CHARACTERIZING COMET 81P/WILD 2 WITH TAGISH LAKE ANALOG FOILS

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Introduction: NASA's Stardust mission flew through the trail of comet 81P/Wild 2, returning the first definitively cometary material to Earth in 2006. Aluminum foils present on the cometary collector successfully captured Wild 2 material. However, this material experienced extensive alteration as a result of the spacecraft's high collection velocity (6.1 km/s) [1].

Simulating the Stardust capture conditions in a laboratory environment can improve our understanding of the impact processing experienced by the returned Wild 2 material. Our study focused on analog foils created using samples of the Tagish Lake meteorite matrix. Tagish Lake is an ungrouped type 2 carbonaceous chondrite known for containing an abundance of organic materials [2]. Comparing the residues found in analog craters with the unfired meteoritic material provides insight into the impact processing experienced by the collected Wild 2 material and allows for better characterization of the comet. Study of analogs created using the Tagish Lake meteorite also provides unique insight into the behavior of organic materials during these high velocity impacts.

Experimental Methods: Material from the Tagish Lake meteorite was fired at 6.1 km/s towards flight-spare Stardust foils using the University of Kent's light gas gun, simulating the conditions experienced by the Stardust sample collector. This material disintegrated during the firing process, resulting in impactors on the scale of microns.

The analog foils were imaged by a Mira Tescan SEM. Impact craters from 0.8-4.0 μm in diameter were elementally characterized with spectra collected by an EDAX-EDS system. Craters of this size were selected for study to maximize the possibility of finding surviving crystalline material [3]. Craters found to contain traces of Si or Mg, indicative of surviving impactor materials, were selected for further study and extracted as ~100 nm thin sections with a FEI Quanta 3D FIB-SEM. Further imaging and EDS analysis was performed on the thin sections with a JEOL 2000 TEM.

Results and Discussion: 52 craters were elementally characterized on the analog foil. 17 craters returned measurable (>1 at. %) Si or Mg signals, from which 8 were selected for further investigation with FIB/TEM techniques. All investigated craters contained weak C signals, but it is difficult to assess whether this is an indicator of surviving impactor material in the craters or simply the presence of a thin organic contamination layer present on the foils. The 8 extracted craters ranged from 1.46 to 3.12 μm in diameter and were similar in size to craters that were studied in previous investigations of the Stardust foils [4, 5].

TEM study of the crater thin sections revealed deep, bowl-shaped craters indicative of impacts by a single, dense body. All craters contained thin (10-50 nm) melt layers coating the crater walls. The melt layers were largely composed of O/Si/Mg/Fe, with S and Ni present within Fe-rich residues. Si/Mg ratios rarely varied within melt regions from the same crater. However, the concentration of Fe-rich residues within certain regions of the crater residues, coupled with the lack of Fe-vesicles, suggests that melting was incomplete and rapid solidification occurred. Trace Ca was observed in 4 of the crater residues, and significant C was present in one crater residue. No surviving crystalline material was observed within the craters. Two of the craters had large gaps in the melt layers, suggestive of a loss of impacting volatile material.

A large component of the Tagish Lake matrix is composed of phyllosilicates such as serpentine and saponite [2], suggesting Si or Mg should have been present in a majority of the craters. The lack of significant Si or Mg within two-thirds of the craters studied with SEM-EDS may be a result of the small craters containing too little Si or Mg-rich residue to be seen over the signal from the nearby Al peak. Additionally, phyllosilicates are likely to be more easily destroyed than other silicates (e.g. olivine) and may have been lost on impact. The volatility of C-rich impactors may also have resulted in craters that do not contain observable residue when examined by SEM-EDS.

The lack of C within the craters investigated with FIB/TEM may partially be due to our inability to select craters for further study based upon C abundances observed in SEM-EDS. Although carbonates have been identified in Stardust aerogel samples [6], they have yet to be seen in foil samples [7]. The Tagish Lake meteorite's abundance of organic materials [2] was not reflected in our TEM-EDS results suggesting that organic materials may have been destroyed during the impact process. However, N isotopic anomalies have been observed in craters from the Stardust foils, indicating that some organic material does survive impact processing [8].

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