

Peridotite alteration in OmanDP cores

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Here we present some preliminary results constraining peridotite alteration in cores from several Oman Drilling Project (OmanDP) boreholes, from the Samail ophiolite in the Sultanate of Oman. Hole BT1B in Wadi Mansah east of Fanjah was drilled through 200 m of fully carbonated and/or serpentinized peridotites of the mantle wedge, through the basal thrust of the ophiolite, into the metamorphic sole. Holes BA1B, BA3A and BA4A were drilled into extensively serpentinized peridotite of the eastern Wadi Tayin massif.

Fully carbonated peridotites (listvenites) and serpentinites of Hole BT1B reflect carbonation and hydration by fluids rising from the Cretaceous subduction zone at the base of the ophiolite, at about 100° C (Falk & Kelemen GCA 2015). Though there is extensive, 0.01-10 m scale chemical variation, the average, volatile-free composition of the listvenites is almost identical to that of partially serpentinized harzburgites throughout the ophiolite mantle section. This observation and thermodynamic modeling indicate that, during addition of CO₂, H₂O, Ca and K from subduction zone fluids, Mg/Fe/Si ratios were nearly unchanged, suggesting very minor export of dissolved, major elements. In turn, this requires a large increase in solid volume. One possibility is that major volume expansion occurred at a serpentinization front, perhaps advancing via reaction-driven cracking, followed by smaller amounts of expansion at the carbonation front. Observed mineral parageneses and thermodynamic modeling require relatively CO₂-rich aqueous fluids, and perhaps an exsolved, CO₂-dominated fluid. CO₂ contents were higher than for fluids in equilibrium with underlying metasediments at any likely depth for formation of the observed listvenite, and thus suggest that fluids derived from higher temperature and pressure devolatilization migrated up the subduction zone to this site.

Highly serpentinized peridotites from Holes BA1B, BA3A and BA4A record steep chemical gradients, with sharply decreasing $f(\text{O}_2)$ and $f(\text{CO}_2)$ downhole, beginning at the present-day erosional surface. Moreover, inferred conditions based on mineral parageneses are consistent with present-day borehole water compositions. Oxygen fugacity reaches the limit for H₂ production from H₂O at < 100 meters below the surface. These borehole observations are consistent with previous observations (14C in carbonates, reduced sulfides, oxides and metals, highly alkaline and reduced fluids, H₂ gas) and thermodynamic modeling indicating that carbonation and serpentinization-related redox reactions are ongoing. Given experimental data suggesting that serpentinization of olivine is slow, evidence for low temperature “serpentinization” raises interesting questions about natural rates, and the nature of reactants and products, in the present-day weathering environment.

Keywords: Global carbon cycle, Oman Drilling Project, Peridotite weathering, Serpentinization, Carbon mineralization aka mineral carbonation, Natural production of H₂ hydrogen gas

