IDENTIFICATION OF COMETARY AND ASTEROIDAL PARTICLES IN STRATOSPHERIC IDP COLLECTIONS. D.E.Brownlee, D. J. Joswiak, S. G. Love, Dept of Astronomy, Univ. Of Washington, Seattle, WA 98195, A.O. Nier, D.J. Schlutter, Dept. of Physics, Univ. of Minnesota, Minneapolis, MN 55455, and J. P. Bradley, MVA Inc., 5500 Oakbrook Parkway, Atlanta, GA, 30093.

We have determined He release temperature curves for a specially processed set of 5μm to 15μm stratospheric IDPs whose masses, densities and compositions have been accurately measured. The He release temperature in combination with atmospheric entry calculations yields a most probable entry velocity for each particle and association with either an asteroidal (low velocity) or cometary (high velocity) origin. We find that over half of the 5-15μm IDPs have entry velocities consistent with asteroidal origin and that at least 20% have cometary origins. A few of the asteroidal particles are porous aggregates and it appears that there may be close material similarities among some primitive asteroids and comets. In the processing of individual 5μm IDPs and determination of entry velocities we preserve a few dozen microtome slices that can be used for a variety of detailed TEM, IR and ion probe studies. These procedures provide laboratory samples that can be generically associated with asteroids and comets and are in a sense a limited sample return mission from these primitive bodies.

Earth encounter velocity is a distinguishing property of cometary and asteroidal dust [1,2]. The 1AU nodal crossing velocities estimated by Zook & Jackson [3] give typical asteroidal and cometary entry velocities into the atmosphere of 12 km s^{-1} and 19 km s^{-1}, respectively. For identical 10μm particles entering at 45° this velocity contrast results in a >300 °C difference in peak atmospheric heating. Using measured peak temperature we can calculate the entry velocity required to produce this temperature and clearly distinguish typical cometary dust particles on elliptical orbits from low inclination, low eccentricity dust that has spiraled in from the asteroid belt by Poynting Robertson drag.

In this project we determine the maximum heating temperature by measuring the temperature dependence of He release from particles subjected to pulsed step-wise heating [4]. The particles are heated to successively higher temperatures by 5s thermal pulses that mimic heating curves for atmospheric entry. Tests of lunar grains and IDPs have shown that the temperature release curves are reliable indicators of prior heating and degassing of the samples[4,5]. Estimated errors due to material differences and other factors are believed to be less that 100 °C. The smallest IDPs that can effectively analyzed by this step-wise heating technique are 5μm and so we have chosen this diameter as our preferred IDP size. The remarkable ability to do the He analysis on 10^{-10}g IDPs is the result of technique refinements [5] and increasing He concentrations of smaller IDPs that approach 1 cc (STP) g^{-1} at 5μm diameter. The great advantage of using the smallest IDPs is that they are the least modified during atmospheric entry. For 5 μm IDPs, typical 12 km s^{-1} particles are heated to 400-500 °C and 19 km s^{-1} particles are heated to 800-900 °C. Larger cometary particles are heated to higher temperatures and may be significantly altered.

The particles used for this study were specially picked from U2 collection surfaces to provide a random sampling of the smallest IDPs. They include a large

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number of 5μm particles, a size that is not commonly removed from surfaces and curated. We picked particles and mounted them on special TEM mounts that carry 100 particles each in a square array. All particles were processed and analyzed by identical techniques. We did quantitative elemental analysis in the SEM at 20KV using the EDX techniques described by Schramm et al. [6]. To determine entry velocities from measured peak heating temperatures it is necessary to know the mass and density of each particle. We made this determination in the TEM with 120KV electrons using the technique described by Love et al. [7]. Individual particle masses are determined by absolute measurement of the Fe mass and dividing this by the fractional abundance of Fe. We believe that the mass, density and peak temperature measurements are sufficiently accurate to distinguish typical asteroidal and cometary particles.

The computation of velocity from peak heating temperatures is done with the atmospheric entry model of Love and Brownlee [8]. Velocities are computed for 45°, the most probable entry angle. Entry at shallower angles results in lower temperatures, but only a small fraction of particles enter at low enough angles to yield serious underestimates of velocity. A situation producing erroneously high implied velocity could occur when a 5μm particle is generated by fragmentation of a larger particle deep in the atmosphere. Due to the higher air density, such a particle is much more strongly heated than one that enters as an initially small particle. However, the extremely high He concentrations in the IDPs analyzed, , indicate that their surfaces were exposed to space and that they are not fragments of larger particles. They have much higher He concentrations than found in gas-rich meteorites.

To date we have analyzed enough particles to show that the majority of small IDPs have low entry velocities consistent with asteroidal origin. We have also clearly identified cometary particles that are present at an abundance of >20%. An initial finding is that porous IDPs are found with both asteroidal and cometary orbits. Although much more work remains to be done, this finding suggests significant similarities between comets and at least one class of asteroid material. To significantly expand our ability to study particles that are destructively analyzed for He we have recently developed a procedure where a few dozen microtome slices are removed from each 5μm particle before it is run for He. This preserves a set of material with known generic origin that can be extensively studied. It is hoped that this work will provide vital information for comparison of the mineralogical, elemental and isotopic properties of asteroids and comets at the micron and sub-micron size scales. Using the sulfur embedding techniques discussed by Bradley et al. [9] we believe it will be possible to directly study cometary organics preserved in 5μm IDPs.

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