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COSMIC DUST CATALOG

(PARTICLES FROM COLLECTION FLAG W7017)

COMPILED BY

COSMIC DUST PRELIMINARY EXAMINATION TEAM (CDPET)

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COSMIC DUST CATALOG #1

(Particles from Collection Flag W7017)

Compiled By

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PREFACE TO CATALOG #1

This compilation represents the first presentation of sample information resulting from the NASA/JSC Cosmic Dust Program. It is provided in a form that will permit each user to organize a loose-leaf notebook which can accommodate future additions to be distributed later. We anticipate that each future catalog will be devoted to particles from one collection surface (approximately 100-150 particles at one particle per page). The basic format of the present catalog will probably be retained in later catalogs, although improvements will be actively pursued.

We will attempt to provide catalogs of additional particles to all persons with scientific research interest in cosmic dust. However, future catalog distributions will be limited to those persons who return the printed reply form attached below or the form from the cover letter.

Please maintain my name on the distribution list for NASA Cosmic Dust Program sample catalogs.

My correct mailing address is as follows:

Name _____
Title _____ ← Please
Address _____ Print or
Type

Return to: Curator/CDL
Code SN2
NASA/Johnson Space Center
Houston, Texas 77058

1. INTRODUCTION

Since May, 1981, the National Aeronautics and Space Administration (NASA) has used aircraft to collect cosmic dust (CD) particles from Earth's stratosphere (altitude ~18 km). Specially designed dust collectors experience pre- and post-flight handling in an ultraclean laboratory constructed for this purpose at the Lyndon B. Johnson Space Center (JSC) in Houston, Texas. Particles are individually retrieved from the collectors, examined and cataloged, and then made available to the scientific community for research. Cosmic dust thereby joins lunar samples and meteorites as an additional source of extraterrestrial material for scientific study.

This catalog summarizes preliminary observations on some of the particles retrieved from collection surface W7017. W7017 was one of eight flat plate "flags" (each with ~30 cm² surface area) which were coated with silicone oil and then flown aboard a NASA WB57F aircraft during a series of flights across the western United States from July 7, 1981, to September 15, 1981. The flags were installed in specially constructed wing pylons which ensured that the necessary level of cleanliness was maintained between periods of active sampling. During successive periods of high-altitude (~60,000 ft.) cruise, the flags were exposed to the atmosphere by pilot command and then retracted into sealed storage containers prior to descent. In this manner, a total of 45 hours of stratospheric exposure were accumulated for Flag W7017.

Details of particle collection, processing, and examination techniques will be published in the future. However, the following information summarizes these techniques so that the catalog can be more fully understood and utilized.

2. PROCESSING OF PARTICLES

Particle mounts designed for the JEOL 100CX scanning electron microscope (SEM) are currently the standard receptacles for CD particles in the JSC laboratory. Each mount consists of a graphite frame (size ~3x6x24 mm) onto which a NucleoporeTM filter is attached. A conductive coat of carbon is vacuum-evaporated onto the mount and then a microscopic reference pattern is "stenciled" onto the carbon-coated filter by vacuum evaporation of aluminum through an appropriately sized template. CD particles are individually removed from collection flags using micromanipulators under a binocular stereomicroscope. Each particle is positioned on an aluminum-free area of a freon-cleaned, carbon-coated mount filter and washed in-place with hexane to remove silicone oil. Each mount is normally limited to 16 particles. All processing and storage of each particle is performed in a Class-100 clean room.

3. PRELIMINARY EXAMINATION OF PARTICLES

Each rinsed particle is examined by optical microscopy before leaving the Class-100 clean room processing area. Each mount is studied with a petrographic research microscope equipped with transmitted, reflected and oblique light illuminators. At a magnification of 500X, size, shape, transparency, color, and luster are determined and recorded for each particle.

Next, each mount (with uncoated particles) is examined by SEM. A JEOL 100CX instrument, equipped with PGT 6000 solid-state X-ray analyzer, is used to obtain a secondary electron image and an energy-dispersive X-ray spectrum (EDS) of each particle. The SEM is operated at an accelerating voltage of 40 kv and the EDS is obtained for the range of 0-10 ev by a standard integrated count of 100 sec. SEM images so obtained are necessarily of relatively low resolution due to the deliberate avoidance of conventionally applied conductive coats (carbon or gold-palladium) which might interfere with later elemental analyses of the particles. Exceptional cases in this catalog are SEM mounts W7017B and W7017E which were allocated in entirety for research and, as a consequence, were coated by the PI with gold-palladium. However, preliminary examination data for both mounts were included in the catalog for completeness.

Following SEM preliminary examination, each mount is stored in a dry nitrogen gas atmosphere in a sealed cabinet.

4. CATALOG FORMAT

Each page in the main body of the catalog is devoted to one particle and consists of an SEM image, an EDS spectrum, and a brief summary of preliminary examination data obtained by optical microscopy. The unique identification number assigned to the particle appears at the top of the page. Sources of the descriptive data are as follows:

SIZE (μm) is measured using the original SEM image and its known magnification factor. For an irregularly shaped particle, the minimum dimension in the field of view is located and determined; then a second (maximum) dimension is measured at a right angle to the first. For a spherical or equidimensional particle, only a single size is recorded.

SHAPE is generalized to be spherical (S), equidimensional (E), or irregular (I). Particles having shape intermediate between S and E or E and I are not uncommon.

TRANSPARENCY (abbreviated TRANS.) is determined by optical microscopy to be transparent (T), translucent (TL), or opaque (O).

COLOR is determined by optical microscopy using a combination of reflected normal and oblique (fiber-optic) illumination. Although color perception may vary with observer, the distinction of dark (Dk.) from light (Lt.) particles is unambiguous. Similarly, the distinction of colorless (CL) from colored particles is only occasionally in doubt.

LUSTER is determined by optical microscopy using a combination of reflected normal and oblique (fiber-optic) illumination. Commonly applied descriptions, adopted from mineralogical usage, include dull (D), metallic (M), submetallic (SM), subvitreous (SV), and vitreous (V). Lusters transitional between categories or difficult to identify are indicated accordingly (D/SM, ?, etc.).

TYPE indicates a provisional first-order identification of the particle based on its morphology (from SEM image), elemental composition (from EDS), and optical properties. We emphasize that, for catalog purposes, types are defined for their descriptive and curatorial utility, not as scientific classifications. We indicate "type" only to aid the users of this catalog in distinguishing cosmic dust particles from other particles which are invariably collected during cosmic dust sampling. Categories used in this catalog are defined as follows:

AOS: aluminum oxide sphere

(Based on work by D.E. Brownlee and collaborators, AOS particles are thought to be products of solid-fuel rocket exhausts. Nonspherical particles of similar composition are of enigmatic origin and have been provisionally called Al' particles by Brownlee and R.M. Walker.)

C: cosmic dust (variety unspecified)

TCA: terrestrial contamination (artificial or man-made)

(This category includes particles produced or derived from aircraft operation or collector hardware.)

TCN: terrestrial contamination (natural)

(This category includes mineral, rock, or soil material from Earth or various biological contaminants such as spores, insect parts, etc.)

?: identification uncertain

COMMENTS are included for particles with special features or histories. Particles lost during or after preliminary examination, or particles with possible genetic relationships to other particles are noted here.

****IMPORTANT NOTES:** (1) EDS, some copper X-radiation is emitted from
viii

some of the SEM internal parts by the electron beam. The peaks labelled "CU" may, therefore, represent a contribution from both sample and instrument. The instrument is being modified to remove the machine artifact.

- (2) Particles labelled W7017B... or W7017E... have already been allocated for research and are gold-palladium coated.

5. SAMPLE REQUESTS

Scientists desiring to perform detailed research on particles described in this catalog should apply in writing to:

Curator/CDL
Code SN2
NASA/Johnson Space Center
Houston, Texas 77058
U.S.A.

Telephone: (713) 483-3274

Sample requests should refer to specific particle identification numbers and should describe the research being proposed as well as the qualifications and facilities of the investigator making the request. NASA will arrange for a review of the scientific merits of each request and will inform the requester of the results. Approval of a sample request does not imply or include funding for the proposed research.

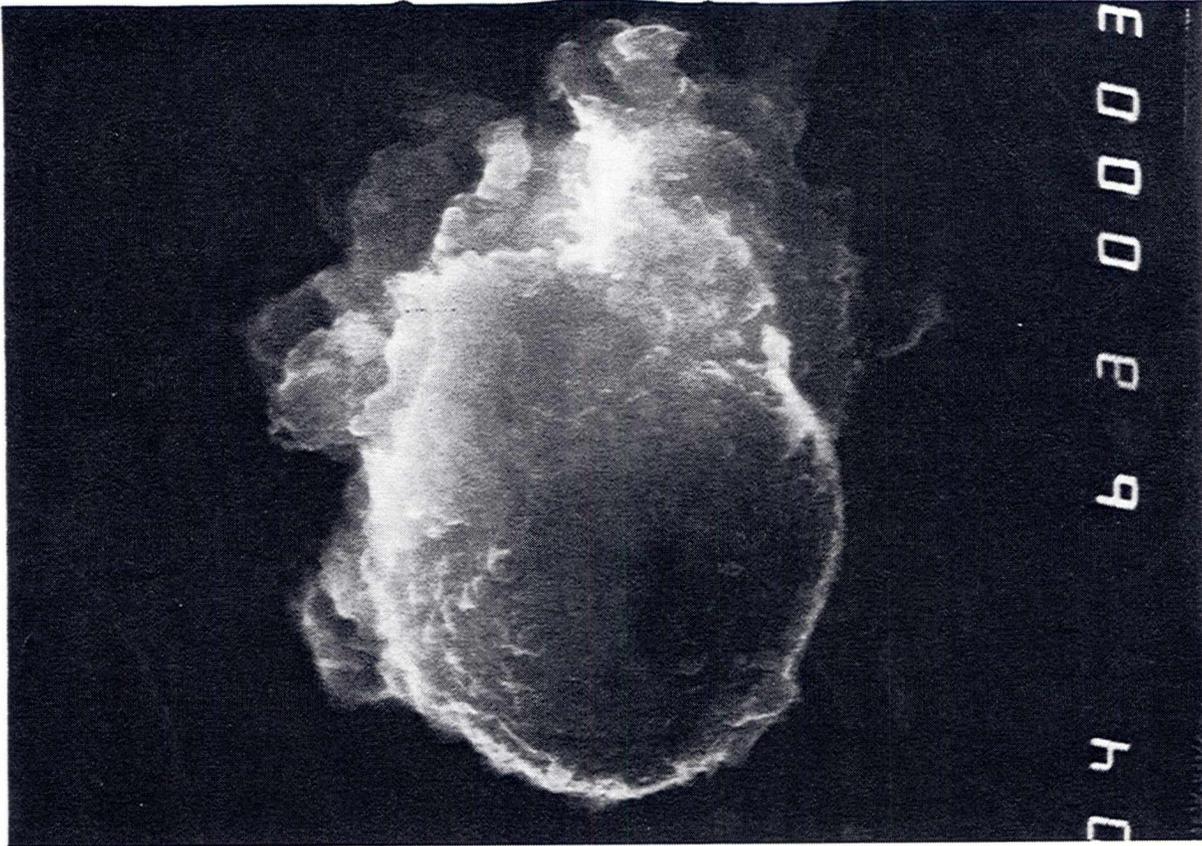
It should be noted that particles labelled W7017B... or W7017E... have already been allocated for research and, thus, are not available from the inventory summarized in this catalog. Again, preliminary examination data for this allocated mount is included for completeness.

6. ACKNOWLEDGEMENTS

Dr. Donald E. Brownlee (University of Washington, Seattle) generously provided information, advice, and material cooperation which contributed greatly to the successful start of the JSC Cosmic Dust Program. Dr. Robert M. Walker and Dr. Philip B. Fraundorf (Washington University, St. Louis) advised us on particle identification problems.

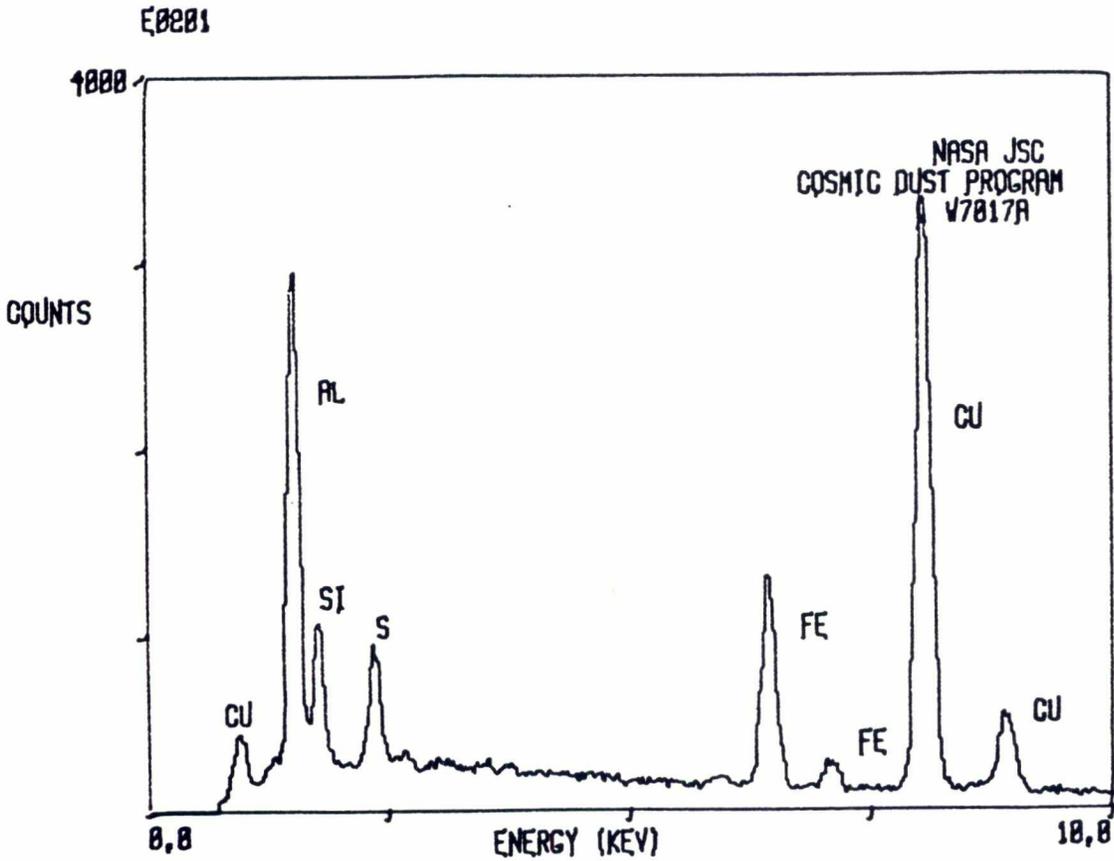
MOUNT W7017A

W7017A2



S-81-40130

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
10x13	I	0	Dk. Brown/Black	SV/SM	TCA?	

