HIGH CONCENTRATION OF SULFIDES IN THE JUPITER-FAMILY COMET WILD2. Andrew J. Westphal[1], Anna L. Butterworth[1], Sirine Fakra[2], Zack Gainsforth [1], Matthew A. Marcus [2], Ryan C. Ogliore [1], [1] *Space Sciences Laboratory, U. C. Berkeley, Berkeley CA 94720, USA* [2] *Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA* .

Introduction: That the oxidation state of Fe varies systematically between meteorite groups was recognized by Urey and Craig[1] more than 50 years ago. In the Urey-Craig plot of concentration of metal + sulfides versus concentration of oxidized iron (Fe^{2+} and Fe^{3+}), both normalized to Si, meteorite groups fall into distinct, mostly non-overlapping regions (Fig. 3). The carbonaceous chondrites (CR, CO, CV, CM, CI, CK) are oxidized to varying degrees, with the CI group extensively oxidized by aqueous alteration. The enstatite chondrite groups EH and EL contain essentially no oxidized Fe. The ordinary chondrites and the unclassified group K (Kakangari) are intermediate in oxidation state.

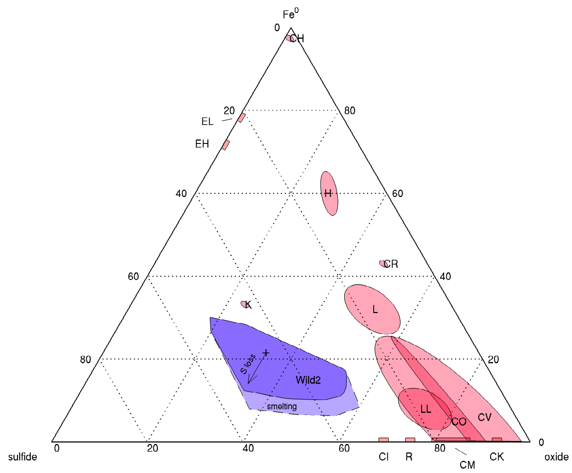

Fig. 1: Ternary plot of fraction of Fe^0 vs. sulfides vs. oxides for various meteorite groups. The arrow labelled "S loss" indicates the effect of sulfide loss during capture in aerogel. The region labelled "smelting" indicates the effect of reduction of Fe to carbide form during capture[2].

Here we report synchrotron-based x-ray micro-probe measurements of the bulk oxidation state of Fe in Stardust cometary samples. We used X-ray Absorption Near-Edge Spectroscopy (XANES) analysis at the Fe K-edge with a microfocussed x-ray beam on beamline 10.3.2 at the Advanced Light Source. By comparing measured spectra with those in an extensive library of standards, we separately measured the relative fractions of Fe in metal, sulfides and oxidized form. In a ternary diagram of metals, sulfides and oxidized Fe we find that Wild2 is inconsistent with any recognized family or group of meteorites. Wild2 is reduced in comparison with most chondritic meteorite families, and is sulfide rich, similar to Kakangari.

Discussion: Flynn *et al.*[3] reported synchrotron x-ray fluorescence measurements of abundances of elements from S through Se. They reported that S was significantly underabundant (S/Fe $\sim 0.2\times$ CI), but that the moderately volatile chalcophile elements Cu, Zn and Ga were significantly ($\sim 2\sigma$) overabundant as compared with CI values. Conversely, we find an overabundance of S. Our measurement of the abundance of FeS with respect to Fe (Fig. 1), gives a lower limit on S/Fe (our measurement is blind to volatilized S or S in non-Fe-bearing phases.) We find that S/Fe $> 1.02 \times$ CI (2σ), and is consistent with the overabundance of volatile chalcophile elements. We hypothesize that S was underestimated in the fluorescence measurements because of the short attenuation length of S Kα x-rays in large sulfide grains.

Ishii *et al.*[4] have recently reported that returned Stardust samples from Wild2 are not similar to chondritic-porous IDPs, based on the lack of GEMS (Glass Embedded with Metals and Sulfides) and on the crystallography of an enstatite whisker, and other lines of evidence. They conclude that Wild2 more closely resembles asteroidal material, as represented in collections of chondritic meteorites. Our measurement points strongly away from this conclusion. Apparently, the response to the question regarding the Stardust cometary sample that was posed before its return — "Have we seen this material before?"[5] — is "no."

Although Wild2 and the K grouplet show clear different mineralogy, the fact that they are both sulfide-rich suggests that a possibility of sulfidization. In their study of the mineralogy of Kakangari, Berlin *et al.*[6] have concluded that Kakangari underwent extensive reduction and sulfidization. They suggested that sulfidization could have taken place through the reaction

$$2\ FeMgSi_2O_6 + 2\ Fe + 4\ H_2S + C \rightarrow Mg_2Si_2O_6 + 4\ FeS + 2\ SiO_2 + 2\ H_2O + CH_4$$

Since most comets contain significant H_2S in their comas, this raises the possibility that such a reaction may be responsible for the high abundance of sulfides in Wild2 samples. Whether the reaction rate for this reaction is sufficiently high that it can take place in the cold, solid-state conditions of a cometary interior could be tested experimentally in the laboratory.

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