

MASS-DEPENDENT PALLADIUM ISOTOPE VARIATIONS IN IRON METEORITES.

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Introduction: Insight into processes that occur during planet formation in the early solar system can be gained from mass-dependent isotope studies of siderophile elements in meteorites and terrestrial samples. For example, Pt isotopes record evidence for Pt addition to the mantle as a ‘late veneer’ after the end of core formation on Earth [1]. Mass-dependent isotope studies on terrestrial rocks and chondrites, believed to be the planetary building blocks, provide evidence for Pt and Mo isotope fractionation during terrestrial core formation [1, 2]. These data provide precious constraints on the conditions that prevailed during terrestrial core formation. Moreover, large isotope variations recorded for Cu [3], Zn [4] and Ru [5] in different iron meteorites from the same group were attributed to liquid-solid fractionation during cooling and solidification of planetary cores. Here we present the first mass-dependent Pd isotope data for iron meteorites to evaluate the potential of Pd isotopes to constrain the conditions under which planetary cores formed.

Methods: Mass-dependent isotope fractionation occurring during ion exchange separation of Pd or during mass spectrometric analyses was accounted for using a ¹⁰⁴Pd-¹⁰⁸Pd double spike. The spike was added to the sample after initial dissolution and prior to ion exchange chromatography. Purification of Pd was achieved using the method outlined in [6, 7] and the isotope compositions were determined using MC-ICP-MS following the analytical procedure used for mass-independent Pd isotope analysis [6]. Several spiked NIST SRM 3138 Pd standard solutions with different sample-to-spike ratios (0.5 – 3.5) yielded no resolvable variations demonstrating that our procedure is insensitive to a wide range of sample-to-spike ratios. Several aliquots of NIST SRM 3138 Pd doped with Pd spike and processed through the entire ion exchange procedure were within uncertainty of the unprocessed NIST SRM 3138 standard solution ($\delta^{106}\text{Pd}/^{105}\text{Pd} = 0.002 \pm 0.005$, 2 SD). This demonstrates that isotope fractionation that occurs during sample preparation and analysis is accurately accounted for by our double spike procedure. Repeat analysis of several individually processed aliquots of Gibeon (IVA) yield a $\delta^{106}\text{Pd}/^{105}\text{Pd}$ value of -0.108 ± 0.025 ‰ (2 SD) relative to our NIST SRM 3138 standard solution. Modelling of nucleosynthetic and cosmic ray exposure-induced mass-independent offsets, of similar magnitude to those found in meteorites [8], shows that these can significantly affect the accuracy of the data if they are not accounted for.

Results and discussion: We will present mass-dependent Pd isotope data for samples from the IAB, IIAB, IID, IVA and IVB iron meteorite groups. Initial results identify small, but resolvable, mass-dependent Pd isotope variations between different iron meteorite groups (IAB < IVA ≤ IID < IVB). Our data show that most iron meteorites are enriched in heavier Pd isotopes compared to chondrites [9]. The IVBs have the heaviest Pd isotope composition, while the IABs are within uncertainty of the chondrite isotope composition reported by [9]. These Pd isotope variations may be due to liquid-solid metal fractionation. To evaluate this idea, analyses of samples from the IIAB iron meteorite group, covering the entire range of the fractional crystallisation sequence, are underway. Other explanations for the Pd isotope data could include metal-silicate fractionation during core formation or nebular conditions during asteroid accretion.

References:

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