EXPERIMENTAL STUDY OF THE MECHANISMS OF FORMATION OF NANOSULFIDES IN COMET WILD 2.

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Introduction: NASA's Stardust mission flew through the coma of comet 81P/Wild 2 and collected its freshly ejected dust, which carved tracks in ultra-low density, silica aerogel collection tiles [1]. Based on geometry, three types of tracks (A, B, and C) have been distinguished [2]. Particles extracted from the walls of the bulbous part of type B tracks and type C tracks are Si-rich glass blobs with numerous nano-particles from matrix of comet Wild-2 agglomerates [3]. This glass is vesicular and originates from quenching aerogel melts. Inclusions range from Fe-S-Ni and Fe-Ni compounds (few to 100 nm), to enstatite and forsteritic olivine (0.5-1 μm), to phyrrhotite and Fe-silicide spheres[e.g. 3,4,5]. Although these observations suggest that S was retained and recondensed within the aerogel, the mechanism(s) by which this occurred has remained unexplained. In this paper we experimentally explore how disequilibrium condensation from a S-Si-Fe-O gas could have produced these observed nanosulfides.

Results and Discussion: Samples were produced by vaporizing solid S in a furnace tube into which a H_2, Fe-carbonyl, silane, and O, with two Fe:Si:O ratios (50:20:40 and 50:20:20). Gases cooled rapidly as they flowed into a room temperature chamber, condensed and were deposited as powders on an aluminum collector. Resulting samples were mixed with a C-based epoxy and pressed between two pieces of Si, and ion-milled to electron transparency at low temperatures (< 260 K).

TEM images from these runs show abundant nanosulfides and magnetite embedded in Fe-Si-bearing amorphous materials [6], which are similar in texture to vesicular low-Mg silica glass observed in tracks B and C from Wild 2 [3,4,5,7,8,9]. Compositions of the resulting nanosulfides are also similar to those observed in Wild 2 nanosulfides, ranging from nearly pure Fe to nearly pure S [e.g. 7]. [10] proposed that decomposition of small FeS grains in Wild 2 agglomerates and the formation of Fe-silicides occurred in a vapor phase . Our observations are consistent with this scenario. According to [4,5,10], pre-existing cometary Fe-Ni sulfides vaporized as they carved cavities in the aerogel. These gases gave rise to nanosulfides in low-Mg silica glass. Such a formation mechanism leads to deep metastable eutectic compositions that account for departures from stoichiometric sulfide compositions reported for Stardust nanosulfides. SAED data for the nanosulfides with compositions ranging from almost pure metal and FeS suggest they are "frozen" non-equilibrium compounds that can be (1) random nanometer-scale mixtures of Fe-Ni sulfide and Fe-metal, or perhaps Fe-oxide, or (2) eutectic intergrowths of Fe-Ni sulfide and Fe-metal.

References: [1] Brownlee et al. 2006. *Science, 314,* 1711 [2] Horz et al. 2006. *Science, 314,* 1716. [3] Zolensky et al. 2006. *Science, 314,* 1735. [4] Rietmeijer et al. 2008. *MAPS* 43, 121-134. [5] Rietmeijer (2009 *MAPS* 44, 1121-1132. [6] Abreu & Nuth (2010) Abstract #1423. 41st LPSC. [7] Leroux et al., 2008. [8] Tomeoka et al. 2008. [9] Nakamura et al. 2008. [10] Rietmeijer (2008) Abstract #1188. 39thLPSC.

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