CHARACTERIZATION OF THE FINE COMPONENT OF COMET WILD 2: ANALYSIS OF 11 STARDUST CRATERS FROM FOIL C2010W.

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Introduction: NASA's Stardust mission provided the first known cometary material, flying through comet 81P/Wild 2's coma at a relative velocity of 6.1 km/s. While Wild 2's coarse component (>1 μm) has been extensively studied through analysis of material captured by the cometary collector's aerogel tiles, the comet's fine component (<1 μm) has proved more difficult to analyze due to the extensive alteration experienced during the violent collection process [1]. Prior FIB-TEM analyses of impact craters present in the aluminum foils from the collector have succeeded in returning crystalline material from the comet's fine component [2,3]. Continued analysis of these foils is necessary for further characterization of the fine component of comet Wild 2.

Experimental Methods: 146 craters on Stardust cometary foil C2010W with diameters from 0.5 to 7.2 μm (average diameter of 1.36 μm) were elementally characterized with SEM-EDX using Cliff Lorimer analysis [4]. Craters in this size range were selected to maximize the likelihood of discovering surviving crystalline material in further FIB-TEM analysis [5], as well as for comparison with previous studies of similarly-sized craters [2]. These craters were additionally analyzed with Auger spectroscopy to elementally characterize the crater surfaces. Eleven craters with diameters from 0.71 to 3.28 μm were selected for further analysis based upon their elemental compositions in order to allow for the detailed study of a range of impacting cometary material, with focus placed on craters displaying silicate or silicate-sulfide compositions. Cross sections of these craters were extracted and thinned to electron transparency with a FEI Quanta 3D FIB-SEM prior to analysis with a JEOL 2000 TEM at Washington University.

Results: SEM-EDS and Auger results demonstrate that the Stardust fine component is largely composed of Si and Mg rich impactors and iron sulfides, as well as aggregates of these two types of impactors, with aggregate impactors comprising the majority of the investigated craters. Mg-Si-Fe ratios are often consistent with olivine and pyroxene impactors. One third of the investigated craters contain traces of Ca (1-14 at. %), and another third of the craters contain traces of Ni (1-21 at. %) along with Fe (12-57 at. %). Iron sulfides have average Fe/S ratios of 1.95.

TEM analysis of the craters revealed that one of the impact craters is dominated by an Fe-rich contaminant known to be present in the Stardust foils [6]. Six impact craters are dominated by relatively homogenous melt layers composed largely of Mg-Si-Fe-S, whereas four other craters, though displaying similar elemental compositions, have compositions that vary with location in the crater bottom. Traces of Ca were also present in five of the investigated craters, while Ni along with Fe was found in six of the craters. No surviving crystalline material was observed in any of the craters. Iron sulfides identified in the TEM-EDX analysis have average Fe/S ratios of 1.59. One crater displays a clear absence of Al within the impactor melt layer. No Fe vesicles are observed.

Discussion: The prevalence of aggregate impactors within the investigated craters demonstrates the small sizes of most particles belonging to Wild 2's fine component and is consistent with observations from other Stardust foils [2,3]. The presence of Ni and S indicates that the majority of the studied craters are the result of cometary impacts rather than contamination, as Ni and S are absent in observed Fe contamination native to the foils. The homogenous melt layers observed in six of the craters are indicative of the high temperatures and pressures experienced by the impactor materials as a result of the high velocity at which they were collected. The presence of Ca within the craters suggests that much of the collected material is fairly refractory in nature.

The Fe/S ratios of the analyzed melts are low, consistent with troilite or pyrrhotite, and suggest a lack of S loss. This is in contrast to observations in analog studies, where S loss has been observed repeatedly, suggesting higher energy impacts [7,8]. The lack of S loss is, however, in agreement with previous analyses of Stardust foils [2,3]. The absence of Fe vesicles and the lack of Al in one of the observed craters are also in agreement with the lower-energy impacts implied by the low Fe/S ratios [8].

Several craters exhibit melt layers that are heterogeneous in composition, also suggesting lower energy impacts than previously studied analog craters [7,8]. However, a puzzling observation is the continued lack of crystalline material in the impact craters. This is in contrast with previous studies of impact craters from the Stardust foils [2]. Thus, the investigated craters appear to have undergone less energetic impacts than those from the analog studies, but may have experienced slightly higher energies than previously studied craters from the Stardust foils.

References: [1] Kearsley A. T. et al. 2008. *Meteoritics & Planetary Science* 43:41-73. [2] Leroux H. et al. 2008. *Meteoritics & Planetary Science* 43:143-160. [3] Stroud R. M. et al. 2010. Abstract #1792. 41st Lunar & Planetary Science Conference. [4] Croat et al. 2016. Abstract #2204. 47th Lunar & Planetary Science Conference. [5] Croat et al. 2015. *Meteoritics & Planetary Science* 50:1378-1391. [6] Kearsley A. T. et al. 2006. *Meteoritics & Planetary Science* 41:167-180. [7] Wozniakiewicz et al. 2011. *Meteoritics & Planetary Science* 46:1007-1024. [8] Haas B. A. et al. 2016. Abstract #1597. 47th Lunar & Planetary Science Conference.