Sulfide Aggregation in Ophiolitic Dunite Channels Explains Os-Isotope Mismatch between Oceanic Crust and Mantle

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Abstract: The osmium-isotope mismatch commonly reported between mid-ocean-ridge basalts (MORBs) and residual mantle might reflect evolution of the MORB Re-Os system after extraction from the asthenosphere, or preferential contribution of radiogenic Os components from mantle. However, in a MOR system, the role of dunite melt channels from the upper mantle and Moho transition zone in regulating isotopic systems between mantle and crust has rarely been evaluated. We report new Re-Os isotopic compositions of base-metal sulfides (BMS), chromites and dunites from dunite lenses with low spinel Cr# [Cr2+/ (Cr2++Al3+) ≤ 0.66] (products of interaction between MORB-like melts and upper-mantle harzburgites) from the Zedang ophiolite (South Tibet). Re-Os isotopic compositions of low-Cr# dunites from the Oman ophiolite are also shown for comparison. Mineralogical evidence suggests that the Zedang sulfides were originally precipitated as monosulfide solid solutions. The highly variable ~188Re/188Os initial ratios (0.1191-0.1702) and low ~187Os/188Os (~<0.22) of the sulfides suggest that the chromite acted as a sink for Os-bearing sulfides, aggregating discrete Os components with heterogeneous isotopic signatures from asthenospheric or lherzolitic mantle into dunite channels. The Zedang chromites and dunites show ~187Os/188Os ratios similar to the primitive upper mantle (PUM), except for two dunites with sub-PUM ratios, reflecting the contribution of Os balanced by smaller volumes of Os-rich, unradiogenic sulfides (likely nucleating on Os nanoparticles) and larger volumes of Os-poor radiogenic BMS. Such isotopic heterogeneity, despite with less variation, has been observed in dunite channels from the Oman ophiolite and present-day mid-ocean ridges. Formation of dunite channels in the upper mantle thus can aggregate Os-bearing sulfides with chromite, leaving high Re/Os components into the residual melts. Once such channel systems were built up at the crust-mantle transition zone, the newly incoming MOR magmas would preferentially melt and dissolve the volumetrically abundant radiogenic BMS and retain Os-rich nanoparticles in the channels, further amplifying the Os-isotope mismatch between oceanic crust and mantle. This study sheds new light on the multistage evolution and small-scale behaviors of chalcophile and siderophile elements (e.g., Re-Os) and their isotopes (e.g., ~187Re-~188Os) with sulfides and chromites in a silicate-dominated melt plumbing system beneath mid-ocean ridges.

Key words: sulfide aggregation, dunite melt channels, Re-Os isotopes, Os-isotope mismatch of oceanic crust and mantle, melt plumbing system, mid-ocean ridges

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