RELATIONSHIPS BETWEEN HED AND MESOSIDERITE METEORITES: AN IRON ISOTOPE PERSPECTIVE.

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Introduction: The HED meteorite group broadly comprise: (a) cumulate, pyroxene-rich diogenites, (b) plagioclase-pigeonite bearing basaltic/gabbroic eucrites, and (c) impact brecciated polymict howardites. Geochemical, petrologic and isotopic data indicate that the HEDs derive from a single parent body, possibly asteroid 4 Vesta [e.g. 1].

Mesosiderites are breccias and comprise basaltic silicates (orthopyroxene, plagioclase and olivine) and HED-like lithic clasts (diogenites, cumulate and basaltic eucrites, and dunites) mixed with metallic FeNi-metal [e.g. 2,3]. The favoured mechanism of mesosiderite formation is by impact-mixing of silicates and metal [e.g. 4] and textural evidence suggests that the metal component was mainly molten when mixing occurred [e.g. 3]. The origin of the silicate portion of mesosiderites is debated. Some researchers believe that the silicates are genetically related to the achondritic HED meteorites [e.g. 5].

We examined the variation of iron isotopes within the HED meteorites, with a view to ascertaining the variation (if any) in ^{56}Fe and ^{57}Fe and the effect (if any) of magmatic (diogenites and eucrites) and impact processing (howardites) within an asteroidal setting. The fractionation systematics of mesosiderites were than investigated to determine their relationship to HED meteorites.

Sample Set: (Table 1) The sample set consists of 18 individual meteorites taken from the mesosiderite group and the howardite, eucrite and diogenite group. A variety of eucrite sub-groups are represented. In addition to bulk digests, stepwise digestions were also undertaken on two mesosiderite samples (Estherville and Vaca Muerta), allowing separation of the silicate digest from the metal digest.

Experimental Techniques: A Phillips XL-30 SEM and a Cameca SX-50 electron microprobe were used for textural and compositional characterization, respectively. Dissolution follows a two step HF-$HClO_4$-HCl method [6]. Digests are purified using anion exchange chromatography, which separates out Fe, Cu and Zn. This procedure has been detailed elsewhere [6]. Fe-isotope compositions (^{56}Fe and ^{57}Fe) were measured on a fixed resolution (m/ m = 500) MC-ICP-MS (IsoProbe, GV Instruments, U.K.) with respect to the Fe-isotope standard IRMM-014, using the sample-standard bracketing method [6]. Correction for ^{54}Cr on ^{54}Fe is made by monitoring the ^{53}Cr signal and applying an on-line mathematical correction at mass 54. Blank subtraction is undertaken off-line. The effect of $Ar^{40}O^{16}H$ background at mass 57 is reduced by analyzing at approximately 10ppm concentration and sample and standard solutions are concentration matched to within 2% [6]. Typical errors are 0.05 permil.

Fe-isotope Fractionation - HED: All of the HED samples analyzed plot within a restricted range on a 3-isotope plot. This range is -0.02 to 0.21 ‰ for ^{56}Fe and 0.00 to 0.31‰ for ^{57}Fe (Figure 1A). Data fall on a mass fractionation line and all three groups overlap in 3-isotope space (Figure 1B). Eucrites display the greatest range of compositional variation and ^{56}Fe values fall between -0.02 and 0.21‰ (Figure 1C). In contrast, howardites and diogenite ^{56}Fe values are more limited in range.

Fe-isotope Fractionation - Mesosiderites: Five bulk mesosiderite samples were analyzed and these range from 0.01 to 0.20‰ for ^{56}Fe and 0.04 to 0.23‰ for ^{57}Fe. Stepwise digestions of Estherville and Vaca Muerta permitted characterization of the separated metal and silicate components and the range exhibited by these components are small, but they bracket the bulk compositions (Figure 1C).

MESOSIDERITES	**EUCRITES**
Clover Springs	Bereba*
Estherville	Camel Donga*
Mount Padbury	Juvinas*
Pinnaroo	Stannern‡
Vaca Muerta	Millbillillie†
	Pasamonte†
HOWARDITES	
Frankfort	**DIOGENITES**
Petersburg	Johnstown
Pavlovka	Shalka
Kapoeta	Tatahouine

Table 1: Sample Set
* Non Cumulate Group-Main Group
‡ Non Cumulate Group-Stannern Trend
† Polymict Group

Discussion: Fe-isotope signatures are tightly grouped and fall on the mass fractionation line already described for Allende and Chainpur chondrules [7], and other solar system samples [8] (Figure 1A). The range in iron isotope fractionation within the HEDs, which is slightly greater than that seen within terrestrial magmatic systems, indicates that magmatic processing on extraterrestrial bodies does not result in significant iron isotope fractionation.

