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Serpentinization in the Oman Ophiolite: oceanic to continental alteration processes in the Wadi Dima harzburgites (Wadi Tayin massif, Sultanate of Oman).

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Serpentinization is a widespread process in ophiolitic mantle. It involves the hydration of the main constitutive minerals of mantle rocks (olivine and pyroxenes) by seawater- or meteoric- derived fluids. It can occur over a wide range of temperatures in association with oceanic hydrothermal circulation, fluid contamination during obduction or meteoric waters flowing through present day peridotite aquifers. The contribution of these different stages of serpentinization to the overall alteration of ophiolitic mantle sections remains poorly known. In order to characterize these processes, reaction paths and fluid pathways, we carried out mineralogical (Raman spectroscopy), bulk and in-situ geochemical (major and trace elements, carbon isotopes) and in-situ oxygen isotopes (SHRIMP) studies of harzburgites sampled in the Wadi Dima area (Oman ophiolite). This area exposes moderately serpentinized ($\sim$ 60%) to completely serpentinized harzburgites crosscut by carbonate vein networks. The Wadi Dima harzburgites have depleted bulk rock compositions typical of refractory Oman peridotites (Yb $<$ 0.39 x C1-chondrite).

The degree of serpentinization of harzburgites, and the morphology and composition of serpentine minerals vary with the distance to carbonate veins, with the most serpentinized samples observed near veins. Three types of serpentines are distinguished. Serpentine in moderately serpentinized harzburgites is mesh textured lizardite with olivine cores (S1). The S1 lizardite mesh rims have δ^{18}O-values from 2.8 to 4.1‰ (estimated temperature $\sim$ 200-220°C). In completely serpentinized harzburgites, dark serpentine selvages (S2) in contact to carbonate veins are distinguished from the typical serpentine matrix (S3). S2 serpentine exhibits larger variability in REE abundances (Yb = 0.02-0.65 x C1-chondrite) compared to S3 serpentine (Yb = 0.03-0.20 x C1-chondrite), suggesting a strong mobilization of chemical elements close to carbonate veins acting as fluid pathways. S2 and S3 serpentines display Ce anomalies (both positive and negative; Ce/Ce* = 0.2-4.6) indicating interactions with seawater derived fluids. S2 serpentine has a well-developed mesh texture which is locally overprinted at the interface with carbonate veins. S2 mesh textured serpentine is composed of lizardite mesh rims having δ^{18}O-values ranging from 2.6 to 9.3‰ and chrysotile cores having δ^{18}O-values ranging from 6.5 to 9.2‰ (estimated temperature $\sim$ 200-100°C). S3 serpentine is composed of lizardite mesh rims and chrysotile and/or carbonate cores formed after olivine relics. Lizardite mesh rims have δ^{18}O-values ranging from 7.5 to 9.5‰ while chrysotile cores have δ^{18}O-values ranging from 7.1 to 7.9‰ (estimated temperature $\sim$ 140-80°C).

These results suggest that serpentinization starts in an oceanic setting at $\sim$ 200-220°C, probably during the onset of the oceanic lithosphere cooling and during the intra-oceanic detachment. At this stage, lizardite mesh rims act as preferential flow paths at the micro-scale. These microscale flow paths are re-exploited as the mantle lithosphere cools from 140°C down to 80°C, resulting in the hydration of olivine relics and the formation of chrysotile cores. The latest stage of serpentinization is concurrent with the formation of carbonate cores during the early stage of carbonatization resulting in the complete alteration of peridotites hosting carbonate vein networks.