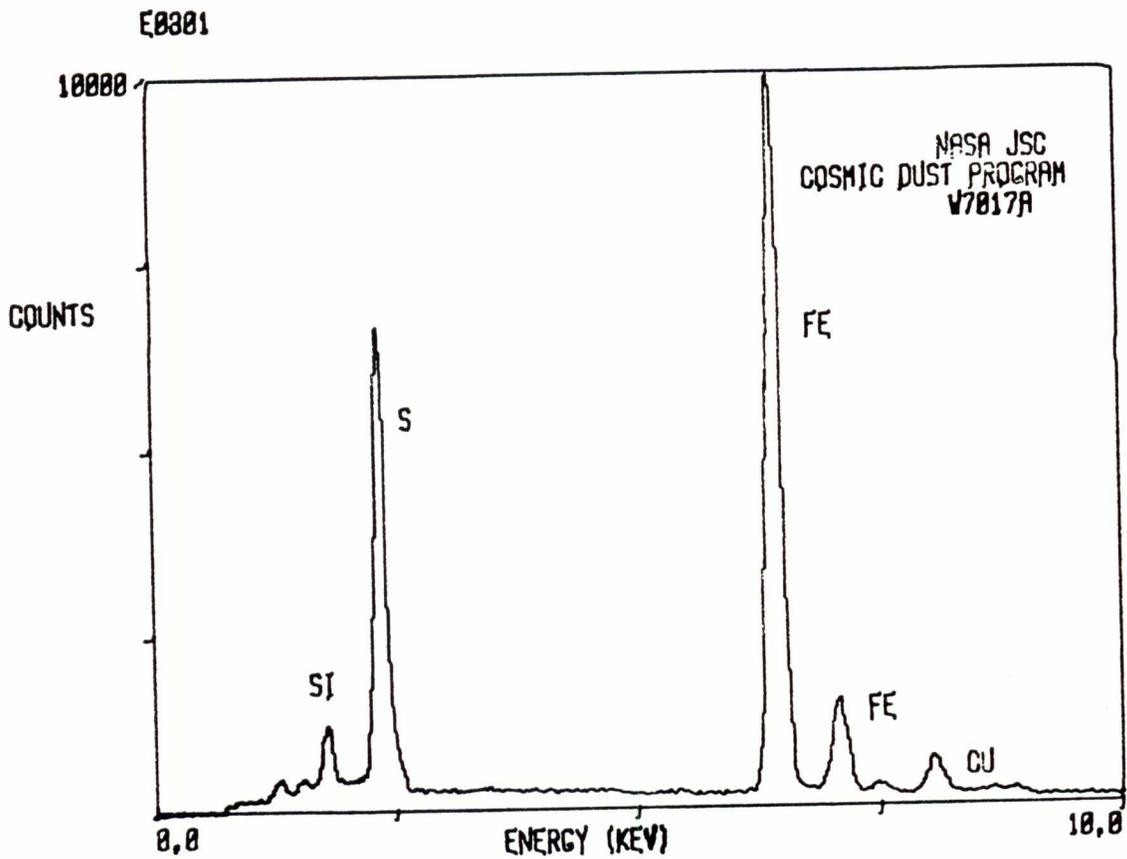


W7017A3

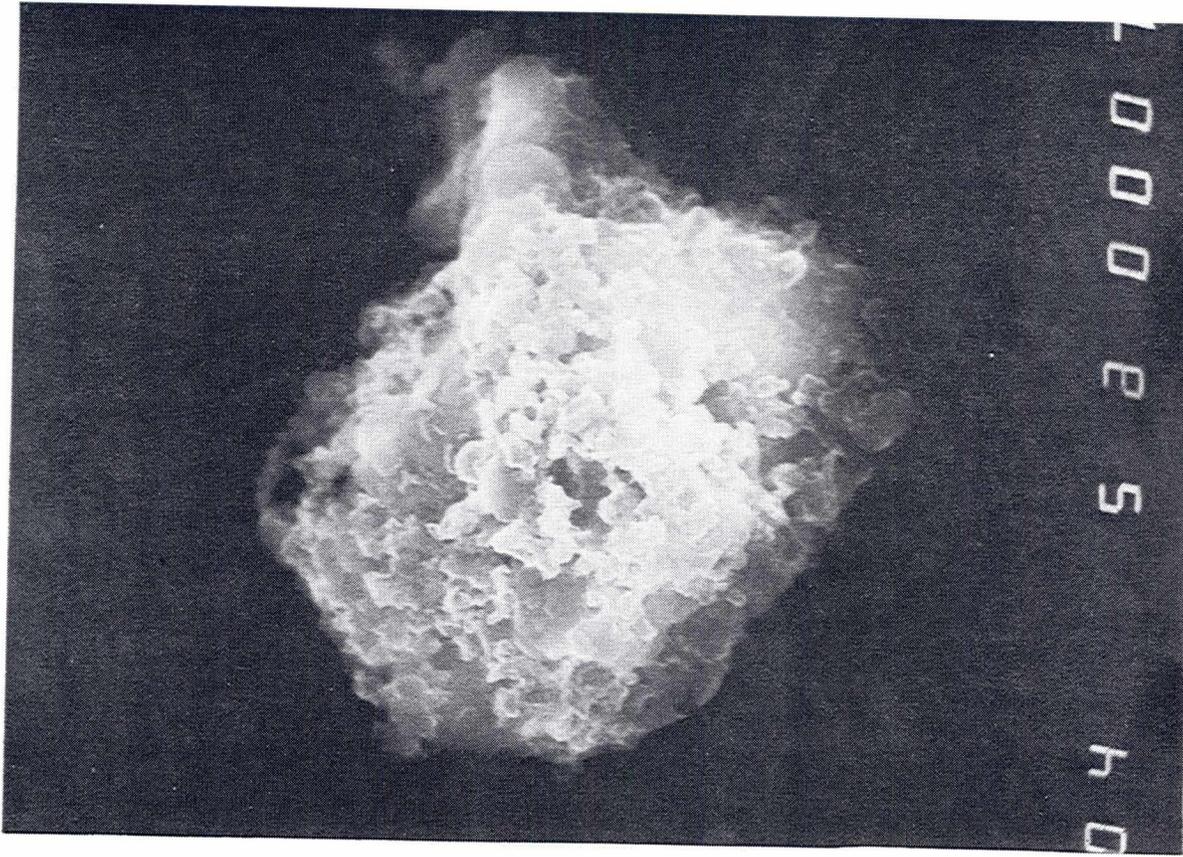


S-87-40137

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
14x30	I	0	Black	SV/SM	C	



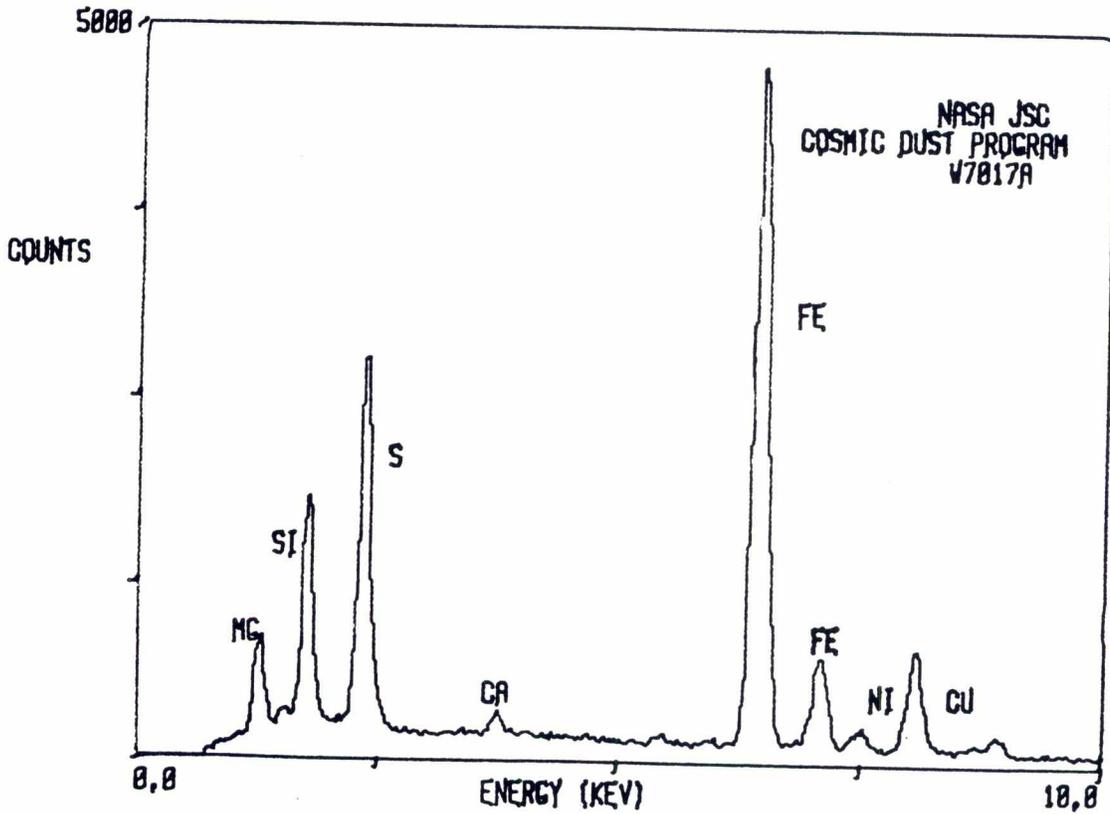
W7017A4



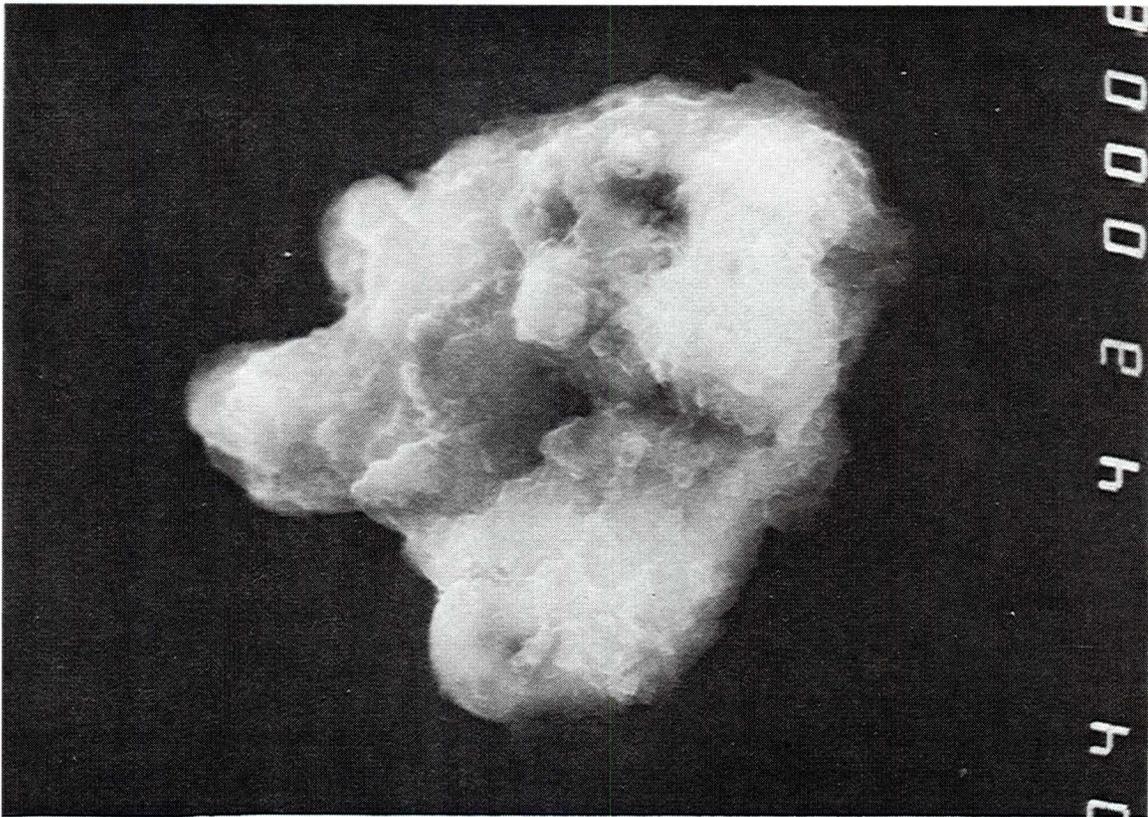
S-81-40132

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
10x12	I	0	Dk. Gray/Black	SV	C	

