Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.15925

Chromium and strontium isotopic evidence for the fractional crystallization of parent magma of Chang'e 5 mare basalts

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Chang'e 5 (CE 5) mission returned ~2.0 Ga mare basalts from Oceanus Procellarum, highlighting the importance of the Eratosthenian volcanic activities. However, the mantle source of the parent magma and its melting mechanism is still in hot debate. Also, CE 5 samples showed its uniqueness of a high degree of magmatic evolution, with an average Mg# at around 33, providing a window to examine the nature of the later mare magmatic evolutions. Stable isotopic fractionations are sensitive to the crystallization and separation of specific minerals, such as spinel for Cr isotopes and plagioclase for Sr isotopes. Thus, the isotopic fractionation behaviors of Cr and Sr, along with other isotopic systems can provide important insight on the fractional sequence of the magmas.

Here, we performed high-precision analyses of stable Cr, and Sr isotopic compositions for an evolved mare basalt clast and a regolith CE5C0600 (CE5-600). The CE5-052 exhibits a significantly lighter Cr isotopic composition ($\delta^{53}Cr = -0.58 \pm 0.04‰$), agreeing with its low Mg# (14.5) and Cr content (220 ppm), while the Cr isotopic composition of the lunar soil CE5-600 is identical to other mare basalts. Fractional crystallization modeling with AlphaMELTS2 shows that the highly evolved Cr isotopic signature in CE5-052 is consistent with a high crystallization proportion of mafic minerals (>50%). However, the Sr isotopic composition of CE5-052 is identical to CE5-600 and other mare basalts, reflecting limited plagioclase (<3%) crystallization proportion. The inadequate plagioclase crystallization could be attributed to an Al-depleted magma compared to Apollo low-Ti basalt magma at a given MgO or CaO content.