CADMIUM ISOTOPE VARIATIONS IN BULK CHONDRITES: THE EFFECT OF THERMAL NEUTRON CAPTURE.

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Introduction: At the bulk meteorite scale, nucleosynthetic isotope variations are observed for several refractory elements (e.g. Ti, Mo, Zr [1-3]). However, for the moderately volatile elements, only Zn potentially shows such variations [4]. Cadmium is a highly volatile element with a half-mass condensation temperature (652 K) similar to Zn (726 K) [5]. Cadmium has eight stable isotopes: ^{106}Cd and ^{108}Cd are produced by the *p*-process, ^{110}Cd mainly by the *s*-process, and the rest by a combination of the *s*- and the *r*-process [6, 7]. Therefore, Cd is a particularly suitable candidate to further investigate potential nucleosynthetic isotope variations in volatile elements and their origin. In addition to nucleosynthetic variations, thermal neutron capture effects can also alter the Cd isotope composition of meteorites. This is due to the very large neutron capture cross-section of ^{113}Cd [e.g. 8], which can lead to the burnout of ^{113}Cd and the corresponding production of ^{114}Cd. Depending on shielding depth and exposure age of the analysed samples, the magnitude of this offset is predicted to be large enough [8] to be resolved with our current analytical precision (> 20 ppm). The aim of this study is to obtain high-precision Cd isotope data for bulk carbonaceous and enstatite chondrites, as well as acid leachates of Jbilet Winselwan (CM), in order to identify potential mass-independent variations, of both nucleosynthetic and cosmogenic origin.

Analytical Method: Bulk samples of 6 carbonaceous and an enstatite chondrite were powdered and dissolved in Parr® bombs. Additionally, 7 leach fractions were produced from the stepwise dissolution of Jbilet Winselwan. Cadmium was purified using a three-stage chromatographic separation procedure using anion exchange and TRU-Spec resin. The final Cd elution was checked for interfering elements such as Zn, Zr, Mo, Ge, Ru, Se and P. If the solutions yielded ^{66}Zn/^{111}Cd ratios above ~0.01, an additional anion exchange column was adapted to minimize the production of Zn-argide interferences on the low abundance isotopes ^{106}Cd and ^{108}Cd. The ion exchange procedure was optimized to separate both Cd and Sn from the same sample aliquot. The Sn isotope results are reported in a companion study [9].

Cadmium isotope measurements were performed with a Nu Plasma II MC-ICPMS using a DSN-100 introduction system. Two measurement cycles were used to allow all Cd isotopes to be collected simultaneously (first cycle), and ^{115}In, ^{118}Sn and ^{105}Pd (second cycle) to monitor direct isobaric interferences. Each individual analysis comprises of 30 dynamic isotope measurements, with 10 s (first cycle) and 5 s (second cycle) integrations. The isotope data were internally normalized to ^{116}Cd/^{111}Cd = 0.578505 [10] with the exponential law, and in addition also to ^{112}Cd/^{114}Cd, ^{110}Cd/^{114}Cd and ^{113}Cd/^{111}Cd to help with the interpretation of the results. Using a 200 ppb Cd Alfa Aesar standard solution, an average daily reproducibility (2SD, n = 30) of ± 115 ppm for ^{106}Cd/^{111}Cd, ± 111 ppm for ^{108}Cd/^{111}Cd, ± 30 ppm for ^{110}Cd/^{111}Cd, ± 21 ppm for ^{112}Cd/^{111}Cd, ± 28 ppm for ^{113}Cd/^{111}Cd and ± 28 ppm for ^{114}Cd/^{111}Cd was achieved. On average, one analysis consumed 120 to 140 ng Cd (nebulizer flow-rate ~50 µl/min).

Results: Analyses of bulk CV (Allende), CM (Jbilet Winselwan) and enstatite (Indarch) chondrites show small resolvable negative offsets in their ε^{113}Cd value relative to the Cd standard and terrestrial samples, such as the USGS Fe-Mn reference nodules Nod-A-1 and Nod-P-1. Further results of bulk CM (Murchison) and CR (EET 92048) chondrites also hint at negative ε^{113}Cd offsets, but were unresolvable from the bracketing standards within uncertainty (2SD daily reproducibility). Jbilet Winselwan shows the most pronounced offsets, with a deficit of 0.6 ± 0.1 on ε^{113}Cd, accompanied by a smaller but still resolvable excess of 0.2 ± 0.1 on ε^{114}Cd. Results of the bulk samples and the first measured leachate (most Cd rich fraction) of Jbilet Winselwan are in good agreement with each other.

Discussion: The observed offsets are not well reproduced with s-process excess or deficit models, arguing against a nucleosynthetic origin. However, models of thermal neutron capture [e.g. 8] agree well with the pattern and magnitude of the measured Cd isotope variations. This provides strong evidence that the Cd isotope variations of chondrites are the result of the irradiation with galactic cosmic rays during their travel through space. The overall implication is that Cd may be very useful as a neutron capture monitor for samples with sufficient Cd. Further bulk measurements of two additional CR chondrites and the Jbilet Winselwan acid leachates are underway to confirm these results and our interpretation.

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