Mg/Ca-derived temperatures for *Neogloboquadrina pachyderma* (s) in low temperature environments

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Reconstructing polar ocean temperature is vital for understanding the climate system response to past radiative and internal forcings. However, Mg/Ca paleothermometry in planktic foraminifera is generally limited to waters less than 3°C due to a poorly understood reversal of Mg/Ca temperature dependence [1]. We investigate the ability of a flow-through time-resolved analysis technique (FT-TRA) [2] to measure Mg/Ca in *Neogloboquadrina pachyderma* (sinistral) tests from core MD99-2227, located in the East Greenland Current [58°12.64 N, 48°22.38 W]. Our results show foraminiferal Mg/Ca values as low as ~0.5 mmol/mol.

$\delta^{18}O_{Npl}$ (per mil)	Mg/Ca (mmol/mol)	T (°C)
4.66	0.498	-0.98
4.21	0.529	-0.37
4.61	0.530	-0.36
4.20	0.537	-0.22
4.16	0.539	-0.19
4.15	0.544	-0.09
3.71	0.547	-0.04
4.01	0.552	0.06
4.28	0.558	0.16
4.70	0.559	0.18

Table 1: Oxygen isotopes ($\delta^{18}O_{Npl}$) [3] and Mg/Ca-derived temperatures (T) [4] for ten *N. pachyderma* (s) samples with lowest Mg/Ca.

Core intervals analyzed are from glacial Terminations I and II, with lowest Mg/Ca values surrounding the Last Glacial Maximum (~21 ka). Additionally, $\delta^{18}O$ of *N. pachyderma* (s) tests with very low Mg/Ca reflect glacial values for the North Atlantic [3]. We therefore suggest that the FT-TRA technique enables Mg/Ca paleothermometry to be performed on *N. pachyderma* (s) samples originating from waters at least as cold at -1°C, just above the freezing point of seawater.

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Focused Ion Beam (FIB) combined with TEM reveals nano-scale processes in geosciences

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Phase transformations, mineral reactions and replacement reactions describe the P-T path of rocks. Occasionally it is difficult to decipher reactions that have occurred in minerals and rocks because phase transformations, mineral reactions and replacement reactions occurred at an atomic or nanometer scale. Fortunately, microscopic and much more frequently submicroscopic textures or microstructures are preserved in minerals indicating the mechanisms, which have operated during transformation, reaction or replacement reaction. Transmission electron microscopy (TEM) is the ideal tool to identify such structures. Modern TEM allows the measurement of the chemical composition with unsurpassed spatial resolution. High-resolution imaging and electron diffraction provide structural information from the same location. It is the combination of microstructure, crystal structure and chemical composition that fully characterizes the investigated mineral section. High-resolution elemental mapping or line scans with drift correction acquire complete EDX spectra pixel by pixel. Subsequent data evaluation allows connecting the spectrum with the respective elemental map/line scan and the image, thus illustrating spatially resolved chemical composition. Focused ion beam technique (FIB) is the appropriate TEM sample preparation method that allows the preparation of electron transparent foils with typical dimensions of 15 x 10 x 0.150 µm from locations of interest (site-specific). FIB sample preparation consumes only a small volume of the sample (approximately 2300 μm^3), leaving most of the material completely unaffected.

The large capability of FIB/TEM method is demonstrated with examples such as coupled dissolution/reprecipitation reactions, reactions (symplectite) and phase transformations.