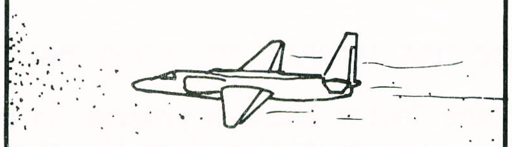
Cosmic Dust Courier



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Number 4 **January 1984**

COSMIC DUST COURIER NO. 4

Contents

	Page
Cosmic Dust Program: The First Two Years	2
Cosmic Dust Lab Survives Hurricane Alicia	2
Availability of Cosmic Dust Samples	4
Guidelines for Preparing a Sample Request	12
Large-Area Collectors: Progress and Plans for the Future	12
Sample Containers for Shipment of Allocated Dust Particles	14

COSMIC DUST PROGRAM: THE FIRST TWO YEARS

In 1981, NASA/Johnson Space Center began a program to collect large numbers of certified extraterrestrial dust particles from the stratosphere and to distribute those samples to research scientists for detailed analysis and interpretation. Previous work by Dr. Donald E. Brownlee and co-workers had already shown that, not only could interplanetary dust be identified among stratospheric samples, but that it apparently included primitive solar system material that was not represented among existing meteorite or lunar sample collections. The opportunities for progress in planetary science through the laboratory study of cosmic dust particles seemed bright, if only adequate numbers of the diverse particle population could be collected. The NASA/JSC Cosmic Dust Program has contributed to that progress by making available many more sample particles than could have otherwise been collected and documented in the same period of time.

This issue of the Cosmic Dust Courier summarizes the status of the Cosmic Dust Program through the end of calendar year 1983. During the first two years, more than 50 different collection surfaces were flown on three different high-altitude aircraft and sampled a total integrated stratospheric volume of more than five million cubic meters. From among those samples, nearly 200 extraterrestrial particles of 5-50-micrometer size have been retrieved and scientifically described and probably ten times that number remain on various collection surfaces. Twenty-eight formal requests for samples have been received and samples have been allocated to eleven different research groups. In addition, 24 other collectors sampled material from the stratospheric cloud generated by the 1982 eruption of El Chichón volcano and allowed us to allocate volcanic dust samples in response to requests from nine different research groups. Furthermore, development work is proceding for construction and deployment of large-area collectors that will substantially increase the rate of collection of "large" (> 50-micrometer size) particles and thereby further increase the variety of analyses that can be performed and the rate at which scientific progress can be made.

The first two years of the Cosmic Dust Program have been highly productive despite the stratospheric pollution created by the El Chichón volcanic explosion of 1982, the damage to our facilities caused by Hurricane Alicia in 1983, and the effects of budget cuts (both real and threatened) in both years. The following articles in this newsletter summarize our progress. We look forward to reporting further progress in the future.

COSMIC DUST LAB SURVIVES HURRICANE ALICIA

On August 18, 1983, the eye of Hurricane Alicia made landfall near Galveston, Texas and, proceding on a northerly course through Houston, passed a few miles west of the Johnson Space Center. Wind and rain damage at JSC was significant and included partial loss of the roof from Building 31 that houses, among other facilities, the cosmic dust laboratory. (Building 31A, which houses the lunar sample collection, sustained no damage). On the day prior to landfall, when it became apparent that the upper Gulf Coast was a prime target for Alicia, all cosmic dust samples were evacuated from the laboratory and moved into secure storage in Building 31A. In addition, critical laboratory equipment was shut down and sheathed in protective plastic covers, using procedures that are rehearsed each year at the beginning of hurricane season as part of normal curatorial work. On August 19, the cosmic dust curatorial team returned to JSC and began the task of assessing damage and (literally) mopping up. Leakage of water into the laboratory was minimal and did not affect the Class-100 tunnel. However, the the blower assembly that services the solvent flow bench in the tunnel was badly damaged during destruction of the roof. After roof and blower repairs and cleanliness recertification, the cosmic dust laboratory resumed normal operations on October 31, 1983.

AVAILABILITY OF COSMIC DUST SAMPLES

To date, particles from a total of four different flags have been examined in detail and cataloged. In addition, reconnaissance sampling of relatively large and interesting particles has been performed for several other flags. Descriptions of the cataloged particles were published as seven installments in the Cosmic Dust Catalog series as well as in Cosmic Dust Courier No. 2 of the current newsletter series. A large number of the cataloged particles, and a few pristine flags, have been allocated to interested research scientists for detailed study. As an aid to researchers planning future sample requests, the current availability of samples in inventory (both cataloged and uncataloged) is summarized in Table 1. The information in Table 1 is explained in the accompanying "Key to Table 1" and in the following discussion.

Prompt allocation of samples in response to approved sample requests serves the interests of the cosmic dust science community but also creates a minor problem in parallel efforts to publicize the current status of available samples. Unlike lunar and meteorite samples, cosmic dust samples, with the exception of relatively rare paticles greater than 20-30-micrometer size, cannot be split or subdivided for allocation to more than one sample requestor. Therefore, once an individual dust particle has been approved for allocation to a given investigator, it immediately becomes unavailable for allocation to other investigators. Prior to this newsletter, the availability of individual particles was published in Cosmic Dust Courier No. 3 (February, 1983) and updated with a cover sheet attached to Cosmic Dust Catalog, Vol. 4/No. 2 (September, 1983). In this newsletter, the current allocation status of each sample in inventory is summarized in Table 1, following the format established in Courier 3.

The key to Table 1 is mostly self-explanatory. For complete clarity, though, the following additional explanations are offered for each column of the table:

Line Number

The first and last columns of the table are simply reference numbers that identify the respective lines in the table. Those numbers are included as an aid in reading individual lines in the table.

Sample Number

The generic designation of each dust particle begins with the number of the collection surface on which it was collected. Because only collection "flags" (small-area collectors) are currently being flown, the "Sample Number" entry refers to the flag number. Flags flown on the WB57F aircraft are numbered "W7iii," and those flown on U-2 aircraft are numbered "U2iii," where "...iii" is a three-digit (integer) number.

