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Magnesium- and iron-isotope evidence for the origin of kimberlitic melts from Udachnaya-East pipe (Siberian Craton, Russia)

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Kimberlite is a carbonate-rich volcanic rock representing deep mantle melts (>150 km). However, its post-emplacement alteration (e.g., serpentinisation) and a large amount of external material (xenoliths and xenocrysts) complicate the identification of the origin of primary kimberlite melt as well as the parental source to kimberlite magmas [1,2]. To address the origin of kimberlite magmas, we analysed major and trace elements, as well as Mg-Fe isotopes, from five rare, fresh, non-serpentinised kimberlites from Udachnaya-East, Siberian Craton, Russia. In addition to that, we analyse serpentinised kimberlites from the same pipe and sedimentary bed rock.

The Mg isotopic compositions (δ^{26}Mg = -0.31 ~ -0.24‰) of non-serpentinized kimberlites fall within the range of the mantle (~ -0.25 ‰), MORB (~ -0.25 ‰) and OIB (~ -0.26 ‰), whereas their Fe isotopic compositions (δ^{56}Fe =0.06 ~ 0.12 ‰) are heavier than the mantle (~0.00 ‰) and comparable to MORB (~0.10 ‰) and OIB (~0.11 ‰). Crustal contamination, fractional crystallisation, and diffusion processes are excluded as controls on these isotopic variations. By subtracting the contribution of mantle-derived components, we obtain the Mg-Fe isotopic compositions of the kimberlite melt (δ^{26}Mg = -0.34 ~ -0.24 ‰, δ^{56}Fe =0.10 ~ 0.21 ‰). Kimberlite melts exhibit carbonate-like signatures, such as low Hf/Hf* (0.27~0.29) and Ti/Ti* (0.56~0.89), however, their Fe isotopic composition contrasts with that of igneous carbonates (-0.30 ~ -0.10‰) and aligns with mantle-derived silicate melts (0.05 ~ 0.33‰). The Mg-Fe isotopic range of kimberlite melts overlaps with that reported for melilitites (δ^{26}Mg = -0.27±0.04 ‰, δ^{56}Fe =0.13±0.06‰) [3,4], which are assumed to be generated by low-degree (1–2%) melting of carbonated peridotite.

We conclude that the isotopic data supports the origin of kimberlite magmas from low-degree melts of carbonated peridotite metasomatised by deep mantle carbonates, with source oxygen fugacity ranging from FMQ-2.9 to FMQ-0.3.

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