2.3.5 MAGELLAN COLLECTIONS OF LARGE COSMIC DUST PARTICLES

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Abstract

A new balloon collection technique, Magellan, for obtaining large cosmic dust particles $\geq 50\mu$ is described. The technique utilized a 40 m^2 aperture funnel suspended 300 m below a balloon at an altitude of 25 km. First results indicate that the collected particles are diverse both chemically and physically.

The Magellan collection system evolved from the earlier Sesame program for collecting cosmic dust. Although Sesame provided considerable data[1] concerning particles in the mass range 10^{-9} to 10^{-7} grams, the number of particles collected, being considerably less than anticipated, indicated the need for a system with a much larger area-time product to improve the signal to noise ratio and to extend the measurement to particles larger than 10^{-7} gram (i.e. $> 50\mu$ dia.). The Magellan system utilizes a funnel having a collection area of $40 m^2$, $\sim$2000 times greater than for Sesame, and when flown on an earth orbiting superpressure balloon, can collect a significant number of particles greater than 50μ. The Technique is described in detail in a paper by Wlochowicz et al[2]. The feasibility of such long duration experiments was demonstrated when a superpressure balloon launched in January 1973 from Australia "orbited" the earth several times before landing in the Pacific 210 days later. Unfortunately our collection experiment was not recovered. Since then two successful Magellan collection flights on zero-pressure balloons have been obtained with sampling times indicated in Table 1.

Magellan - 1 May 6, 1974

Sample Number	1	2	3
Collection Time (hours)	-	16	.67
Candidate Particles Collected	-	18	3

Magellan - 2 October 17, 1974

Sample Number	1	2	3
Collection Time (hours)	3	34	3
Candidate Particles Collected	6	126	3

Table 1

The quality of the data from Magellan primarily depends both on the ability of the collection funnel to shed contaminants and on the ability of particles falling into the funnel to reach the collecting surface. The performance was evaluated under several conditions. With the funnel deployed in a hanger, a sample of spherical particles and a sample of irregular particles was dropped into the funnel and in each case 70% of the particles $>$ 50μ was recovered. Humidity was found to affect the experimental collection efficiency; at 33% relative humidity, the smallest particle recovered was 20μ, at 45%, 40μ and at 70% 60μ. Under conditions simulating those at balloon altitude, tests on the funnel fabric indicated that particles greater than 40μ tumbled down the inclined test surface. On the basis of these tests and by considering only particles larger than 50μ for the analysis, it was expected that at altitude contaminants initially in the funnel would be shed while the funnel was open at the bottom and that subsequently, the majority of particles falling on the collection surface would be those falling into the collection funnel.

To test whether the system would shed particles as predicted from the laboratory tests, approximately 15mg of nickel microspheres were dusted into the closed funnel prior to launch of the second flight. An additional contamination test, to determine if the balloon was a source of contamination, involved dusting approximately 15mg of aluminum microspheres on the recovery parachute located just below the main balloon 300m above the experiment. Despite the precautions to avoid and shed contaminants it appears that a significant amount of sand-like material found its way into the funnel and subsequently into the collection boxes. These particles are very similar physically and chemically to soil particles taken from the launch area in Palestine, Texas. Apparently the time constant for the contaminants to clear the funnel was longer than anticipated. Further evidence for a long decay time for contamination comes from the fact that nickel microspheres were found in the first two collection boxes. Three were found in the first box exposed for 4 hours and 72 were found in the box exposed for 34 hours. No microspheres were found in the third box which provides some measure of time for the system to cleanse itself. None of the aluminum test spheres from the parachute were found in the collection boxes.

The possible contaminant material has the appearance of a clear glassy particle either rounded or angular in shape with varying amount of red-brown debris on the surface with silicon being the most abundant element found. Until each questionable particle can be removed from the plexiglas collection slide and examined in detail, all such particles have been, for the present, put aside. The remaining candidate particles must include many real cosmic dust particles and the numbers of candidate particles collected during each exposure are also shown in Table 1.

Figure 1 - 6 illustrates some of the particles considered to be collected cosmic dust particles. The micrographs shown were taken in a scanning electron microscope. Many of the following descriptions include optical observations.

Figures 1 and 2 show examples of particles which have most probably been heated, at least at the surface. Note the fine cracks in the surface of these particles which we believe resulted from the heating and subsequent cooling experienced when the particle entered the atmosphere. Only aluminum and chlorine were detected in the particle in Figure 1 while the particle in Figure 2 contains a significant fraction of iron with lesser amounts of calcium and chlorine plus traces of five other elements.

