LOW-TEMPERATURE SULFIDES IN STARDUST: TEM ANALYSIS OF A SPHALERITE/PYRRHOTITE ASSEMBLAGE FROM TRACK 7

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Introduction: Stardust achieved its mission goal of catching comet and interstellar dust particles and returning them to Earth for analysis. The particles collected span a wide range of compositions, each of which yields information about the comet's history. The refractory components in this collection reveal the large-scale distribution of high-temperature components in the early Solar System. Studies of sulfides complement this information by revealing the low-T processes, as well as minor element mobilization recorded in these samples. We investigate a terminal particle from track 7, which has co-existing minerals from the Fe-Ni-S and Fe-Zn-S systems.

Results & Discussion: A microtomed section of a Stardust particle from track 7 (T7, 10, 85) was analyzed via TEM at JSC and at the University of Washington. The particle is polycrystalline and is predominately Ni-free pyrrhotite that shows distinct superstructure reflections in electron diffraction patterns. The particle also contains a µm-sized grain of Ni-bearing pyrrhotite $[(Fe_{0.93}Ni_{0.07})_{1-x}S]$ showing the same superstructure reflections, and a µm-sized grain of Fe-rich sphalerite (Zn,Fe)S. The sphalerite contains minor Mn (<2 at.%) and shows fine-scale twinning on (111). The sphalerite and Ni-bearing pyrrhotite are not in direct contact.

The pyrrhotite superstructure reflections are only stable below ~340 °C [1]. If the grain were heated above this temperature, the superstructure reflections can be recovered only through slow cooling. The persistence of these reflections indicates that the pyrrhotite did not experience high temperatures during aerogel capture.

If sphalerite and pyrrhotite are in equilibrium then the wt% Fe in the sphalerite constrains temperature and sulfur fugacity of their formation [2]. Using the temperature 340 °C yields a value for log fS_2 of -34. However, sphalerite and pyrrhotite can not coexist under these conditions in equilibrium [3]. We conclude that these minerals are not equilibrated.

Many of Stardust Fe-Ni sulfides contain <2 at.% Ni (except pentlandite). This range matches sulfide compositions in anhydrous IDPs [4]. The increased Ni-content in a portion of this pyrrhotite, as well as the disequilibrium between the pyrrhotite and sphalerite, indicates that this grain has experienced processing, and may be more similar to hydrous IDPs or chondritic samples. One possibility is that Ni- and Zn-bearing pyrrhotite formed in the nebula. The Ni and Zn may have subsequently migrated during solid state thermal metamorphism. A second possibility is precipitation of pyrrhotite during parent-body aqueous alteration followed by Ni and Zn precipitation at a later time. Either case suggests that the grain had to remain at relatively low temperatures (<340 °C) during either nebular transport to Wild 2 or parent body alteration within Wild 2.

References: [1] Li F. et al. 1996. *Journal of Solid State Chemistry* 124: 264-271. [2] Scott S. D. and Barnes H. L. 1971. *Economic Geology* 66: 653-669. [3] Scott S. D. and Barnes H. L. 1972. *Geochimica et Cosmochimica Acta* 36: 1275-1295. [4] Zolensky et al. 2006. *Science* 314: 1735-1739.