IRON-TITANIUM SULFIDE AND PHOSPHIDE SPHERULES IN ACFER 182 (CH3)

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Introduction: The CH chondrite Acfer 182 contains abundant fine-grained clastic debris, along with chondrules, CAIs, metal (up to 20%), and rare sulfides (<1 vol. %) [1]. The exogenous material present in CH chondrites seems to mostly have originated in carbonaceous-chondrite-like parent bodies. Here, we report three objects which likely were liberated by impact from reduced, inner Solar System bodies: a 100×50 μm heideite (iron-titanium sulfide) grain with FeTi-oxide exsolution lamellae and Fe-Ni metal shock veins, and two 50–100 μm schreibersite spherules with Fe-Ni metal inclusions.

Samples and Methods: We acquired high-resolution BSE and X-ray maps of an Acfer 182 thin section using techniques described in [2] (`https://presolar.physics.wustl.edu/maps/Acfer182_X.html`). We noticed a region bright in both Ti and S in these maps, as well as two circular P-rich areas which showed unusual textures. We investigated these three objects in more detail with SEM-EDS and EPMA (JEOL JXA-8200, 15 kV, 25 nA). We removed the carbon coating with 1-μm diamond polish and analyzed the sulfide grain with Raman spectroscopy (inVia Raman imaging spectrometer, 532 nm laser, 0.5–5 mW).

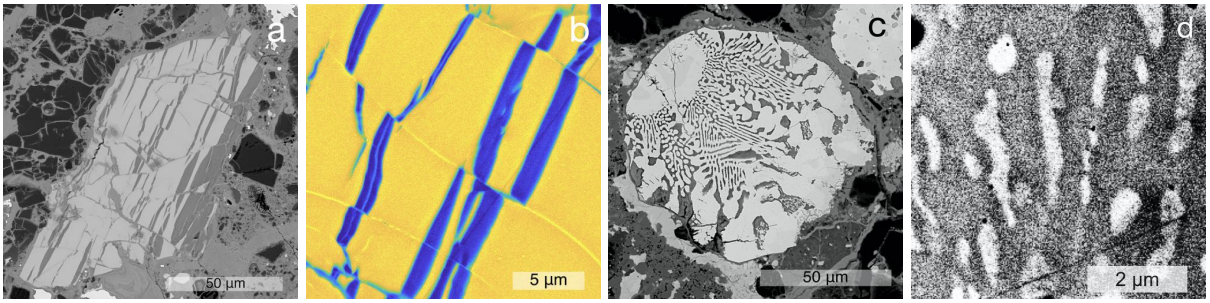

Figure 1: a) BSE image of heideite object in Acfer 182. b) Backscattered electron images with a parula color map to better distinguish between heideite (yellow-orange), oxide phase (dark blue), terrestrial alteration (light blue), and Fe-Ni metal shock veins (yellow-white). c) BSE image of a phosphide spherule in Acfer 182. d) Contrast-enhanced close up of (c) showing Fe-Ni metal (bright) within schreibersite (dark).

Results: EPMA measurements show that the sulfide object is consistent with the mineral heideite, first discovered in the Bustee aubrite [3]. BSE imaging (Figure 1) shows dark veins (an Fe-Ti oxide phase by EPMA) in the heideite that are cross-cut by smaller brighter veins (Fe-Ni metal by EPMA, which can be formed by shock in sulfides). The darker veins are offset where they are cross-cut by the Fe-Ni metal. The Fe-Ti oxide phase is contaminated by terrestrial weathering (Figure 1), making a precise phase determination from EPMA difficult (future FIB-TEM analyses will be useful in distinguishing the Fe-Ti oxide phase from terrestrial alteration). Raman spectra of the heideite shows peaks at 345 and 298 cm^{-1}. The alteration phase (turquoise in Figure 1b) and Fe-Ti oxide phase (blue in Figure 1b) have distinct Raman spectra, with a major peak at 681 and 706 cm^{-1}, respectively. A broad peak at 350 cm^{-1} for the alteration phase points towards ferrihydrite. The Fe-Ti oxide phase is not completely consistent with known oxides [4], but may be altered ilmenite. The circular P-rich objects are mainly schreibersite with accessory barringerite. The schreibersite spherules contain Fe-Ni metal blebs in a dendritic pattern, most of which have been oxidized by terrestrial weathering to form the dark dendritic patterns seen in the BSE image (Figure 1).

Discussion and Conclusions: Heideite is a very rare sulfide, previously reported only in aubrites and the Kaidun meteorite. We conclude that the Fe-Ti oxide veins in the Acfer 182 heideite formed by exsolution during cooling on a prior parent body. The Fe-Ni metal shock veins were formed during impact, cross-cutting the Fe-Ti oxide. The Fe-Ni metal blebs in the schreibersite spherules are similar to a schreibersite-kamacite eutectic structure in a metallic Apollo 12 regolith particle [5], thought to have formed by impact and remelting of an iron meteorite. These three objects appear to represent impact-liberated objects from highly reduced, possibly inner Solar System parent bodies, which were subsequently transported outward to be accreted by the parent body of the CH chondrites.

References: [1] Goldstein, J. I., et al. 2007. *MAPS* 42.6:913. [2] Ogliore, R. C. 2021. *Earth Space Sci.*, in press. [3] Klaus, K. and Brett, R. 1974. *Am. Mineral.* 59.5:465. [4] Wang, A., et al. 2004. *Am. Mineral.* 89.5:665. [5] Goldstein, J. I. and Yakowitz, H., 1971. *LPSC Proceedings*, 177.