E0401

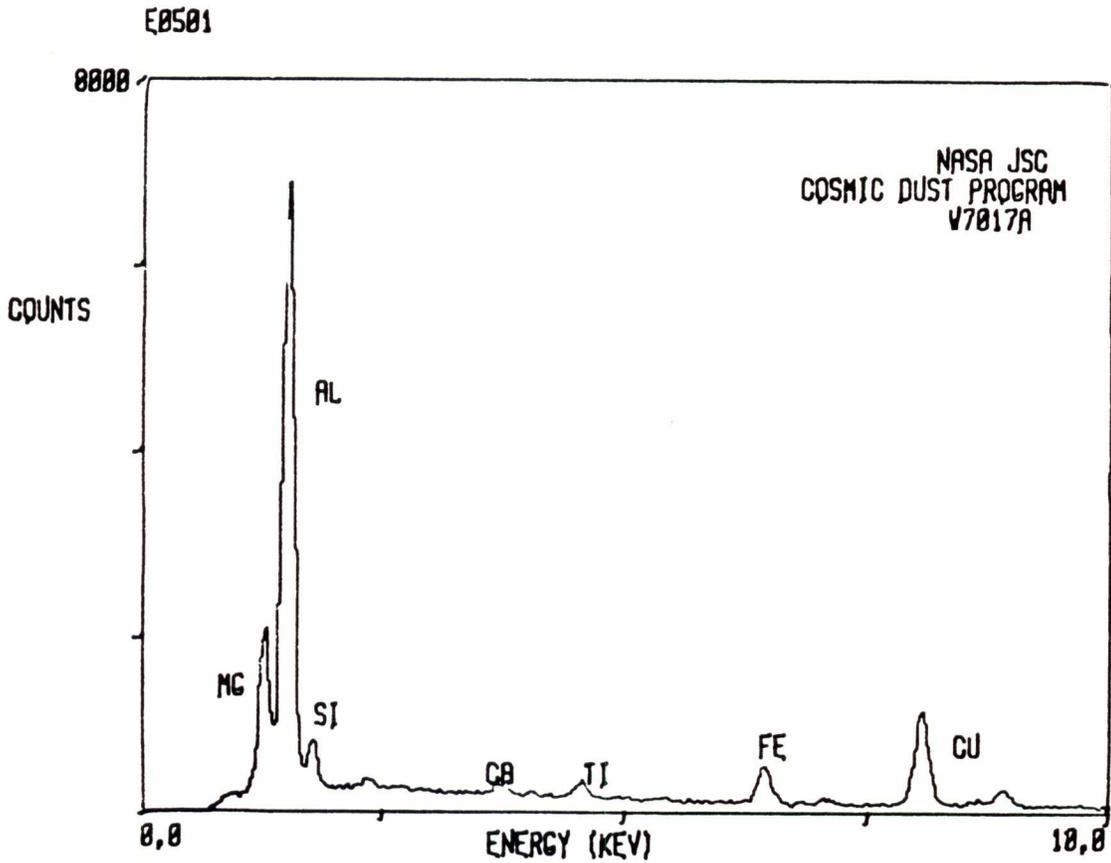


W7017A5

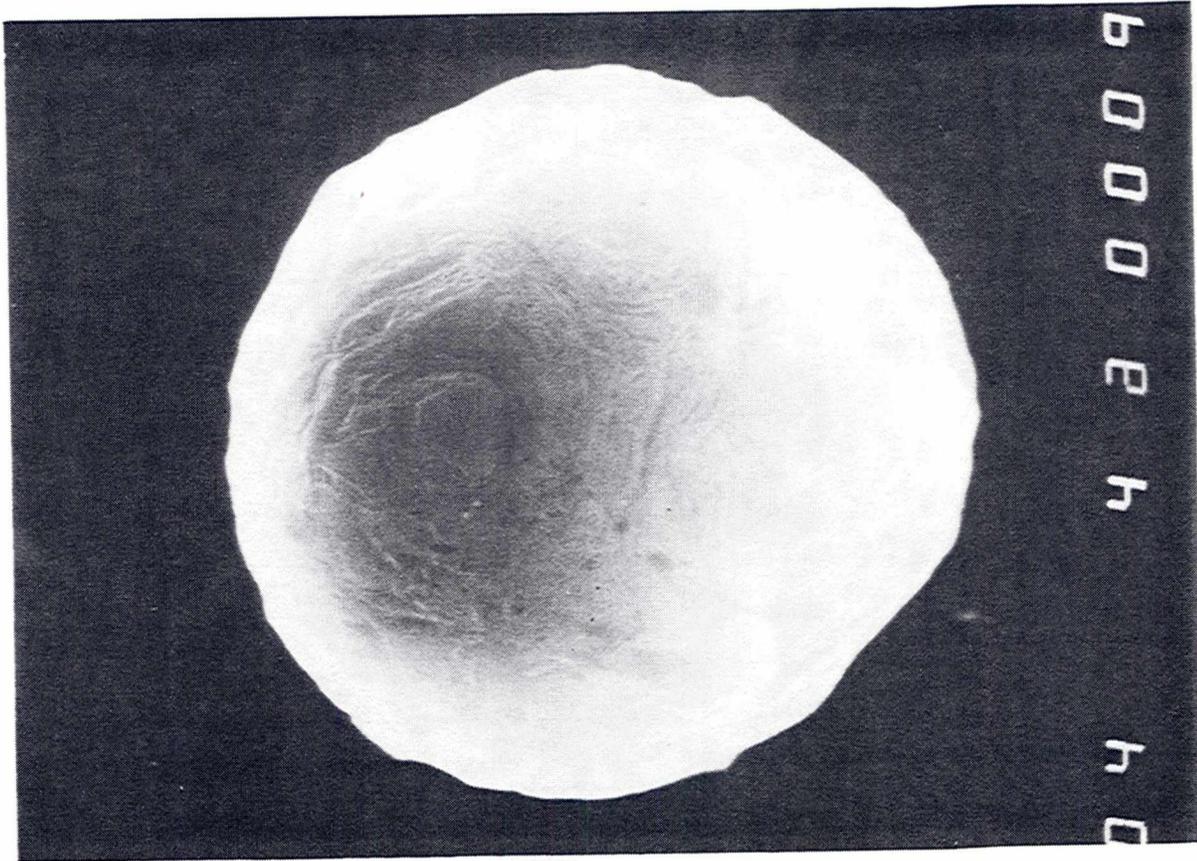


S-81-40133

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
14x16	I	0	Dk. Gray/Black	SV	C?	

