

Earth's core in the mantle?

Experimental fractionation of Re-Os-Pt in core-forming phases

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On the basis of high Os ($^{186}\text{Os}/^{188}\text{Os}$ and $^{187}\text{Os}/^{188}\text{Os}$) isotopic signals in a few lavas from ocean-island localities, it has been suggested that source of these magmas is sampling an outer-core component. By enriching the outer core in Pt and Re (over Os; for example by fractional crystallization at the outer-inner core interface), one way to achieve these high Os isotopes is if the Earth's outer core is transferring material back into the mantle that is finally delivered to the surface in the form of plumes. Thus, if correct, identification of this core component in the mantle-derived products has major implications in understanding siderophile/lithophile geochemistry of the mantle, source(s) of the so-called plume-magmas, and very importantly the highly debated origin of plumes rising from the core-mantle boundary. Understanding the ultimate origin of these chemical signatures also has the potential either to validate or discredit current models for formation, differentiation, and early evolution of the planet. In this contribution, by performing Re-Os-Pt partitioning experiments between sulfidized solid/molten-iron metal, we test the proposed core signature in the mantle. Experiments, spiked with 1 wt% each of Re, Os, and Pt, were done on the Fe-FeS (7 wt% S in the bulk) join at 3-22 GPa and 1300-1775 C. Run charges are free of metallic nuggets. Concentrations of Fe, S, Re, Os, and Pt were determined using JEOL-8800 JXA microprobe with WD spectrometry. At a constant pressure, the retrieved partition coefficients ($D_{\text{solid-metal/liquid-metal}}$) show a strong positive dependence on the sulfur content of the liquid-metal (S_{liq} ; 9-21 wt%). At similar S_{liq} (12 wt%), values of D_{Os} , D_{Re} , and D_{Pt} range from 6-8.5, 4.6-5.9, and 3.2-3.3, respectively, and thus in the 3-22 GPa pressure range D values are not drastically affected. However, the relative fractionation, Pt/Os and Re/Os, is more consequential, as it is the fractionation of Os from Pt and Re that is necessary to generate enriched Os signals. At a given S_{liq} , $D_{\text{Re}}/D_{\text{Os}}$ appears to be pressure independent, implying that with increasing pressure, Os and Re do not readily fractionate from each other. Importantly, however, at a given S_{liq} , $D_{\text{Pt}}/D_{\text{Os}}$ increases with pressure, indicating, that Pt is actually becoming more compatible in the solid-metal. Thus, if these experimental trends continue down to the outer-inner core boundary inside the planet, then it is conceivable that it will be almost impossible to suitably and strongly fractionate Pt and Re from Os (in a core that contains sulfur as the principal dilutant), as needed in geochemical models. As the required fractionation may be impossible to generate, an outer-core contribution in some ocean-island basalts can be

dismissed. It is our view that future efforts to more severely address the measured Os signals should focus on cautiously pushing the limits of the multianvil modules to higher pressures by using sintered diamond cubes, innovative ways to do post-experiment dissection on tiny, diamond-anvil cell charges with an aim to understand the effect of pressure on partitioning, better models that narrow the huge uncertainty in the nature of light element(s) in the outer core, and the effect of a multitude of light dilutants on D systematics. Also, besides better defining the budget of Re, Os, and Pt in the most accessible upper-mantle, sea-floor, and crustal rocks, we need to properly understand the factors controlling the distribution and fractionation of these elements in a variety of rocks in different tectonic settings.