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The transition-zone water-filter model: Geochemical implications

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The formation of isolated mantle reservoirs are usually thought to occur through differentiation processes including (1) core-mantle separation, (2) continental crust formation and (3) partial melting at mid-ocean ridges. In this traditional picture, on-going differentiation only occurs in the shallow upper mantle (process (3)); it is therefore difficult to reconcile the persistence of reservoirs with the whole-mantle circulation suggested by geophysical studies. In our recent paper [1] we proposed that dehydration melting at 410km will act as a barrier to incompatible elements while the majority of mantle materials circulate at the whole-mantle scale. In this model, the OIB source is undepleted, heterogeneous material in the deep mantle (>410km) and the source materials for MORB are those processed through the 410km filter. The separation of MORB source materials is assumed to occur currently at 410km and therefore it is important to examine if our model is consistent with trace element abundance patterns and isotopic observations including those with slow radioactive decay (i.e., $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$). Proposed melting would result in enhanced depletion of incompatible elements in the MORB source region, and changes in the concentration of radioactive elements. We have calculated the trace element abundance patterns based on our model and published partition coefficients for various degrees of partial melting and garnet mass fraction. Our model involves three melting events, i.e., formation of continental crust, transition-zone melting, and melting at mid-ocean ridges. As a result of additional melting, our model shows a higher degree of trace element depletion in the MORB source regions, and explains the gross trace element abundance pattern including that of Pb without assuming the unusual partitioning often assumed. Isotopic observations such as $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ can also be explained by our model assuming well-known chemical properties of Sr, Rb, Sm and Nd, if the source region of OIBs is dominated by the Hawaii source or FOZO, and efficient mixing occurs in the melt layer at 410km.

References

[1] Bercovici D., and Karato S. (2003) *Nature* **425**, 39-44.

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The bulk silicate Earth as MORB source and isotope geochemical approach to the origin of D"-layer

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The generalization of Nd initial isotope compositions for mantle rocks of various ages demonstrates that there is no CHUR in Sm-Nd isotope systematics at least for the last 4 Ga years and that the main mantle material is identical to MORB source. Using Pb-Pb isotope systematics it is possible to show that the MORB source corresponds to Bulk silicate Eatrh (BSE), which has arisen simultaneously with formation of the core. As well as MORB source, the BSE is depleted with light REE in comparison with chondrites. However such depletion does not contain that petrogenetic meaning which was traditionally attributed to it, because deficit of LREE has arisen at the earliest stage of the planet evolution and it is not connected with formation of the crust. Moreover, because LREE are refractory elements they couldn't be removed together with gases, K and Rb during the accretion of the Earth. So, if the ratio of refractory elements in initial planetary material really corresponded to chondrite one, the simple observance of balance demands that deficient LREE to be concentrated in the core. The core should be segregated from protoplanetary material without full melting of a silicate geosphere and with preservation a basalt component in it. It is possible only in the case if segregation of a liquid core occurred by the cotectic or eutectic partial melting. The partial melting is always accompanied by partial extraction of incompatible trace elements including volatiles. That is why the core should contain these elements, in particular LREE and rare gases with excess of ^{3}He and ^{129}Xe. But first of all it should contain Fe-Mg silicates. Crystallization of such core like layered intrusions will lead to separation of cumulates into solid core and silicate layer D". According to the developed model the layer D" is rather young formation. This layer arises due to differentiation of the most ancient reservoir, which is liquid core, and inherits its isotope characteristics. This layer is inevitably destroyed in a course of the mantle convection and again is regenerated with renewal of the core crystallization.

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