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THIN-SECTIONING AND MICROANALYSIS OF INDIVIDUAL EXTRATERRESTRIAL PARTICLES

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A longstanding constraint on the study of micrometeorites has centered on difficulties in preparing them for analysis. This is due largely to their small dimensions and consequent practical limitations on sample manipulation. Chondritic micrometeorites provide a good example; although much has been learned about their chemistry and mineralogy almost nothing was known about such basic properties as texture and petrographic associations. The only way to assess such properties is to examine microstructure indigenous to the particles. Unfortunately, almost all micrometeorites, out of necessity, have been crushed and dispersed onto appropriate substrates prior to analysis, and most information about texture and petrography was lost. Recently, thin-sections of individual extraterrestrial particles have been prepared using an ultramicrotome equipped with a diamond knife. This procedure has been applied to stratospheric micrometeorites and Solar Max impact debris. In both cases the sections have enabled observation of a variety of internal particle features, including textures, porosity, and petrographic associations.

Sectioning Procedure

Because of the small dimensions of a typical micrometeorite careful sample preparation and good quality light optics (stereobinocular) on the ultramicrotome are important. In addition, illumination of the specimen during sectioning may be facilitated using supplementary high-intensity lighting. Initially, a selected particle (usually 5-20 µm diameter) is mounted in a low viscosity epoxy (e.g. Embed-812), which upon curing forms a bullet-shaped mount 7-mm x 18-mm. The particle is embedded towards the tapered extremity of the mount, and in order to highlight its exact position several carbon fibers are arranged symmetrically about the particle. Then using glass knives the mount is trimmed until a "mesa" ($\sim$ 200 µm square) is fashioned around the embedded particle. At this point the particle should be located close to the center of the 200 µm square and be at least within a few microns of the surface on which sectioning is to take place. Then using a diamond knife, sections are cut from the working face, floated away from the diamond edge, and transferred onto TEM grids for analysis.

Whilst sections are being produced it is essential to position the illumination so that the floating sections exhibit maximum reflectivity to incident light. This is important for two reasons: firstly, incident light is reflected both off the surfaces of the flotation liquid (usually H_2O) and the upper surface of the floating sections. These light waves, moving out of phase, produce interference colors related to the thickness of the sections. It is therefore possible to monitor specimen thickness during sectioning. Secondly, it is important to observe the point at which the diamond knife intercepts the embedded particle. This is determined by examining each section as it is cut. When viewed through a stereobinocular, sections containing meteoritic material will be marked by the presence of a small black speck (the sectioned particle) surrounded by dark lines (the sectioned carbon fibers). These sections are then concentrated (using a single human eyelash mounted on a stick), and retrieved from the flotation liquid. (Details of ultramicrotomy technique are provided by Reid (1)).

Results

Chondritic micrometeorites - The most striking result of the thin-sectioning procedure is that it simplifies classification of this group of stratospheric particles. Until now classification has been based either on particle appearance or the presence of characteristic infrared transmission absorption bands. Observations of morphology and surface microstructures enable particle descriptions like CP (chondritic porous), CF (chondritic filled), CS (chondritic smooth) (2). The major drawback with this type of scheme is that not all micrometeorites fall clearly into a given category. Using infrared spectroscopy Sanford and Walker (3) find that most chondritic micrometeorites fall into one of two categories; those whose mineralogy is dominated by anhydrous silicates and those dominated by hydrated (layer lattice) silicates. Examination of thin-sections confirms the infrared results. There appears to be only two classes of chondritic micrometeorite, those that are hydrous and those that are not. Moreover, these classes of particles can be easily distinguished from one another in thin-section on the basis of texture alone. One is a highly porous aggregate of anhydrous mineral grains and carbonaceous material, while the other is a low porosity assemblage of hydrated silicates.

Solar Max Particles

Two particles were hand-picked from Solar Max impact substrates. These particles were chosen because their morphologies and chemical compositions suggested that they might be relatively unaltered particles. (Both particles exhibit chondritic elemental signatures, although their sulfur abundances seem to be depleted). However, thin-sections reveal that, despite outward appearances, both particles are structurally perturbed and chemically segregated. Additional Solar Max particles are being sectioned in order to determine whether any material has survived impact without melting.

REFERENCES

(1) N. Reid, Ultramicrotomy, in series Practical Methods in Microscopy, (Elsevier, New York, 1975) v 3.

(2) D.E. Brownlee, E. Olszewskii, M. Wheelock. Lunar Planet Sci. 13, 71 (1982); I.D.R. Mackinnon, D.S. McKay, S. Nace, A.M. Isaacs, J. Geophys. Res. 87, A413 (1982); K.M. Kordesh, I.D.R. MacKinnon, D.S. McKay, Lunar Planet, Sci. 14, 389 (1983).

(3) S.A. Sanford and R.M. Walker. Astrophys. J. 291, 838 (1985).