Eucrite samples define the greatest range of ^{56}Fe values, with those from the non-cumulate main group showing the largest spread (Figure 1C). In contrast, non-cumulate Stannern trend and polymict group samples define a comparatively narrow range. All eucrite sub-groups overlap in composition (Figure 1C).

Impact processed howardite samples [9] could be expected to show Fe-isotope compositions which are heavier than their constituent eucrite and diogenite components, due to the volatile loss of Fe during impacting. Instead, howardites show a limited extent of fractionation which is well within the range for the non-cumulate main group eucrites, and slightly greater than that seen in the diogenites. Impact processing may homogenize howardite Fe-isotopic signatures, which are derived from eucritic and diogenitic components, without significant Fe volatilization. Further howardite analyses, which will even out the current sampling bias towards eucrites, may clarify this.

Mesosiderite fractionation spans a range which is slightly smaller than that of the eucrites. The isotopic composition of the metal and silicate separates, while slightly different, indicates that these components are not greatly fractionated from each other, at least in the two meteorites analyzed in this way. This may indicate that the impact event homogenized the iron isotopes.

The bulk composition of these two mesosiderites is intermediate to the composition of the silicate and metal fractions. Mount Padbury and Pinnaroo, which are the isotopically heaviest bulk samples, must contain an isotopically heavy component, be it metal or silicate, or perhaps both. This question merits further investigation.

Although mesosiderites contain material which is very similar in composition to that of the HEDs, they originated on a different parent body to the HEDs (based on REE evidence, [10]). However, iron isotope composition does not distinguish between the silicate material from these two parent bodies.

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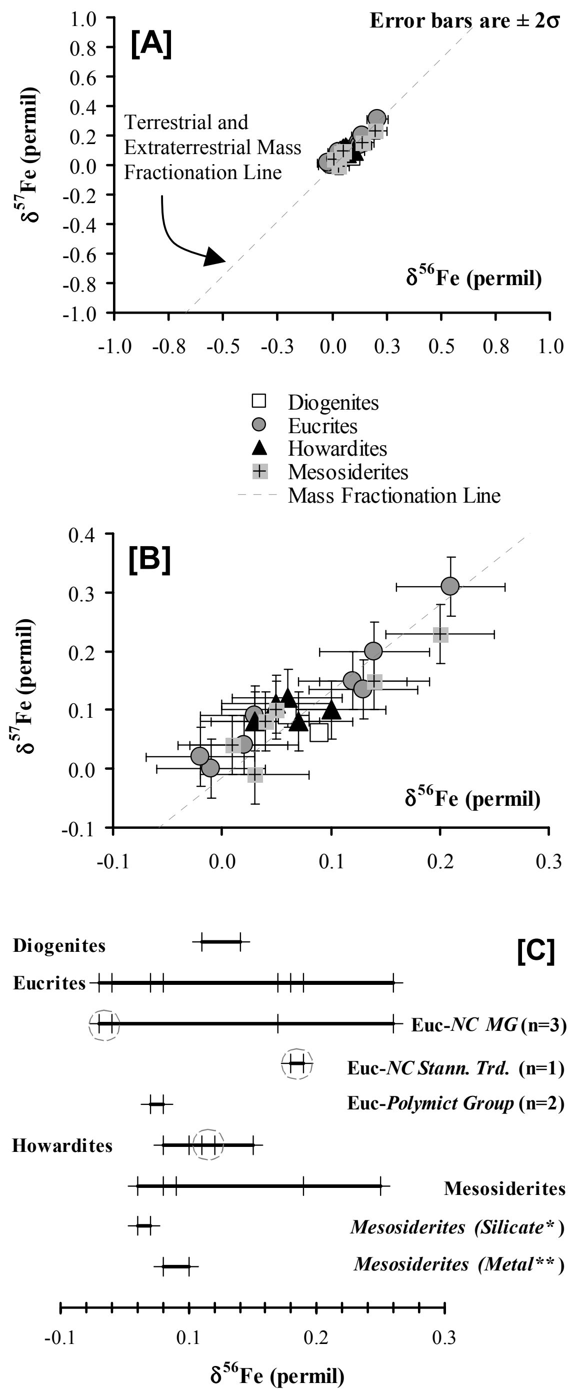

Figure 1: Iron isotope composition of HED and mesosiderite samples. NC = Non-cumulate, MG = main group, Stann. Trd. = Stannern Trend. * Silicate and **metal fractions from Estherville and Vaca Muerta. Circled points on graph C are replicates.