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Developing Microgram Scale $\delta^{37}Cl$ Measurements with Accelerator Mass Spectrometry for the Study of Astromaterials

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The volatile element chlorine can be lost during the formation and evolution of planetary bodies, leading to fractionation of its two stable isotopes ^{35}Cl and ^{37}Cl. Chlorine isotope variations (reported as $\delta^{37}Cl$ in parts per thousand (‰) relative to Standard Mean Ocean Chloride, SMOC) are documented to exceed 80‰ between different lunar rock samples [1] and have been variably interpreted as the fingerprint of degassing during accretion, magma ocean, or volcanic portions of lunar history [2,3,4,5].

The large *intersample* and *intrasample* variations observed by both bulk isotope ratio mass spectrometry (IRMS) and in-situ secondary ion mass spectrometry (SIMS) methods are difficult to interpret in part because of a paucity of bulk Cl isotope measurements. This lack of high-precision bulk data is due to the relative rarity of IRMS laboratories capable of making these high precision measurements on small samples of precious planetary materials such as those returned by human or robotic exploration.

Here we present a new method for performing high precision $\delta^{37}Cl$ measurements using the high intensity Cs-sputter ion source of an existing accelerator mass spectrometer. For samples with as little as 1 µg Cl–the equivalent of 2-4 mm^3 of a typical lunar rock sample–the average cathode accuracy is ~1‰. Cathode reproducibility is typically ~1‰ (2σ) for samples with at least 10 µg of Cl, increasing to ~3-6‰ for aliquots with ~1-2µg Cl, similar to published SIMS results and sufficient to study astromaterials from the Moon, Mars, or 4 Vesta, which have tens of ‰ observed variations. Our hope is that this method will be used to supplement existing techniques, reducing the cost and complexity of bulk Cl measurements, and making urgently needed $\delta^{37}Cl$ measurement capabilities more widely accessible.
References: [1] Wang et al. Sci. Rep., 2019; [2] Sharp et al. Science, 2010; [3] Boyce et al. EPSL, 2018; [4] Barnes et al. EPSL, 2016; [5] Boyce et al. Sci. Adv., 2015.