Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31183

Hydrated komatiites: the Archean record of seafloor rock-water interaction

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The hydration of ultramafic rocks is a critical process in the geological water cycle. Serpentinisation of exposed mantle peridotite on the seafloor is an important and effective process of rock-water interaction found on the modern Earth. However, in the Archean (4–2.5 Ga) seafloor hydrothermal processes may have been quite different. Ultramafic rocks were present as komatiites, high-temperature plume-derived lavas which erupted onto oceanic plateaux, containing igneous olivine, glass ± plagioclase, pyroxene and spinel. We present data from hydrated komatiites from the Kapvaal, Superior, Singhbhum, Yilgarn and Pilbara Cratons to investigate the record of Archean seafloor alteration. These komatiites are extensively hydrated and contain significant amounts of water (~6 wt. %) bound in antigorite, chlorite and tremolite. These silicate phases are enriched in fluid mobile elements such as Li, Cl, B, W, As and Sb, which were derived from seawater or seawater-sediment derived fluids, with B/Cl ratios indicating high fluid-rock ratios during rock-water interaction. The $\delta^{18}O$ compositions of antigorite measured in-situ via SIMS are homogenous within sample, with most falling in a range between 1.5–4.1 ‰. Oxygen isotope modelling of serpentine in equilibrium with Archean seawater with a $\delta^{18}O$ composition of -1 ‰[1] suggests that these samples were hydrated at temperatures of ~ 200–250 °C, after komatiite lava crystallisation. These komatiites also contain a record of extensive molecular hydrogen production (up to 315 mmol/kg) during seafloor alteration in the form of magnetite, which may have been a source of energy for early methanogenic life. The pervasive hydration of komatiite lavas was likely due to their low viscosity and high surface area, and the promotion of fluid circulation in cooling of piles of lava flows within oceanic plateaux. Despite their relatively low abundance in the Archean geological record (7–10% of greenstone belts crust), spatially extensive komatiite lava flows may have impacted the geochemistry of the Archean oceans and atmosphere.

[1] McGunnigle, J. P., et al. "Triple oxygen isotope evidence for a hot Archean ocean." *Geology* 50.9 (2022): 991-995.