Flag Status

This column indicates the type of work that has been performed on the flag in question. The "p" notation indicates that particles have been picked from the flag in the NASA/JSC Cosmic Dust Laboratory whereas the "r" notation indicates that the flag has been "reserved" (set aside to assure that representative sample material will be available for future scientific studies). An entry of "I..." indicates that the entire flag has been allocated to a cosmic dust investigator (see "Key to Table 1" for identification). A blank entry in the "Flag Status" column indicates that no sample processing has yet occurred for that flag.

Mount Status

For flags from which particles have been picked, the "Mount Status" column identifies the sample mounts that have been created during the picking operation. The current procedure for picking and preliminary examination of particles utilizes a scanning electron microscopy (SEM) mount with 16 uniquely defined particle storage locations. The mounts that receive particles from a given flag are designated "A, B, C,..., etc." in the order that they are filled with particles. A blank entry in the "Mount Status" column indicates that no particle mounts have yet been created for the flag in question.

Particle Status

This group of 16 columns summarizes the status of each of the 16 particles that comprise the normal sample load of the SEM mount identified under the "Mount Status" column on the same line. An entry of "I..." indicates that the particle has been allocated to a sample investigator (see "Key to Table 1" for identification). An entry of "n" indicates that the particle was lost during handling whereas an entry of "u" indicates that no particle has yet been assigned the sample number in question. If the "Mount Status" column indicates that a particle mount has been created, a blank entry under one of the "Particle Status" columns on the same line indicates that the particle in question exists and is available for allocation. If more than 16 particles were documented on the mount, status of each of the extra particles is given in the "Comments" column (see below) using the same notation just described.

Comments

This column provides additional information that is needed to supplement or clarify entries made elsewhere in the table. Types of information listed under "Comments" include identification of flags that contain abundant terrestrial contamination (e.g., volcanic material), allocation status of particles existing on individual sample mounts but numbered outside the normal 1-16 series, and cross-references to samples that have been renumbered.

If the "Comments" column indicates that a flag is significantly contaminated (entry of "Ground contam.", "Volcanic ash", etc.), other areas on that line in the table will commonly contain descriptive information that does not follow the normal column-by-column definitions given above. In that case, the information given reflects the fact that, because of fundamental differences between "contamination" and "cosmic" material, processing and sample allocations of the "contamination" followed a different course than is normally followed for "cosmic" samples. "Volcanic" contaminants, as listed in Table 1, are attributable almost exclusively to the March/April 1982 eruption of El Chichon volcano (see Courier 3) whereas "ground" contaminants accrue from instances in which flight crew errors lead to exposure of flags at undesirably low (tropospheric) altitudes. Although "cosmic" particles may occur on some of the contaminated flags, their selection from among abundant contaminant particles would be extremely time-consuming.

Allocation status information found in the "Comments" column follows the same format described above for the "Particle Status" column, except that the allocation status code is separated from the particle number by a "/" symbol. For example, the entry of "Also 17/I7; 18-19" under "Comments" on line 203 in the table indicates that, in addition to the normal complement of 16 particles on sample mount U2001D, particles 17-19 were also deposited but that particle U2001D17 has been allocated to investigator I7.

Cross-references to other sample numbers occur under "Comments" in those cases where sample renumbering has occurred. Normally, sample renumbering is avoided but does occur in each case where preliminary examination of a small fragment of a large (usually, > 20-micrometer size) particle indicates that the large particle is probably of extraterrestrial ("cosmic") origin. Then, the number assigned to the preliminary examination fragment will be replaced by a new number indicating that the fragment was the first split of a large cosmic particle. For example, preliminary examination of a large particle on flag W7029 indicated that the particle was cosmic, leading to the naming of the particle as W7029*A. Therefore, as shown on line 53 of the table, the preliminary examination fragment that was originally named W7029C1 was renamed as W7029*A1. By referring to the status information for W7029*A, given on line 62 of the table, it is clear that W7029*A1 was allocated to investigator I1 and that additional fragments of the particle were allocated to several other investigators.

TABLE 1

NASA/JSC COSMIC DUST PROGRAM: SAMPLE AVAILABILITY SUMMARY

Effective Date: January 16, 1984

	SAMPLE NUMBER	FLAG STATUS	MOUNT STATUS	PARTICLE STATUS 01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	COMMENTS	
1	W7001																			Ground contam.	1
2	W7002																			Ground contam.	2
3	W7003																			Ground contam.	3
4	W7004																			Ground contam.	4
5	W7005																			Ground contam.	5
6	W7006																			Ground contam.	6
7	W7007																			Ground contam.	7
8	W7008																			Ground contam.	8
9	W7009																				9
10	W7010	p	A	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	Also 17-32/I1	10
11			B	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	Also 17-39/I1	11
12	W7011	r																			12
13	W7012	I2																			13
14	W7013																				14
15	W7014																				15
16	W7015																				16
17	W7016	r																			17
18	W7017	p; I1	A	n	I1	I1	I1	I1	I1	I1	I1	I1	n	I1	I1	I1	I1	n	I1	Also 17/n, 18/I1	18
19			B	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	n	I1		19
20			C		I1			I1			n			n		n	n	n		Also 17	20
21			D	n		I6	n					n	n				n	n	n		21
22			E	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	I1	Also 17-19/I1	22
23			F			I4	I1		n				n	I6				I4	I1		23
24			G	I1		I1	I5		I1		I1		I1	n	I5	I1	I1	I3			24
25			H	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	Storage only	25
26			I	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u	Storage only	26
27	W7018	I3																			27
28	W7019																				28
29	W7020	r																			29
30	W7021	I3																			30
31	W7022																				31
32	W7023	r																			32
33	W7024																				33
34	W7025	r																			34
35	W7026	p	A	I4			u	u	u	u	u	u	u	u	u	u	u	u	u	1 = W7026*A1	35
36	W7026*A			I4	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u		36
37	W7027	(I2); p	A			c	I11	n				n	n	I2		I11		I11		Also 17; 18/n	37
38			B								I9		n	n	n				n		38
39			C	n			I2		n	I9											39

