ISOTOPIC DETECTION OF POSSIBLE CORE-MANTLE INTERACTIONS IN PLUME SOURCES: RULES OF ENGAGEMENT. Richard .J Walker, Department of Geology, University of Maryland, College Park MD 20742. rjwalker@geol.umd.edu

If some plumes arise from the core-mantle boundary *and* there is limited chemical interaction between the core and mantle within D", it is possible that these plumes could contain a unique chemical or isotopic fingerprint that is characteristic of the core. Unequivocal identification of a core component in a plume could, thus, potentially settle a major question in geodynamics. The ideal tracers of a core component in a plume would be elements that occur in very high abundance in the core relative to the mantle and crust, such that a very modest transfer of matter from the core to the mantle would result in a resolvable geochemical signature. The most sensitive suite of elements for geochemically identifying possible core contributions to plumes that may arise from the core-mantle interface are the highly siderophile elements (HSE = Pt, Re, Os, Ir, Pd, Ru, Rh, Au), and certain moderately siderophile elements (MSE) such as Ag, W and Mo. Because of the extreme preference of the HSE for metal relative to silicates, the formation of the core nearly quantitatively sequestered the Earth's HSE, and also likely dominates the budget of moderately siderophile elements. Mass balance is, therefore, potentially optimal for detection of core additions to the mantle.

Formation of the inner core may have fractionated the HSE, as occurred in early and late stage differentiates of asteroidal cores (e.g. Cook et al., in review) and as is predicted from experimental studies (e.g.. Jones and Malvin, 1990). We have previously suggested that the coupled ^{187}Re-^{187}Os and ^{190}Pt-^{186}Os isotope systems may be useful in identifying the presence of an evolved outer core component in mantle-derived rocks (Walker et al., 1995; Brandon et al., 1999). This hypothesis is based on conclusions from the study of asteroidal core crystallization (e.g. Cook et al., in review) and experimental studies (e.g. Walker 2000) indicating that Pt, Re and Os have become fractionated from one another in the outer core as a consequence of inner core crystallization. If a significant inner core formed sufficiently early (e.g. within 2 Ga of planetary formation), the outer core may exhibit coupled ^{187}Os and ^{186}Os enrichments of >7% and >0.01%, respectively, relative to chondrites.

Coupled enrichments in ^{186}Os-^{187}Os have been detected in intrusive rocks related to the *ca*. 250 Ma Siberian flood basalt event, the *ca*. 89 Ma Gorgona Island (Colombia) komatiites, and in some rocks generated recently by the Hawaiian plume (Walker et al., 1997; Brandon et al., 1999; Brandon et al., 2003)(**Fig. 1**). All three igneous systems are generally assumed to be associated with large mantle plumes. We have argued that the coupled enrichments detected are not consistent with the presence, via recycling, of any presently characterized crustal materials in the source regions of these magmatic systems, or via contamination of the magmas within the crust.

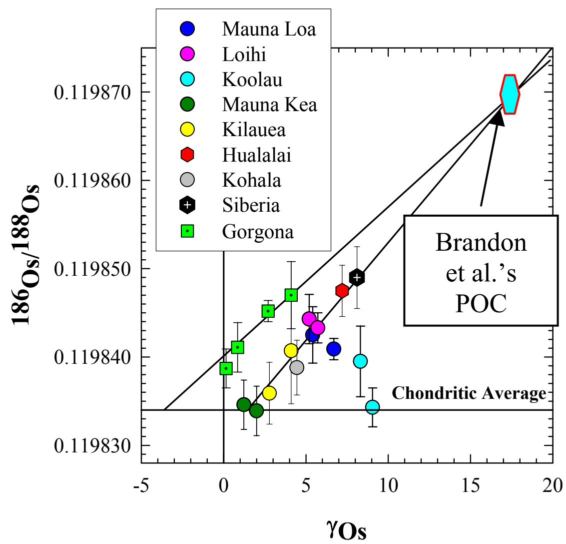

Figure 1. Correlated variations in $^{186}Os/^{188}Os$ relative to initial γ_{Os} (initial $^{187}Os/^{188}Os$ relative to the bulk solar system average). Brandon et al. (2003) concluded that the two trends may converge (POC: point of convergence) on a common endmember with $^{186}Os/^{188}Os \approx 0.119870$ and $\gamma_{Os} \approx +17$.

The ^{186}Os-^{187}Os "test" for core material, however, is not without its weaknesses. It requires relatively early crystallization of the inner core, and processes other than core-mantle interaction could be envisioned to explain our observations. Additional data and new methods will be necessary to more convincingly demonstrate or refute core-mantle interactions.

Decay of so called "short-lived" nuclides during the first few tens of Ma of solar system history almost certainly led to the generation of isotopic compositions in the core that are resolvable from the silicate earth. Consequently, short-lived isotope systems are the best hope to confirm a core signature implicated by Os isotopes (Os isotopes alone can never "prove" the existence of a core component in mantle-derived rocks). It is even possible that a short-lived system can uniquely identify a core component. It is also important to note that a potential short-lived tracer for core-mantle interaction has an advantage relative to ^{186}Os-^{187}Os in that the magnitude of the anomaly would not be time dependent (all growth of the daughter isotope is complete within approximately the first 50 Ma of the birth of the solar system). Hence, if the short-lived systems can be demonstrated to be viable indicators of core contributions to modern plumes, then the contributions to ancient magmatic systems could also potentially be examined.

There are a variety of nuclides with approximately 10^6 to 10^7 year half-lives that were seeded into (or created within) the solar nebula just prior to the initiation of condensation. The positive identification of the decay products of short-lived systems with HSE or MSE, including ^{107}Pd-^{107}Ag and ^{182}Hf-^{182}W, have been carefully documented for a variety of meteorites and components within meteorites (*c.f.* Chen and Wasserburg., 1996; Lee and Halliday, 1996). Anomalies for the ^{98}Tc-^{98}Ru, ^{99}Tc-^{99}Ru and ^{97}Tc-^{97}Mo systems could also be useful, however, our recent work suggests that Tc did not exist in sufficiently high abundance to be useful for this application (Becker and Walker, 2003; Becker and Walker, in review).

Of greatest importance here is that recent work on the ^{182}Hf-^{182}W isotopic systematics of chondrites (Yin et al., 2002b; Kleine et al., 2002; Schoenberg et al., 2002a) has convincingly refuted earlier claims that the Earth has a chondritic W isotopic composition (Lee and Halliday, 1996). Instead, chondritic meteorites have ε_W values (part per 10,000 deviation of ^{182}W/^{18x}W relative to terrestrial standards) of approximately -2. This is potentially very important for identification of core components because the earlier results required rather late core formation and a minimal difference between the isotopic composition of W in the core and mantle. The new results require that the mantle and core have different W isotopic compositions (presumably combined they must have a chondritic composition). Mass balance requires that the core must have an ε_W value that is slightly less than –2, compared to 0 for mantle rocks. Thus, sufficient transfer of core W to a plume could generate a resolvable negative ε_W value in the mixture. The magnitude of the deviation would depend on the proportion of W transferred, and this in turn is dependent on the ratio of W in the core to W in the mantle. Unfortunately, W is apparently an MSE and is likely not as highly concentrated in the core as the HSE (though this bears additional testing). Assuming the core has W concentrations 10 times that of the mantle, transfers of 0.2 to 1% core material to a plume, as has been proposed to explain ^{186}Os-^{187}Os enrichments, would result in ε_W deviations from the terrestrial standard of 0.2 units or less. The possible level of heterogeneity is just within the resolution capabilities of modern mass spectrometers.

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