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隕石における高精度モリブデン同位体比分析法の開発
Development of highly precise and accurate molybdenum isotope analysis using N-TIMS in meteorites

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Recent developments of mass spectrometry have made it possible to detect isotope anomalies of some heavy elements present in a variety of meteorites. Some of the anomalies are only marginal with <10 ppm deviations from terrestrial samples. To make highly precise and accurate isotope analysis, it is essential to develop the following techniques: 1) Completely dissolve terrestrial and extraterrestrial materials. 2) Separate target elements in the materials with high recovery. 3) Develop isotope analysis of the elements using state-of-the-art mass spectrometer. These points are very important not only to preserve precious meteorites but also to detect the isotopic compositions in tiny materials.

Molybdenum is one of the promising elements for the study of isotopic anomalies in meteorites. It has seven stable isotopes that were synthesized from three different nucleostynthetic processes (s-, r- and p- process). A recent study using MC-ICP-MS reported variable Mo isotope anomalies in some meteorites [1], but there still remains an unsolved question regarding the origin of the anomalies because Mo isotopic compositions in meteorites have been reported only in limited studies. As a preliminary stage to produce a new comprehensive dataset of highly precise and accurate Mo isotopes in bulk meteorites and their components, here we have developed a new chemical separation method for Mo, W and HFSE from meteorite sample. We also developed highly precise and accurate isotope analysis of Mo using N-TIMS.

The separation method consists of a two-stage column chemistry using anion exchange resin (Eichrom 1X8, 200-400 mesh). We have evaluated the performance of our technique by using powdered terrestrial rock samples (JB-3 and JLk-1) and meteorites (Charcas and Allende). A quadrupole-type ICP-MS (X SERIES II, Tokyo Tech) was used to determine the elution profiles as well as recovery yields of Mo, W and HFSE. Recovery yields of these elements were near 100%.

Molybdenum isotope analysis was carried out using N-TIMS (TRITON plus, Tokyo Tech) equipped with nine moveable Faraday cups. Molybdenum dissolved in HNO_3-HCl solution was loaded on degassed Re filament, and it was covered with Gd, La and Ca as emitter. The filament was heated to 1230-1280 degrees C for stable analysis of Mo isotopic compositions. The isotopes were measured as MoO_3^- ion. No interferences from Zr and Ru isotopes were observed. The precision of isotope analysis was determined by repeated analysis of a standard Mo solution (Kanto Chem.) and some terrestrial rock samples. The accuracy of isotope analysis was evaluated by measuring multiple in-house Mo isotope standards that were gravimetrically prepared by mixing the Mo standard solution with ^{97}Mo enriched and ^{100}Mo enriched spikes in different proportions.

References: [1] Burkhardt C. et al. (2011) EPSL, 312, 390-400.

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