PROGRESS IN ANALYSIS OF SAMPLES RETURNED BY THE NASA GENESIS MISSION

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Introduction

The NASA GENESIS spacecraft mission (2001-2004) collected the first-ever sample of the solar wind by exposing ultrapure substrates outside of the Earth's magnetosphere to the ion flux from the Sun's surface. This exposure (884 days) provided a few picograms/cm^2 of the more abundant elements (e.g., Mg and Fe). On return to Earth, the spacecraft's parachutes failed to deploy and the sample canister smashed into the Utah desert at a velocity of ~200 km/h. The accident fractured the substrates and compromised the ultraclean environment of the sample canister with Utah mud. Since the solar wind particles were ion-implanted at depths of about 100 nm, careful cleaning of the sample surfaces can, in principle, allow researchers to recover some, if not all, of the chemical information contained in the substrates.

At present, only small sub-cm fragments have been allocated for testing cleaning procedures. Laboratories around the world are carrying out similar tests to determine the extent of contamination of the samples, and the degree to which this contamination can be removed without compromising the underlying solar wind signal. A high-density of dust on the surfaces has been reported. Prior to cleaning, our initial efforts have focused on imaging the dust particles and characterizing their chemical compositions. We have also analyzed the elemental composition of mud from the crash site by Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

Experimental

Electron Microscopy was performed at the NHMFL's Microanalysis Laboratories using an ElectroScan E-3 Environmental Scanning Electron Microscope (ESEM). A focused 20 keV, 80 micro-Amperes beam was used for imaging. The specimen chamber was operated at a water vapor pressure of 1.0 torr (~133 Pa) and the samples were examined without preparation or conductive coating. Semi-quantitative analysis was performed using a *Princeton Gamma-Tech* energy dispersive x-ray and imaging analysis system. Elemental analysis of Utah mud samples was performed using facilities in the NHMFL's Geochemistry program. Sample preparation was performed under Class-10 to Class-100 conditions in the Clean Lab. Elemental analysis was performed by magnetic sector ICP-MS using the Finnigan Element™ mass spectrometer.

Results and Discussion

ESEM imaging of a test sample (#60041) revealed a high density of particles ≤ 10 μm in diameter embedded into the sample surfaces. The majority of the particles imaged and analyzed were fragments of Si and Ge wafers from the collector assembly. A number (3) of Zn-Ga particles originating from paint within the spacecraft were observed. Most significantly, we have not identified a single particle, large enough to be analyzed by EDX, which originated from Utah mud. This is reason for cautious optimism that some of the fragmented samples may have escaped exposure to Utah mud, and can be analyzed for solar wind signatures despite the presence of particles originating from other parts of the collector assembly.

We have also carried out the first extensive set of elemental analysis of mud from the crash site. Our results show the mud to be composed of typical sediment with a significant amount of salts. Comparison of the elemental composition of the Utah mud with that of the solar wind shows that the Fe-peak elements (Cr-Ni; one of GENESIS's major goals) are least likely to be contaminated and will be the immediate target of investigation by both our group and others.

Conclusions

1. Particles >1μm embedded in the test samples appear to be derived from the sample canister, including the ultrapure Si and Ge substrates, and not from the Utah mud.
2. The mud composition was analyzed and has low Fe-peak elements relative to the solar wind, so these elements will be priority targets for mass spectrometric analysis.

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