CARBON PETROGRAPHY AND THE CHEMICAL STATE OF CARBON AND NITROGEN IN IDPS. Lindsay P. Keller[1], Kathie L. Thomas[2], and David S. McKay[3], [1]MVA, Inc., 5500/200 Oakbrook Parkway, Norcross, GA 30093, [2]Code C23, Lockheed, NASA/JSC, Houston, TX 77058, and [3]Code SN, NASA/JSC, Houston, TX 77058.

Introduction. Carbon is a major component of interplanetary dust. The carbonaceous material in IDPs has a strong effect on the physical and optical properties of IDPs, and is the likely carrier of isotopic anomalies in hydrogen and nitrogen [1,2]. Despite their abundance and importance, little is known about the nature and distribution of light elements in primitive IDPs. We report here on our TEM and electron energy-loss spectroscopy studies of carbon and nitrogen in a suite of anhydrous IDPs.

Methods. We are studying the carbonaceous materials in IDPs using a modified sulfur embedding technique combined with ultramicrotomy [3], followed by detailed analysis using electron microscopy. This procedure completely eliminates the carbon background from embedding media and substrates. The indigenous carbonaceous materials in the thin sections are readily observed in the TEM; carbon distribution, along with other light elements, can be mapped using EDX (Energy-Dispersive X-ray spectrometry) and EELS (Electron Energy-Loss Spectroscopy) techniques, and the nature of the organic materials can be investigated using various spectroscopies. Futhermore, the unsectioned part of the IDP can be recovered from the sulfur droplet and used for other types of analyses such as isotopic and trace element measurements.

Carbon Petrography. In the 10 anhydrous IDPs we have analyzed to date, the carbonaceous material is typically homogeneously distributed throughout the particles. Its petrographic setting is as a matrix binding the other fine-grained components (mineral grains, etc.) together. A common assemblage is the occurrence of GEMS (glass with embedded metal and sulfides, see [4]) as inclusions which are embedded in carbonaceous material. Two main textural varieties of carbon are observed, featureless and vesicular. There is an apparent correlation of vesicular carbon and magnetite rims, suggesting that the vesiculation results from the loss of a volatile component during atmospheric entry heating. High-resolution TEM images along with electron diffraction data indicate that the carbonaceous material in most of these IDPs is very-poorly ordered. Two exceptions however, are IDPs L2005C13 and L2005F31, which show rare thin rims (~10 nm thick) of poorly-graphitized carbon (PGC) surrounding Fe-Ni sulfides. In these two IDPs, it is not clear whether the PGC formed prior to accretion as a result of Fischer-Tropsch-type reactions or if it results from atmospheric entry heating.

Chemical state of C and N in IDPs. The EELS data provide information on the bonding environment of specific elements within the analyzed region. For carbon, the fine-structure in the EELS spectra indicate that the typical carbonaceous material in anhydrous IDPs is very poorly ordered and is most consistent with EELS data from amorphous carbons. The featureless and vesicular carbons in the same IDP show no significant structural differences. Other types of carbon are rare in IDPs. One anhydrous IDP (L2008F4) shows a split π^* peak at the C k-edge, a result that is confirmed by x-ray absorption (XANES) measurements [5] on the same particle. The XANES and EELS data show interesting similarities to spectra from C_{60} [5].

Like carbon, nitrogen is strongly fractionated among meteoritic materials and it is well known that the most primitive carbon-rich meteorites also tend to have high nitrogen abundances [6]. Nitrogen-bearing compounds are also a significant component of the carbonaceous material (CHON particles) sampled during the comet Halley encounter [e.g. 7]. We have recently detected nitrogen in four IDPs using EELS [8]. The EELS data from carbon-rich amorphous regions of the analyzed IDPs typically show a small, but distinct nitrogen edge at ~400 eV. The nitrogen is not homogeneously distributed in the carbonaceous material in the four IDPs analyzed to date, but occurs in "hot spots". However, these "hot spots" do not appear to be associated with a distinct N-bearing mineral (e.g. nitrides); the nitrogen is indigenous to the carbonaceous material in these IDPs. Comparison of the fine-structure in the N k-edge in the IDPs to EELS data from N standards shows that the IDP N is <u>not</u> present as nitride, nitrate, or cyano-groups. Ion probe measurements indicate that the N in one of the analyzed IDPs (L2011R11) is enriched in ^{15}N by ~190 ‰ (S. Messenger, pers. comm.).

Conclusions. The TEM and EELS measurements of 10 anhydrous IDPs show that: 1) the carbonaceous material in most IDPs is highly disordered and most closely resembles amorphous carbon rather than poorly-graphitized carbon or graphite, 2) the carbonaceous material in these IDPs is intimately associated with inferred presolar grains (GEMS), and 3) significant nitrogen concentrations have been detected in the carbonaceous material of several high-carbon IDPs.

References. [1] Messenger, S. *et al.* (1995) *Meteoritics* 30, 546. [2] McKeegan, K. D. *et al.* (1985) *GCA*, 49, 1971. [3] Bradley, J. P. *et al.* (1993) LPSC 24, 173. [4] Bradley, J. P. (1994) *Science* 265, 925. [5] Bajt, S. et al. (1996) this volume. [6] Kerridge, J. F. (1985) *GCA* 49, 1707. [7] Fomenkova, M. N. *et al.* (1994) *GCA* 58, 4503. [8] Keller, L. P. *et al.* (1995) *Meteoritics* 30, 526.