Effects of galactic cosmic rays on nickel isotopes in iron meteorites

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Galactic cosmic rays (GCR) can induce nuclear reactions within meteoroids that may alter their isotopic composition. Effects from GCR include high energy spallation reactions and lower energy neutron capture reactions [1]. Iron meteorites tend to have cosmic ray exposure ages > 100 Ma [2], increasing their susceptibility to GCR effects. For example, such effects in iron meteorites were reported for Os, Pt, and W isotopes [*e.g.*, 3]. The identification of nucleosynthetic isotope anomalies and the application of radiometric dating techniques may be compromised by GCR effects. We have combined isotopic measurements and theoretical calculations to determine the effect of GCR on Ni isotopes in iron meteorites.

Nickel isotopes were measured on aliquots of metal samples from six non-magmatic (IAB) iron meteorites for which we previously reported Fe, Pt, and W isotopic data [4,5]. In addition, we analyzed four terrestrial Fe-Ni alloys including two naturally-occurring alloys and two NIST steels (SRM 361, SRM 126c). The latter was chosen as an external standard and measured repeatedly to determine the external precision. Nickel was separated by ion exchange chromatography modified from [6]. Isotopic measurements were performed on the ThermoScientific Neptune Plus MC-ICPMS at ETH Zürich.

No anomalies were observed in any Ni isotopic ratios beyond the analytical uncertainties (*i.e.*, precision at the sub-epsilon level). However, measurements of Pt and W isotopes on aliquots from the same digestions of these IAB irons [5] show clear evidence for neutron capture effects in some samples. The lack of resolvable collateral variations in Ni isotope ratios is consistent with our theoretical calculations of GCR effects in iron meteorites. Hence, GCR do not appear to significantly modify the initial Ni isotopic composition of iron meteorites, and they likely do not affect ^{60}Fe-^{60}Ni systematics used in early solar system chronology.

[1] Leya & Masarik (2013), *Meteor. Planet. Sci.* **48**, 665-685. [2] Herzog (2007), *Treatise on Geochemistry*, 1-36. [3] Wittig et al. (2013), *Earth Planet. Sci. Lett.* **361**, 152-161. [4] Cook et al. (2015), *Meteor. Planet. Sci.* **50**, #5326. [5] Hunt et al. (2016), *Lunar Planet. Sci. Conf.* **#1867**. [6] Cook et al. (2006), *Anal. Chem.* **78**, 8477-8484.