

A FRESH IN SITU SEARCH FOR SIGNS OF ^{60}Fe IN PRIMITIVE CHONDRITES.

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Introduction: The presence of the short-lived radioactive isotope ^{60}Fe ($t_{1/2} \sim 2.60 \times 10^6$ years) at the birth of our solar system has been debated, and so has its importance as a heat source for the differentiation of early solar system bodies. In particular, there is a discrepancy between the initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratios inferred from bulk rock and in situ mineral data (e.g., [1,2]), with some in situ measurements yielding 1–2 orders of magnitude higher inferred initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratios than bulk rock and other in situ data. In order to unequivocally answer the question, whether there was any time or place in the early solar system with ^{60}Fe present at significantly higher levels than the Galactic background ($^{60}\text{Fe}/^{56}\text{Fe} \leq \sim 3 \times 10^{-7}$ [3,4]), or the level suggested for the source region(s) of angrite and HED parent body matter ($^{60}\text{Fe}/^{56}\text{Fe} \sim 1 \times 10^{-8}$, [2]), we are measuring the $^{60}\text{Ni}/^{62}\text{Ni}$ and Fe/Ni ratios of high Fe/Ni phases (troilite, chondrule silicates, and CAI minerals with sufficiently high Fe/Ni ratios) from primitive L/LL, CO, and CR chondrites in situ, using the NanoSIMS. The new Hyperion primary ion source of this instrument allows Fe-Ni isotope analysis with a better spatial resolution than before (2–3 vs. ~ 10 μm spot diameter) at the same primary ion intensity. This helps to avoid cracks and grain boundaries for improved in situ analyses at the same precision, following the protocol of [1].

Results and Discussion: Detailed petrography and electron microprobe measurements of thin sections of Semarkona (LL3.0), North West Africa 8276 (L3.0), and Dominion Range 08006 (CO3.0) have been completed, and we performed our first isotope measurements on Semarkona troilite grains. Prior NanoSIMS test measurements on troilite from the Mundrabilla meteorite and on artificial iron-sulphide minerals, as well as Monte Carlo simulations suggest that statistical effects resulting from the low nickel count rates during NanoSIMS analyses do not cause a significant positive bias in the measured $^{60}\text{Ni}/^{62}\text{Ni}$ as a function of Fe/Ni ratios. Our preliminary isotope measurements do not indicate the former presence of ^{60}Fe in Semarkona troilite grains, as all of them yielded identical $^{60}\text{Ni}/^{62}\text{Ni}$ ratios within two times analytical uncertainty (Figure 1). This is in contrast to the results of [1], who observed a positive correlation between $^{60}\text{Ni}/^{62}\text{Ni}$ and $^{56}\text{Fe}/^{58}\text{Ni}$ ratios in Semarkona troilites, which they interpreted to be the result of in situ ^{60}Fe decay. Note however, that we have not yet analysed troilite with the highest Fe/Ni ratios found by [1] (Figure 1).

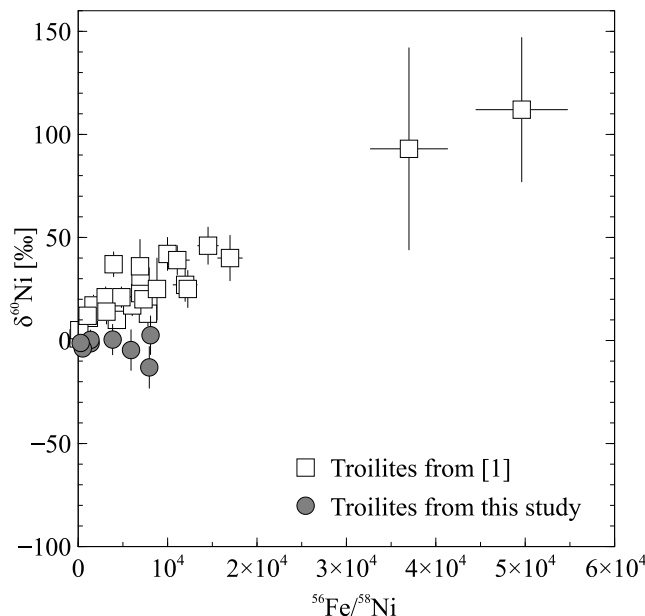


Figure 1. ^{60}Ni isotope anomalies as a function of $^{56}\text{Fe}/^{58}\text{Ni}$ ratios in Semarkona troilites. $\delta^{60}\text{Ni} = 1000 \times [(^{60}\text{Ni}/^{62}\text{Ni})_{\text{Troilite}} / (^{60}\text{Ni}/^{62}\text{Ni})_{\text{Terrestrial}} - 1]$. $^{56}\text{Fe}/^{58}\text{Ni}$ ratios were calculated from measured $^{54}\text{Fe}/^{62}\text{Ni}$ ratios, assuming that the troilite grains have terrestrial $^{54}\text{Fe}/^{56}\text{Fe}$ and $^{62}\text{Ni}/^{58}\text{Ni}$ ratios. Errors are 1σ .

Outlook: We plan to re-analyse minerals with high inferred initial $^{60}\text{Fe}/^{56}\text{Fe}$ ratios with the Chicago Instrument for Laser Ionization [5]. Being able to measure all nickel isotopes simultaneously, the latter instrument can reveal isotope fractionation effects that cannot be detected by (Nano)SIMS [6] and avoids isobaric interferences on ^{60}Ni and ^{62}Ni . The Al-Mg isotopes of high Al/Mg phases associated with the targets of our Fe-Ni isotope measurements will be also analysed (NanoSIMS) to constrain the objects' age relative to canonical CAIs. Transmission electron microscopy is also planned, to track possible disturbance of the iron-nickel system in minerals with or without apparent initial excess of ^{60}Fe .

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