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Recycled carbonates in the mantle sources of natural kamafugites: A zinc isotope perspective

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Abstract

Kamafugites are strongly silica-undersaturated melts that are difficult to produce by partial melting of volatile-free peridotites but can be produced experimentally in the presence of CO_2. Nevertheless, there is not yet direct evidence for a CO_2-rich mantle source and the possible presence of recycled carbonates in the source of natural kamafugites. Marine carbonates have a heavier zinc isotopic composition ($\delta^{66}Zn$) than that of the mantle by up to 1.0‰, making zinc isotopes a sensitive tracer for recycled carbonates in the sources of mantle-derived magmas. Here we take Cenozoic kamafugites from the West Qinling orogen in China as an example to address the origin of this rare volcanic rock. The West Qinling kamafugites are strongly silica-undersaturated (SiO_2 = 37.0 to 43.0 wt%) and have significantly higher $\delta^{66}Zn$ (0.30‰ to 0.47‰) than that of the normal mantle (0.18 ± 0.05‰). No correlation between $\delta^{66}Zn$ and MgO or SiO_2 contents is observed, indicating that the high $\delta^{66}Zn$ was not a result of magmatic differentiation. Modeling of melting indicates that even at extremely low degree (~0.5%), partial melting of a normal peridotitic source is still unlikely to produce silicate melts with $\delta^{66}Zn$ values exceeding 0.30‰. Thus, the elevated $\delta^{66}Zn$ of the West Qinling kamafugites demonstrates the presence of recycled carbonates in their mantle sources. Binary-mixing modeling suggests that the source contains ~5 to 15% recycled carbonates, which is supported by the positive correlation between $\delta^{66}Zn$ and CaO/Al_2O_3. Overall, the West Qinling kamafugites represent the products of low-degree partial melting of a recycled carbonate-bearing peridotite source, which provides evidence for an important role of recycled carbonates in the origin of natural kamafugite suites.

Keywords: Kamafugites, Zn isotopes, recycled carbonates, CO_2-rich source, West Qinling