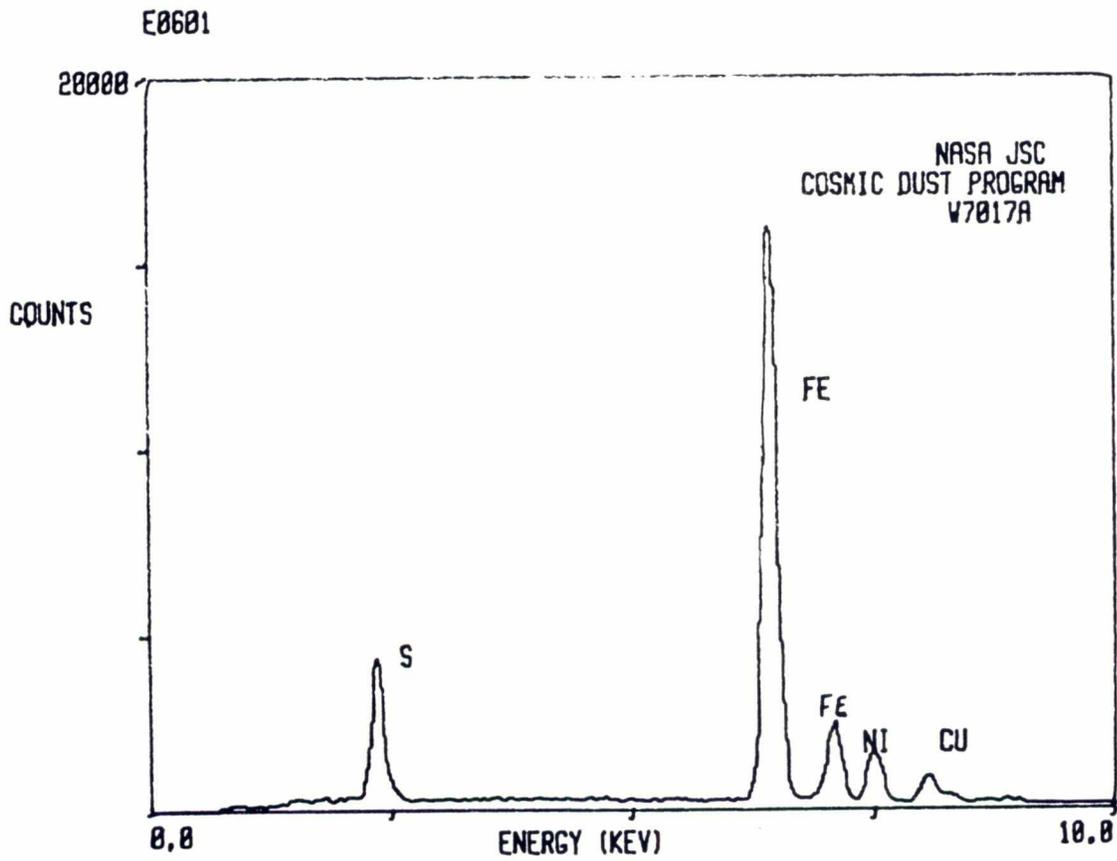


W7017A6

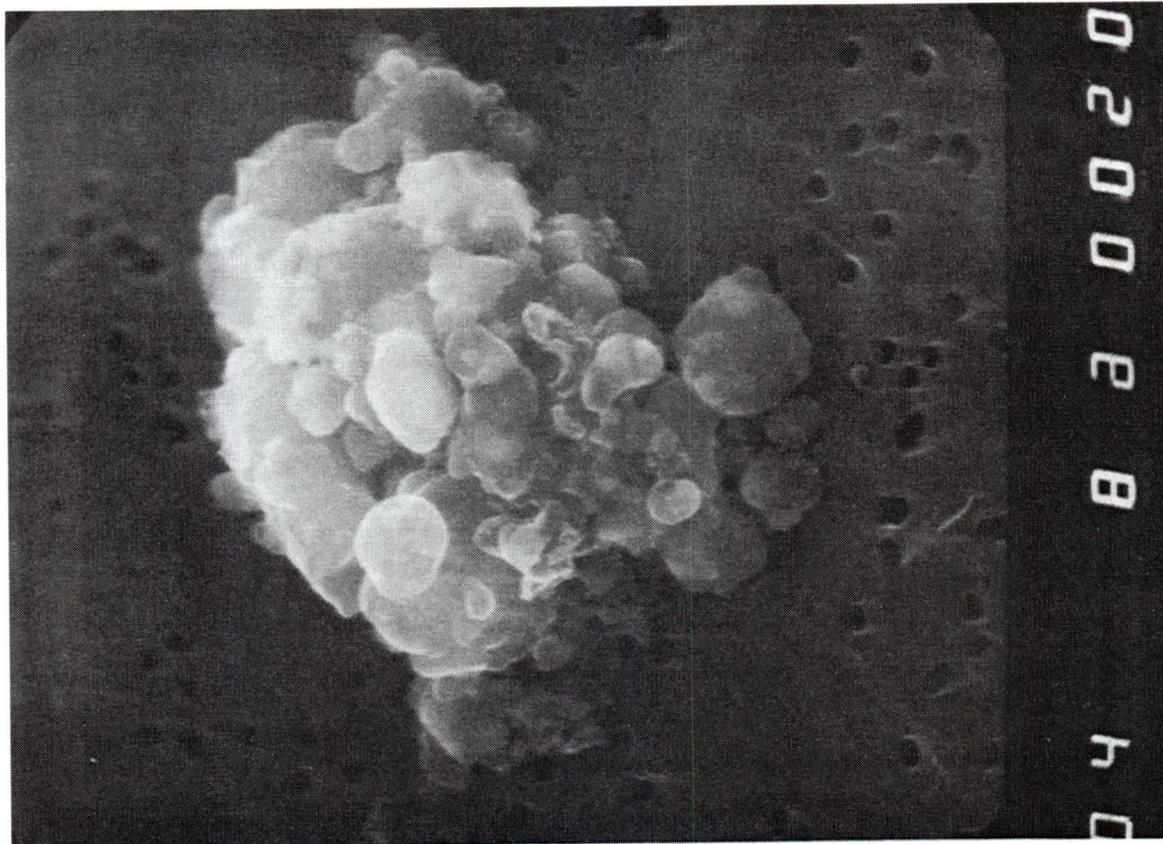


S-81-40134

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
17	S	0	Black	M	C	

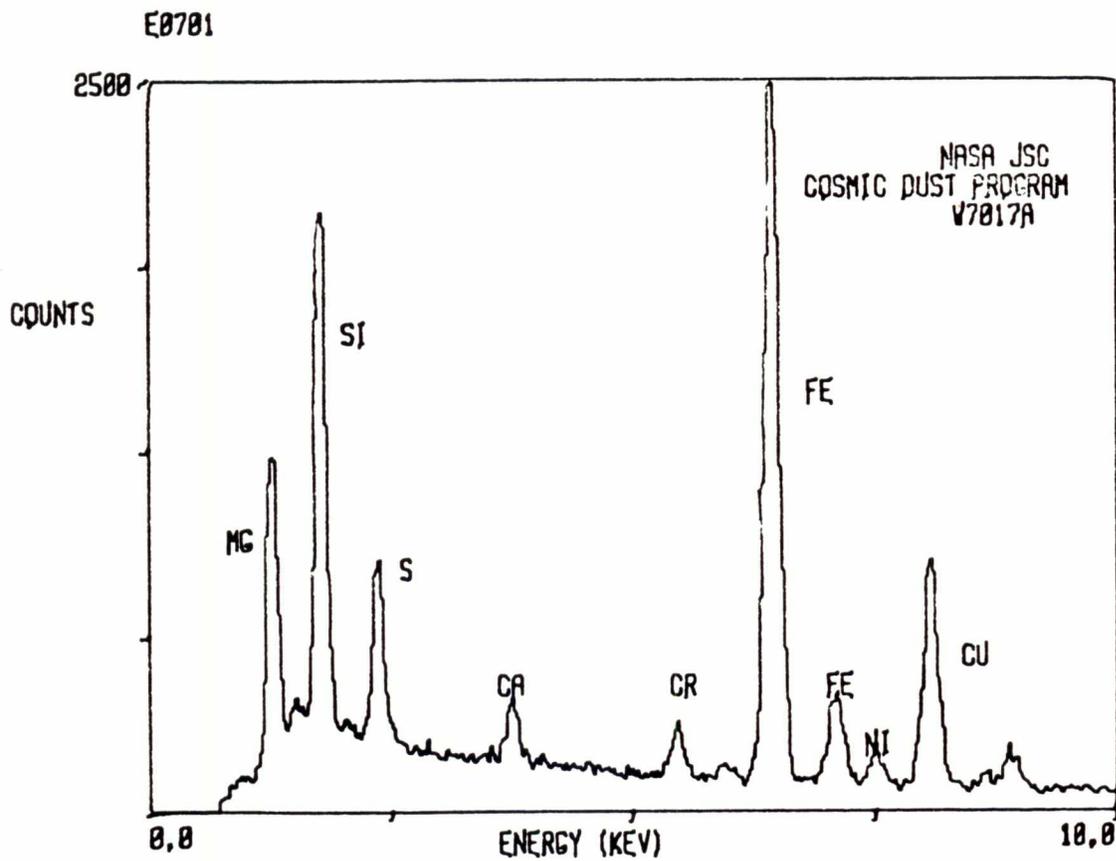


W7017A7

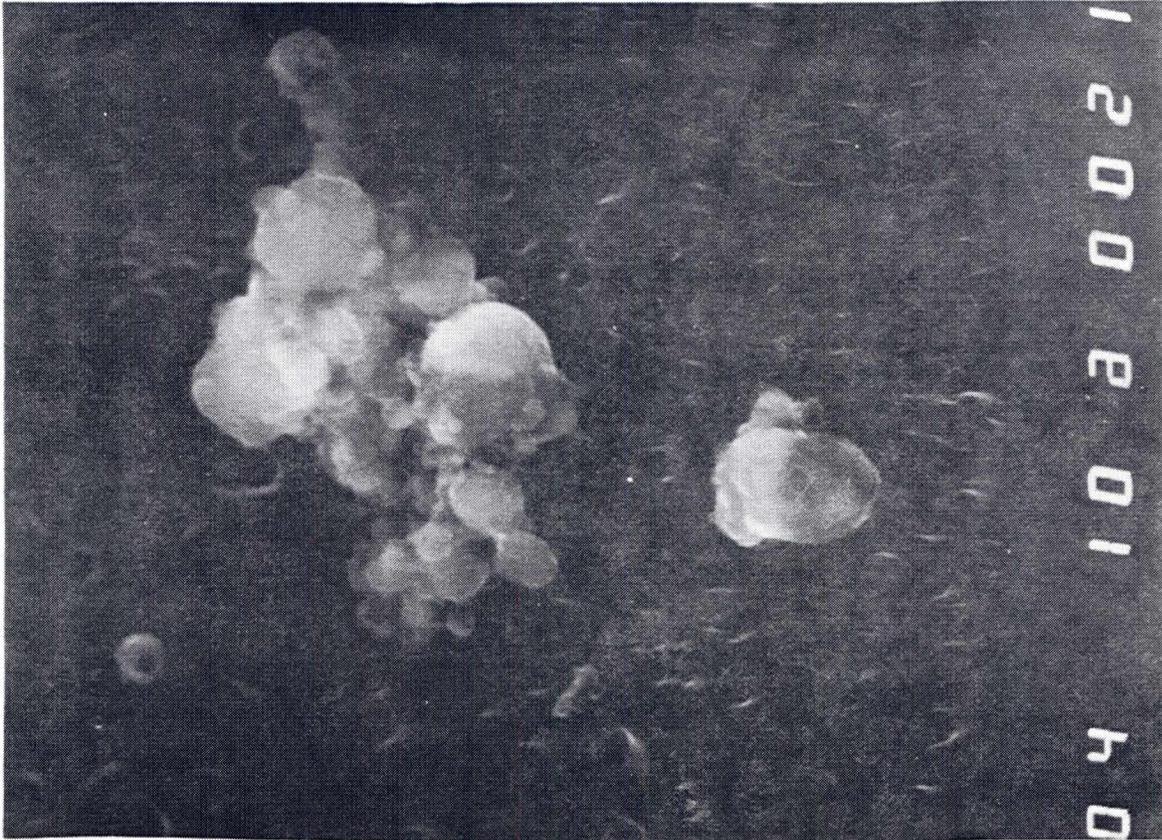


S-81-40135

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
7x9	I	0	Black	SV/SM	C	

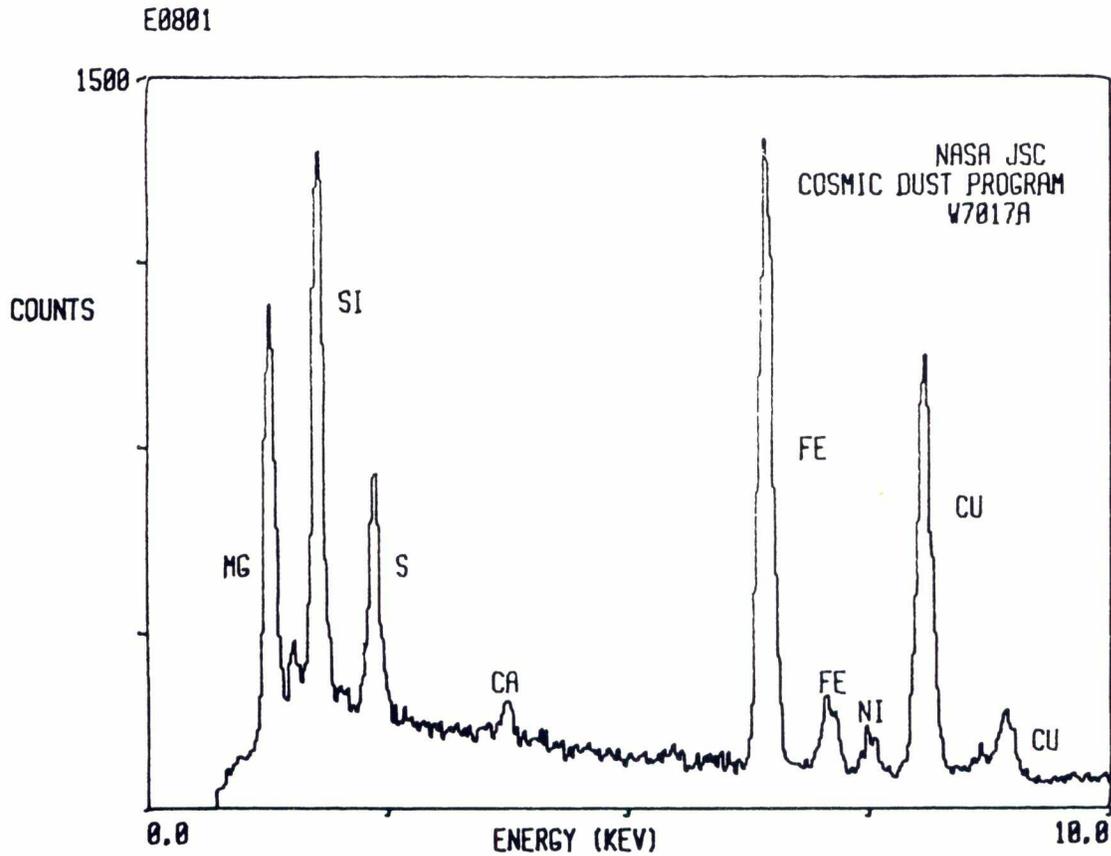


W7017A8



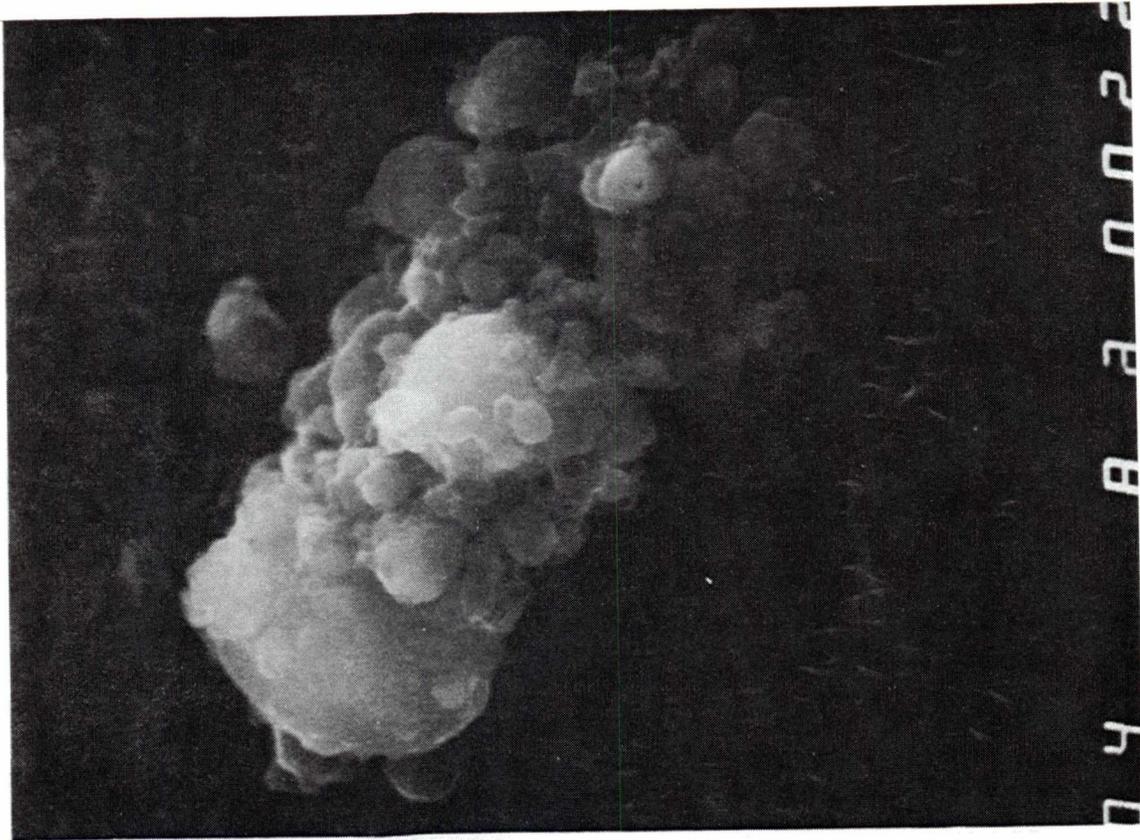
S-81-40136

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
3x6	I	0	Black	SV/SM	C	Fragment of W7017A7

