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A Look Inside Meteorites: A paired low-Cl AMS and multi-element ICP-MS analysis of lunar meteorites

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Chlorine is a relatively abundant element consisting of two stable isotopes, ^{35}Cl and ^{37}Cl, which have a natural ratio on Earth of $^{35}Cl/^{37}Cl = 3.127$. Specialized methods are required to extract and isolate it from Cl-bearing minerals for isotopic analysis, but existing analytical techniques either require relatively large amounts of chlorine or are restricted to in-situ analysis of specific mineral phases[1].

On Earth, $\delta^{37}Cl$ values, which measure permille $^{35}Cl/^{37}Cl$ difference from standard mean ocean chloride[2], exhibit relatively limited variation, typically ~0‰. Lunar samples have significantly wider variations of up to +81‰[3]. Proposed mechanisms for these variations include magmatic degassing and late-stage interaction with volatile gas phases produced during devolatilization processes, particularly in lunar surface materials approximately 4 billion years ago[4], though all mechanisms result in drastically reduced Cl concentrations of ~ 0.1-10 ppm in remaining materials.

Recently, Anderson et al. developed a method capable of measuring chlorine isotope ratios in samples containing as little as 1–10 µg of chlorine using the pre-acceleration components of an accelerator mass spectrometer (AMS)[5]. In this study, we apply this methodology to measure $^{35}Cl/^{37}Cl$ isotope ratios and $\delta^{37}Cl$ values at the microgram scale to investigate chlorine fractionation in lunar materials.

We perform paired analyses of lunar meteorite samples to evaluate Cl isotopic variations with AMS and other volatile elements isotopic ratios with ICP-MS to have broader understating of the sample's alteration processes and compositional background. By extending previous work, we investigate processes that may have driven chlorine fractionation and depletion in planetary materials and assess the applicability of this technique to other astromaterials.

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