Unraveling carbon uptake sequences in fast cooling oceanic serpentinites (Batin, Oman ophiolite): Insights from O and C isotopes

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Serpentinization is a major component of carbon exchanges between the deep Earth and its outer envelopes from oceanic settings to subduction. It consists in the hydration of the mantle lithosphere and is coupled to redox reactions producing H_2. When CO_2 is present, it is associated to the precipitation of carbonates and of reduced carbon as carbonaceous matter (CM). To investigate the links between serpentinization, carbonatization and carbon reduction, we studied serpentinized dunites from the Batin area (Oman ophiolite), close to OmanDP BA sites, using mineralogy and geochemistry (major and trace elements, $\delta^{13}C$ and $\delta^{18}O$).

The Batin mantle section comprises large tabular dunites discordant to concordant to the dominantly harzburgitic mantle section, crosscut by sub-horizontal gabbros and pyroxenitic dykes; it may represent an embryonic off-axis mantle diapir. Dunites are completely serpentinized but they preserve evidence of high melt/rock interactions with bulk rock Fe contents up to 11.3 wt.% Fe_2O_3. Serpentine is dominantly lizardite cross-cut by chrysotile veins. It has locally Fe-Mg-zoned fingerprint textures, interpreted as formed by a liesegang-type process. It has in situ $\delta^{18}O_{SMOW}$ values of 7.5-8.2‰ in veins and 4.3-7.1‰ in matrix (T~110-170°C). Fingerprint serpentines have $\delta^{18}O_{SMOW}$<2‰ indicating disequilibrium; they are interpreted as related to fast cooling of the serpentinite basement. Rare late carbonate veins have $\delta^{18}O_{SMOW}$>24‰ (T<60°C). Batin serpentinites have carbon contents of 3100-4600 ppm and TOC of 1050-1200 ppm (TOC/TC = 0.2-0.4). They have identical $\delta^{13}C_{TOC}$ of -28.2/-28.5‰ (VPDB) contrasting with their variable $\delta^{13}C_{TC}$ of -4.2/-9.4‰ (VPDB), and $\delta^{13}C_{TIC}$ of -2.5/8.2‰ (VPDB). We posit that carbon precipitated first as reduced CM during serpentinization, inducing Rayleigh fractionation as recorded by inorganic carbon. Late carbonate veins have low and variable $\delta^{13}C$ (-12.2/-8.1‰ (VPDB)), suggesting localized CM oxidation. Efficient serpentinization of fast cooling Batin dunites likely limited further fluid percolation from oceanic to ophiolitic settings; this allowed preserving the reduced carbon signatures in the Batin serpentinites.