Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.6168

Tungsten-182 and Neodymium-142 evidence for an ancient kimberlite source

NAO NAKANISHI[1], RICHARD W. CARLSON[2], MARY F. HORAN[2], ANDREA GIULIANI[3,4], JON WOODHEAD[4], D. GRAHAM PEARSON[5] AND RICHARD J. WALKER[1]

[1]University of Maryland
[2]Carnegie Institution for Science
[3]ETH Zurich
[4]University of Melbourne
[5]University of Alberta

Presenting Author: nnakanis@umd.edu

Kimberlites are igneous rocks that are derived from the deep mantle. Recent studies of compiled $^{143}Nd/^{144}Nd$, $^{176}Hf/^{177}Hf$, and $^{87}Sr/^{86}Sr$ data for a global suite of kimberlites suggest that at least some kimberlites originate from a primitive, isotopically-homogenous, deep mantle reservoir that evolved in isolation for at least 2.5 billion years [1, 2]. To decipher whether or not this reservoir preserves remnants of an early-formed mantle domain, we report $^{182}W/^{184}W$ and $^{142}Nd/^{144}Nd$ data for kimberlites from ten worldwide localities, ranging in age from 1153 to 52 Ma. Most are characterized by uniform $\mu^{182}W$ and $\mu^{142}Nd$ values (ppm difference in $^{182}W/^{184}W$ and $^{142}Nd/^{144}Nd$ between sample and standards) averaging -5.9 ± 1.0 ppm (2SE, n = 13) and +2.7 ± 1.2 ppm (2SE, n = 6), respectively. The remarkably homogeneous, modestly negative $\mu^{182}W$ values, coupled with chondritic to supra-chondritic initial $^{143}Nd/^{144}Nd$ and $^{176}Hf/^{177}Hf$ ratios over a span of nearly 1000 Myr is powerful evidence that the kimberlites were derived from an early-formed mantle reservoir that was largely isolated from the convective vigor of the accessible upper mantle throughout Earth history. Possible explanations for the modestly negative $\mu^{182}W$ value include the ancient transfer of W from the core to the mantle source reservoir, creation of the source reservoir as a result of early silicate fractionation, or an overabundance of late accreted materials in the source reservoir. Each of these possibilities requires a well-mixed, deep mantle source to leave a globally-accessible, isotopically-uniform reservoir.

By contrast, two younger kimberlites emplaced at 72 and 52 Ma, and characterized by lower initial $^{176}Hf/^{177}Hf$ and $^{143}Nd/^{144}Nd$ than the older kimberlites, have $\mu^{182}W$ values consistent with the modern upper mantle. This is consistent with the interpretation that the mantle source of some kimberlites younger than 200 Ma was modified by the incorporation of a deeply subducted component with low $^{143}Nd/^{144}Nd$ and $^{176}Hf/^{177}Hf$. The ^{182}W isotopic compositions likely reflect contamination of the ancient kimberlite source with the addition of recycled crustal components with $\mu^{182}W \geq 0$.

[1] Woodhead et al., 2019. Nature, **573**, 578-581
[2] Giuliani et al., 2021. PNAS, **118**, e2105211118