

Redox controlled stable chromium isotope fractionation during planetary differentiation

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The lunar and Vesta basaltic rocks have slightly lighter Cr isotope compositions than terrestrial basalts, and two processes have been previously proposed: volatilization loss of oxidized Cr species during planetary magmatic ocean stage [1, 2]; and redox-related isotope fractionations during partial melting or crystal fractionation [3]. Our recent work has shown that Cr isotope fractionation factors between mantle minerals is controlled by oxygen fugacity [4]. Therefore, it is necessary to investigate Cr isotope behaviors during magma processes and the effect of oxygen fugacity.

In the current study, we analyzed twenty-one well-studied OIBs from three Hawaiian volcanos: Kilauea, Koolau and Mauna Kea. The homogenous $\delta^{53}\text{Cr}$ of Koolau and Mauna Kea lavas implies that post-magmatic alterations do not significantly change Cr isotope systems. In contrast, $\delta^{53}\text{Cr}$ of Kilauea Iki basalts vary from -0.18‰ to 0.00‰, and are positively correlated to MgO and Mg#. This is interpreted as a result of crystallization and accumulation of spinel and olivine during magma differentiation.

Combining these results, we present a quantitative model that relates Cr isotope compositions of the basaltic rocks from Earth, Moon and Vesta, to the crystallization assemblage, the fractionation degree, and the $\text{Cr}^{2+}/\Sigma\text{Cr}$ ratios of minerals and melts (dominated by f_{O_2}). We speculate that the lunar and the Earth's mantle have the same Cr isotope composition (-0.16‰ to -0.09‰). The low $\delta^{53}\text{Cr}$ in the lunar mafic rocks is the result of redox-controlled crystal fractionation and accumulation of lunar magma ocean.

[1] Sossi *et al.* (2018) *PNAS*, 115, 10920-10925. [2] Zhu *et al.* (2019) *GCA*, 266, 598-610. [3] Bonnand *et al.* (2016) *GCA*, 175, 208-221. [4] Shen *et al.* (2018) *EPSL*, 499, 278-290.