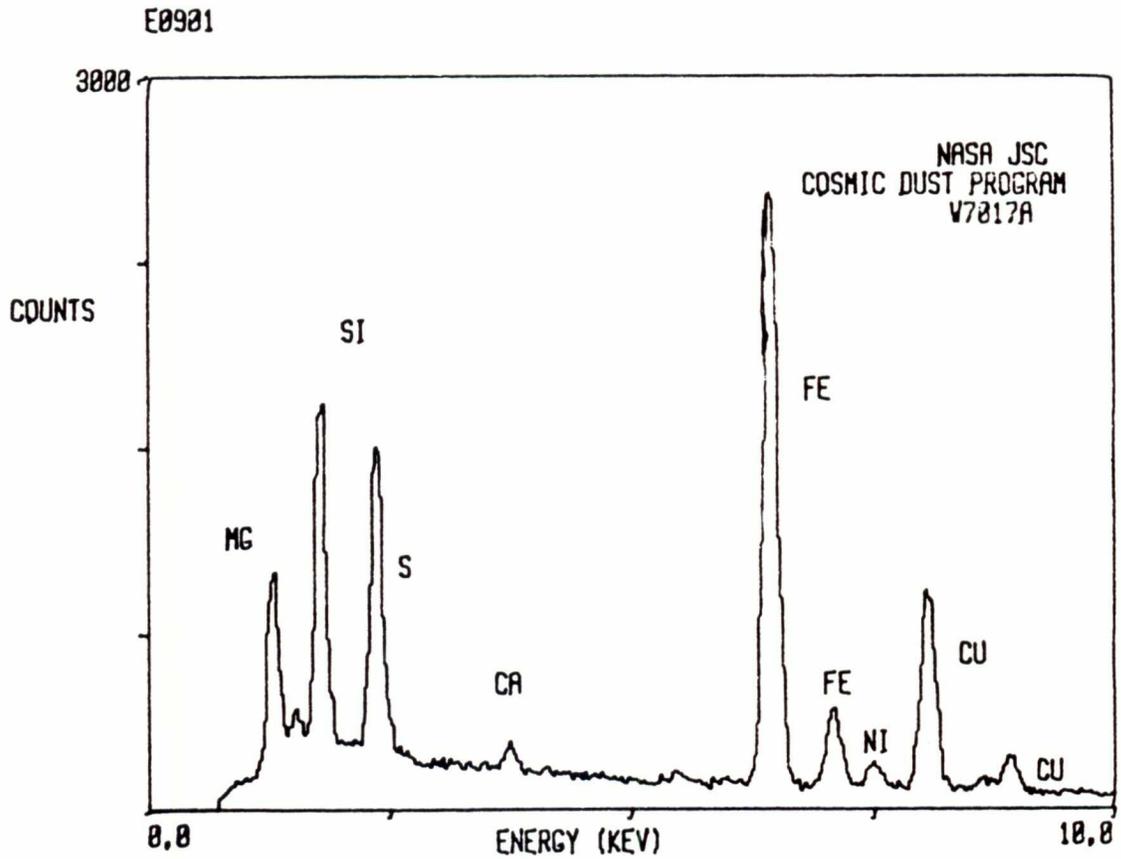


W7017A9

S-81-40137

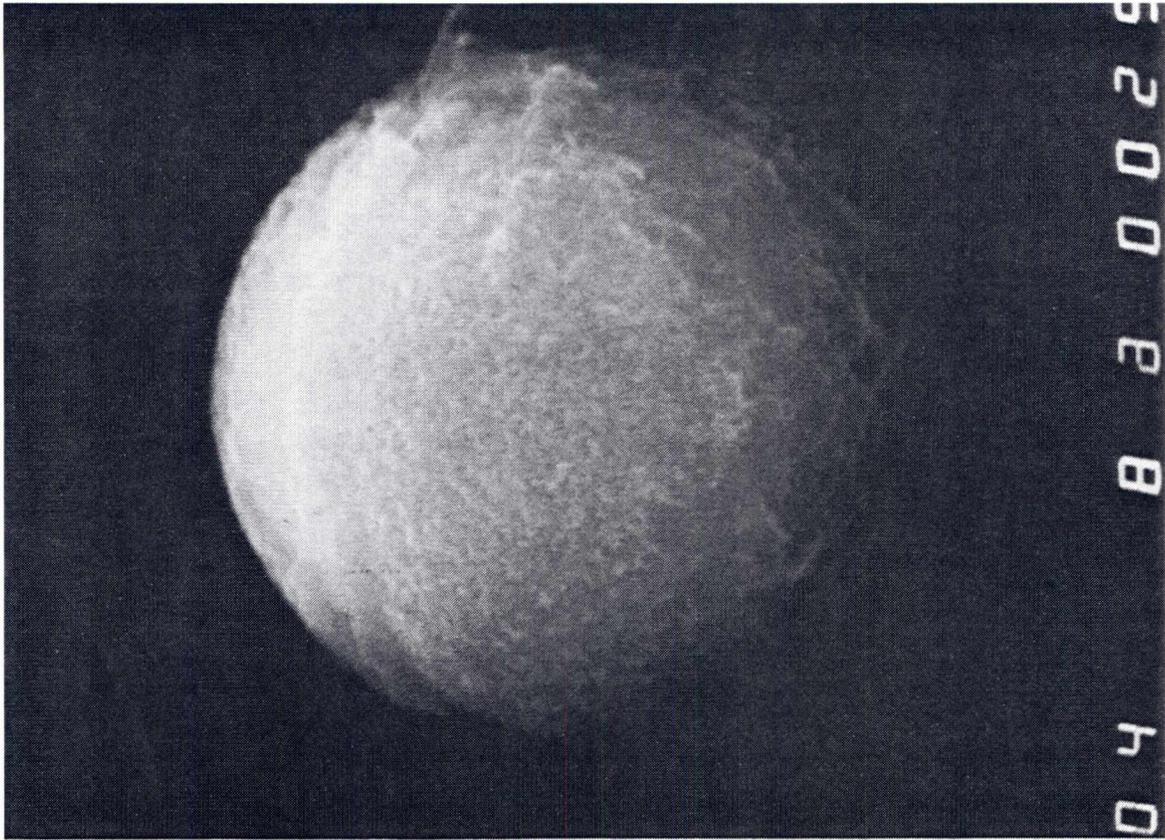


<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
5x10	I	0	Black	SV/SM	C	Fragment of W7017A7



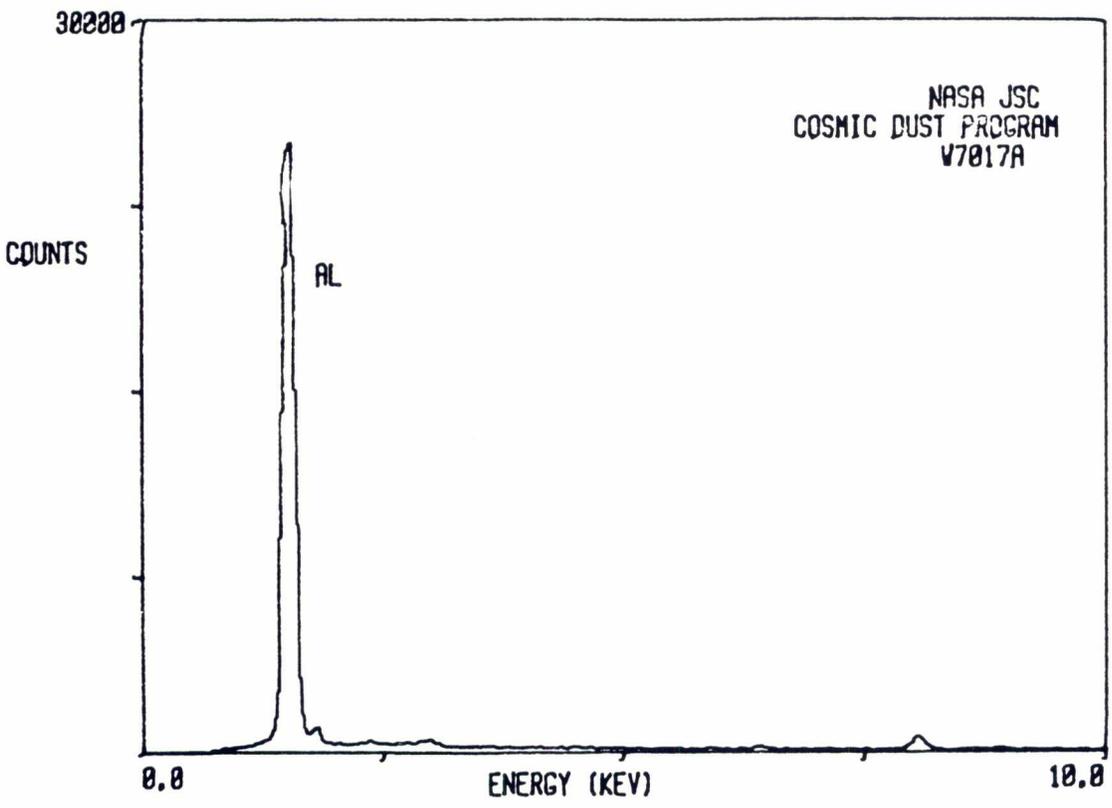
W7017A11

S-81-40138

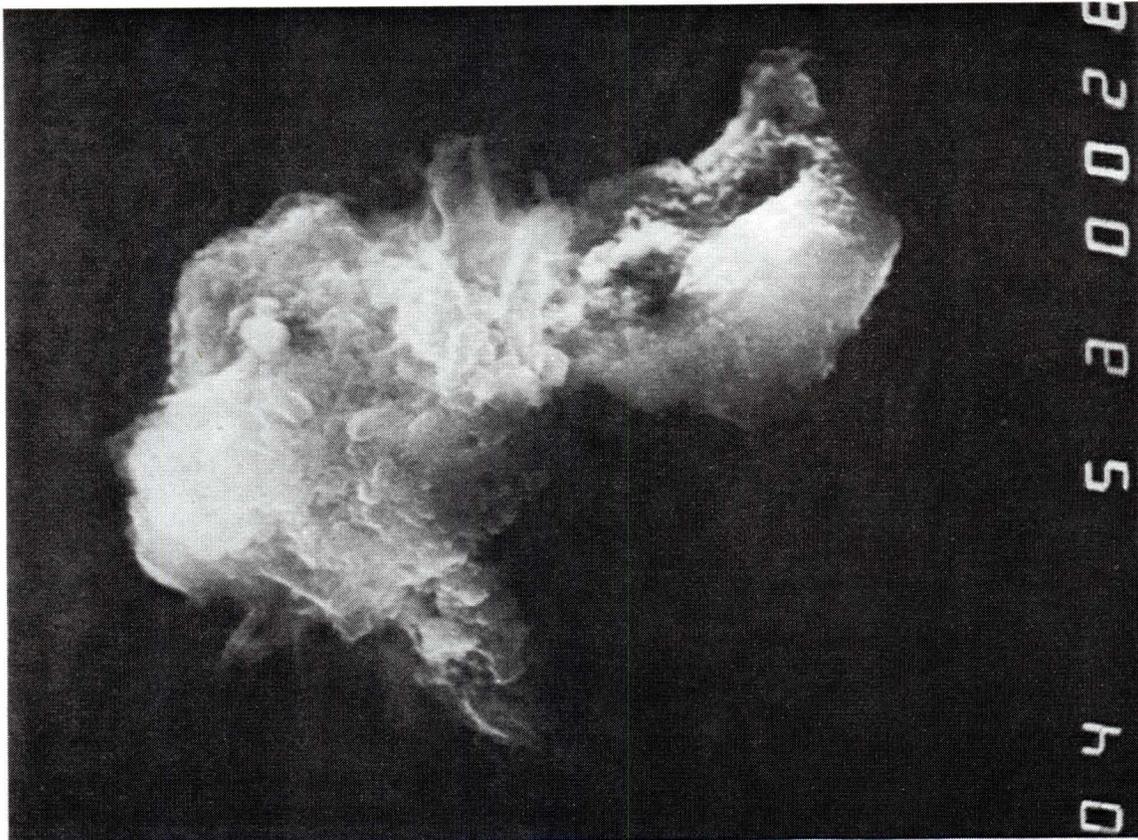


<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8	S	0	Dk. Metallic Gray	M	AOS	

