Advances in Measuring the Chlorine Isotopes of Planetary Materials

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Chlorine isotope measurements within the suite of lunar rocks yield δ^{37}Cl values up to +81‰ [1] relative to terrestrial standard mean ocean water chlorine. These elevated δ^{37}Cl have been interpreted as the result of fractionation driven by degassing during eruption of anhydrous basalts [2], or during earlier stages of lunar history [e.g. 3, 4, 5].

However, interpretation of ***inter**sample* lunar δ^{37}Cl is complicated by large ***intra**sample* variations which manifest in both isotope ratio mass spectrometry bulk analyses of *soluble* versus *insoluble* Cl (up to 10‰ [2]) and also in the more abundant but usually less precise, in situ, secondary ion mass spectrometry analyses of the Cl-rich mineral apatite (up to 15‰, see [5] for examples). Clearly, neither bulk nor in situ methods are capturing the full range of lunar δ^{37}Cl, and more data—especially bulk measurements—are needed.

As part of a series of projects designed to explore other possible means of generating δ^{37}Cl data, we have made preliminary δ^{37}Cl measurements using accelerator mass spectrometry (AMS) at Lawrence Livermore National Laboratory. The nine total different aliquots of KNSTD 1600 standard used in this study differ only in that they vary in sample mass (three each of approximately 36 μg, 15 μg, and 7.5 μg total Cl). We find in our first test of δ^{37}Cl by AMS that the mean uncertainty (defined by the reproducibility of five 100 second blocks for each aliquot) is ±1.8‰ (2σ, N=9), though the interaliquot reproducibility is poorer (±3‰, ±6‰, and ±2‰ 2σ for 36, 15, and 7.5 μg Cl aliquots, respectively). If all nine blocks are taken together, the 2SE bounds of the mean is less than ±2‰. Uncertainties of a few ‰ on samples containing less than 10 μg of Cl are already sufficient to study the lunar sample suite that spans ~100‰ in δ^{37}Cl, as well as the smaller but not insignificant variations observed for rocks thought to be from 4 Vesta and Mars. With further refinement, it is anticipated that the minimum sample size can be further decreased, and the reproducibility can be improved, making the existing AMS laboratories an exciting resource for planetary stable isotope work. **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.