-----Continued-----

	SAMPLE NUMBER	FLAG STATUS	MOUNT STATUS	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	COMMENTS	
40	W7027		D				n						n							Also 17-18	40
41			E												n					Also 17/I2	41
42			F																	Also 17	42
43			G																	Also 17-27	43
44			H	u																Also 17-19	44
45			I															u	u		45
46	W7028	p	A				I4										u	u	u	4 = W7028*C1	46
47			B	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	I4x	Also 17/I4x	47
48	W7028*C			I4	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u		48
49	W7029	p	A						I6	I1			I4							Also 17-19	49
50			B	I4	I4		I1					I1		n			I6			Also 17/I6;	50
51																				13 = W7029*B1	51
52			C	I1	n	I1	n	n	n	I1	I1	I1	n	n	I1	I1	I1	I1	I1	Also 17/n;	52
53																				1 = W7029*A1	53
54			D														I1				54
55			E			I1								I1		I4	I11			Also 17-20/n	55
56			F	n			I4					n		n	n	I7	n	n	n	Also 17/I1	56
57			G		I7	I1						I1	I4	I1			I7	I4			57
58			H							I4	I4	I1	I1	I1		I7	n	I1	n		58
59			I	I1							I1					n	I7			Also 17-20;18/I11	59
60			J	n					n	n		n								Also 17/n, 19/I1,	60
61																				18, 20	61
62	W7029*A			I1	I8						I3				n	I3		I2	I3	Also 17/I8,	62
63																				22-26/I1	63
64	W7029*B				I3	I6	I1	I1	I1	I1											64
65	W7030	r																			65
66	W7031	(I2), p	A					I4										n	n	1 = W7031*A1,	66
67																				2 = W7031*B1,	67
68																				5 = W7031*C1	68
69																				9 = W7031*D1	69
70	W7031*A				I1	u	u	u	u	u	u	u	u	u	u	u	u	u	u		70
71	W7031*B				u	u	u	u	u	u	u	u	u	u	u	u	u	u	u		71
72	W7031*C			I4	u	u	u	u	u	u	u	u	u	u	u	u	u	u	u		72
73	W7031*D				u	u	u	u	u	u	u	u	u	u	u	u	u	u	u		73
74	W7032	p	A								u	u	u	u	u	u	u	u	u		74
75	W7033	Rinsed onto Nucleopore filter membrane																		Volcanic ash	75
76	W7034	Rinsed onto Nucleopore filter membrane																		Volcanic ash	76
77	W7035	r																		Volcanic ash	77
78	W7036	p	A	Contingency sample "scoops"																Volcanic ash	78
79			B	Contingency sample "scoops"																	79
80			C-K	"Scoops" onto electron microscopy substrates / I5																	80
81	W7037	Rinsed onto Nucleopore filter membrane / I10																		Volcanic ash	81
82	W7038	Rinsed onto Nucleopore filter membrane																		Volcanic ash	82
83	W7039	Rinsed into Freon-113																		Volcanic ash	83
84	W7040	r																		Volcanic ash	84
85	W7041	Rinsed into Freon-113																		Volcanic ash	85

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	SAMPLE NUMBER	FLAG STATUS	MOUNT STATUS	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	COMMENTS	
86	W7042	Rinsed into Freon-113																		Volcanic ash	86
87	W7043	Rinsed into Freon-113																		Volcanic ash	87
88	W7044	Rinsed into Freon-113																		Volcanic ash	88
89	W7045	Rinsed into Freon-113																		Volcanic ash	89
90	W7046	Rinsed into Freon-113																		Volcanic ash	90
91	W7047	Rinsed into Freon-113																		Volcanic ash	91
92	W7048	r																		Deployment failed	92
93	W7049	Rinsed into Freon-113																		Volcanic ash	93
94	W7050	Rinsed into Freon-113																		Volcanic ash	94
95	W7051	r																		Volcanic ash	95
96	W7052	Rinsed into Freon-113																		Volcanic ash	96
97	W7053	r																		Volcanic ash	97
98	W7054	Rinsed into Freon-113																		Volcanic ash	98
99	W7055	Rinsed into Freon-113																		Volcanic ash	99
100	W7056	r																		Volcanic ash	100
101	W7057	r																		Broken flag	101
102	W7058	p	A-B	Droplets mounted on electron microscopy substrates / I5																Volcanic aerosol	102
103	W7059																			Volcanic aerosol	103
104	W7060																			Volcanic aerosol	104
105	W7061																			Volcanic aerosol	105
106	W7062																			Volcanic aerosol	106
107	W7063																			Volcanic aerosol	107
108	W7064																			Volcanic aerosol	108
109	W7065																			Volcanic aerosol	109
110	W7066																				110
111	W7067	r																			111
112	W7068																				112
113	W7069																				113
114	W7070	r																			114
115	W7071																				115
116	W7072																				116
117	W7073																				117
118	W7074																				118

-----Continued-----

	SAMPLE NUMBER	FLAG STATUS	MOUNT STATUS	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	COMMENTS	
200	U2001	p	A			I7		I11			I11	I1	I11	n						Also 17/n; 18-20	200
201			B	I4	n	I1	n	n			I7	I1	I11	n				I1		Also 17/I4	201
202			C				I11					n	I1					I4	I1	Also 17	202
203			D				I1							I4						Also 17/I7; 18-19	203
204			E		I1	I4		I4			I7								I1	Also 17-20	204
205	U2002	r																			205
206	U2003																			Volcanic ash	206
207	U2004	r																		Volcanic ash	207
208	U2005																			Ground contam.	208
209	U2006																			Ground contam.	209
210	U2007																			Volcanic ash	210
211	U2008	r																		Volcanic ash	211
212	U2009																			Ground contam.	212
213	U2010																			Ground contam.	213
214	U2011																				214
215	U2012	r																			215
216	U2013																				216
217	U2014																				217
218	U2015																				218
219	U2016																			Ground contam. ?	219

KEY TO TABLE 1

A, B, C, . . . , etc.	=	particle SEM mount designation used in preliminary examination or storage.
I . . .	=	sample allocated to Investigator "I . . ." (see separate listing, below).
I . . . x	=	sample allocated to Investigator "I . . ." but without preliminary SEM examination (i.e., no catalog-type data were published).
(I . . .)	=	sample now at NASA/JSC but previously allocated to Investigator "I . . .".
c	=	particle tentatively identified as a laboratory contaminant.
n	=	sample not available as a result of loss during handling or preliminary examination.
p	=	particles "picked" (i.e., retrieved from collection surface to yield samples as listed.
r	=	reserved for posterity.
u	=	unassigned sample number (i.e., no sample having this number exists in inventory).

