LARGE MINERAL GRAINS IN INTERPLANETARY DUST; D. E. Brownlee, L. S. Schramm, Dept. of Astronomy, University of Washington, Seattle, WA 98195; M. M. Wheelock, Dept. of Geology, University of New Mexico, Albuquerque, NM 87131; and M. Maurette, Laboratoire Rene Bernas, Universite de Paris, Paris, France.

Introduction. Typical micrometeorites are dominated by submicron material but often contain large (> 4μm) mineral grains as minor constituents. Some particles are predominantly composed of either a single mineral grain or assemblages of large grains. The large mineral grains could be condensates or fragments derived from preexisting coarse-grained materials such as chondrules or inclusions. They may or may not have formed in the same environment that created submicron grains. Large grains provide important clues to the origin of interplanetary particles. For example the literature contains speculation that such large mineral grains should not exist in comets or interstellar grains. The compositions, textural relations, and mineral associations of the large grains provide a straightforward means of investigating links between small stratospheric interplanetary dust particles (IDPs) and chondrites as well as large interplanetary particles collected from Antarctica, Greenland and the ocean floor. The large grains are particularly important in large interplanetary particles collected from the Earth's surface because they are less altered by weathering and atmospheric heating than fine-grained "matrix" materials.

Technique and Samples. The samples in this study include 5-50μm stratospheric IDPs and 50μm to 1mm extraterrestrial particles from the sea floor, Greenland and Antarctica that are either unmelted or contain unmelted relict grains. The size ranges barely overlap and so there is a strong dichotomy between the samples. The airborne samples are small and relatively pristine while the surface samples are larger and somewhat more altered due to heating and weathering. Most of the work on the samples has been SEM and electron microprobe analysis of polished samples potted in epoxy mounts.

Mineralogy. The most common minerals composing the large grains in micrometeorites are forsterite, Fe-bearing olivine, enstatite, Fe and/or Ca-bearing pyroxene, and iron sulfide. CAI related minerals, metal, carbonate, phosphate and plagioclase are very rare. Based on a limited sampling for the stratospheric particles, enstatite is the most abundant large mineral type, followed by iron sulfide, then olivine. The dominance of enstatite over forsterite agrees with whole particle analysis of the subset of stratospheric IDPs that are assemblages of large single mineral grains. The bulk analysis of unsectioned particles of this type (Fig. 1) show that most have compositions that are consistent with mixtures of enstatite and an Fe-rich material but only a few contain substantial amounts of forsterite. The high pyroxene/olivine ratio is also apparently typical for the fine-grained fraction of anhydrous IDPs as evidenced by IR and TEM studies (1). Large mineral grains in particles from Antarctica are dominated by enstatite as well. The relatively high En/Fo ratio in interplanetary particles is quite different from the lower ratios found in CI and CM chondrites (2) but is in general agreement with published condensation calculations (3). In contrast to the stratospheric and Antarctic particles, large mineral grains in the deep sea particles are dominated by forsterite; Fe-bearing olivine and enstatite follow in abundance, then Ca-bearing pyroxene (diopside). The large relative forsterite abundance in these samples could be an artifact of resistance to weathering on the sea floor. Large sulfide grains are rare in all samples except the stratospheric IDPs.

Mineral Chemistry. Klock *et al.* (4, pers. comm.) have found that many olivine and pyroxene grains in stratospheric IDPs have anomalously high Mn relative to olivine and pyroxene in chondrites. The few large forsterites (>Fo95) in stratospheric particles that we have studied so far have MnO contents ranging from 0.4 to over 1 wt% MnO and one enstatite grain contains 1.6 wt% MnO. The MnO concentration in Antarctic and deep sea forsterite and enstatite include high values but average only 0.1 to 0.3 wt% MnO. The values for forsterites in the larger particles are lower than for the stratospheric IDPs and are compatible with the range seen by Steele *et al.* (5) in forsterites of deep sea particles and chondrites.

Texture and Mineral Associations. Large mineral grains are usually anhedral in micrometeorites, although euhedral forsterite and sulfide grains have been seen. It is relatively common to find forsterite and enstatite in direct contact and we have seen several cases of enstatite rimming forsterite. Usually the contacts are sharp without interstitial glass. Both silicates and sulfides commonly contain inclusions. The silicates contain micron and larger kamacite spheroids and micron and smaller rounded blebs of feldspathic glass. Faceted voids that appear to be negative crystals have been observed in forsterite. The large sulfides commonly contain abundant micron and smaller rounded olivine, pyroxene and feldspathic glass inclusions as well as Zn-rich areas. Both the silicate and sulfide grains have small grains and glass bonded to parts of their exteriors. The sulfides often have deep embayments filled with enstatite, forsterite and feldspathic glass. Some also have large silicate grains bonded to their surfaces. The silicates are not fragments; it appears that the sulfides grew from the silicate surfaces. Large silicate grains often contain small sulfides on their surfaces and embedded within a few microns of surfaces but they do not occur as inclusions in the central regions of grains.

Conclusion. The properties of large mineral grains are important data for comparing various types of interplanetary dust with each other and chondrites. The relative abundances of minerals, their compositions and petrographic associations are very unusual and provide important clues to determining the origin of the particles. Some of the properties vary with the size of the collected particles; this may be an indication of different sources for large and small particles or it may result from selection effects associated with atmospheric entry or sample recovery. The high abundance of Mg silicates suggests a high temperature origin for the coarse-grained fraction of IDPs and possibly a different origin for the submicron material that more closely matches chondritic elemental composition. Among the most interesting properties of the large mineral grains are their minor element abundances, the composition of their inclusions and the nature of particles bonded to their surfaces.

References:

(1) Bradley, J.P. (1988) GCA 52, p. 889. (2) Kerridge, J.F. and McDougal, J.D. (1976) ESPL 29, p. 341. (3) Grossman, L. (1972) GCA 36, p. 597. (4) Klock, W. et al. (1988) LPSC XIX, p. 613. (5) Steele, I.M. et al., (1985) Nature 313, p. 299.

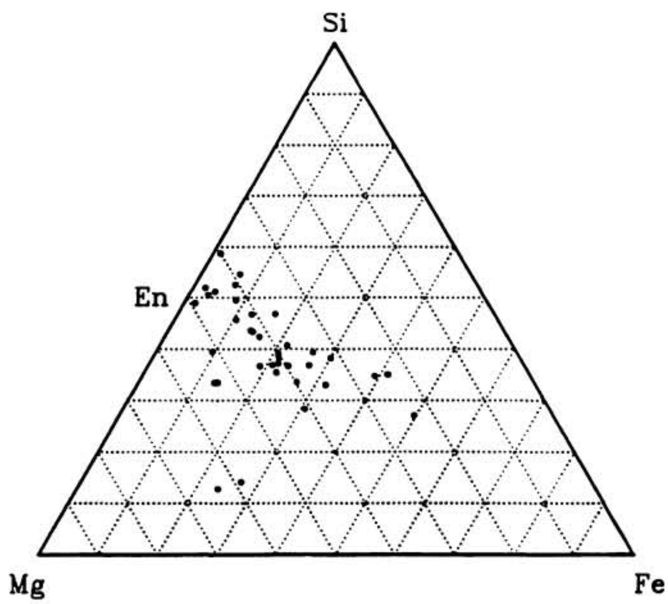

Figure 1. Si-Mg-Fe atom compositions of coarse-grained stratospheric IDPs. (Does not include FeS-dominated particles.)