E1101

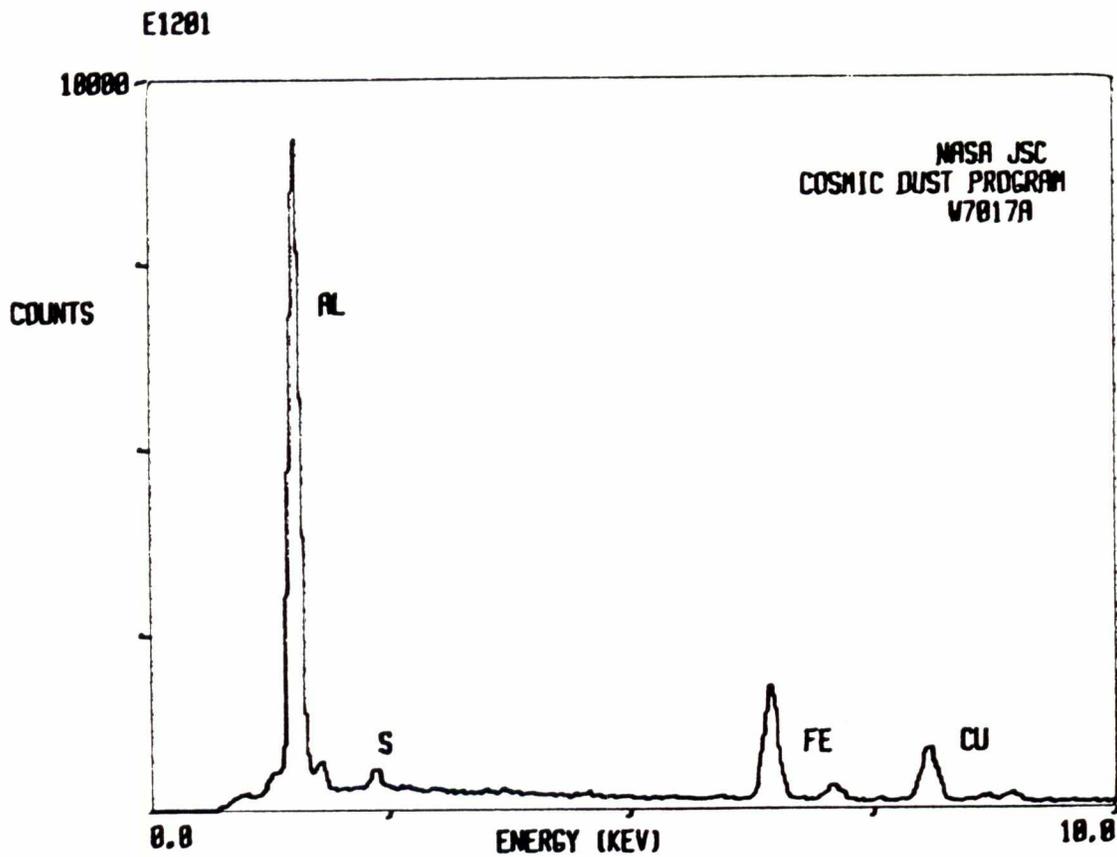


W7017A12



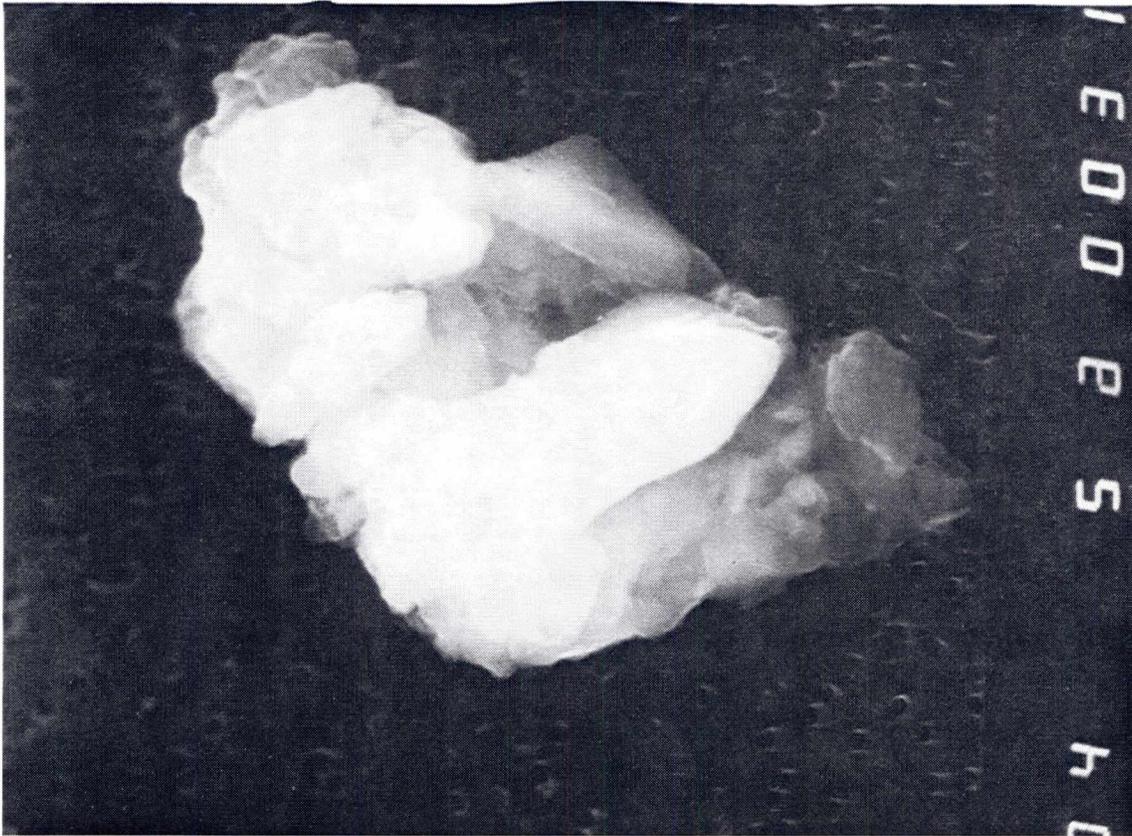
S-81-40139

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
11x15	I	0	Gray with Reddish Area	SM	TCN	

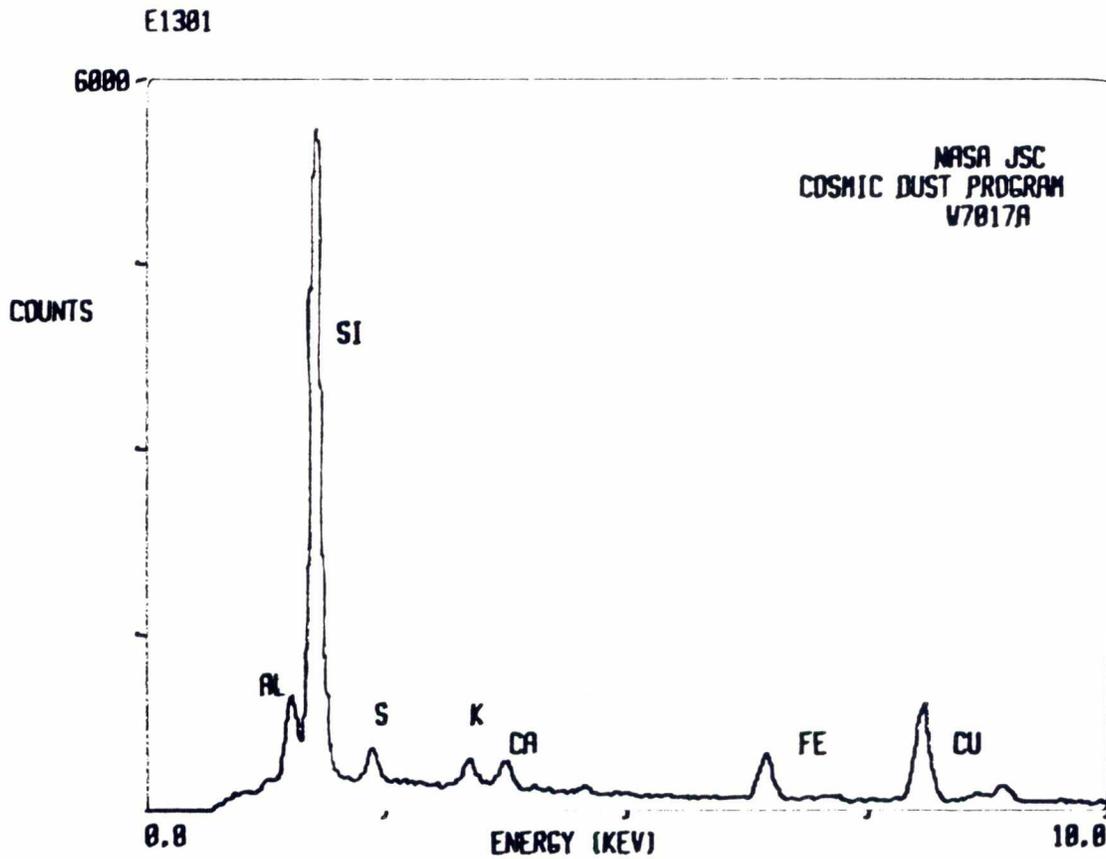


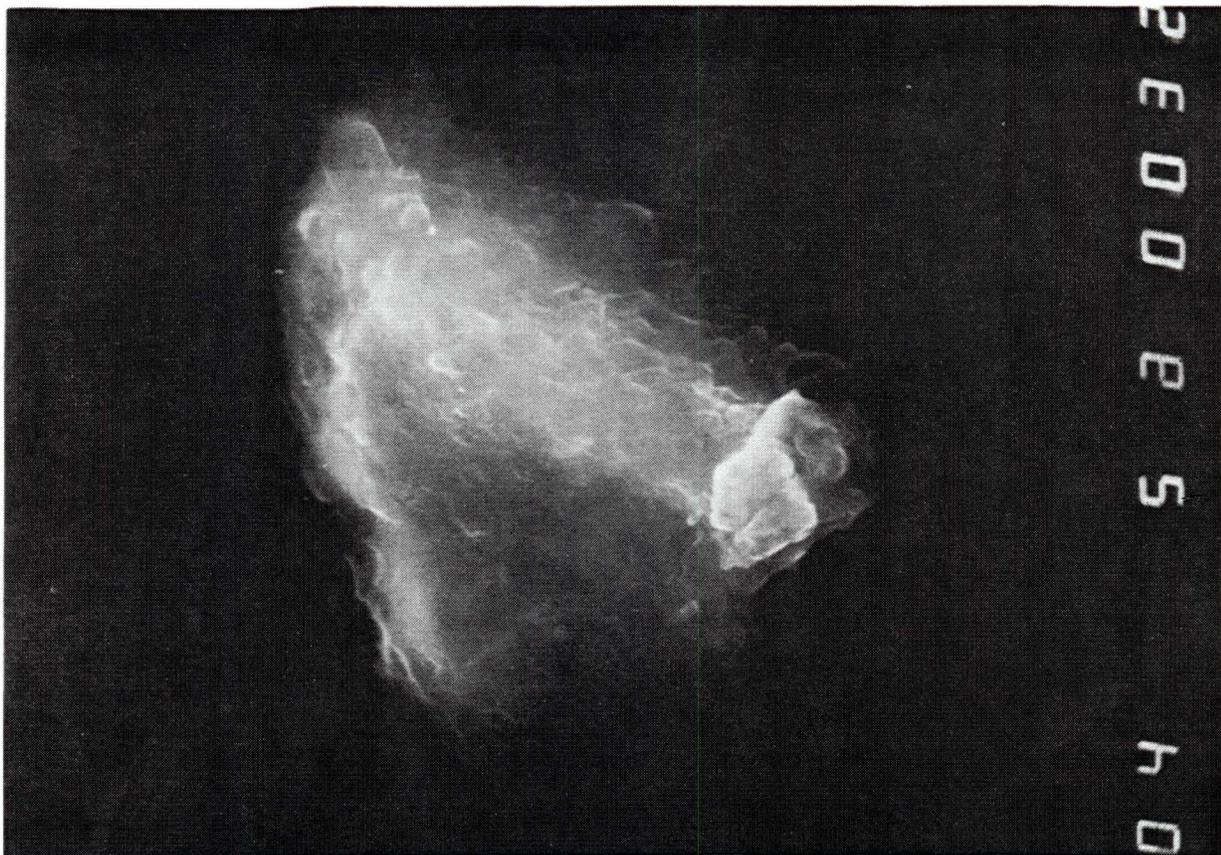
W7017A13

S-81-40140



<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
10x16	I	0	Dk. Gray/Black	SV/SM	TCN	