Investigators:

I1: D. S. McKay (NASA/Johnson Space Center, Houston, TX, USA)

I2: D. E. Brownlee (Univ. of Washington, Seattle, WA, USA)

I3: R. M. Walker (Washington Univ., St. Louis, MO, USA)

I4: P. R. Buseck (Arizona State Univ., Tempe, AZ, USA)

I5: M. Maurette (Laboratoire Rene Bernas, Orsay, France)

I6: G. L. Nord, Jr. (U. S. Geological Survey, Reston, VA, USA)

I7: R. H. Hewins (Rutgers Univ., New Brunswick, NJ, USA)

I8: J. C. Laul (Battelle Pacific Northwest Labs, Richland, WA, USA)

I9: E. K. Gibson, Jr. (NASA/Johnson Space Center, Houston, TX, USA)

I10: W. H. Zoller (Univ. of Maryland, College Park, MD, USA)

I11: T. Esat (Australian National Univ., Canberra, Australia)

GUIDELINES FOR PREPARING A SAMPLE REQUEST

All sample requests should be made in writing to:

Curator/Cosmic Dust
Code SN2/Planetary Materials Branch
NASA/Johnson Space Center
Houston, TX 77058 USA.

Information may be obtained by telephone via (713) 483-6241 or -3274 [FTS 525-6241 or -3274].

Each request should refer to specific samples by their official identification numbers and should contain enough information to permit evaluation of the proposed study and the adequacy of the requestor's facilities. All necessary information should probably be condensable into a one- or two-page letter, although informative attachments (e.g., copies of pages from related proposals, reprints of publications, flow diagrams for analyses) are welcome. In addition, a brief statement regarding the desired method of mounting or containerizing the samples for shipment to the requestor should be included (see article on "Sample Containers for Shipment of Allocated Dust Particles," this newsletter). Each sample request will be reviewed by the Lunar and Planetary Sample Team (LAPST), a committee of scientists that advises NASA on matters related to the curation and allocation of lunar samples and cosmic dust samples. LAPST meetings occur at intervals of approximately three months. The NASA/JSC Planetary Materials Branch will arrange for all required LAPST reviews and will inform requestors of results as rapidly as possible.

Prospective sample requestors may select samples from among those described in any issue of the Cosmic Dust Catalog or Cosmic Dust Courier series. However, reference should be made to Table 1 of this newsletter to check the availability of each sample before it is requested. In addition, we encourage investigators to contact us in advance of submitting their sample requests if further information is desired.

LARGE-AREA COLLECTORS: PROGRESS AND PLANS FOR THE FUTURE

Current design of the Large-Area Collector (LAC) was reviewed at a meeting convened by U. Clanton (NASA/JSC) at the Lunar and Planetary Institute on December 9, 1983. Attendees included J. Arveson (NASA/ARC) and W. Ferguson (Lockheed/Burbank, CA), representing the U2/ER-2 aircraft group at NASA/Ames Research Center, K. Jones of the JSC team that designed the LAC, and with D. Blanchard and J. Gooding as additional representatives of the NASA/JSC Cosmic Dust Program. The cosmic dust science community was represented by R. Walker (Washington University, St. Louis), D. Brownlee (University of Washington, Seattle), D. McKay and F. Horz (NASA/JSC).

Brownlee, Walker, McKay, and Horz summarized the scientific rationale for flying LAC's and emphasized that the LAC's should increase the collection rate of large (> 50 micrometer) particles and, thereby, facilitate the entry of many new investigators into cosmic dust sample science and the performance of new types of analyses that are currently not possible, for lack of suitably large samples.

Ferguson stated that the JSC prototype LAC was acceptable to Lockheed and that Lockheed was willing to build and fly the current configuration of the aircraft pylon that was needed to contain the LAC. In addition, he suggested that Lockheed would slightly modify the current pylon design in order to further improve its aerodynamic performance and to further reduce the prospects for pylon-related contamination of collection surfaces.

Arveson reported that U2 flight tests were being made in order to simulate the drag and vibration effects that are expected to affect the aircraft during LAC flights. Results of those simulation tests, especially as they apply to aircraft performance and possible degradation of imagery produced by other airborne experiments, will effectively determine the types of missions on which LAC deployment will be acceptable.

In summary, the group agreed that the LAC had reached an acceptable design from both scientific and engineering points of view and that only operational constraints remain to be finalized. All parties were positive about building and flying the LAC's and the scientists were eager to study the samples that will be collected.

SAMPLE CONTAINERS FOR SHIPMENT OF ALLOCATED DUST PARTICLES

1. Introduction

Two basic types of "containers" are available for holding sample particles during transfer from the curatorial laboratory to various research laboratories. The first type (described in Section 3) is designed to act both as a storage device and as a mounting device for electron microscopic investigations but can also serve some other types of analyses. The second type (described in Section 4) is simply a containment device used to hold a particle until the researcher can transfer the sample to a storage or mounting device that is appropriate for his research. To expedite sample allocations, each requestor is encouraged to accept allocated particles in one of the two basic formats described below and to perform other necessary transfer or re-mounting of particles in his laboratory. However, under special circumstances, the curatorial staff may be able to modify existing devices or utilize devices provided by the sample requestor in order to complete the allocation (see Section 5).

In all cases, sample mounts sent to researchers are accompanied by photographs and sketch maps that document the location and appearance of each sample particle on each mount.

2. Use of Silicone Oil and Epoxide Resins

High-viscosity silicone oil (Dow-Corning Series-200, kinematic viscosity of 500,000 centistokes) is used to coat stratospheric dust collectors and also as a transfer medium during the laboratory processing of individual sample particles. On the inertial impaction collectors, the oil acts as a chemically inert trap for particles that would otherwise bounce off the collection surfaces during sampling. As a transfer medium, the oil ensures positive adherence of the sample particle to the transfer probe (usually a fine-tipped glass needle) and mounting surfaces and, thereby, greatly reduces the chance of particle loss (a major concern during "dry" transfers).

