SULFUR ISOTOPIC COMPOSITIONS OF MAGMATIC AND NON-MAGMATIC IRON METEORITES.

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Introduction: This abstract presents the preliminary results from a study on the sulfur isotopic composition of troilite (FeS) in iron meteorites. We report the isotopic composition of acid volatile sulfur of fourteen troilite nodules from different iron meteorites. These meteorites are members of the chemical groups IAB, IIIAB, and IVA. We observe systematic differences in the δ^{34}S, Δ^{33}S, and Δ^{36}S of troilite from magmatic and non-magmatic iron meteorites (IIIAB and IVA *vs.* IAB).

Methods: Acid volatile sulfur (AVS) was obtained from crushed troilite nodule samples allowing the measurement of sulfur isotopic ratios in monosulfide minerals. The samples were heated with 5 N HCl bubbled with flowing N_2 gas; the released H_2S (dominantly from troilite) was then passed through condensers, through a trap containing milli-Q water, and captured in a slightly acidic trapping solution containing $AgNO_3$. The precipitated Ag_2S was rinsed with milli-Q water and 1 M NH_4OH solution before drying. This Ag_2S was then reacted with *ca.* 10 times stoichiometric excess of pure F_2 at 250 °C overnight, producing SF_6 gas which was subsequently purified with cryogenic and gas chromatographic techniques. The sulfur isotope abundances were measured using a ThermoFinnigan MAT 253 mass spectrometer monitoring m/z = 127, 128, 129, and 131 ($^{32}SF_5^+$, $^{33}SF_5^+$, $^{34}SF_5^+$, and $^{36}SF_5^+$). All results are reported relative to Canon Diablo Troilite (CDT).

Results: Figure 1 displays the acquired isotopic compositions of the AVS fractions of fourteen iron meteorites: six of group IAB (Bogou, Mesa Verde Park, Pitts, Woodbine, Mundrabilla), four of group IIIAB (Acuña, Sacramento Mountains, Trenton, Grant), and four of group IVA (Gibeon, Altonah, Duchesne, São João Nepomuceno). Error bars represent 2σ uncertainties estimated from repeated analyses of sulfur isotopic ratios in IAEA reference materials, which are generally better than 0.3‰, 0.016‰, and 0.3‰ for δ^{34}S, Δ^{33}S, and Δ^{36}S, respectively.

The analyzed magmatic and non-magmatic irons form resolvable groups in Δ^{33}S *vs.* δ^{34}S, Δ^{36}S *vs.* δ^{34}S, and Δ^{36}S *vs.* Δ^{33}S space.

We obtain small positive Δ^{33}S values for magmatic irons ranging from 0.013‰ to 0.027‰ with a non-zero mean of 0.021 ± 0.004‰ (s.d.). Non-magmatic irons have Δ^{33}S values ranging from -0.007‰ to 0.01‰ with a mean of 0.003 ± 0.006‰ (s.d.).

The observed enrichments in Δ^{36}S are the inverse of those acquired for Δ^{33}S analyses: magmatic irons yield Δ^{36}S values near zero, ranging from -0.072‰ to 0.055‰ with a mean of -0.006 ± 0.041‰ (s.d.); while non-magmatic irons tend to be more enriched in Δ^{36}S, yielding values ranging from -0.006‰ to 0.226‰, with a mean of 0.106 ± 0.093‰ (s.d.).

δ^{34}S values are similar for both types of irons, ranging from -0.505‰ to 0.128‰ for magmatic irons, [with a mean of -0.101 ± 0.250‰ (s.d.)], and from -0.319‰ to 0.252‰ in non-magmatic irons, with a slightly higher mean of 0.048 ± 0.227‰ (s.d.).

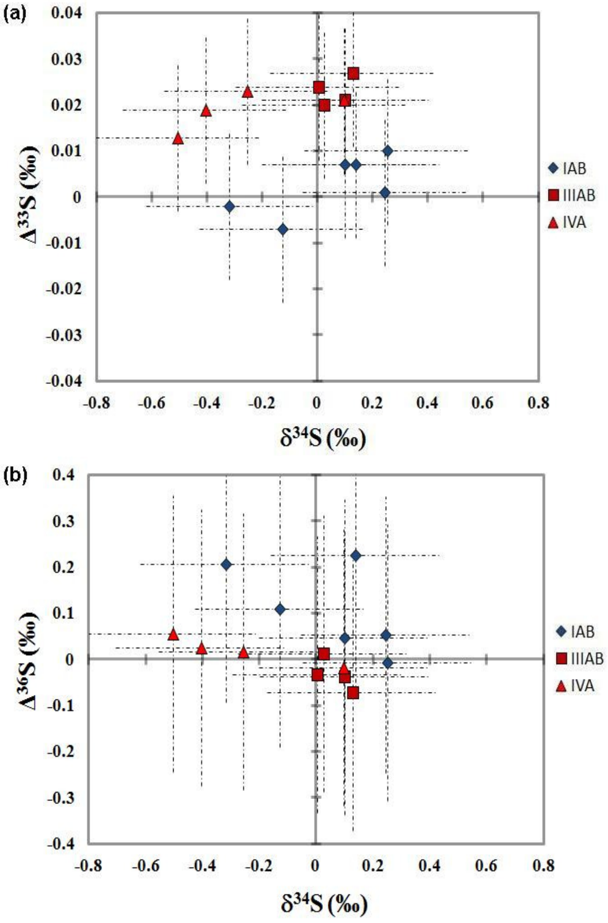

Figure 1 Measurements of (a) Δ^{33}S vs. δ^{34}S and (b) Δ^{36}S vs. δ^{34}S for AVS fractions of troilite from 14 iron meteorites belonging to the groups IAB, IIIAB, and IVA. Non-Magmatic (IAB) and Magmatic groups (IIIAB & IVA) are in blue and red, respectively. Error bars represent 2σ uncertainties.

