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Letter

The chlorine-isotopic composition of lunar KREEP from magnesian-suite troctolite 76535

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Abstract

We conducted in situ Cl isotopic measurements of apatite within intercumulus regions and within a holocrystalline olivine-hosted melt inclusion in magnesian-suite troctolite 76535 from Apollo 17. These data were collected to place constraints on the Cl-isotopic composition of the last liquid to crystallize from the lunar magma ocean (i.e., *ur*KREEP, named after its enrichments in incompatible lithophile trace elements like potassium, rare earth elements, and phosphorus). The apatite in the olivine-hosted melt inclusion and within the intercumulus regions of the sample yielded Cl-isotopic compositions of 28.3 ± 0.9‰ (2σ) and 30.3 ± 1.1‰ (2σ), respectively. The concordance of these values from both textural regimes we analyzed indicates that the Cl-isotopic composition of apatites in 76535 likely represents the Cl-isotopic composition of the KREEP-rich magnesian-suite magmas. Based on the age of 76535, these results imply that the KREEP reservoir attained a Cl-isotopic composition of 28–30‰ by at least 4.31 Ga, consistent with the onset of Cl-isotopic fractionation at the time of lunar magma ocean crystallization or shortly thereafter. Moreover, lunar samples that yield Cl-isotopic compositions higher than the value for KREEP are likely affected by secondary processes such as impacts and/or magmatic degassing. The presence of KREEP-rich olivine-hosted melt inclusions within one of the most pristine and ancient KREEP-rich rocks from the Moon provides a new opportunity to characterize the geochemistry of KREEP. In particular, a broader analysis of stable isotopic compositions of highly and moderately volatile elements could provide an unprecedented advancement in our characterization of the geochemical composition of the KREEP reservoir and of volatile-depletion processes during magma ocean crystallization, more broadly.

Keywords: Apatite, Mg-suite, Apollo, molatiles, moon, magma ocean, melt inclusion, phosphates