COMET MINERALOGY FROM THE STARDUST MISSION: A CHALLENGE

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Comets contain the dust from which the terrestrial planets and cores of the giant planets were formed. Comets are the link between solar systems and the giant dust clouds in the interstellar medium. All sufficient scientific rationale to send the STARDUST probe to collect dust ejected from Comet Wild 2 near its source. The dust, dominated by silicate minerals, impacted at 6.1 km/s, into tiles of under-dense (0.02 g/cc) silica aerogel. Some collected dust survived intact but most was fragmented or melted. Each comet dust unit penetrated into the aerogel and left a distinct track wherein most of the mass is found at the very end of a track. The remainder is scattered along the track wall and nanometer-sized dust deposited within aerogel away from the track wall (Zolensky et al., 2006) Mineralogy and petrology of comet Wild 2 nucleus samples, Science 314, 1735-1739; and other papers in this Wild 2 Science Issue).

The largest particles, a few to ~10 microns, that are found at track's end are Mg-Fe-[Ca]-silicates, Fe-Ni-sulfides, Fe-Ni-metal and rare Ca-Al-[Mg-Ti]-minerals. Similar particles, 'one to a few microns', are scattered along the track walls. The smallest, a few nanometers up to one micron, dust melted and penetrated into melted and compressed aerogel, forming 'particles' of glass with Mg-Fe-silicates and Fe-Ni-sulfides and Fe-Ni-metal embedded in a SiO_2-rich matrix. The particles are extracted individually using micromanipulators and prepared for mineralogical and petrological characterization using a wide variety of electron- and X-ray-microbeam techniques. An unintended consequence of the project is that individual investigators compared and calibrated each others data obtained on the same or very similar samples.

Efforts to constrain elemental compositions of the comet dust found that grain size and the scale of dust distributions are critical to the outcome of the analyses. For example the bulk sulfur content is lower derived from measurements of particles along the tracks and at their terminus than from measurements of the smallest dust in the glass matrix. It appears that grain size and heterogeneities in dust distribution relative to the scale at which data are collected will be critical to the final outcome. In particular since the comet dust was not captured intact.

The first, major challenge will be determining the nature of induced modifications. The next challenge will be selecting optimized techniques to extract the many thousands of particles. Another challenge will be selecting the most suitable analytical techniques and protocols. Finally, there will be challenges finding the best data reduction tools to work around the omnipresent silica matrix. The ultimate goal of this truly Herculean task of Wild 2 dust characterizations will be a comprehensive inventory of the dust present in the outer reaches of the newly forming solar system 4.56 Gyrs ago.