CARBON-BEARING PHASES AND VOLATILES IN INTERPLANETARY DUST PARTICLES. Everett K. Gibson, Jr. and Christopher P. Hartmetz[1], SN2 Planetary Sciences Branch, NASA Johnson Space Center, Houston, TX 77058. [1]now at: Planetary Sciences Unit, Dept. of Earth Sciences, The Open University, Milton Keynes MK7 6AA, England.

Characterization of the indigenous carbon-bearing and volatile phases within interplanetary dust particles (IDPs) is one of the highest goals toward understanding the evolution of the organogenic elements (H, C, N, O, S, and P) and their compounds in IDPs. The analytical techniques required to detect and characterize the carbon-bearing phases and components in IDPs are only now emerging. The relative abundances and distributions of volatiles in IDPs along with the distribution of volatiles within 20-30 micron size regions of carbonaceous chondrites have been measured (1-3). Table 1 summarizes the analytical results for 14 IDPs analyzed by the laser microprobe/mass spectrometry technique (1,3).

Two basic categories of IDPs have been identified from our studies: (l) IDPs with large amounts of indigenous volatiles and (2) IDPs with little or no indigenous volatiles. The IDPs containing volatiles can be separated into four sub-groups: (a) carbonaceous (containing hydrocarbons), (b) carbonate-bearing, (c) hydroxyl-bearing, and (d) sulfur-bearing particles. IDPs that contain large quantities of volatiles may contain more than one sub-group of volatiles within a single particle (Table l). For the sulfur-bearing particles, five of the particles contained only one sulfide-related phase and three of the particles contained more than one or multiple sulfur phases (i.e. elemental sulfur and/or sulfate-related phases) in addition to the sulfide-related phases. Because of the possible presence of sulfur-bearing aerosols in the stratosphere, attention must be paid to the potential of contamination of the IDPs prior to collection. Identification of the volatiles were based upon the extensive studies of (1-4) known reference mineral standards.

Despite contamination introduced during the collection and processing of the IDPs (1,3), several indigenous volatiles have been identified within the IDPs studied. One of the more interesting chondritic IDPs studied was L2003E3 collected on the Large Area Collectors now being flown. This particle possibly contained carbonates (based upon the fragmentation pattern for terrestrial carbonates (4)). EDX spectra confirmed the identification of the carbon within the particle. The volatile release profiles for particle L2003E3 along with L2003D2 and L2004C3 are similar to those from selected areas in the groundmass of CM carbonaceous chondrites such as Murray (2). The higher-molecular weight hydrocarbons in both LAC 2003D2 and LAC2003E3 may be accounted for if polycyclic aromatic hydrocarbons and/or "kerogen-like" compounds which make up the bulk of carbonaceous material in carbonaceous chondrites are present within these IDPs.

Several particles were found to contain little or no indigenous volatiles (L2001D3, L2002C4, and L2004D3). The absence of volatiles within IDPs is not unusual if one considers both the small sizes of the particles, and the fact that several phases in volatile-rich carbonaceous chondrites are volatile-poor (3). Approximately one half of all characterized chondritic IDPs are anhydrous, being composed mainly of olivine, pyroxene and glass. Some fraction of these anhydrous IDPs contain carbon in some form. It is interesting to note that of the hydrous IDPs analyzed in our study, only one particle (U2034D7) contains carbonaceous material. None of the particles with multible sulfur-species contain carbonaceous material. If asteroids are a significant source of IDPs, we might expect to see IDPs with little or no volatiles. On the other hand, comets, sometimes described as volatile-rich "dirty snowballs", are probably not viable sources for the volatile-depleted particles. The PUMA mass-spectrometer analysis of comet Halley's dust detected many volatiles including highly unsaturated hydrocarbons (5), similar to those released from carbonaceous chondrites (2).

Many comparisons have been made between the composition of CI chondrites, IDPs, and comet Halley dust (6-9). However, both volatile (H,C,N,O and S) and nonvolatile elements were analyzed in the Halley encounter, making comparisons to the PUMA analyses difficult. Further complications in this comparison include the very small size and amounts of dust analyzed by PUMA and the contamination problems associated with the collection of IDPs. Until particles

are collected in an uncomtaminated manner, or contaminants are completely accounted for, comparisons of Halley dust with carbonaceous chondrites and IDPs are problematic.

From our analysis of IDPs we are beginning to identify subclasses of volatiles along with particles containing little indigenous volatiles. Obviously a much larger suite of volatile analyses of IDPs, coupled with parallel mineralogical analyses of paired Large Area Collector's particles is necessary before one can use these trends with greater confidence to identify distinct subgroups or classes, and make comparisons between volatiles associated with hydrous and anhydrous IDP particles. Progress is being made in the study of IDPs volatiles and once the problems associated with collecting IDPs in a contamination-free manner are resolved it is anticipated that more definitive answers will appear. Even with the present situation, one can anticipate that the study of the volatile-poor group may reveal important information which lead to the sources of the IDPs.

References:
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TABLE 1. An overview of the volatile species and fragments observed from the analysis of 14 IDPs using the laser microprobe/mass spectrometer technique.

Large Amounts of Indigenous Volatiles	Little or No Indigenous Volatiles	Sulfur-species	Carbonaceous Material	Hydroxide-bearing	CO and CO_2†
L2002C4	L2001D3	(L2002C4)*	L2002C4	U2022F5	L2003D2
L2003D2	L2004D3	(L2004D3)	L2004E3	U2022F20	U2034D7
L2003E3	U2015B20	(L2003D2)	L2003D2	U2034D7	
L2004C3	U2015F20	(L2004C3)	L2004C3		
U2017A4	U2022F5	(U2034D7)	U2034D7		
U2017A5	U2034D1	U2017A4			
U2022G13		U2017A5			
U2034D7		U2022G13			

* Parentheses indicate that the particle contains only one type of S species, often in very low amounts.
† The presence of CO and CO_2 in certain abundances indicates the presence of carbonates.