

Core-Mantle Reactivity

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The compositional and thermal contrast between the liquid iron-alloy outer core and the solid silicate mantle implies chemical reactivity. The isotopes of Os and Fe/Mn ratios of Hawaiian basalts have been used to argue that their plume sources contain a discernible contribution of core material [1,2]. Reactivity at the core mantle boundary will be governed by the simple reaction: $\text{FeO}^{\text{silicate/oxide}} = \text{Fe}^{\text{liq}} + \text{O}^{\text{liq}}$ [3]. This reaction proceeds to the right if the core is undersaturated with oxygen, and to the left if saturated with oxygen. Thus, reactive transfer of siderophile elements such as Fe, Os or W into the mantle implies saturation of the outer core with oxygen. The solubility limit of oxygen in molten iron is a function of T and P. Experiments at less than 25 GPa show low oxygen solubility in molten iron coexisting with solid oxide or silicate [4]. Experiments in the DAC at higher P's and T's [5], as well as consideration of the effects of P on partial molar volumes [3], indicate increasing solubility of oxygen with pressure above 30 GPa. DAC data indicate an increase in oxygen solubility in molten iron equilibrated with solid silicate from less than 1 wt% at 30 GPa to perhaps greater than 5 wt% at core-mantle boundary conditions [5].

Core formation models based on siderophile elements indicate metal segregation from a deep magma ocean at conditions in the range of 25-50 GPa and 2000-3500 K [6]. At such conditions, available data suggest that less than 2% oxygen dissolved into core-forming metal. During transport to higher P metal would not have equilibrated with solid mantle. We postulate that although considerable oxygen may dissolve into iron at core P's and T's, the oxygen content of core-forming metal was relatively low and established at the conditions of segregation. Inner core crystallization increases the outer core oxygen content, but nowhere near to saturation. The reaction given above most likely moves from left to right at the core-mantle boundary; oxygen moves in, not out.

Our arguments are in contrast to the apparent signals in some plume lavas for an input of core material. We argue that W isotopes are a more diagnostic finger-print of the core than either Fe/Mn ratios or elevated $^{186}\text{Os}/^{188}\text{Os}$. Measured $^{182}\text{W}/^{184}\text{W}$ isotope ratios in Hawaiian lavas, the same lavas used to measure $^{186}\text{Os}/^{188}\text{Os}$, show no sign of core-mantle interaction [7]. Oxygen solubility and W isotope arguments indicate that communication of the core with the surface via deep sourced mantle plumes is unlikely.

References

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