STARDUST: THE MISSION AND THE CRITICAL ROLE OF X-RAY CHEMICAL ANALYSIS

George J. Flynn
Dept. of Physics, SUNY-Plattsburgh, Plattsburgh, NY USA

NASA's Stardust spacecraft collected dust in low-density silica aerogel during its passage through the dust coma of Comet 81P/Wild 2 in January 2004. The aerogel capture cells, containing hundreds of Wild 2 particles, were recovered on January 15, 2006.

A compact, single grain captured in low-density aerogel produces an entry damage track several hundred times the diameter of the particle, with an intact particle at the end of the track. Initial inspection of the Wild 2 samples indicated that, as expected, the comet dust was very weak. Most particles broke up on collection, depositing material all along the entry track.

X-Ray Microprobes, with their ability to penetrate into the interior of the aerogel, permitted the distribution of all but the lightest elements (Z < sulfur) to be mapped over the entire entry track. Seven groups of investigators using six synchrotrons on four continents contributed to the preliminary chemical characterization of the Wild 2 samples, determining the element distributions in 23 tracks.

The X-Ray Microprobe analyses demonstrated that the compositions of the terminal particles, which were generally dominated by mineral grains (olivine, pyroxene, or Fe-sulfide) were quite different from the composition of the finer-grained material deposited along the entry track. Thus, the composition of the incident particle could not be determined simply by extracting a terminal grain and analyzing it with conventional laboratory instruments, such as an electron microprobe. X-Ray Microprobes provided the critical analytical capability to characterize the material distributed along the entry tracks.

The average elemental composition of the 23 particles agrees well with the composition of the CI carbonaceous meteorites, which are believed to represent the initial composition of the Solar System for the non-volatile elements. However, several moderately volatile minor elements (Cu, Zn, Ga, and Ge) were found to be enriched over the CI meteorite composition, suggesting the outer region of the Solar Nebula, where comets such as Wild 2 are believed to have formed, may have contained higher concentrations of these elements than the inner region of the Solar Nebula, where the meteorites formed.