

**Volatiles Present in Interplanetary Dust Particles and Contaminants Collected on the Large Area Collectors.** Christopher P. Hartmetz and Everett K. Gibson Jr., SN2, Planetary Science Branch, NASA-Johnson Space Center, Houston, TX 77058.

Interest in interplanetary dust particles (IDPs) stems, in part, from their contribution to an understanding of the cosmic history of the biogenic elements H, C, N, O, S, and P. These elements, and simple molecules, can be effectively analyzed *in situ* via a laser microprobe/mass spectrometer (LMMS, described in 1) system. This can be accomplished at the ~10 micron scale necessary to analyze IDPs. Some of the important issues involved in IDP research include: what are these particles made of, where do they come from, and how did they form? Other important issues concern the contribution, made by biogenic elements in IDPs, to our carbon-rich biosphere (2), and what properties of these materials influenced or were influenced by the origin and early evolution of the solar system (3).

Ten particles from the Large Area Collectors (LAC) were analyzed with a LMMS system. The particles were pressed into a gold substrate and examined for major element compositions with the energy dispersive x-ray spectrometer on a JEOL-35CF SEM. Photomicrographs were taken of the particle after it was identified and analyzed with EDX, and after LMMS analysis to insure that the particle was vaporized. Four out of five particles allocated from the first LAC flown (L2001) were terrestrial contaminants. This was probably because the collection pod did not close at the appropriate altitude. Particle L2001\*D3, and the five particles allocated from LACs L2002 (L2002\*C4), L2003 (L2003\*D2 and L2003\*E3), and L2004 (L2004\*C3 and L2004\*D3), were all chondritic IDPs, determined by EDX analysis. A summary of each particle's type, and the elements present in its EDX spectrum, is given in Table 1. Identification of chondritic IDPs were based on the amounts of Fe, Mg, Si, Al, Ca, and Ni within the EDX spectrum. Sulfur could not be resolved from the gold substrate's background signal.

Prior to analysis of the IDPs, various rinsing techniques were tested. Aluminum spheres were rinsed of their 20:1 mixture of silicone oil and freon (the capture medium) with different solvents. The LMMS analysis of spheres showed that hexane and methyl ethyl ketone solvent residues were left behind in similar amounts. Methyl ethyl ketone was rejected because of its health risks and its potential for removal of indigenous carbon-bearing phases. Oxygen plasma etching after rinsing was employed with success, but was also rejected because of uncertain effects on indigenous carbon components. Therefore, prior to analysis, particles were rinsed with hexane to remove the silicone oil/freon mixture. As noted in (4,5) removal of the silicone oil/freon mixture is difficult, and is not always successful with hexane rinsing. Past analysis of IDPs has shown that residual contaminant volatiles persist, including freon fragments (4). Researchers must, therefore, develop new methods for the removal of silicone oil and freon or attempt to account for this contamination in elemental or compositional analysis.

The LMMS analysis of particles was carried out by the methods of (4). All particles released some silicone oil, freon, and hexane fragments. IDP L2004\*C3 was particularly contaminated with silicone oil; much of the signal was identical to a silicone oil spectrum (4) in content as well as relative abundance. IDPs L2004\*D3 and L2001\*D3 released mostly contaminate species. However, indigenous volatile species are present in the other IDP spectra. Two particles (L2001\*D3 and L2001\*C3) released OH upon laser vaporization, suggesting the presence of hydrated mineral phases. L2002\*C4 (Fig. 1) released significant amounts of alkane/alkene/alkyne related phases, including  $m/z=13$ , and unusually large relative abundances (too large to be accounted for as contamination) of  $m/z=26$ , 27, 28, and 30 in their evolved gas spectrum. The most interesting IDP spectrum, also containing both aliphatic and unsaturated hydrocarbons, was that of L2003\*E3 (Fig. 3). L2003\*E3 may contain a carbon-bearing phase that are responsible for the large amount of unsaturated methyl- and ethyl-species, plus a large amount of high molecular weight unsaturated hydrocarbons ( $m/z=65$  ( $C_5H_5$ ), 66 ( $C_5H_6$ ), 67 ( $C_5H_7$ ), 78 (benzene), 79 ( $C_6H_7$ ), 93, 95, and 100) that are probably recombination biproducts from a laser-produced plasma plume rich in carbon and depleted in hydrogen. This is possibly poorly graphitized carbon (6) or a carbonate mineral phase. The latter would account for

$m/z=44$  ( $\text{CO}_2$ ). However, in a carbonate spectrum, one would expect to see  $m/z=28$  ( $\text{CO}$ ). One of the terrestrial contaminant particles, L2001\*B4 (Fig. 3), may be a piece of silicon carbide (EDX spectrum shows only Si). This contaminant may be due to the LAC pod not closing at the right altitude (7). Undoubtedly, other particles on L2001 are "low altitude contaminants".

**REFERENCES:** (1) Gibson E.K. and Carr R. (1989) *USGS Bulletin*, 1890, 35-49. (2) Thomas P.J. *et al.* (1989) *LPS XX*, 1117-1118. (3) Wood J.A. and Chang S. (1985) *NASA SP-476*, 80 pp. (4) Hartmetz C.P. *et al.* (1990) *Proc. of the 20th Lunar Planet. Sci. Conf.* (in press). (5) Rietmeijer F.J.M. (1987) *LPS XVIII*, 836-837. (6) MacKinnon I.D.R. and Rietmeijer F.J.M. (1987) *Rev. Geophys.* 25, 1527-1553. (7) Warren J. (1989) personal communication concerning the status of LAC2001.