Before it is used, the silicone oil is thinned with ultrapure Freon-113 and filtered through a Nucleopore polycarbonate membrane of 0.4-micrometer pore size in order to remove particulate impurities. Upon evaporation of the Freon, the silicone oil returns to its normal, viscous state.

Although it is a convenient collection and transfer medium, the silicone oil also presents a possible source of contamination. Consequently, considerable effort should be made to rinse all silicone oil from each sample particle before it is analyzed. For particles shipped in droplets of silicone oil (see Section 4), washing must be performed by the researcher in his laboratory. Particles shipped "dry" (see Section 3) are washed in the curatorial laboratory before shipment. Silicone oil is soluble in various liquids although hexane is the solvent preferred in the curatorial laboratory. Details of hexane-washing procedures can be obtained by contacting the curatorial staff (see Section 6.).

Epoxide resins that are particularly resistant to attack by hexane (Vac-Seal epoxy, Perkin-Elmer Ultek part number 288-6000) are used to bond selected particle-holding substrates to some container devices (see Section 3). In each case, epoxy is used sparingly and its contact with the actual particle-holding surfaces is carefully avoided.

3. SEM- and STEM-Style Containers

3.1. General

All three varieties of mount under this category are designed specifically to fit the sample holder of a JEOL-100CX Scanning Transmission Electron Microscope. However, given suitable adapters and sample-chamber geometries, the same mounts can also be used in other types of electron microscopes. Each mount is constructed of sintered, high-purity graphite. The basic block (SEM-1) is machined to produce two other varieties (SEM-2, STEM-1) of the mount (Fig. 1). For shipping, each mount is individually housed in a screw-cap-style glass vial (Fig. 2) that is doubly wrapped in heat-sealed nylon bags.

Regardless of the variety of mount used, once the mount is rinsed free of silicone oil the sample particle adheres to the substrate only through electrostatic attraction or related contact forces that are peculiar to small particles. It is important to bear in mind that those forces can be broken by strong jolts (for example, by dropping the mount) with resultant movement or loss of the sample particle. Although small (< 20 micrometer), irregular particles can be expected to survive long-distance mail transfers on "dry" mounts, large (> 20 micrometer) irregular or spherical particles (any size) are at greater risk of loss from "dry" mounts. High-risk particles are more safely transferred in oil-droplet containers (see Section 4).

3.2. SEM-1

SEM-1 is a solid block and contains no holes or cavities. Because the mount surface is black and rough at the microscopic scale (relief on the order of > 10 micrometers), sample particles placed directly on the graphite would be difficult to relocate and analyze. Consequently, SEM-1 is most usefully employed as a support for smoother, more highly reflective, or more fragile substrates (metal foils, synthetic films, etc.) that better facilitate particle analyses which do not require transmission of radiation through the sample. The desired substrates are attached to SEM-1 by epoxy bonding.

3.3. SEM-2

SEM-2 contains a rectangular hole (with vertical walls and rounded inner corners) that penetrates the block, thereby permitting transmission of light or other radiation through the block's middle zone. For curatorial use (including preliminary examination of particles by scanning electron microscopy), the rectangular hole is covered on the top surface of the block by attaching (epoxy bonding) a 10-micrometer-thick polycarbonate filter membrane (Nucleopore, 0.4-micrometer pore size). The attached filter membrane then receives, by two successive steps of vacuum evaporation, a coat of carbon that is overlain by a grid pattern of aluminum (Fig. 3). The carbon film provides electrical conductivity for electron-beam analyses whereas the aluminum grid pattern provides a reference system for uniquely locating several individual particles on the same mount. The porous membrane substrate facilitates the hexane-rinsing steps that are needed to remove silicone oil from sample particles.

3.4. STEM-1

STEM-1 contains two conical holes that meet near the middle thickness of the block to form a narrow platform that is designed to support a circular grid of the type used in transmission electron microscopy. The two types of grids most commonly used in the curatorial laboratory possess either a standard rectilinear mesh (TEM-A) or a single, oval-shaped hole (TEM-B) (Fig. 1). To act as effective holders of cosmic dust particles, TEM-A grids must be covered by a thin substrate with a characteristic pore size that is smaller than the sample particle size; most commonly, the substrate of choice is a holey film of carbon. The curatorial laboratory does not possess the time or resources to produce holey carbon films on TEM grids. To the extent that they are useful, bare copper grids can be provided in either the TEM-A or TEM-B style. However, researchers requiring special grids (gold, beryllium, graphite, etc., or coated with holey carbon films) are expected to furnish those grids.

Normally, a sample particle is placed either on a wide, flat area of a TEM-B grid or over a hole in a TEM-A grid that has been provided (by the sample requestor) with a holey film of carbon across the gridwork. After receipt of the sample particle, the grid can then be containerized and shipped in either of two formats. A grid can be placed loose in the polyhedral cavity of a covered plastic tray or, alternatively, permanently anchored within the circular cavity of the STEM-1 mount. In the tray container, the grid stands on edge along a diagonal (dimension slightly larger than "d" of TEM-A, Fig. 1) of the cavity so that the particle-bearing surface of the grid does not contact the walls of the cavity. Upon receipt of the tray container, the researcher can use fine-tipped tweezers to remove the grid from the cavity for transfer to a different mount surface. In the STEM-1 mount, the grid is firmly fixed (by bonding with tiny droplets of epoxy) to the circular platform and, for all practical purposes, must be used by the researcher in that format.

At the request of the researcher, sample particles allocated on TEM-style grids can either be left in silicone oil (remaining from the transfer process) or washed with hexane prior to shipment.

