

High-temperature hydrothermal activity in the lower oceanic crust: Petrological and geochemical evidence for fluid pathways in the Oman Ophiolite

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The Oman ophiolite is regarded as best example for fast-spreading oceanic crust on land. Petrological findings indicate that multiple intrusions of gabbroic sills play a significant role for the formation of the deep plutonic crust at fast-spreading oceanic ridges [1], a model which requires a substantial cooling of the deep oceanic crust, probably by seawater-derived high-temperature hydrothermal circulation [e.g.,2]. In this study we present petrological and geochemical data for veins and zones formed by hydrothermal alteration within the lower layered gabbro sequence of the Samail ophiolite in Oman (Wariyah, Wadi Tayin Massiv).

Veins and alteration zones of mm to m scale within an unaltered olivine gabbro record high (>800°C), medium (~600°C), and low temperature (~350–500°C) hydrous alteration indicating possible fluid pathways for hydrothermal circulation. Petrological results show mineral assemblages typical for predicted interaction between olivine gabbro and seawater-derived fluid [3]. High temperature veins display mineral assemblage of olivine + plagioclase + pyroxenes + pargasitic amphibole ± oxides. Decreasing temperature result in a change in alteration paragenesis, where hydrous minerals become more abundant. The typical medium temperature mineral assemblage is plagioclase + clinopyroxene + chlorite + magnesiohornblende ± oxides followed by low temperature veins mainly consisting of epidote + prehnite + actinolite/tremolite.

Geochemical micro-analyses of sub-mm veinlets and adjacent host rocks show systematic enrichment of fluid mobile elements (e.g., LREE, Eu, Mo, W) in these veins and indicate possible element mobility during hydrothermal activity. These preliminary results suggest that hydrothermal circulation at very high temperatures exists.

[1] Kelemen (1997), *Earth Planet. Sci. Lett.* **146**, 475-488. [2] Bosch (2004), *J. Petr.* **45**, 1181-1208. [3] McCollom and Shock, *J. Geophys. Res.* **103**, 547-575.

Can seawater promote *in situ* mineral sequestration?

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Dissolution of mafic and ultramafic rocks in the presence of CO₂ is of great current interest due to the potential for carbon storage in basaltic and/or peridotitic rocks. This storage method involves converting gaseous or supercritical CO₂ into carbonate minerals for its safe, long-term storage. In-situ carbonatization of CO₂ faces a major challenge in that huge quantities of water are required to dissolve CO₂ to promote reactions. This challenge might be overcome by using seawater for the dissolution of CO₂ during its injection.

To assess the possible use of seawater during carbon storage efforts, steady-state silica release rates (r_{Si}) from basaltic glass and crystalline basalt of same chemical composition and dunitic peridotite have been determined in far-from-equilibrium dissolution experiments at 25°C and pH 3.6 in a) artificial seawater solutions under 4 bar pCO₂, b) varying ionic strength solutions, including acidified natural seawater, c) acidified natural seawater of varying fluoride concentrations, and d) acidified natural seawater of varying dissolved organic carbon concentrations. Glassy and crystalline basalts exhibit similar r_{Si} in solutions of varying ionic strength and cation concentrations. Rates of all solids increase by 0.3-0.5 log units in the presence of 4 bar pCO₂ compared to atmospheric CO₂ pressure. At atmospheric CO₂ pressure, basaltic glass r_{Si} were most increased by the addition of fluoride to solution whereas crystalline basalt rates were most enhanced by the addition of organic ligands. In contrast, peridotite rates are unaffected by either the addition of fluoride or organic acids. Most significantly, Si release rates from the basalts are found to be not more than 0.6 log units slower than corresponding peridotite rates at all conditions considered in this study. This rate difference becomes negligible in seawater suggesting that CO₂-charged seawater injected into basalt might be nearly as efficient for mineral sequestration as injection into peridotite.