THE COMPOSITION OF PICOGRAM TO MILLIGRAM METEORITIC SPHERULES; D. E. Brownlee and L. S. Schramm, Astronomy Dept., University of Washington, Seattle, WA 98195.

Spheroidal extraterrestrial particles are found in the atmosphere, the sea floor, polar ice, and continental sediments. Some of these "cosmic spherules" may have been produced by impacts in space (1), but oxygen isotopic composition (2) and interior textures indicate that the vast majority were generated by fusion of meteoritic materials during atmospheric entry. The atmospheric fusion spheres have two modes of formation, spray droplets from the fusion crusts of larger bodies and simple melting of individual small particles. Because the peak in the meteoroid mass distribution occurs at a mass equivalent to a particle of approximately 300μm diameter, it is unlikely that spray droplets are an important source of larger spheres. They could however be a significant component of the sphere population smaller than 100μm. Meteoritic spherules can be collected over a very broad size range and their compositions provide insight into the nature and relative abundance of asteroidal and cometary particles that impact the Earth. It is of particular interest that collected spheres include the size range that dominates the annual mass accretion onto the Earth, the range that is intermediate between micrometeorites and meteorites. They are also in the size range of meteoroids that will be collected by LDEF and the Cosmic Dust Collection Facility on the Freedom space station.

Possible variations of composition with size provide clues to the relative contributions of asteroidal and cometary dust. The ratio of asteroidal to cometary spherules should vary with size due to several factors including differences in orbital evolution to reach the Earth and survival of atmospheric entry. Comet debris systematically enters at higher velocity and survival against vaporization is strongly discriminated against for the larger sizes. At the large end of the size range we expect only asteroidal spheres but at the small end we expect the inverse, a high ratio of comet to asteroid spheres. Nearly all 10μm and smaller asteroidal particles should enter without melting and only cometary particles should enter fast enough to melt.

We have measured the elemental compositions of 500 extraterrestrial spherules covering the size range of 1μm to 1mm. This spans the range from the particles that produce visual meteors to the size where the force of sunlight is similar to the sun's gravity. The samples in the 1-20μm size range were collected from the stratosphere while those from 50μm-1mm were collected from polar ice (3) and sea floor sediments. The small particles were analyzed by SEM EDX without sectioning and the ones larger than 50μm were sectioned and analyzed with the electron microprobe. Some of the data for silicate spherules is illustrated in Figure 1 where bulk element to silicon ratios are normalized to the mean values for 10μm size micrometeorites (unmelted!) measured previously (4). The data shows several size dependent effects and differences between spheres and true micrometeorites Iron, Cr,Co and Ni are depleted in the spheres relative to the unmelted particles and here is a trend of increasing depletion with size. We believe that this effect is not a original property of the materials but rather a result of ejection or vaporization of siderophile rich phases during entry. The size dependence may be the result of greater heating. With the exception of larger dispersion for particles $< 20\mu$m, most of the size dependent effects are fairly subtle, suggesting that cometary and asteroidal particles may have generally similar elemental compositions. Comparison of the sphere data with the results of the two major mineralogical classes of unmelted micrometeorites does show evidence for separation of asteroidal and cometary materials. One micrometeorite class (CP) is predominantly anhydrous and unfractionated and has a suggested cometary origin while the other class (CS) contains abundant layer silicates, some carbonates, and has a suggested asteroidal origin because it is similar to CI/CM matrix and shows evidence of aqueous alteration. In common with the CS micrometeorites and CI matrix, the large spheres have members that are strongly depleted in Ca, a property associated with parent-body weathering and probably

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indicative of origin from asteroids. In contrast, the small spheres are not depleted in Ca, and they show good Al/Ca correlation which is consistent with the CP micrometeorites (4) and a likely property of fine-grained cometary matter. The large spheres also have depleted Mn abundances consistent with the CS particles and concordant with the notion that the CS micrometeorites and most of the large spherules are of asteroidal origin.