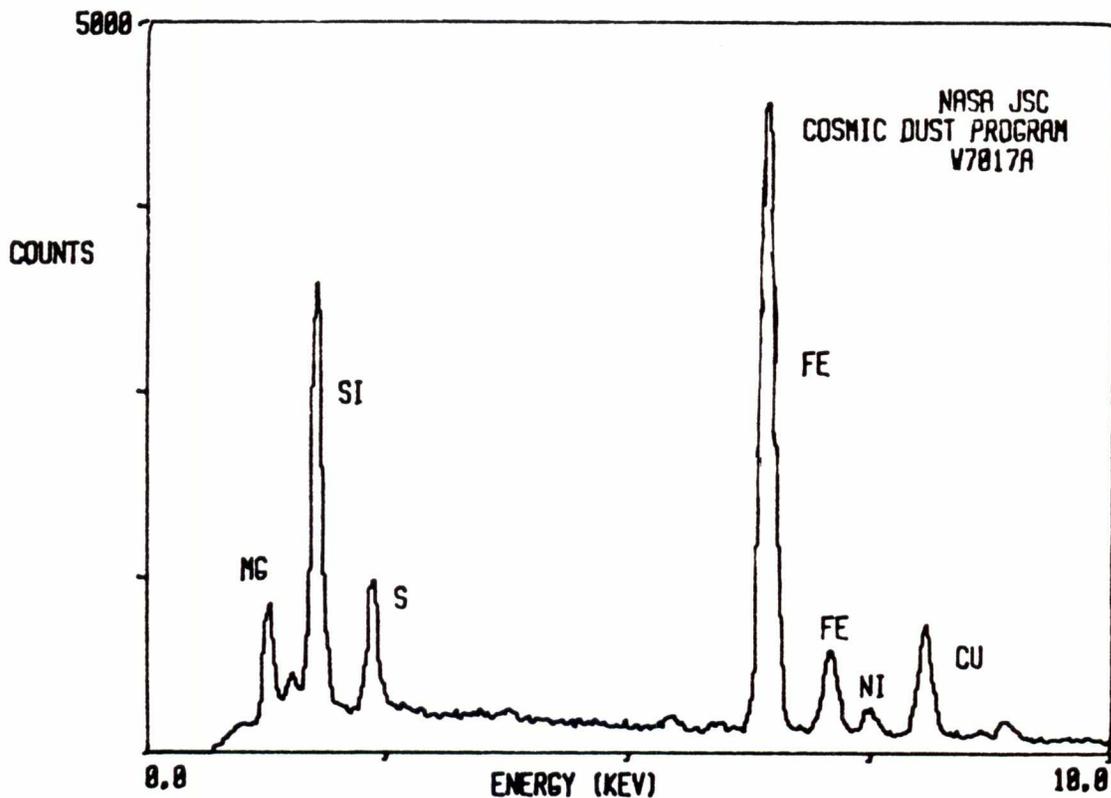




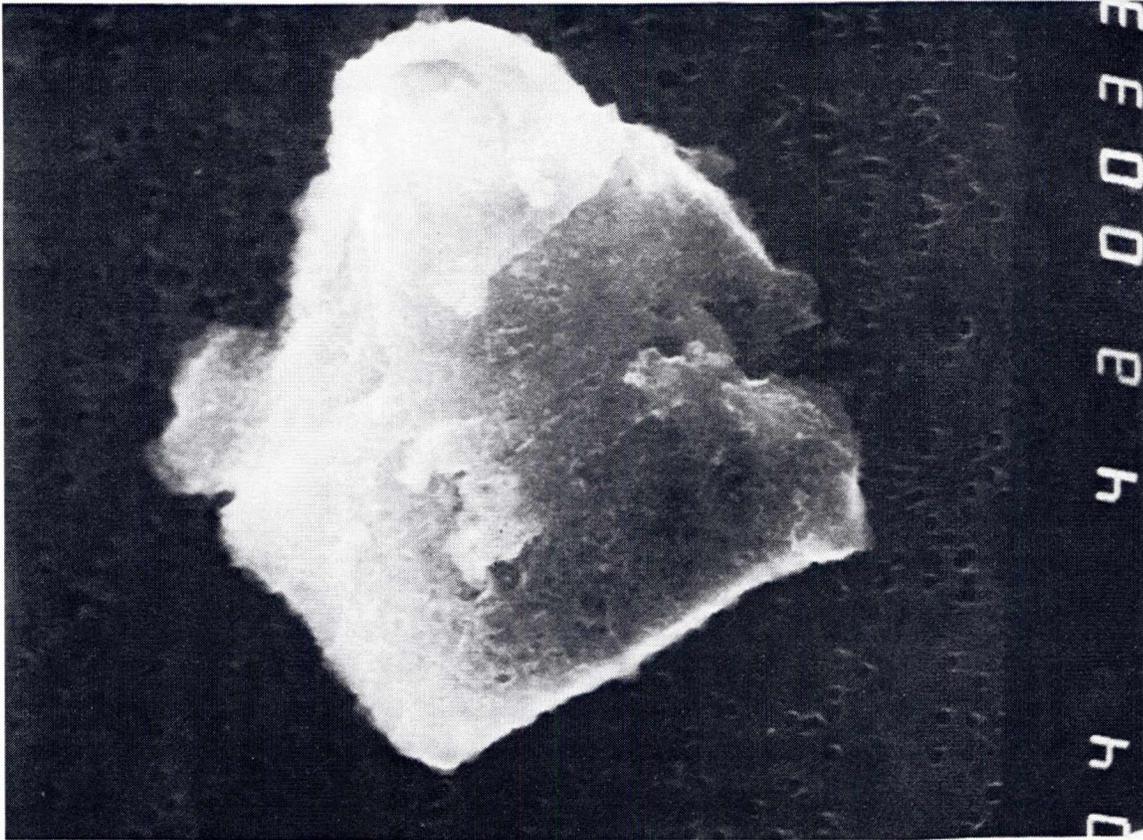
S-81-40141

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
10x12	I	0	Black	SV/SM	C	Oil on Grain?

E1401

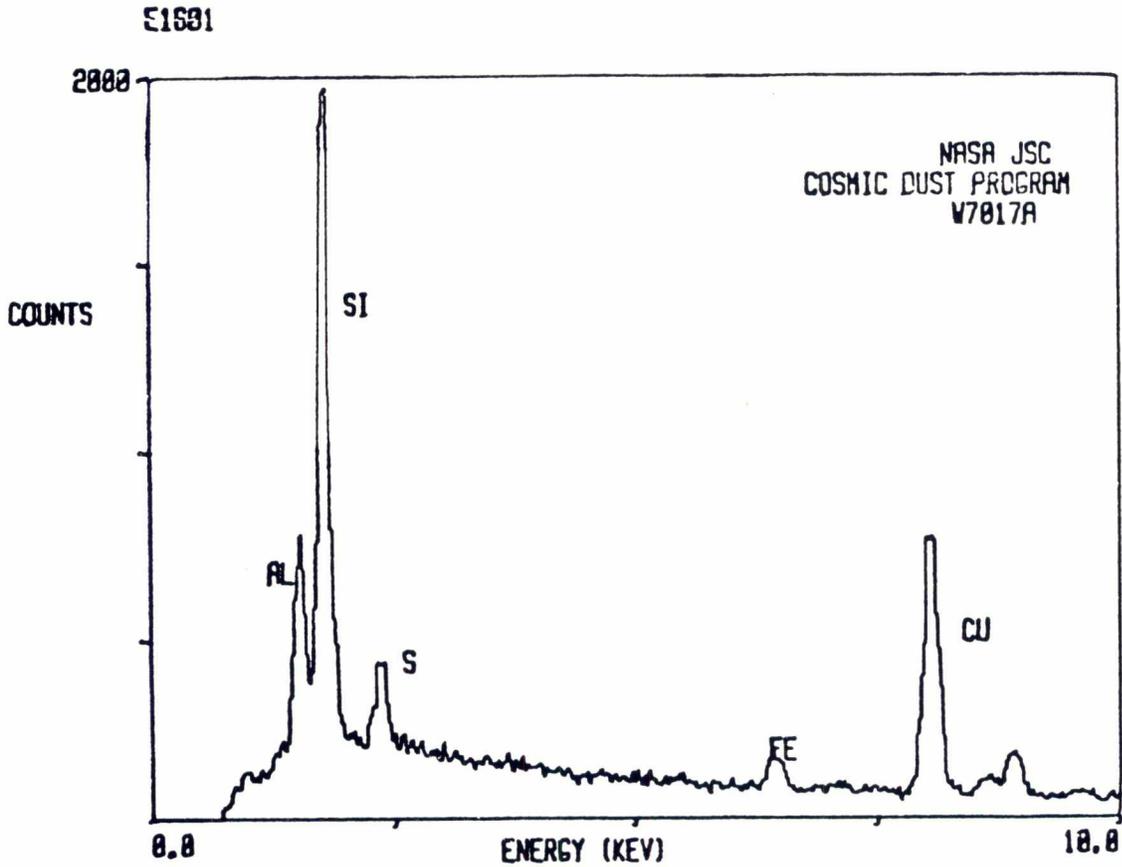


W7017A16

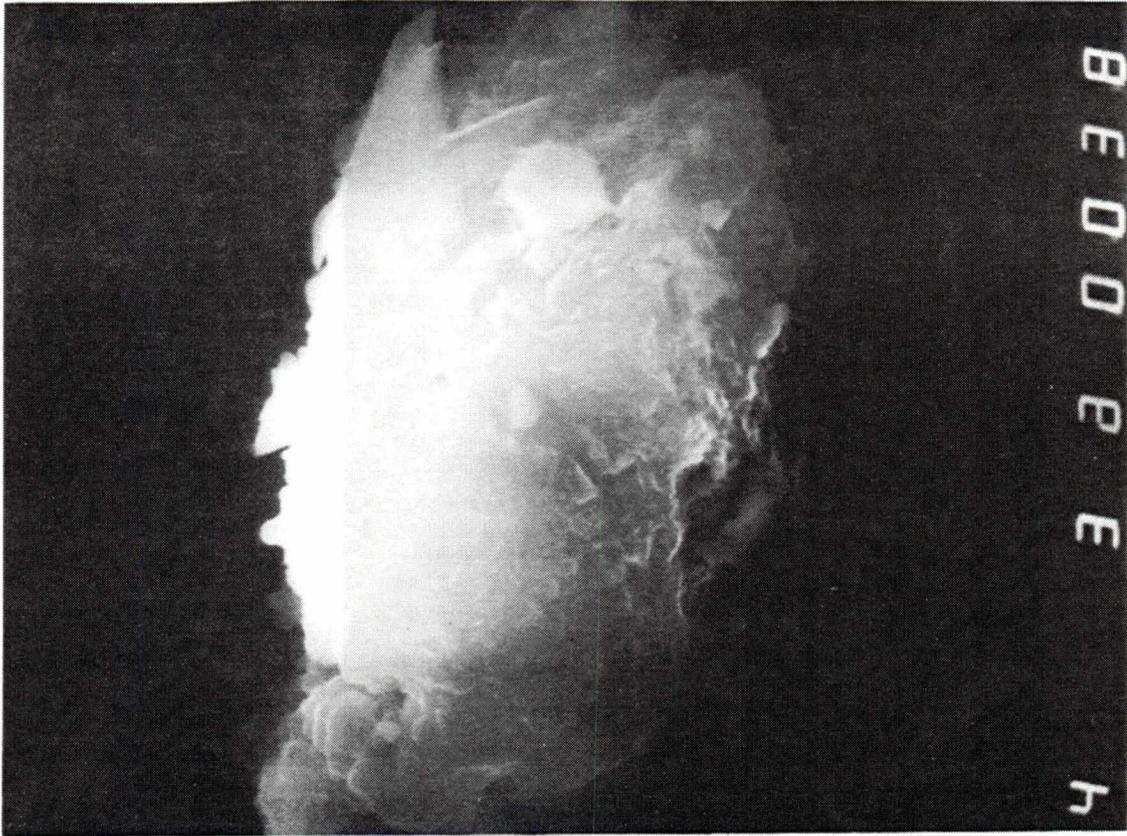


S-81-40142

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
15x16	I	0	Black	SV	TCN	T Grain on Corner

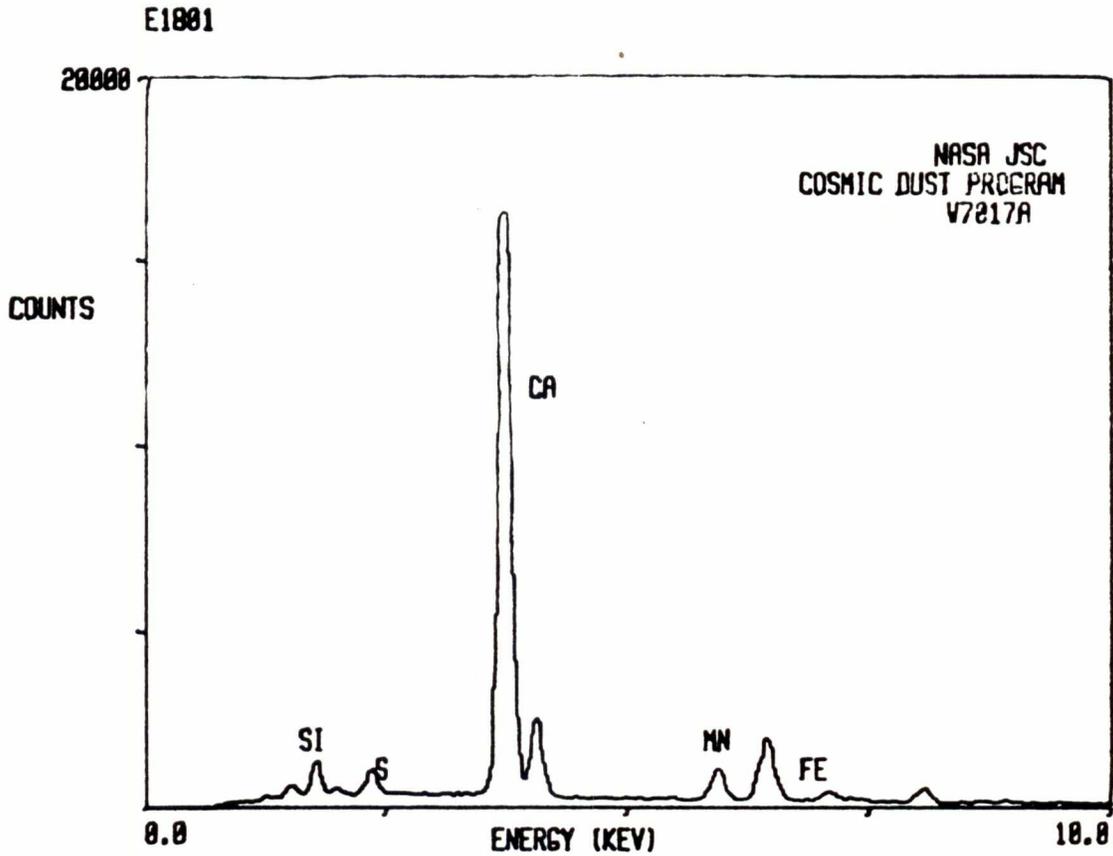


W7017A18



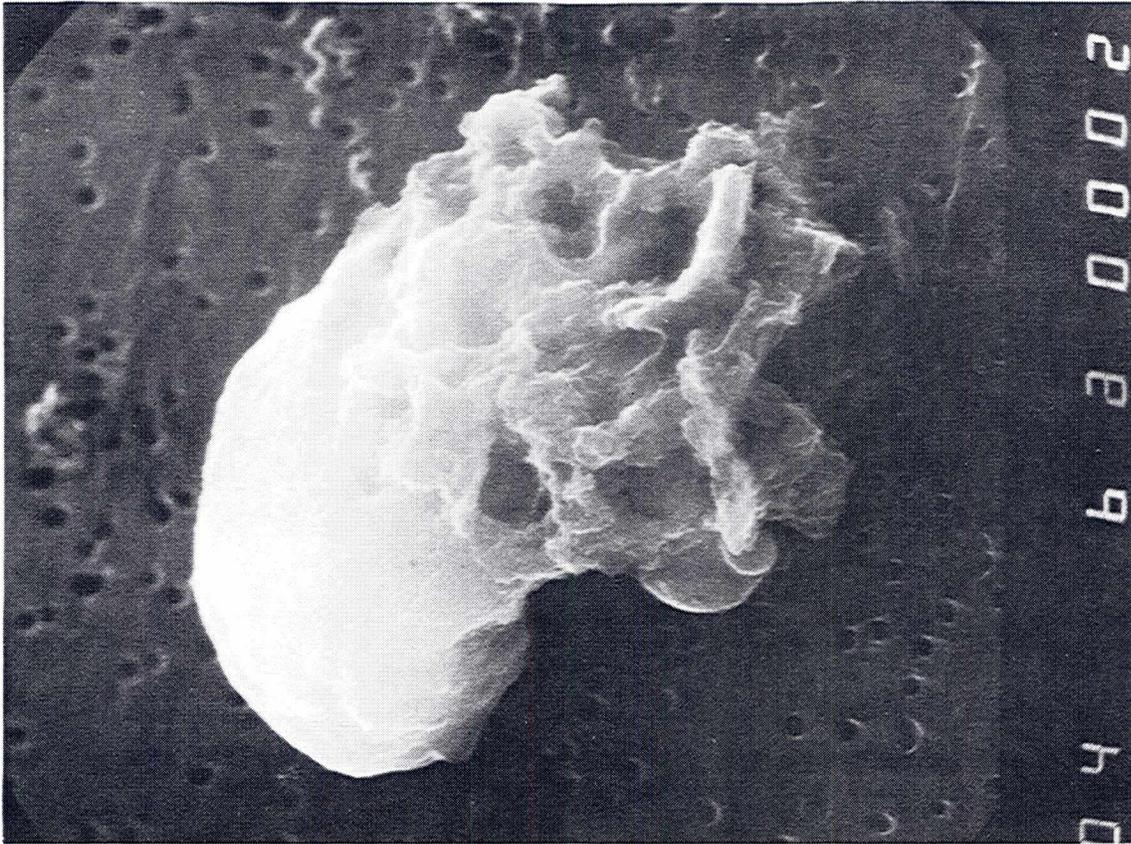
S-81-40143

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
16x28	I	O/TL	Reddish-Brown to Gray	SV	TCA?	TL Grain on Edge