4. Glass-Slide Droplet Container (GSD-1)

GSD-1 isolates the sample particle in the bottom of a pre-formed circular cavity of a 1 x 3-inch (~ 25 x 76-mm) rectangular glass slide (Fig. 4). The particle is contained within a droplet of silicone oil that also serves to anchor the sample to the concavity of the glass slide. A flat glass slide is attached (with Teflon tape) to the top of the concavity slide to seal out contaminants. In addition, the glass-slide "sandwich" is doubly wrapped in heat-sealed nylon bags. After shipping, the two glass slides can be readily separated and the particle can be retrieved from the concavity slide by means of a fine-tipped needle. GSD-1 is the simplest and safest container available for shipping individual particles to researchers who are independently equipped to manipulate small particles.

5. Special Containers and Procedures

The curatorial laboratory is designed to process, catalog, and allocate particles for scientific research, rather than to directly perform such research. Accordingly, each sample requestor is encouraged to accept allocated samples in one of our standard formats and to perform subsequent transfer work and sample preparation in his own laboratory. In the interest of advancing science, though, the curatorial staff is receptive to requests for allocation of particles in formats different from those described above, particularly in support of the initial allocation to a newly approved sample requestor. Any sample requestor who anticipates the need for special handling of his allocated particles should communicate those needs to the curatorial staff at the earliest possible opportunity, preferably as part of each new sample request.

6. Sample-Handling Information and Training

Sample containers can be adequately handled, and particles transferred and remounted, on a laminar-flow clean bench in the investigator's laboratory. Tools required for handling samples are either available commercially or can be fabricated, at reasonable cost, in a machine or instrument shop. It is not necessary for sample requestors to duplicate the curatorial facilities or methods in order to receive and study the samples.

Given sufficient notice, the curatorial laboratory can provide tours of facilities and brief introductions to sample-handling techniques. However, the normally heavy work load in the laboratory requires that all requests for such visits be made well in advance of the dates requested.

For further information, please contact:

Curator/Cosmic Dust
Code SN2/Planetary Materials Branch
NASA/Johnson Space Center
Houston, TX 77058 USA

Telephone: (713) 483-6241 or -3274.

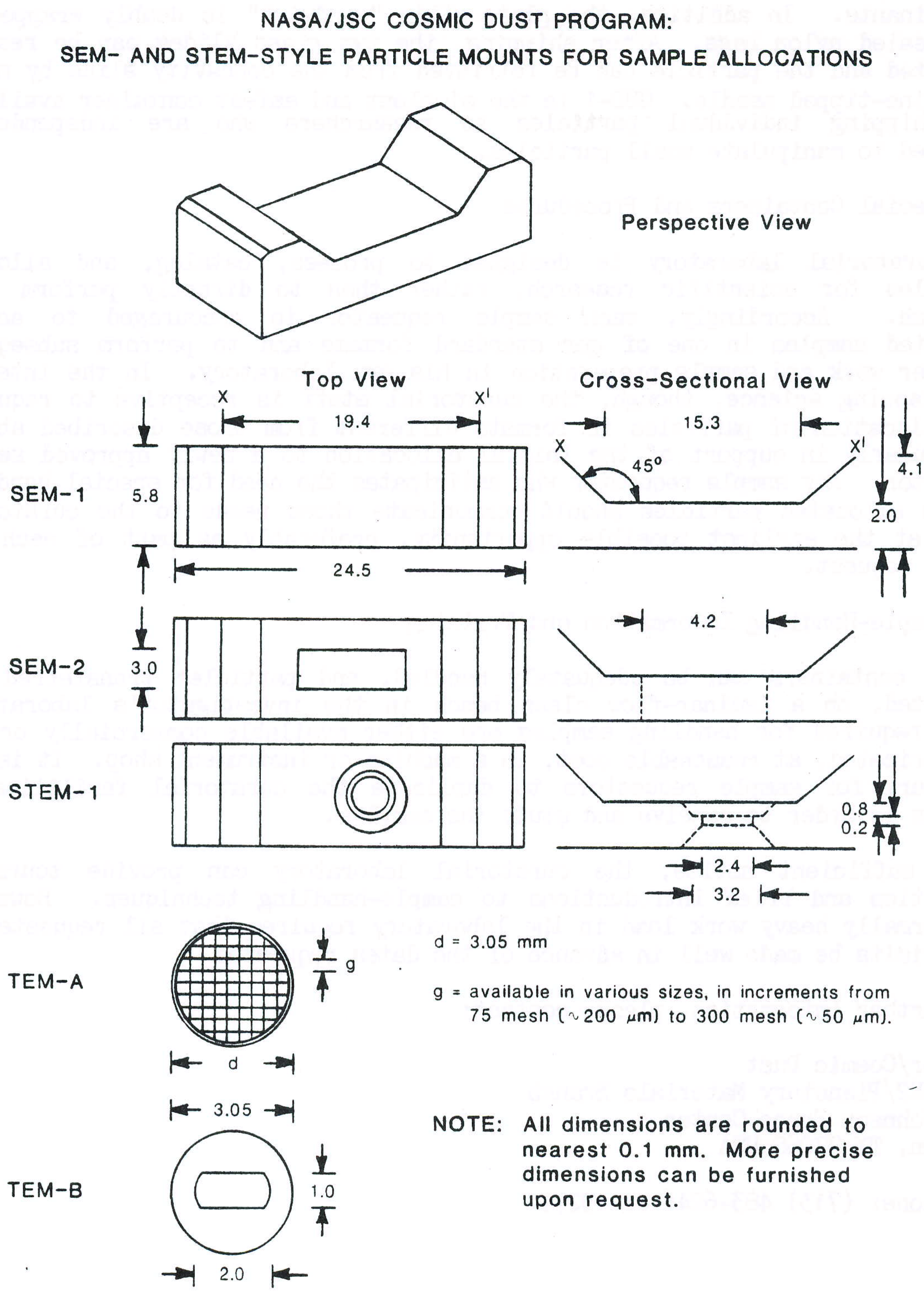

Figure 1. Sketches of SEM- and STEM-style particle mounts used for cosmic dust sample allocations.