Figure 2 depicts the $\Delta^{33}S$ *vs.* $\Delta^{36}S$ of the fourteen analyzed samples. The magmatic and non-magmatic iron meteorites appear to form two different groups, as in the previous diagrams.

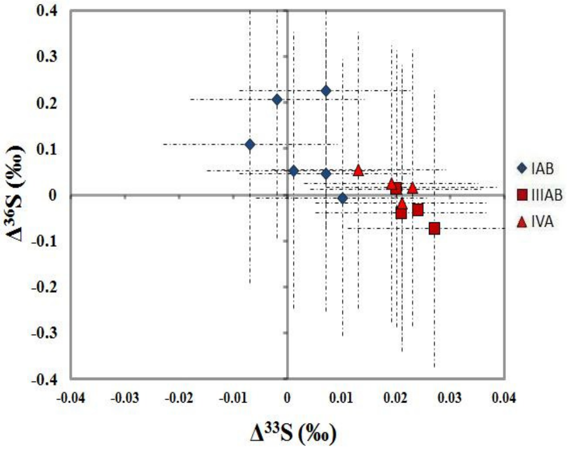

Figure 2 $\Delta^{36}S$ vs. $\Delta^{33}S$ of troilite from the 14 analyzed iron meteorites. Non-Magmatic (IAB) and Magmatic groups (IIIAB & IVA) are in blue and red, respectively. Error bars represent 2σ uncertainties.

Discussion: It appears that troilite nodules from magmatic irons have a small yet resolvable enrichment in $\Delta^{33}S$ compared to those from non-magmatic irons.

The origin of this difference is not yet known. It seems to be related to the sulfur that accreted to form the iron meteorite parent bodies. The results are most likely explained by isotopic differences in the materials that formed the individual magmatic and non-magmatic parent bodies, as opposed to being a product of their different styles of formation, neither of which are thought to explain the differences in $\Delta^{33}S$ given the limited range of $\delta^{34}S$. The ≤1‰ variation of $\delta^{34}S$ is most likely attributable to parent body isotopic fractionation processes.

This variation may instead be inherited from: i) preexisting variation due to mixing of sulfur from different nucleosynthetic sources [1], ii) spallation reactions [2], or iii) photochemical reactions in the early solar nebula [3,4].

Spallation reactions like those described by [2] are ruled out as the cause on the basis of the relationship between the $\Delta^{36}S$ and $\Delta^{33}S$ of the sulfur produced by spallation ($\Delta^{36}S/\Delta^{33}S$ of approx. 8). Nucleosynthetic anomalies like those described by [1] are also ruled out as the cause of these enrichments because these would produce more significant variability for $\Delta^{36}S$.

While the possibility of spallation, and preexisting nucleosynthetic anomalies cannot be completely ruled out, the most parsimonious explanation for the ^{33}S-enrichments in the magmatic iron meteorites compared to non-magmatic iron meteorites is incorporation of components sourced from gas-phase photochemical reactions in the solar nebula [3, 4, 5, 6]. A similar explanation has been invoked to account for anomalous ^{33}S of oldhamite (CaS) from Norton County aubrite [3] and the unidentified minor mineral phase(s) from which ^{33}S enriched sulfur is reported in other meteorites [3, 4, 6, 7].

Recently, mass-independent sulfur enrichments have been discovered in ureilites, in insoluble organic matter from carbonaceous chondrites, within achondrites in general, and in certain components from time-series sulfur extractions of individual chondrules [6, 5, 3, 4].

Magmatic irons are thought to have formed earlier than non-magmatic irons, as the results of extensive magmatic differentiation [8, 9, 10]. This may reflect early formation of their parent bodies, with higher abundances of short-lived radionucliides supplying the heat for their differentiations. Our results imply that the carrier of ^{33}S would also be related to differences in the parent body composition, perhaps created from materials with genetic links to early solar photochemistry.

If these enrichments result from the incorporation of photochemically enriched sulfur components [3], such as refractory sulfides (like oldhamite), into the parent body, they may perhaps be associated with the hot reducing environments where oldhamite is formed [11], as is thought to be the case for aubrites and enstatite chondrites [3,12]. It is interesting to note that the average $\Delta^{33}S$ values reported for aubrites are similar to those found for magmatic irons [3]. Oldhamite forms in reduced nebular environments which are generated by diffusive removal of water or by evaporation of carbon rich materials in the solar nebula [13], in these regions, exposure to UV radiation could cause gas phase photochemical reactions leading to $\Delta^{33}S$ enrichments [3, 4, 5, 6].

Measurements are planned on a total of 57 acquired iron meteorites (representing 8 different chemical groups) that will serve to further characterize sulfur isotopic compositions and enable comparisons between iron meteorites and other meteorite groups.

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