COORDINATED STUDIES OF STARDUST TRACK AND CRATER SAMPLES FROM COMET WILD 2.

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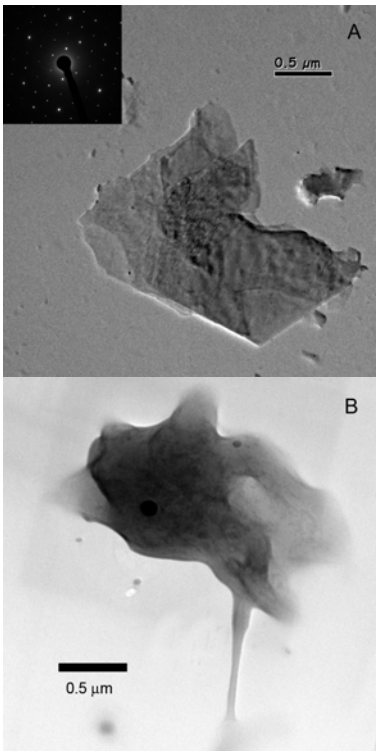
Introduction: The samples from comet 81P/ Wild-2 returned by the NASA STARDUST mission provide a unique opportunity for laboratory analysis of bona fide cometary materials [1]. The collected samples are available in two forms: particles captured in silica aerogel and residues in impact craters in Al foil. Structural, elemental, molecular and isotopic analysis of these samples advances our understanding of both comets and early solar system processes. Results from the Preliminary Examination of the returned samples showed a high abundance of refractory silicate minerals and metal sulfides [2]. Organic matter, and refractory oxide minerals, including at least one assemblage reminiscent of the calcium aluminum-rich inclusions found in chondritic meteorites, were also observed [2]. Although some of the C-rich materials and a few grains have O-isotopic signatures indicative of an extrasolar origin [3,4], the vast majority of the measured samples have solar isotopic composition [4]. These results indicate that much of the material in Comet 81P/Wild-2 condensed as individual refractory mineral grains in the inner solar system and was subsequently transported out to a distance of ~ 50 A.U. prior to accretion. By performing coordinated structural, chemical and isotopic analysis of both track and crater samples, we seek to further constrain the formation conditions and processing histories of Comet 81P/Wild-2 materials.

Experimental Details: We used transmission electron microscopy (TEM), secondary ion mass spectrometry (SIMS), and X-ray absorption near-edge structure spectroscopy (XANES) to analyze STARDUST track and crater samples. The TEM studies were performed on a JEOL 2200FS field emission transmission electron microscope. Three different synchrotron-based scanning transmission X-ray microscopes (STXM) were used: beamline X1A1 at the National Synchrotron Light Source (NSLS), beamline 5.3.2 at the Advanced Light Source (ALS), and beamline 10ID-1 at the Canadian Light Source (CLS). On each instrument X-ray absorption near-edge structure spectroscopy (XANES) at the carbon absorption edge (and nitrogen and oxygen edges, if possible) was performed. The SIMS measurements were performed using Cameca ims 6f and NanoSIMS instruments.

Results and Discussion: Our TEM results on inorganic track particles typically reveal micron-sized pyroxene or olivine grains mixed with nanoscale Fe sulfides, with microstructures overwritten by varying degrees of capture alteration, i.e., thermal alteration and mixture with melted aerogel. The microstructures of organic-rich particles also vary. In some cases the organics have diffused into the porous aerogel, producing a homogenous mixture of C and silica. In other cases, compact carbonaceous grains, minimally mixed with silica, are observed. Bright-field TEM images of two different ultrathin slices of a single track particle (FC9, Track 13 particle 1) are shown in the Figure. In slice A, the particle is a crystalline grain, and exhibits electron diffraction (inset) consistent with enstatite. The composition, determined by energy dispersive spectroscopy is consistent with a mixture of enstatite and silica. In slice B, the particle is very rich in C with minor Si. Thus the grain appears to be a crystalline silicate with an amorphous rim and a carbonaceous mantle. XANES data on slice B indicate that this material contains abundant carbonyl functional groups with some olefinic and/or aromatic carbon, similar to primitive anhydrous IDPs and chondritic meteorites [5]. Isotopic measurements of a thick C-rich section of this grain show D enrichment, suggestive of a molecular cloud or ISM origin [4].



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