MINERALOGY AND MICROSTRUCTURE OF SOME C-TYPE INTERPLANETARY DUST PARTICLES AS DETERMINED BY ANALYTICAL ELECTRON MICROSCOPY, Roy Christoffersen and Peter R. Buseck, Depts. of Geology and Chemistry, Arizona State Univ., Tempe, AZ, 85287

Introduction. We have studied two C-type interplanetary dust particles (W7028B3 and W7029B1) from the JSC collection using various transmission electron microscope techniques, including high-resolution lattice fringe imaging, convergent beam electron diffraction (CBED) and energy dispersive X-ray microanalysis (EDS). Samples were prepared by crushing each particle and dispersing the fragments on a continuous thin carbon TEM grid. The overall chemical and mineralogical characteristics of both particles are consistent with their classification into the "chondritic" category defined by Brownlee et al.(1). The preliminary SEM observations of W7029B1 made by the JSC cosmic dust team show that it is intermediate between the CP and CF morphologies. W7028B3 was not examined in SEM.

Mineralogy. Both particles are composed of single-crystal silicates and oxides up to 1.0 μm in size dispersed in an extremely fine-grained polycrystalline matrix. Identification of single-crystal grains in the 0.5-1.0 μm range was done using selected area diffraction and EDS data. CBED proved useful for identifying smaller crystals. Enstatite appears to be the exclusive large (i.e. greater than 0.5 μm) single-crystal silicate in W7028B3, while W7029B1 contains both single-crystal enstatite and olivine. Enstatites in both particles are commonly highly twinned, and some show irregular strain contrast in bright-field images. Internal strain in W7028B3 enstatite is further reflected by bending of (100) fringes in high-resolution images and broadening of diffraction spots. The images also show that nominal orthoenstatites contain some clinoenstatite lamellae. Other highly twinned crystals are pure clinoenstatite. In W7029B1 we observe distinct, sometimes euhedral, crystals that show only Fe in their EDS spectra and are most likely magnetite on the basis of diffraction data. These grains range up to 0.2 μm in size and to our knowledge are the largest distinct magnetite crystals yet observed in the C-type IDPs. We have yet to observe any distinct iron sulfide grains in either particle although these have been characterized in CP particles by other workers (2).

We have only limited evidence via diffraction or imaging regarding the mineralogy of the very fine-grained matrix. Electron powder patterns indicate the presence of magnetite and enstatite in the matrix of W7028B3. (The presence of a number of other phases in the matrix of both particles is suggested by the EDS data that are discussed below.) High-resolution imaging of thin areas within the matrix show complex fringe patterns that are difficult to interpret and that reflect the extremely fine-grained, intricately intergrown nature of this material.

EDS Analyses. Qualitative EDS analyses were carried out on a number of single-crystal grains and on the matrix in both particles. The enstatites are either essentially pure $MgSiO_3$ or show minor amounts of Ca, Cr, Fe and Mn. Elements in the matrix of W7028B3 are Mg, Si, Al, S, Ni, Mn, and Fe. The presence of S indicates that the matrix probably contains iron sulfide, as is typical for most C-type particles. The identity of the Al-bearing phase in the matrix is not known, but may be melilite as has been suggested by Bradley and Brownlee (2). The matrix of W7029B1 is depleted in S and enriched in Fe

relative to that in W7029B1, and this may reflect heating effects on atmospheric entry.

Conclusions. Our observations of these particular chondritic particles are consistent with the pioneering descriptions of interplanetary dust made by Brownlee and coworkers (1,2) and Fraundorf (3). The fine-grained matrix that makes up the bulk of the particles is an enigma that we hope will yield with further application of some of the more advanced TEM techniques such as electron energy loss spectroscopy, CBED and microdiffraction in STEM. We plan to pursue these techniques in our ongoing study. However, contamination problems are particularly acute with regard to the analysis of the matrix, and it is possible that a "cleaner" method of collecting and preparing the particles will have to be developed before more can be learned about this portion of the particles via electron beam methods.

REFERENCES:

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