

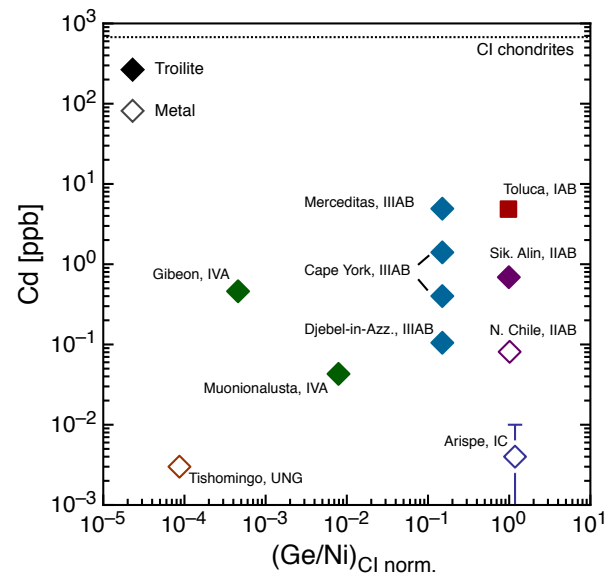
**ABUNDANCE AND ISOTOPIC COMPOSITION OF CADMIUM IN IRON METEORITES.** T.S. Kruijer<sup>1,2</sup>, P. Sprung<sup>2</sup>, T. Kleine<sup>2</sup>, I. Leya<sup>3</sup>, R. Wieler<sup>1</sup>. <sup>1</sup>ETH Zürich, Inst. of Geochemistry and Petrology, Clausiusstrasse 25, CH-8092, Zürich, Switzerland. <sup>2</sup>Institut für Planetologie, Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, D-48149 Münster, Germany. <sup>3</sup>Space Research and Planetary Sciences, University of Bern, Sidlerstrasse 5, CH-3012, Bern, Switzerland. E-mail: thomas.kruijer@erdw.ethz.ch.

**Introduction:** Cadmium is a highly volatile element with a 50% condensation temperature of 652 K [1] and its abundance in meteorites, therefore, is largely governed by volatility-controlled processes in the solar nebula or on the respective parent bodies. Due to the very large thermal neutron capture cross-section of <sup>113</sup>Cd (~20'500 barns) and as evidenced by large <sup>113</sup>Cd deficits of >0.3% in lunar samples [2], Cd has a potential as neutron dosimeter. The quantification of the thermal neutron flux in iron meteorites is of interest, because neutron capture reactions lowered the <sup>182</sup>W/<sup>184</sup>W of most irons [3], severely limiting the applicability of Hf-W chronometry to date iron meteorites [e.g., 4]. Recently, Pt isotopes were shown to be an excellent dosimeter for neutron capture reactions in irons [5,6]. However, since Cd isotopes have larger neutron capture cross sections than Pt isotopes, they might provide a more comprehensive record of neutron capture effects in iron meteorites. The aims of this study are (i) to evaluate the range of Cd concentrations in magmatic irons, and (ii) to investigate the potential of Cd isotopes as neutron dosimeter for iron meteorites. Here we report high-precision Cd concentration data determined by isotope dilution together with combined Cd, Pt, and W isotope data for several troilite and metal samples from iron meteorites.

**Sample preparation:** Metal (1-20 g) and troilite samples (~0.5-4 g) from several IC, IIAB, IIIAB, and IVA iron meteorites were selected for this study. For concentration determination, samples (0.4-0.7 g) were spiked with a <sup>106</sup>Cd-enriched isotope tracer prior to digestion in HCl-HNO<sub>3</sub> (3:1). Cadmium was purified using a two-stage anion exchange chromatography. The Cd isotope compositions of spiked samples were measured on a Nu Plasma MC-ICPMS at ETH Zürich. Total procedural blanks for Cd-ID measurements varied between 2 and 12 pg Cd. External uncertainties on Cd concentration data for troilites were <2% (2SD), but few troilite and all metal samples have larger uncertainties caused by significant blank corrections. Unspiked samples were digested separately and Cd was separated from the matrix using a two stage anion exchange chromatography modified after [7], followed by additional chromatography steps to purify the Cd cuts from remaining Sn. Cadmium isotope compositions were measured on a ThermoScientific Neptune Plus MC-ICPMS at the University of Münster. Measured Cd isotope ratios were corrected for isobaric in-

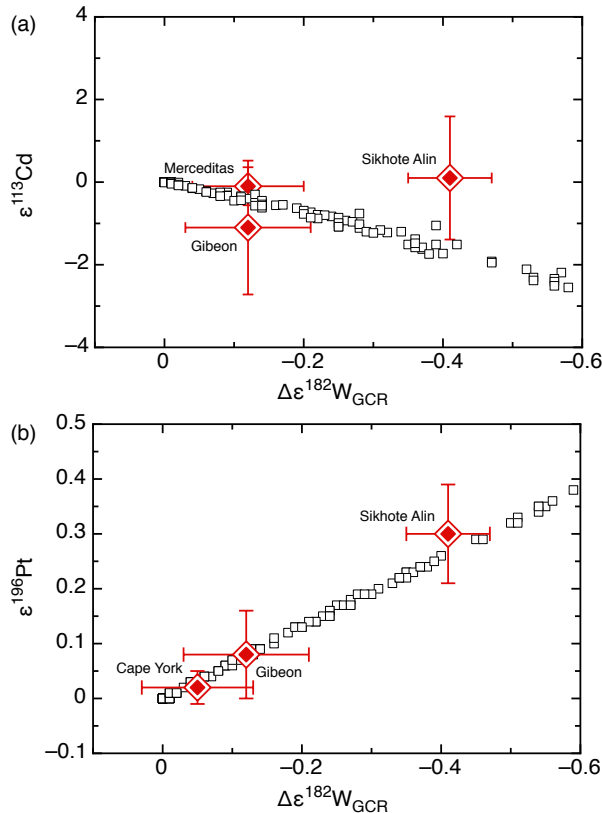
terference from <sup>112,114,116</sup>Sn and <sup>113</sup>In and corrected for instrumental mass bias by normalizing to <sup>116</sup>Cd/<sup>112</sup>Cd = 0.3104. The Cd isotope data are reported as  $\epsilon^{113}\text{Cd}$  (i.e., 0.01% deviations) relative to the composition of a terrestrial Cd solution standard. The external reproducibility for Cd isotope measurements varied between ~0.5 and 3  $\epsilon$ -units (2SD), depending on the amount of Cd available for analysis. The total procedural blank was ~30 pg Cd. Metal samples collected adjacent to the troilite samples used for Cd isotope measurements were also analyzed for their W and Pt isotope compositions, following the methods outlined in [5] and [14].