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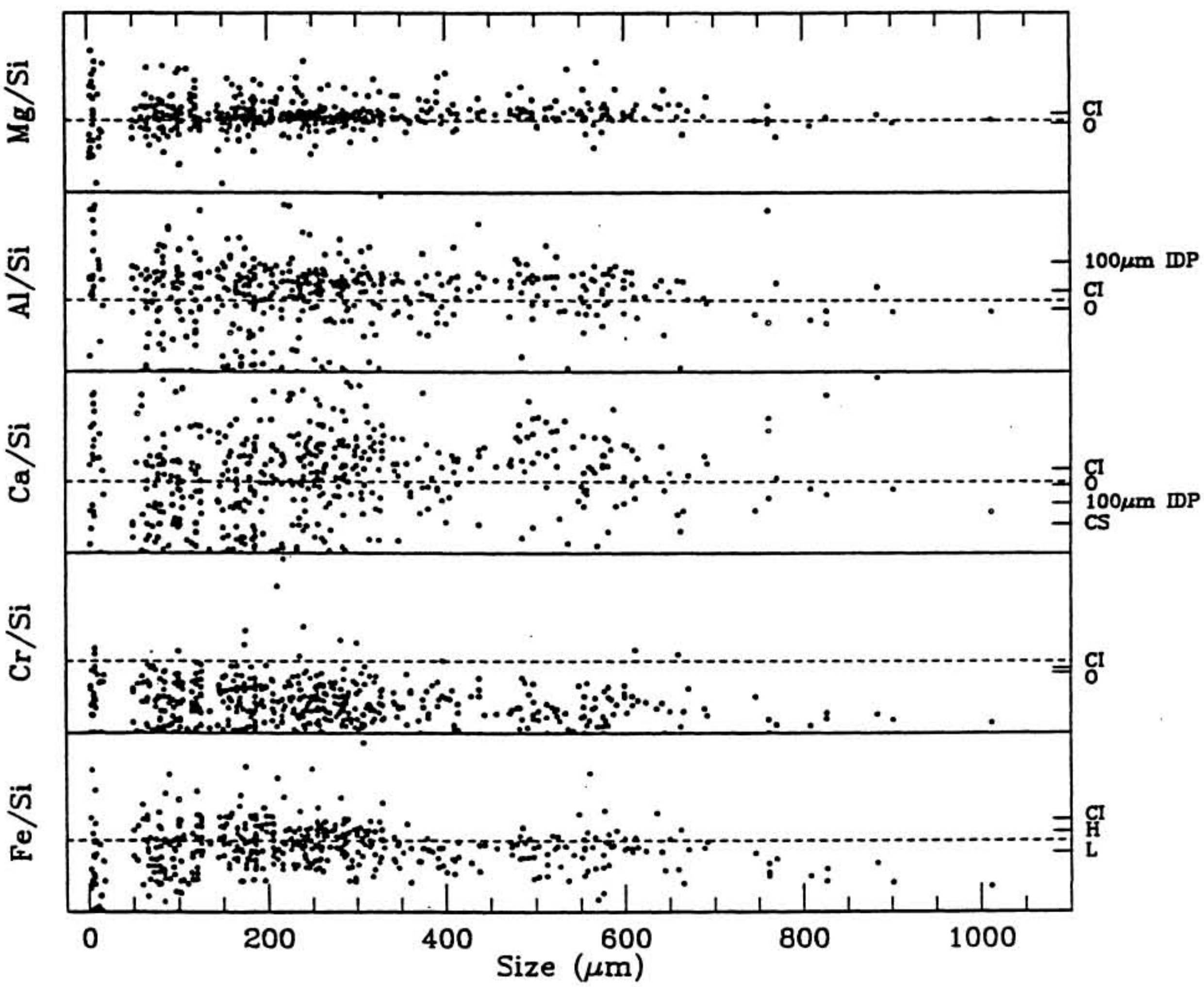

Figure 1. Atom element to silicon ratios versus size for 500 meteoritic spherules. The ratios are normalized to mean unmelted 10μm IDP (4), indicated by the dashed line, and the scale is from 0 to 2.5. For comparison are shown mean ratios of some meteorite and micrometeorite groups. CI, O, H, and L are CI, ordinary, H and L chondrites, respectively. CS is the chondritic smooth 10μm IDP mean (4) and the 100μm IDP mean is the average of 79 unmelted micrometeorites collected in Antarctica (unpublished).

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