^{60}FE-^{60}NI SYSTEMATICS IN THE ANGRITES

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Introduction: The abundance of ^{60}Fe ($t_{1/2}$ = 2.6 Ma) in the early Solar System is not well constrained. Previously reported estimates of the initial ^{60}Fe/^{56}Fe ratio vary considerably depending on the samples and techniques used (e.g., [1-3]). We have begun an investigation of the ^{60}Fe-^{60}Ni systematics in angrites to constrain the abundance and distribution of ^{60}Fe in the early Solar System, preliminary results of which were presented earlier [4]. Here we report Fe-Ni data for additional angrite samples.

Materials and Methods: Nickel isotopes and Fe/Ni ratios were measured by ICPMS using methods described by [4]. The study includes two bulk samples and two mineral separates (olivine and pyroxene) from the quenched angrite D'Orbigny, as well as bulk samples of the plutonic angrites NWA 4590, NWA 4801 and NWA 6291 (paired with NWA 2999).

Results: The three plutonic angrite samples span a wide range of ^{56}Fe/^{58}Ni ratios (~70-10,000), and all have Ni isotopic compositions identical to the terrestrial value within analytical errors. In contrast, while bulk samples and mineral separates of D'Orbigny also span a wide range of ^{56}Fe/^{58}Ni ratios (~4,600-11,000), all have excesses in ^{60}Ni that correlate with their Fe/Ni ratios. The D'Orbigny samples define an internal ^{60}Fe-^{60}Ni isochron corresponding to a ^{60}Fe/^{56}Fe = $(3.4 \pm 1.5) \times 10^{-9}$ and $\varepsilon^{60}Ni_0$ = -0.18 ± 0.29 at the time of the last equilibration of Ni isotopes in this meteorite.

Discussion: A recent investigation of ^{60}Fe-^{60}Ni systematics in angrites showed that ε^{60}Ni* is correlated with Fe/Ni ratios in bulk samples of D'Orbigny, Sahara 99555 (SAH99555) and NWA 2999 [3]. The authors of that study interpreted this relationship as a whole-rock (WR) isochron corresponding to the timing of widespread Fe/Ni fractionation during differentiation of the angrite parent body. They further argue that the source reservoirs of the various angrites formed contemporaneously and have remained closed systems with respect to their ^{60}Fe-^{60}Ni systematics. However, D'Orbigny and SAH99555 crystallized at the same time [5,6] and the ^{60}Fe-^{60}Ni systematics of NWA 2999 are very similar to that of chondrites, making it possible that the angrite WR isochron reported by [3] actually corresponds to the time of formation of D'Orbigny and SAH99555 from a chondritic source. Bulk samples of plutonic angrites NWA 4590 and NWA 4801 have ^{56}Fe/^{58}Ni ratios as high as ~10,000 and should have excess ^{60}Ni if their sources formed contemporaneously with those of the quenched angrites, as suggested by [3]. However, we find no ^{60}Ni excesses in these samples indicating that ^{60}Fe was extinct by the time the source reservoirs of these meteorites formed. Assuming that NWA 4590 and NWA 4801 formed at the same time, we determine a ^{60}Fe/^{56}Fe $\leq 9 \times 10^{-10}$ when this event occurred. This corresponds to an age of $\leq$ 4558.3 Ma relative to D'Orbigny, which is consistent with Pb-Pb ages reported for the plutonic angrites [5]. Finally, the ^{60}Fe-^{60}Ni systematics of D'Orbigny and the age difference between CAIs and this angrite [7] allows us to estimate an initial Solar System ^{60}Fe/^{56}Fe of $(1.2 \pm 0.6) \times 10^{-8}$.

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