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METHODS FOR CHEMISTRY AND PREPARATION OF LOW-CL CONCENTRATION SAMPLES FOR STABLE CHLORINE ISOTOPE MEASUREMENTS WITH AMS

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Introduction: Cl is a volatile element and can be lost during formation and evolution of planetary bodies, which can lead to fractionation of its two stable isotopes, 35Cl and 37Cl. Stable Cl isotope variations (reported as δ37Cl, in parts per thousand (‰), relative to standard mean ocean chloride (SMOC) [1]) have been measured in many lunar samples and have produced a wide range from -4‰ to +81‰ [2-7]. This variation has led to various interpretations of how the fractionation was produced, from degassing during accretion, magma ocean, or volcanic phases of lunar evolution [3, 4].

Chlorine isotope measurements from two methods, SIMS and IRMS, have produced significantly different results, leading to difficulties in interpreting δ37Cl data, which led us to develop a method for high precision (~1-4‰ with 10 µg Cl, 2σ) stable Cl isotope measurements using the cesium sputter negative ion source of an accelerator mass spectrometry (AMS) system [8].

This work is the next step in developing the chemistry and methods required to dissolve, separate, and measure samples from highly fractionated, low Cl concentration materials such as those found in astromaterials from the Moon, Mars and 4 Vesta [2-7,9-12]. Here we will present progress toward a method that can efficiently extract small amounts of Cl from a silicate matrix. Our approach involves bulking with Br carrier following HF digestion to efficiently scavenge Cl with a Ag(Br+Cl) precipitation. The Ag(Br+Cl) is then re-dissolved and Cl is chemically separated from Br via anion exchange chromatography. This will enable sample preparation with microgram-scale Cl masses, to ultimately prepare samples for measurement using the cesium sputter AMS method [8]. The presented experiments are aimed at establishing a robust column separation procedure, potential sources of Cl contamination, and isotope fractionation in the column.

Discussion: We were able to fully separate the 50 µg of added Cl from 500 µg of added Br using anion exchange resin, enabling this method for use in scavenging micrograms of Cl from low mass or low-Cl astromaterials. In a natural sample, the Cl and Br would be co-precipitated together and re-dissolved to be loaded into anion exchange columns.

Our finding that the column chemistry slightly fractionates the Cl samples can likely be precisely quantified and accounted for with further measurements or may not be present with other forms of resin, which will be tested.

The current source of Br standard solution adds approximately 4 µg of Cl per ml to the sample. In addition to exploring a new Cl-free Br source, cleaning the Br solution of Cl using this anion exchange method will be tested.

Anderson et al. [8] outlined how to measure stable chlorine isotopes using only the Cs sputter source of an AMS facility at high precision. This work represents an important next step to being able to fully dissolve rock samples and scavenge small masses of Cl for stable Cl isotopic measurements of low mass or low-Cl concentration lunar and meteoric samples with AMS.

Future tests will use different chemical forms of resin such as the OH- form to quantify any Cl fractionation or contamination and note any process changes.

Conclusion: We have shown the ability to chemically separate Cl from Br, representing important initial steps toward a method for scavenging small Cl masses from natural samples for stable Cl isotope measurements with AMS.

Applications of this sample preparation method coupled with the high precision measurement of stable chlorine isotopes shown in [8] to problems in planetary science and astrophysics will be discussed.

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