Table 1

## EDX analysis and classification of LAC particles

Sample #	Type	Components
L2001*B4	TCA	Si
L2001*C3	TCA	Cu, Al, (Si)
L2001*D3	IDP	Si, Fe, Mg, (Ca), (Ni), (Cr)
L2001*E4	TCA	Si, Ti, Fe, Cl, (Ca)
L2001*G4	TCA	Fe, Al, Cu, (Si)
L2002*C4	IDP	Si, Al, (Ca), (Mg), (Fe)
L2003*D2	IDP	Si, Mg, Fe
L2003*E3	IDP	Si, Fe, Mg (Ni), (Cr)
L2004*C3	IDP	Si, Mg, Fe, (Ni)
L2004*D3	IDP	Si, Fe, Mg, (Ni), (Ca), (Al)

Gold substrate's background signal precludes EDX analysis for sulfur. Major and minor element components are listed in order of their abundances, and trace amounts are indicated by parentheses.

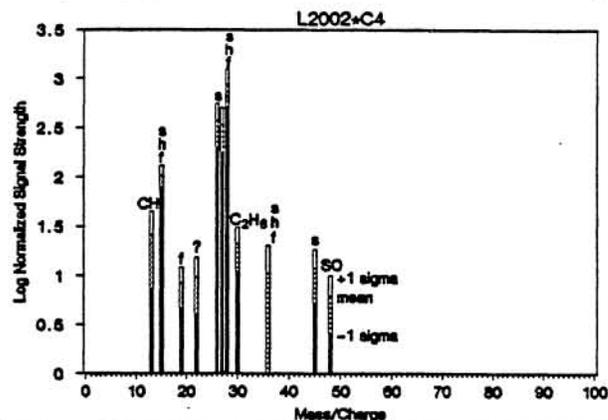


Figure 1. Plot of log relative abundance vs. mass/charge for L2002\*C4. EDX spectra indicate this is an IDP. The top of stippled bars is the mean and the top of open and filled bars represent  $\pm 1\sigma$ , respectively. In all Figs. indigenous species are labeled with capitals and contaminants are labeled with s, h, or f depending on which contaminant is that peaks source. Note the presence of hydrocarbons  $m/z=13$ , and large abundances of 26, 27, 28 normally considered silicone oil contamination, however, their abundances are an order of magnitude greater than what silicone oil releases (4).

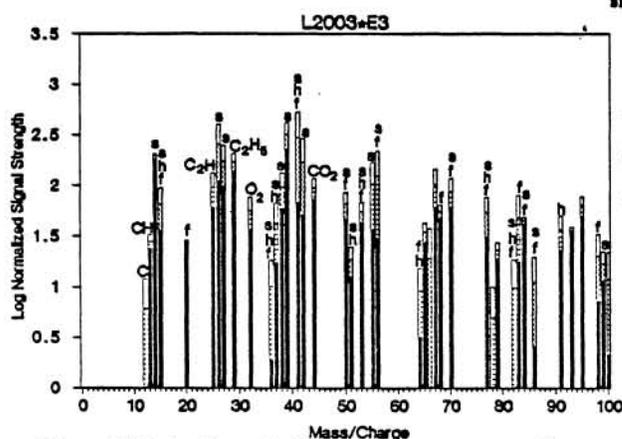


Figure 2. Plot of log relative abundance vs. mass/charge for L2003\*E3. EDX spectra indicate this particle is an IDP. Bars are the same as in Fig. 1. Note the presence of noncontaminant related methyl- and ethyl-species and the presence of many high molecular weight unsaturated hydrocarbons. Because of a lack of space these peaks are not marked, however, they are discussed and interpreted in the text.

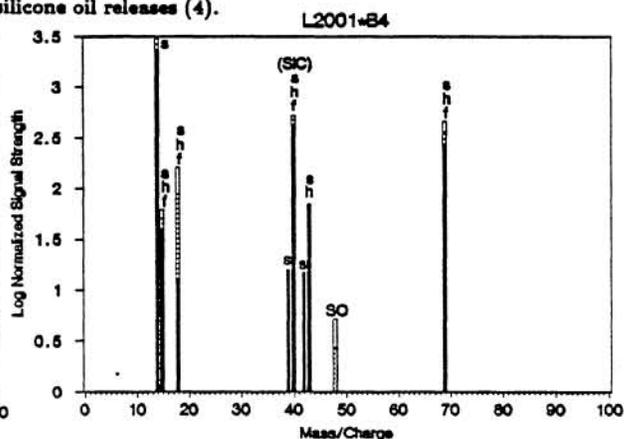


Figure 3. Plot of log relative abundance vs. mass/charge for L2001\*B4. EDX spectra indicate this particle is a terrestrial contaminant. Bars are the same as in Fig. 1. Note the presence of large amounts of  $m/z=14$  ( $\text{CH}_2$ ), and  $m/z=40$  ( $\text{SiC}$ ) that may be from silicon carbide.