Is there primordial reservoir in lower mantle?

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Tungsten isotope composition provide important constraints on the sources of the ocean-island basalts (OIB). If the core formation occurred within the first 60 Myr of the solar system formation, the silicate mantle should be characterized by high Hf/W and positive μ^{182}W, whereas the metallic core has very low Hf/W and negative μ^{182}W. Recently μ^{182}W of the young OIBs with high ^{3}He/^{4}He have shown two distinct features: positive μ^{182}W from Phanerozoic flood basalts (Ontong Java and Baffin Bay) indicating a presence of primordial reservoir [1], and negative μ^{182}W from modern OIBs (Hawaii, Somoa, Iceland) [2]. However, later study suggested that a positive μ^{182}W anomaly can potentially be caused by nuclear shift isotope fractionation affecting primarily the odd isotope (^{183}W) and basalts from Ontong Java have also shown negative μ^{182}W anomaly [3]. Thus, there is no evidence from tungsten isotopes to constrain the existence of a primordial reservoir in the lower mantle. On the other hand, negative μ^{182}W anomaly becomes a universal feature of the modern OIBs. One possibility to produce the negative μ^{182}W is chemical interaction of the mantle with the Earth’s outer core. An experimental study has shown that W grain boundary diffusion in the lower mantle phases is quite fast process and displays strong temperature dependence [4]. W isotope can be modified significantly at the base of the lower mantle through the whole Earth’s history. When highly-oxidized slabs accumulate at the CMB oxidizing the outer core at the interface, a large W flux with negative μ^{182}W can be added to the silicate mantle. As a result, the source region of the OIB would be effectively modified to a negative μ^{182}W. A good correlation of μ^{182}W and ^{3}He/^{4}He observed in modern OIBs invokes that ^{3}He is also provided by the outer core liquid. In this case, there is no necessity to envision a primordial reservoir in the deep lower mantle. Future studies should be accompanied by coupled investigations with diffusion of ^{3}He/^{4}He to further constrain core-mantle interaction.

References

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