FURTHER CONSTRAINING THE CHLORINE ISOTOPE COMPOSITION OF THE SOLAR NEBULA: MAIN GROUP IRON METEORITES

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Introduction: The δ^{37}Cl value of the bulk Earth is approximately 0‰ [1, 2]. Lunar samples (-0.7 to >+30‰), and Martian meteorites (-4 to +8‰) have a much wider range of Cl isotope compositions [3-6]. The high δ^{37}Cl values in lunar samples are explained by volatilization of lunar magma, whereas the low δ^{37}Cl values in the olivine phyric shergottites (-2 to -4‰) are explained by the direct incorporation of nebular HCl [3, 4, 6]. Chondrites however, are more limited in δ^{37}Cl values, clustering from -2 to +1‰, with the exception of two ordinary chondrites with low δ^{37}Cl values between -4, and -5‰ (Parnallee LL3.6 and NWA 8276 L3.00)[1, 3, 7]. These low δ^{37}Cl values in ordinary chondrites are consistent with the direct incorporation of nebular HCl, whereas higher δ^{37}Cl values are explained by the incorporation of HCl ice ($HCl{\bullet}3H_2O$) during the accretion of respective chondrite parent bodies [1, 3, 4]. Here, we present preliminary data on the chlorine isotope compositions of main group iron meteorites (Campo Del Cielo, Canyon Diablo, Grant, Odessa and Cranbourne) in order to further constrain the δ^{37}Cl value of the solar nebula, and the sources of volatiles to the terrestrial planets.

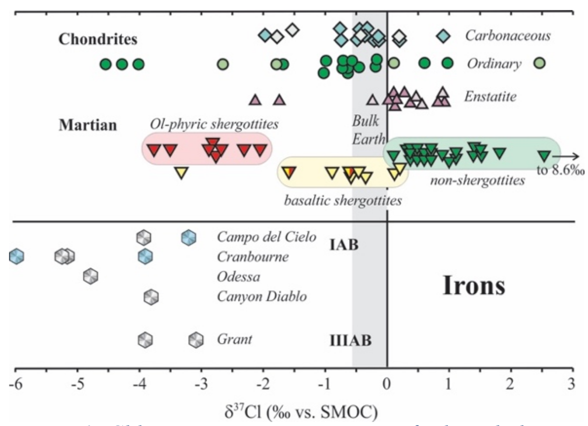

Figure 1: Chlorine isotope composition of selected planetary materials, and iron meteorites. Iron meteorite samples are separated by WSF (blue), and SBF (silver).

Results: We measured the chlorine isotope composition of the water-soluble fraction (WSF), and struturally-bound fraction (SBF) of selected main group iron meteorites. Iron meteorites were dissolved in concentrated nitric acid to obtain the SBF. Samples were prepared and analyzed following a modified methodology outlined Sharp et al., 2007 using IRMS on a Delta^{plus}Xl [2]. Both the WSF, and SBF were prepared and analyzed separately. The δ^{37}Cl values of both fractions ranged in chlorine isotope values from -6 to -3.1‰, with no apparent relation between the fractions (Fig. 1).

Discussion: The snow-line is the region in space where volatiles such as water condensed out of the solar nebula. This region separates the terrestrial volatile-poor planets, from the jovian volatile-rich planets [8, 9]. The source of volatiles to the terrestrial planets is commonly assumed to be chondritic in origin from the late delivery of volatile-rich material from beyond the snow-line [10-13]. Beyond the snow line, at temperatures between 140-160K, $HCl{\bullet}3H_2O$ forms, and produces a +3 to +6‰ chlorine isotope fractionation, as $HCl{\bullet}3H_2O$ preferentially incorporates the heavy chlorine isotope [1, 14]. If chondritic material were to incorpate chlorine from $HCl{\bullet}3H_2O$, it is expected to overprint the nebular chlorine isotope composition to higher δ^{37}Cl values.

The δ^{37}Cl value of the solar nebular has been proposed to be light (-5‰), with chondritic variations explained by interactions with heavy $HCl{\bullet}3H_2O$ from beyond the snow-line [1, 3, 4]. The chlorine isotope composition of primitive iron meteorites suggest a nebular origin, with light δ^{37}Cl values ranging from -6 to -3.1‰. These results support the idea that the solar nebula had a low δ^{37}Cl, approximately -6‰ or less. If we assume the predominant control on chlorine isotope fractionation in the early solary system to be the formation of $HCl{\bullet}3H_2O$, then these data suggest that incorporation of $HCl{\bullet}3H_2O$ in chondritic material was widespread, and that iron meteorites formed inside of the snow-line.

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