NASA/JSC COSMIC DUST PROGRAM:

SHIPPING CONTAINER FOR

SEM- AND STEM-STYLE PARTICLE MOUNTS

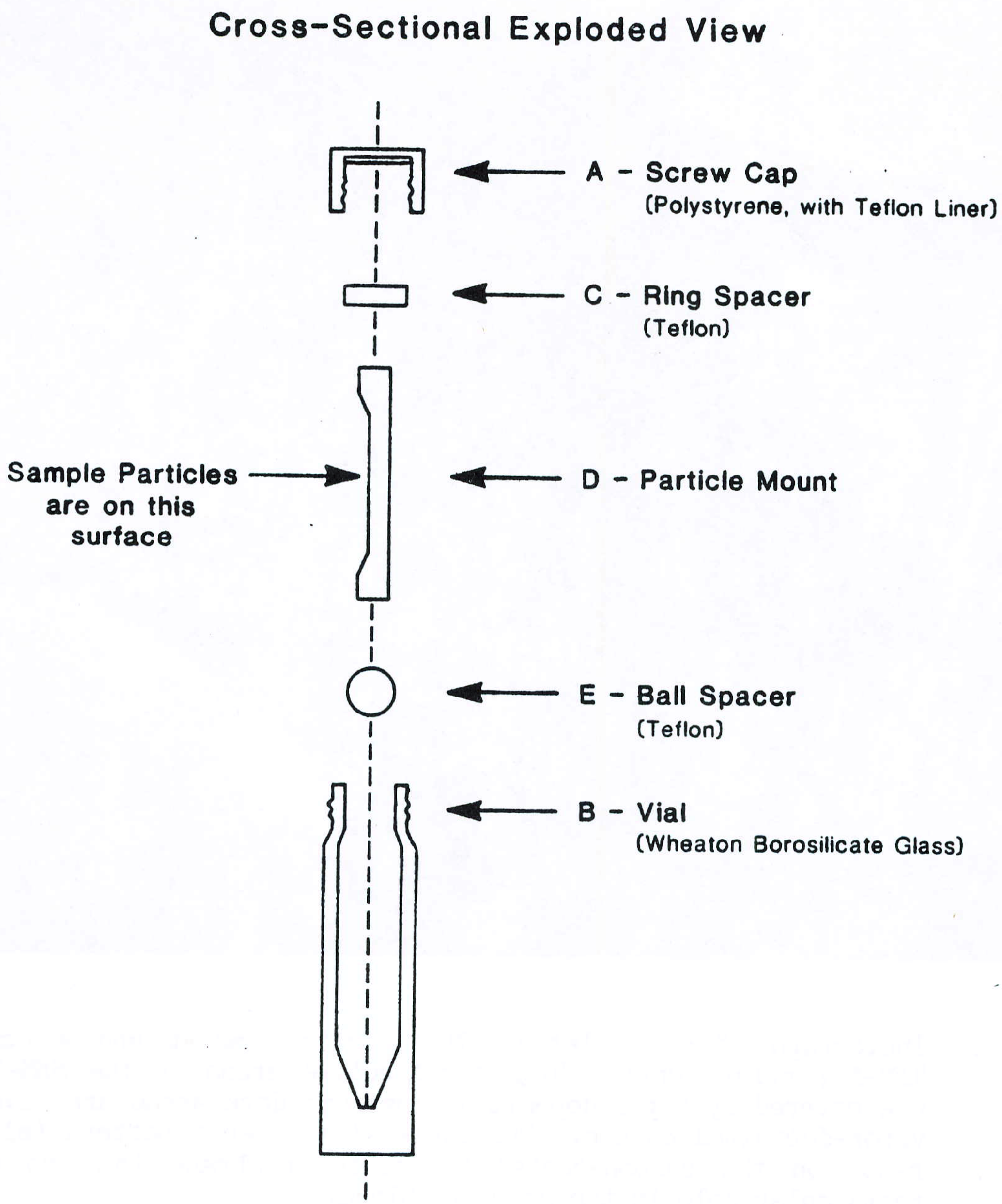

Figure 2. Sketch of glass-vial shipping container for SEM- and STEM-style particle mounts.

