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Hydrothermal Alteration of the Crust-Mantle Transition and Upper Mantle in the Samail Ophiolite: Insights from the Oman Drilling Project

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Phase 2 of the Oman Drilling Project recovered the transition from layered gabbroic lower crust to upper mantle sequences of the Samail Ophiolite at Holes CM1A (400m) and CM2B (300m), providing an unprecedented opportunity to study crustal accretion and alteration processes in oceanic lithosphere. Alteration reactions and veining occurred under a range of temperatures and fluid compositions, throughout the lifespan of the ophiolite, from the Tethyan mid-ocean ridge, through obduction to present-day exposure in the mountains of Oman. In both holes, high-temperature hydrothermal amphiboles are rare and temperatures of pervasive alteration are estimated to be within greenschist facies conditions (300-400°C). Alteration intensity in the gabbroic rocks, recovered in the upper 150m of Hole CM1A, varies from fresh (5%) to highly altered (95%) with an overall average alteration of approximately 30%. In both holes, alteration of the gabbros is highest near hydrothermal veins and in rodingitized domains within the crust-mantle-transition sequences. A sheared rodingite interval within serpentinized dunite marks the transition from the crustal to mantle sequences. Within the Crust-Mantle Transition, alteration intensity is consistently highest in serpentinized dunites and generally exceeds 95% in Hole CM1A and 80% in Hole CM2B.

A greater number of rodingitized intervals are found in Hole CM1A, altered to varying proportions of diopside, chlorite, vesuvianite, (hydro)garnet, xonotlite, and less commonly, uvarovite and titanite; vesuvianite was not found in Hole CM2B. Harzburgites within the mantle sequences are distinctly less altered and more variable than the dunite domains. Serpentinization of the ultramafic rocks is dominated by serpentine and magnetite ± brucite mesh textures, which are cut by multiple generations of serpentine ± magnetite ± carbonate veins. The bottom 10m of Hole CM2B is marked by spectacular carbonation features and a progressive transition from serpentinized harburgite to talc-serpentine-calcite-dolomite harzburgite to talc-magnesite-dolomite serpentinite. Magnesite and dolomite occur as coarse-grained, well crystallized veins, lenses, and irregular patches up to 30 cm long. A chaotic distribution of alteration phases and irregular veining patterns suggest high fluid pressures and hydrofracturing associated with infiltration of CO_2-rich fluids under greenschist facies conditions.