Linkages between serpentinization and carbon trapping in the Oman Ophiolite: Evidence from the Wadi Dima and Batin peridotites

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The Oman Ophiolite preserves a section of Tethyian oceanic lithosphere obducted onto the Arabian peninsula. Its mantle section is variably serpentinized. It hosts H_2-rich alkaline springs, suggesting that serpentinization is still active today, and highly serpentinized carbonate-rich areas, which could be used as analogues to develop techniques for CO_2 geological storage. By combining petrostructural, mineralogical, and geochemical approach (major and trace elements, C and O isotopes), we investigated the linkages between serpentinization and associated carbonate-forming reactions at two key locations : the Wadi Dima carbonate-rich serpentinized harzburgite basement and the Batin dunite-dominated basement, close the OmanDP active alteration site.

We show that the ophiolite underwent first, widespread serpentinization, triggered by the ingress of seawater-derived fluids during oceanic lithosphere cooling and/or intra-oceanic detachment (T > 200-220°C). Lizardite mesh rims acted as flow paths and, locally, serpentine veins formed along weaknesses controlled by the olivine crystallographic preferred orientations. Serpentinization lasted down to T~110°C along serpentine veins acting as flow paths for CO_2-bearing seawater-derived fluids. Dm-thick selvages preserved evidence of concurrent chrysotile and carbonate replacement of relict olivines thus marking incipient carbonate formation. As obduction progressed, CO_2-bearing sediment- to meteoric water- derived fluids followed the same pathways, and serpentinite veins were progressively replaced by carbonates, down to T<50°C. A striking feature is the occurrence of reduced carbon in serpentinites (TOC up to 1500 ppm and $\delta^{13}C$ of -28‰) and low $\delta^{13}C$ in associated early carbonates (down to -15‰). This suggests that carbon was trapped as reduced carbon species during serpentinization. These species were, at least in part, preserved from oceanic to ophiolitic settings. They are distributed ubiquitously in the serpentinized mantle section compared to the highly localized carbonate veins, and could thus contribute significantly to the carbon budget of the Oman ophiolite.