

**PETROLOGIC CHARACTERIZATION AND IN-SITU  $^{60}\text{Fe}$ - $^{60}\text{Ni}$  SYSTEMATICS OF CO3 CHONDRITES.**

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**Introduction:** The presence of  $^{60}\text{Fe}$  ( $t_{1/2} = 2.6$  Ma) in the early solar system, inferred by excesses in  $^{60}\text{Ni}$  found in meteorites, could potentially help constrain the timing and environmental conditions of the early forming solar system [1, 2]. Live  $^{60}\text{Fe}$  in the early solar system cannot be a product of particle irradiation in the solar protoplanetary disk, therefore, its presence above galactic background levels would imply addition from a stellar source (e.g. supernova) [3]. Previous estimates on the inferred initial ratio from bulk and SIMS analyses have given conflicting results [4, 5]. Bulk analyses indicate initial  $^{60}\text{Fe}/^{56}\text{Fe}$  consistent with background, while initial ratios inferred from SIMS are consistently higher [2]. Another major concern is that UOC chondrites show chemical alterations and significant remobilization of Fe and Ni, plaguing analyses in UOCs even at low petrologic types [6]. However, CO3.0 chondrites appear to be more pristine than UOCs based on presolar grain abundances [7], potentially providing a better sample set for constraining the initial  $^{60}\text{Fe}/^{56}\text{Fe}$  of the solar system. Here, we discuss petrographic analyses of primitive CO3.0 samples and in situ Fe-Ni systematics using secondary ion mass spectrometry (SIMS).

**Methods:** We characterized a large suite of CO3.0 chondrites for this study using Raman spectroscopy. Raman analysis characterizes the degree of defects in matrix carbon which correlates with the metamorphic grade. This technique is especially sensitive to thermal alteration of low petrologic types ( $< 3.2$ ) [8]. CO3.0 chondrites analyzed for this study were DOM 08006, DOM 10104, DOM 14359, DOM 14305, DOM 14019, DOM 14127, MIL 11213, MIL 090785, MIL 090480, MIL 090038, NWA 7892, and NWA 8737.

Following characterization, we then measured Ni isotopes in magnetite from DOM 14305 (type 3.1 based on our Raman analyses) using the Hyperion II  $^{16}\text{O}^+$  beam on the Cameca 1290 ion microprobe at UCLA. We used monocollection mode with a 3-5 nA beam current and a 10  $\mu\text{m}$  spot size. Ni isotopes counted during analysis are summed and isotope ratios were calculated. Excess  $^{60}\text{Ni}$  was calculated by applying a linear mass fractionation correction to  $\Delta^{60}\text{Ni}$ , then converting  $\Delta^{60}\text{Ni}$  back to ratios using terrestrial reference values [2]. Isochrons are generated by weighted linear regressions of  $\Delta^{60}\text{Ni}$  and Fe/Ni ratios normalized using both  $^{61}\text{Ni}$  and  $^{62}\text{Ni}$  to check for consistency.

**Results:** Raman spectroscopy confirmed that these samples are petrologic type 3.0 and relatively unaltered. DOM 14305 was particularly interesting because it showed some of the least alteration, second only to DOM 08006, the least altered CO3.0 as of now [7]. Because radiogenic  $^{60}\text{Ni}$  is scarce relative to natural  $^{60}\text{Ni}$ , samples chosen need to have high Fe/Ni ratios and low Ni concentrations. CO3.0 chondrites rarely contained low Ni and high Fe silicate minerals so we decided to focus on magnetite for SIMS analysis as it has the highest Fe/Ni ratios and suitable grain sizes for Fe-Ni measurements. Even then, there were only few magnetite grains suitable for these analyses. We analyzed two magnetites from DOM 14305 and two from UOC Semarkona for comparison. Both do not show any resolvable excess  $^{60}\text{Ni}$ . Given our conservative estimate of errors for excess  $^{60}\text{Ni}$  and  $^{56}\text{Fe}/^{62}\text{Ni}$  ratios of up to 16 million, we constrain initial ratios to  $< 9.6 \times 10^{-8}$ .

**Discussion:** There appears to be no observable amount of excess  $^{60}\text{Ni}$  in magnetite grains in CO3.0 chondrites. Magnetite is not an ideal mineral to analyze because the timing of its formation is poorly understood. There are several reasons why magnetite does not show excess  $^{60}\text{Ni}$  could including 1) Formation after the decay of  $^{60}\text{Fe}$ , given that the ages are not well-constrained. 2) Secondary alteration and mobilization of Fe and/or Ni [6], but this is unlikely because of the high abundance of pre-solar grains in CO3.0 chondrites [7]. 3) Excess  $^{60}\text{Ni}$  exists below our detection limits and is constrained by the upper limit of the initial ratio of  $9.6 \times 10^{-8}$ . Troilite was analyzed in this study but had large discrepancies in Fe/Ni ratios between SIMS and electron microprobe analysis for reasons that are unclear but may be related to the presence of an oxide layer. Although Fe-rich silicates are rare in CO3.0 chondrites, they do occur and would be good targets for future resonance ion mass spectrometry (RIMS) analysis that could potentially better constrain excess  $^{60}\text{Ni}$  [9].

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