The tungsten isotopic compositions of kimberlites: constraints on material circulation in the deep Earth

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The short-lived ^{182}Hf-^{182}W isotopic system (^{182}Hf →^{182}W + β-) has been widely used to probe early differentiation events (*e.g.*metal-silicate segregation and silicate differentiation). Since ^{182}Hf has a short half-life of 8.9 Myr (Vockenhuber *et al.*, 2004), it decayed into ^{182}W during the first 60 Myr of the solar system' s history. Given that W is moderately siderophile, it preferentially partitioned into the Earth' s core during its segregation. Hf, in contrast, is lithophile and is retained in the silicate portion of the Earth. As a result, the ^{182}W/^{184}W ratio of the Earth' s core is estimated to be ~220 ppm lower than the terrestrial mantle (Touboul *et al.*, 2012). In addition, early silicate differentiation could have also created the variation in ^{182}W/^{184}W ratios. Since W is more incompatible than Hf, an "early depleted reservoir" may have an excess in ^{182}W and, in contrast, its complementary "early enriched reservoir" (EER) may have a deficit in that value.

Mundl *et al.* (Mundl *et al.*, 2017) reported negative μ^{182}W (deviations in ppm from the ^{182}W/^{184}W isotopic composition of the terrestrial standard) values in oceanic island basalts (OIB) which negatively correlate with ^{3}He/^{4}He. This result suggests that there exist early-differentiated reservoirs in the present-day deep mantle, since OIB are considered to have their sources in the lower mantle. Several processes have been proposed to explain the deficits in ^{182}W, for example, core-mantle interaction and the contribution from the EER. However, none of the hypothesis can satisfy geochemical constraints. This study provides new constraints on this issue by investigating plume-derived rocks, kimberlites.

In this study, we performed ^{182}W isotope analysis of kimberlites from South Africa, China and Brazil with MC-ICP-MS (*Thermo Fisher Scientific* Neptune Plus). Kimberlites are ultrabasic rocks that are presumed to have their origin deep in the Earth like OIB. On the other hand, globally distributed kimberlites have relatively undifferentiated isotopic compositions close to those of bulk silicate Earth (BSE), whereas OIB have relatively differentiated values. From these results, kimberlites are considered to originate from an isotopically primordial reservoir like the Earth' s primitive mantle (Woodhead *et al.*, 2019).

All measured ^{182}W/^{184}W values of kimberlites were within analytical error of a terrestrial standard, which is considered to have the value of the modern accessible mantle. The present result indicates that the depletion of the present-day upper mantle in incompatible elements has occurred after ^{182}Hf was no longer extant, as there is no difference in ^{182}W values between the primordial mantle and the already depleted mantle. In addition, given that OIB show μ^{182}W negative anomalies (Mundl *et al.*, 2017), whereas kimberlites didn't show any anomalies, the source mantle of OIB is considered to be more strongly affected by the core-mantle interaction or the EER than that of kimberlites.

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