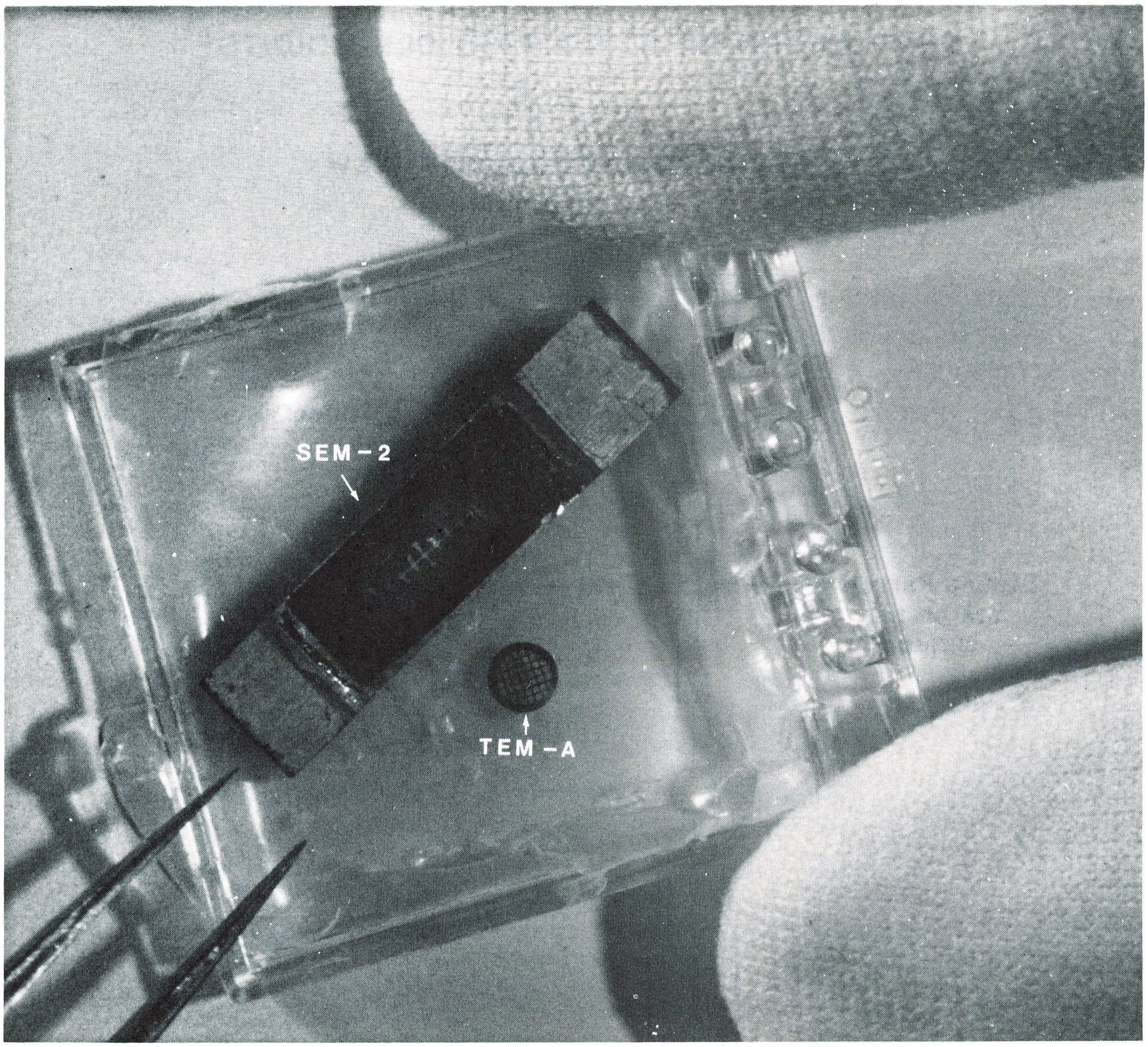

Figure 3. Photograph of a completed SEM-2 particle mount and a completed TEM-A particle grid. Highly reflective areas on the SEM-2 mount are covered by vapor-deposited aluminum; dark areas are covered by vapor-deposited carbon. The skeletal reference pattern (aluminum) rests on the carbon-coated Nucleopore membrane that covers the rectangular hole in the graphite block.

NASA/JSC COSMIC DUST PROGRAM:

GLASS-SLIDE CONTAINER FOR OIL-DROP SHIPMENT OF PARTICLE

NOTE: Oil drop containing the sample particle is located on surface A in the area overlying circle C.

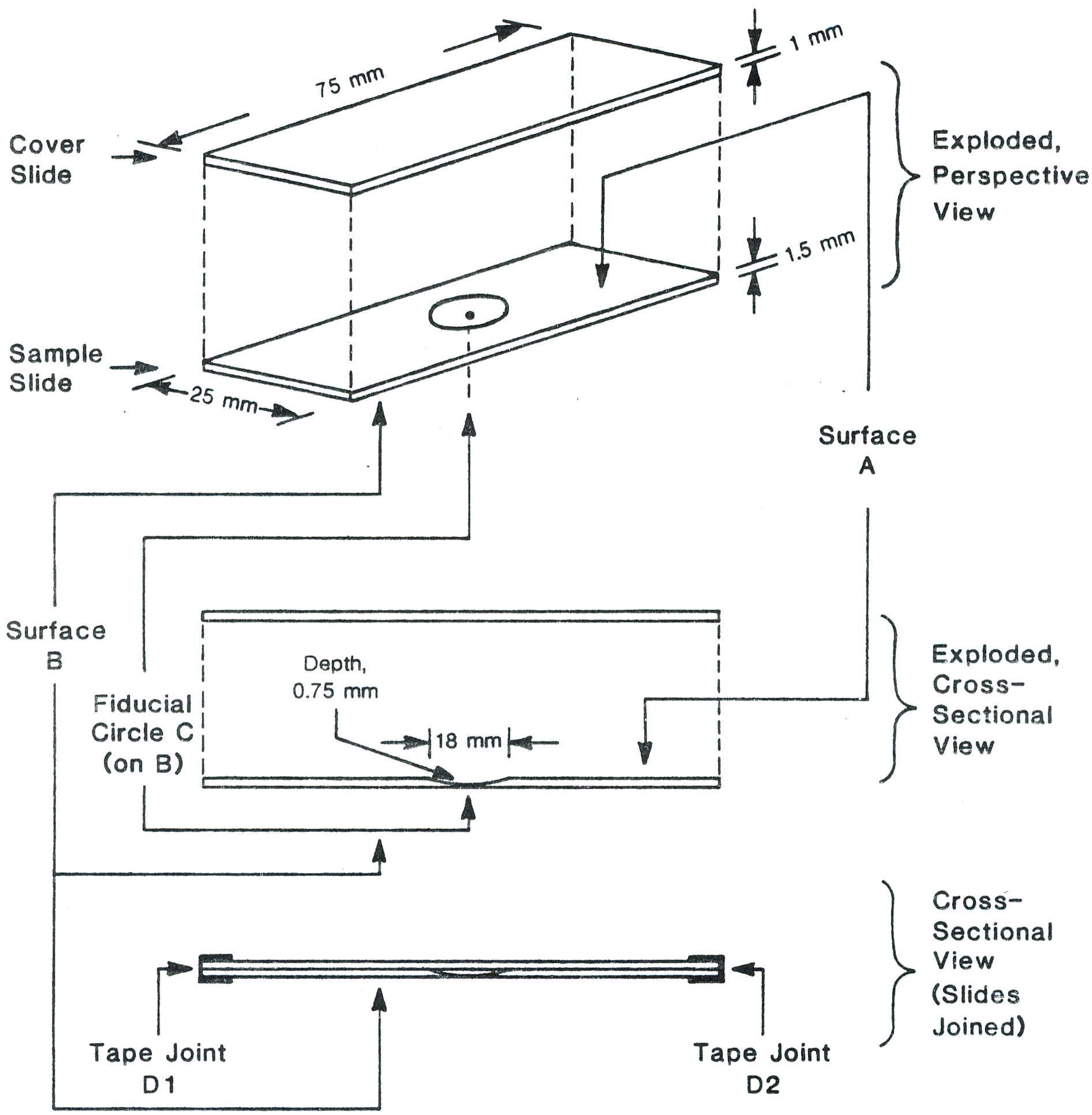

Figure 4. Sketch of glass-slide container GSD-1 used to containerize a cosmic dust particle in a droplet of silicone oil.

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