Several types of spherical particles have been found. Figure 3 shows a

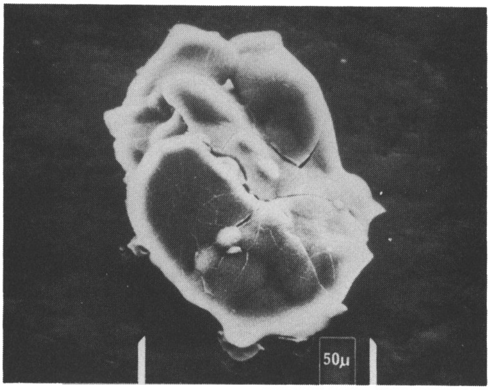

Figure 1
Particle with Heating Cracks

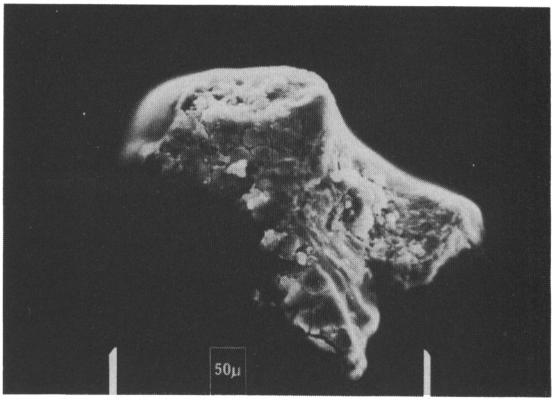

Figure 2
Particle with Heating Cracks

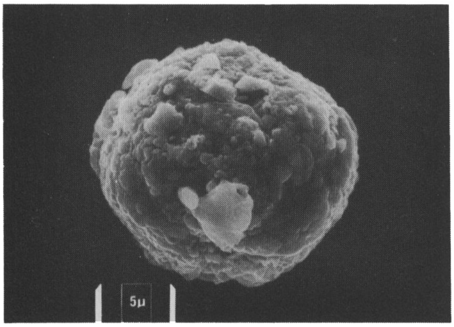

Figure 3
White Spherical Particle

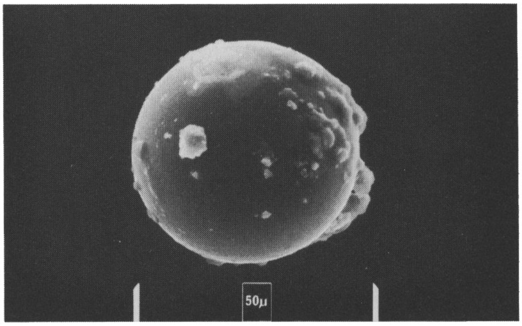

Figure 4
Hollow Glassy Sphere

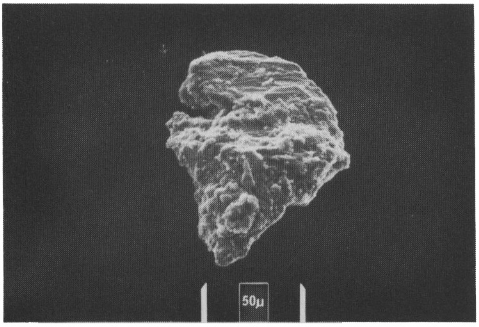

Figure 5
Iron Rich-Particle with Metallic Luster

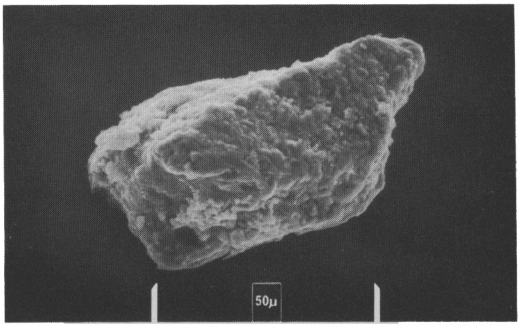

Figure 6
Iron-Rich Particle; Black in Color

particle which appears milky white with small dark inclusions at the surface. The composition of these particles varies widely from particle to particle with Ca, S, Fe, and Ti the major elements. The hollow spherical particle shown in Fig. 4 is water white and contains about equal portions of Na, Si, and Fe. Figures 5 and 6 show particles in which only iron was detected. That in Figure 5 is metallic in appearance whereas Figure 6 shows a black particle with a granular surface. From these few examples which do not represent all of the particle types it is clear that the collected particles are indeed diverse.

Figure 7 shows the S-149 impact crater flux measurement[3] and fluxes computed separately for all of the candidate particles, for the particles which show signs of ablation or heating, and for glassy spheres. From this curve it can be seen that the flux as measured by the Magellan ballon technique is in rough agreement with the flux from Skylab S-149.

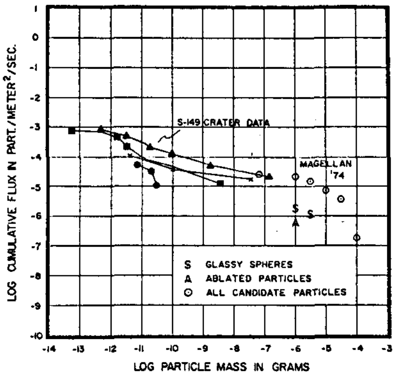

Figure 7
Flux Curve Comparing Magellan Result with S-149 Skylab Data

The candidate particles are greatly different from each other both in morphology and in chemical analysis. The observed morphology is interesting in that there are few particles which show signs of ablation. Micrometeorite theory[4] predicts that 100μ diameter particles or even particles as large as 1000μ can, under special conditions, enter the atmosphere unablated. Blanchard[5] in studies simulating ablation of olivine and magnetite showed that 5 and 20% respectively of the shock fractured fragments failed to show signs of ablation. It is reasonable to find some particles with no signs of melting but to find so few is surprising.

It would be expected that the chemical abundances would bear some resemblence to average abundances determined by other techniques, i.e. the major constituents would be magnesium, silicon and iron. This is not the case. Based only on semi-quantitative analysis aluminum, silicon, calcium and iron are the most abundant elements detected. Nickel has been detected in trace quantities in only two out of 67 candidate particles.

References

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