**Results:** Cadmium concentrations in troilite samples vary between 0.1 and 4.9 ppb (Fig. 1), while metal samples contain lower amounts of Cd (3- 40 ppt).



**Fig. 1:** Cd concentrations from this study plotted vs. Ge/Ni in the metal of the respective meteorite (rel. to CI chondrites). Ge and Ni data are from [8-13].

The Cd, Pt, and W isotope compositions of the studied irons are presented in Fig. 2. The  $\Delta\epsilon^{182}\text{W}_{\text{GCR}}$  values represent the difference between the measured  $\epsilon^{182}\text{W}$  of the sample and the pre-exposure  $\epsilon^{182}\text{W}$  determined for the respective iron meteorite group [5,15]. All samples show  $\epsilon^{113}\text{Cd}$  indistinguishable from the terrestrial value (Fig. 2a). In contrast (Fig. 2b), some samples show excesses in  $\epsilon^{196}\text{Pt}$  (+0.02 to +0.30) and neutron capture effects on <sup>182</sup>W/<sup>184</sup>W as evident from deficits in  $\Delta\epsilon^{182}\text{W}_{\text{GCR}}$  (-0.1 to -0.4).



**Fig. 2:** Cd, Pt, and W isotope data for iron meteorite samples from this study. (a)  $\epsilon^{113}\text{Cd}$  vs.  $\Delta\epsilon^{182}\text{W}_{\text{GCR}}$ , (b)  $\epsilon^{196}\text{Pt}$  vs.  $\Delta\epsilon^{182}\text{W}_{\text{GCR}}$ . The W isotope data are from [14], except for Merceditas. Shown as white squares are model calculations for the neutron capture effects on Pt, Cd, and W isotopes in iron meteorites (see also, [5]).

**Discussion:** The newly determined Cd concentrations in the metal phase of irons are significantly lower than values reported in two previous studies employing instrumental-neutron-activation analyses (INAA) [16, 17], but in agreement with a more recent study [18]. The cause of this discrepancy is unclear, but may relate to the large blank corrections reported for some of the INAA measurements (e.g., up to several 100% in [17]). In contrast to large systematic, volatility-controlled variations in the concentration of moderately volatile elements like Ga and Ge ([19]; Fig. 1), there is no systematic variation in Cd concentration amongst troilites or metal phases of different iron meteorite groups (Fig. 1). Instead, Cd is strongly depleted in all magmatic irons, consistent with very low abundances of other highly volatile elements like Tl [20].

The well-correlated  $\epsilon^{196}\text{Pt}$  and  $\epsilon^{182}\text{W}$  variations reflect the effects of cosmic ray-induced neutron capture effects on Pt and W isotopes, indicating a significant fluence of epithermal neutrons for Sikhote Alin (Fig. 2b). In spite of the large thermal neutron capture cross section of  $^{113}\text{Cd}$  and the evidence for epithermal neu-

tron capture effects in some samples, there are no resolvable Cd isotope variations (Fig 2a), clearly demonstrating the dominance of epithermal neutron capture reactions in iron targets, consistent with a recent study on mesosiderites [21]. The model calculations presented here further support the observation that neutron capture effects in iron meteorites are dominantly caused by epithermal neutrons. Fig. 2a shows that for Sikhote Alin a  $^{113}\text{Cd}$  deficit of  $\sim 1\epsilon$  would be predicted, consistent with the measured  $\epsilon^{113}\text{Cd}$  of  $0.2 \pm 1.5$ .

The low Cd abundances in the metal samples restricted the Cd isotope composition measurements to large troilite conclusions that contained sufficient Cd. However, even for these samples the amount of Cd available did not exceed 1.5 ng (except for Merceditas) limiting the precision that could be achieved for Cd isotope measurements to  $\sim 1\text{--}3\epsilon$  (2SD). This resolution is insufficient to resolve the small  $\epsilon^{113}\text{Cd}$  predicted for neutron capture in iron meteorites by our model. The combination of low Cd concentrations and low fluences of thermal neutrons thus makes Cd isotopes an imperfect neutron dosimeter for iron meteorites.

**Conclusions:** All investigated iron meteorite groups are more depleted in Cd than previously reported, suggesting that highly volatile elements like Cd do not show the systematic variation among iron meteorites observed for moderately volatile elements. No resolvable Cd isotope anomalies were found, whereas neutron capture-induced Pt and W isotope anomalies for the same samples are well correlated. This demonstrates that neutron capture in iron meteorites mainly occurs at epithermal (and higher) energies. The low fluence of thermal neutrons combined with the very low Cd concentrations in iron meteorites hamper the use of Cd isotopes as a neutron dosimeter to monitor cosmic ray-induced W isotope shifts in iron meteorites.

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