Calcium Isotopes as Tracers of Ocean Crust Alteration - Implications for Proxy Records

FLORIAN BÖHM[1], ALEXANDER ROCHOLL[2], MICHAEL WIEDENBECK[2], VOLKER LIEBETRAU[1], ANTON EISENHAUER[1]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany
[2]GFZ German Research Centre for Geosciences, Postdam, Germany

Calcite cements in ocean crust basalts of the deep sea form from mixtures of cold seawater and warm hydrothermal fluids (about 0-70°C). Such low temperature alteration (LTA) calcites have recently gained new interest as proxy recorders of seawater composition, e.g. [1], [2], [3]. Reconstructions of the evolution of seawater Sr/Ca based on LTA calcites indicate considerable increases of seawater Sr/Ca ratios from the Paleogene to Recent times. These reconstructions assume that for precipitation temperatures reflecting deep ocean conditions strontium and calcium concentrations in the LTA fluids were close to the contemporary seawater composition.

Calcium and strontium isotope compositions of seawater and basalt differ significantly. Therefore, the two isotope systems can be used as tracers of basement influence in LTA fluids. We consequently use an extended multi-proxy approach with oxygen isotopes, $^{87}Sr/^{86}Sr$ ratios, calcium isotopes and stable strontium isotopes to quantify the basement influence on the composition of LTA calcites that were recovered from several DSDP and ODP drill sites. The calcium isotope results indicate significant impacts from basalt alteration for all sites older than 50 Myr, where 20 to 60% of the calcium in the LTA fluids were derived from leaching of basement rocks. The calcium isotope corrected Sr/Ca record indicates that seawater Sr/Ca ratios remained close to the modern seawater composition during the last 130 Myr.

SIMS measurements of microscale calcium isotope variations in a LTA calcite vug show an evolution from an early seawater-dominated stage to a later rock-dominated stage. Consequently, early stage calcite precipitates from suitable LTA vugs may be used to reconstruct the original seawater composition, even if the bulk calcium isotope composition indicates a significant basement influence.

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