COMETARY INTERPLANETARY DUST PARTICLES? AN UPDATE ON CARBON IN ANHYDROUS IDPS

K.L.Thomas [1], L.P. Keller[2], G.E. Blanford[3], and D.S. McKay[2]
[1]Lockheed C-23, Nasa Rd.1, Houston, TX 77058 [2]NASA/JSC SN, Houston, TX 77058
[3]University of Houston Clear Lake, Houston, TX 77058

Introduction

Chondritic anhydrous interplanetary dust particles (IDPs) are widely considered to be the most pristine samples available for the study of the early solar system because of their primitive mineralogy, chemistry, and isotopic characteristics. Previously, we quantitatively analyzed anhydrous IDPs for light elements and found that these particles have significantly higher bulk carbon abundances than known chondritic meteorites [1]. We have also identified a relationship between carbon abundance and silicate mineralogy which, in general, shows that particles dominated by pyroxenes have a higher carbon abundance than those dominated by olivines. Particles containing equal amounts of olivine and pyroxene show a range of carbon contents and can be grouped with either the pyroxene- or olivine-dominated particles based on their carbon abundance. We have suggested that high carbon pyroxene-rich IDPs are derived from cometary sources [1].

In this study, we have determined bulk compositions and mineralogy of four additional IDPs; one particle has the highest carbon abundance reported in IDPs or any other chondritic material, with the possible exception of the carbon-rich Halley particles.

Methods

Our procedures and extensive analytical checks for quantitative SEM EDX light element analysis are described in detail elsewhere [1]. Following the chemical analysis, the IDPs were embedded in epoxy, thin sectioned using an ultramicrotome, and examined in the TEM.

Results and Discussion

Four IDPs have been added to the data set: L2006P2, L2006B21A, L2005W13, and L2006B23. L2006P2 has bulk carbon abundance of ~4 wt.% and is composed predominantly of olivine (Fo 20-90) with minor enstatite, magnetite and Fe-Ni sulfides (~3-7 wt.% Ni). L2006B21A is a high carbon IDP (~15 wt.% C) which is dominated by low Ca pyroxene grains. A partial magnetite rim is present; olivines are ~Fo 65-70. Both of these IDPs follow the relationship between carbon abundance and silicate mineralogy determined previously for anhydrous IDPs [1].

L2005W13 is a unique IDP because it is composed of two mineralogically and chemically distinct lobes. One lobe is composed of sulfide, enstatite, and olivine (Fo 40-60) grains, while the other lobe is dominated by a Si-rich glassy matrix surrounding tiny crystals <10 nm in size. Both lobes have partial magnetite rims indicative of atmospheric entry heating [2]. SEM EDX measurements indicate that L2005W13 has a carbon abundance of 8 wt.%. However, one of our major assumptions for quantitative carbon analysis is that the carbon is homogeneously distributed throughout the particle. The mineralogical heterogeneity of L2005W13 suggests that the carbon may not be homogeneously distributed throughout both lobes. Since this particle is mineralogically atypical for anhydrous IDPs, we have not included it in our modeling of carbon abundance and mineralogy.

L2006B23 is an ~ 15 um fragment of a group of particles comprising cluster 14 from collection surface L2006. All elements (relative to Si) are chondritic within a factor of two with the exception of Na (7xCI) and C (~13.5xCI). The bulk carbon content of L2006B23 is ~46 wt.%. Examination in the TEM confirms that the particle is dominated by amorphous carbonaceous material. Several sub-micrometer sized fine-grained aggregates also occur similar to those observed in other anhydrous IDP [3]. These aggregates contain numerous FeS and FeNi (kamacite) grains, typically ~5 nm in diameter (ranging from 1-50 nm) embedded in a Si-rich matrix. Sulfide grains are generally coarser grained than the kamacite; Ni ranges from ~1.5-11.5 wt.%. Grains of forsteritic olivine, on the perimeter of the fine-grained aggregates, are 100-200 nm in size. Like L2005W13, this particle is not included in our modeling because carbonaceous material is the dominant phase and anhydrous silicates are a minor component (<20 vol.%). Of the 15 IDPs studied, only these two particles, L2005W13 and L2006B23, do not fit our model.

Two related IDPs (L2006B15 and L2006B20), from the same cluster as L2006B23, have been analyzed by others using various techniques. Synchrotron X-ray Fluorescence (SXRF) measurements of L2006B15 show that its CI normalized Zn/Fe ratio is 0.27 which indicates that this particle has undergone little or no atmospheric heating (G. Flynn, pers. comm.). Another fragment of the cluster (L2006B20) was heated to determine ^4He amounts and ^4He release temperatures. These measurements indicate that L2006B20 is definitely an extraterrestrial particle which has undergone little atmospheric heating (A. Nier, pers. comm.).

We have proposed that the high carbon, pyroxene-rich anhydrous IDPs are strong candidates for cometary dust particles. Although we do not exclude the possibility that some carbon-rich IDPs could be derived from asteroids in the outer belt (*e.g.*, P and D asteroids), the abundance of carbonaceous material relative to silicate material is poorly constrained for these asteroids. On the other hand, the olivine-dominated, low carbon IDPs are probably derived from asteroids [1]. The distribution of carbon abundances in the mixed mineralogy particles indicates that this group may contain representatives from either asteroidal or cometary sources. If true, then the low carbon anhydrous IDPs are derived from very primitive sources unlike the carbonaceous chondrites but perhaps resembling the fine-grained material in unequilibrated ordinary chondrites (*e.g.*, Semarkona).

Implications

SXRF and ^4He measurements indicate that fragments related to L2006B23 are either unheated or only mildly heated. The lack of heating effects suggests that the entry velocity for this cluster was low, of the same magnitude as dust derived from asteroidal sources [4]. The abundant carbonaceous material and fine-grained aggregates in L2006B23 are incompatible with any known meteorite group. Infrared spectra from anhydrous IDPs containing abundant fine-grained aggregates show similarities to some cometary dust [5]. The compositional and mineralogical data indicate a cometary source for L2006B23. However, cometary particles are generally believed to arrive at the Earth's atmosphere with high velocities. If L2006B23 is truly a cometary particle, then the ^4He and SXRF data indicate it arrived at a low velocity. Calculations by [6] show that there are comets with low eccentricities and perihelia > 1.5 AU which should contribute low velocity particles to the stratospheric IDP population.

References: [1] Thomas K.L. *et al.*, (1993) *GCA*, In press. [2] Thomas K.L. *et al.*, (1992) *LPSC 23*, 1427. [3] Bradley J.P. (1993) *LPSC*, this volume. [4] Flynn G.J. (1989) *Icarus*, 287. [5] Bradley J.P. *et al.*, (1992) *Astrophys.J.*, *394*, 643. [6] Blanford G.E. (1993) *LPSC*, this volume.