mol.%. Individual grains either display a constant composition or minor An variations (±5 mol.%) which in some grains appear oscillatory with wavelengths of up to 1000 µm.

Anhedral to subhedral tabular coarse cumulus plagioclase of the *dark anorthosite* is optically clear and contains dust like Fe-Ti oxide inclusions. The An contents range between 43-75 mol.%. Some plagioclase phenocrysts display oscillatory zoning with wavelengths of up to 1500 µm and differences in the An-content of up to 8 mol.%, whereas others are characterized by a homogeneous composition.

Oscillatory zoning patterns of plagioclase from both anorthosite units are interpreted to be ingneous in origin, reflecting movements of the crystals in the magma reservoir. Plagioclase phenocrysts that display a nearly constant composition, on the other hand, are suggested to be affected by a post-magmatic reequilibration.

Since plagioclase is the main mineral present in anorthosites, major and trace element zoning patterns can provide important information about processes like cumulate formation, ascent of magma, and possibly also post-emplacement alteration. LA-ICP-MS analyses on profiles across plagioclase phenocrysts are in progress to examine the behaviour of the trace elements during the different stages of anorthosite formation.