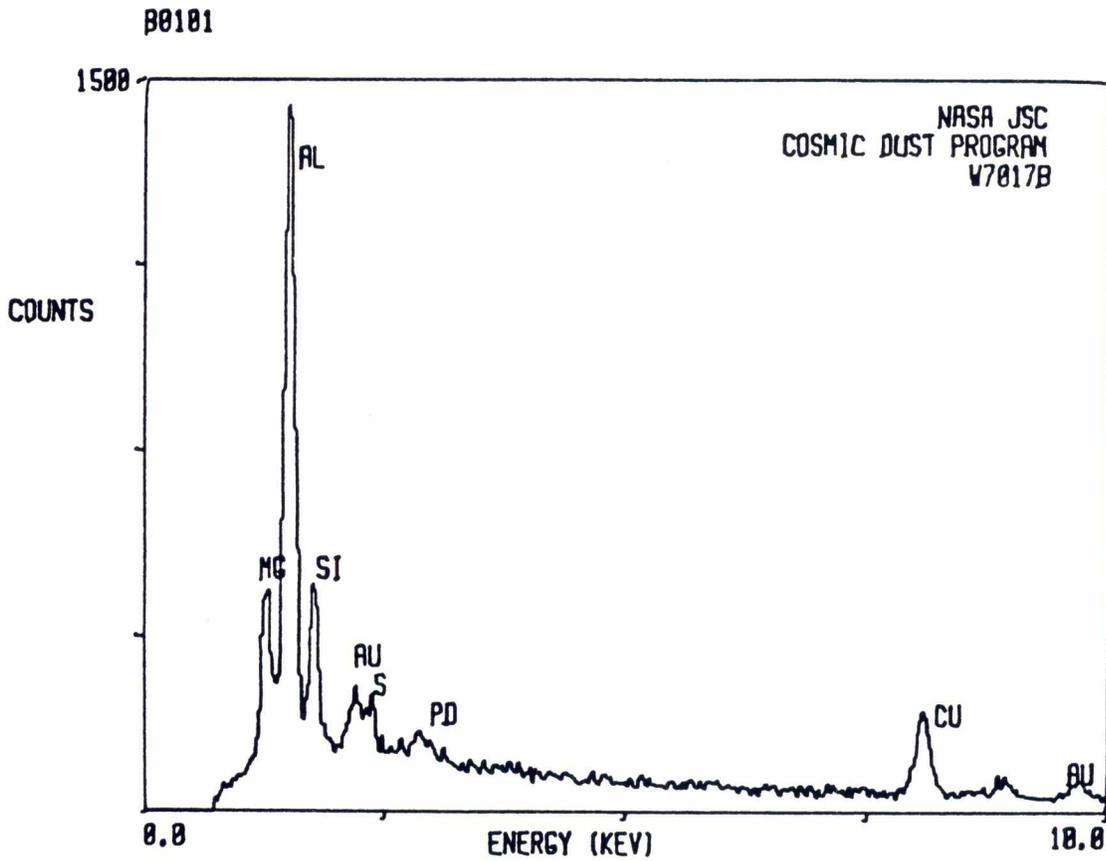
MOUNT W7017B

W7017B1

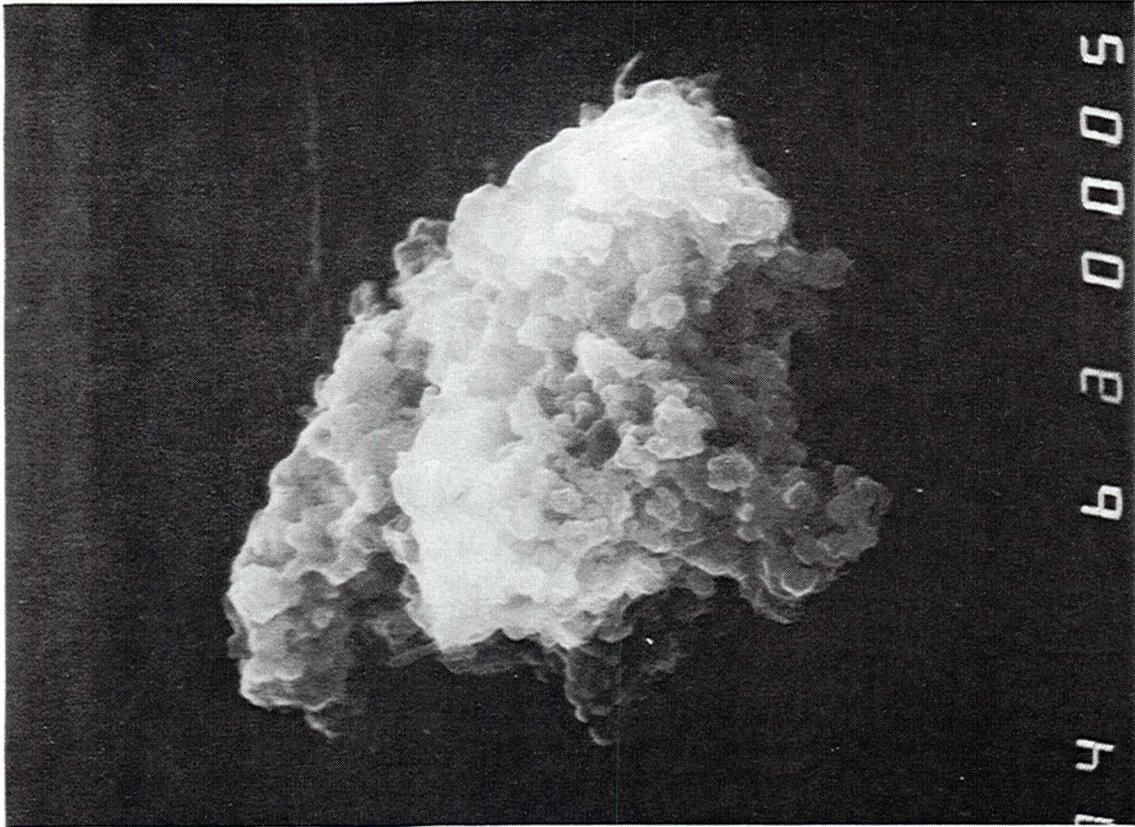


S-81-39961

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8x11	I	0	White	D	C	

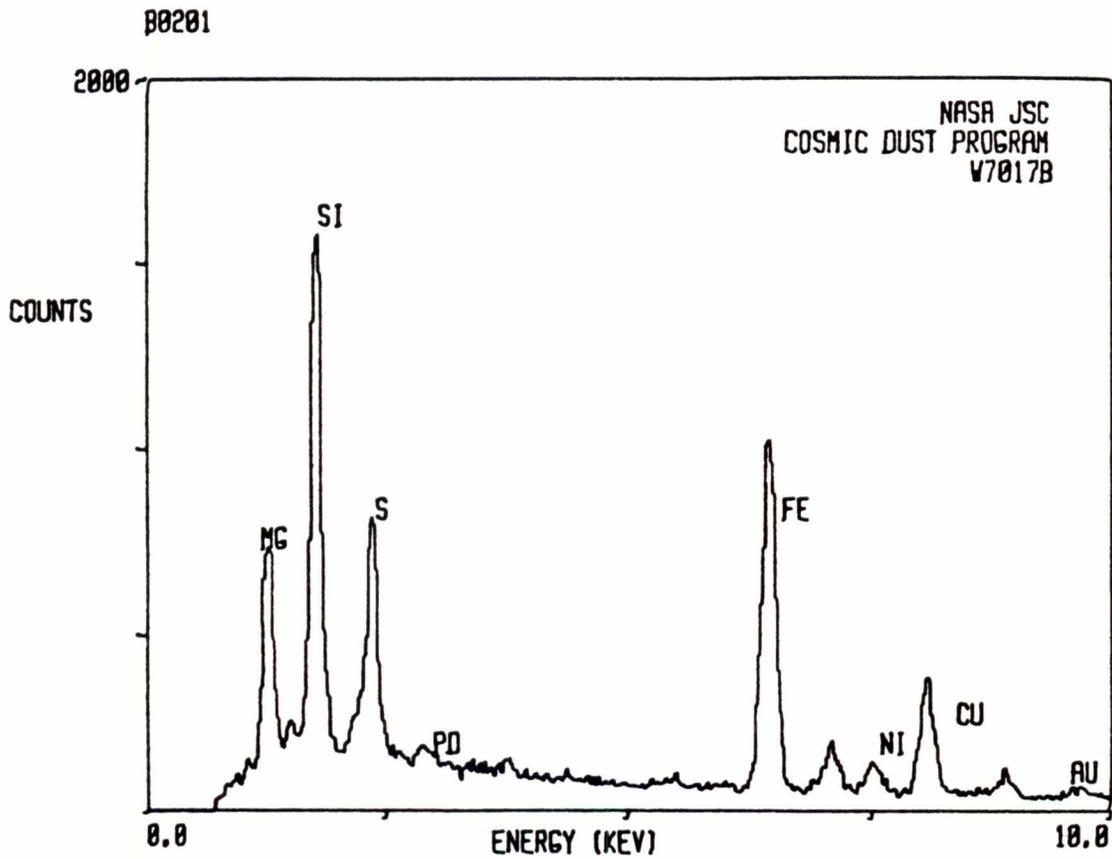


W7017B2

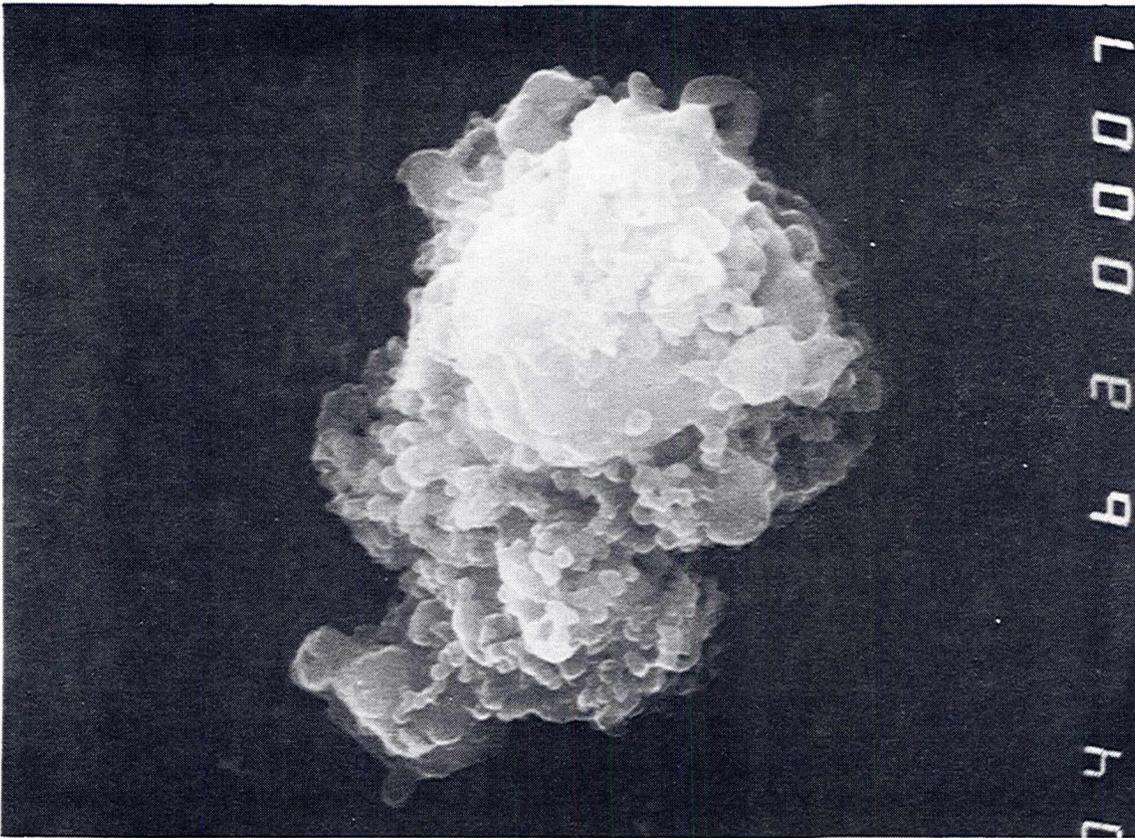


S-81-39960

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8x11	I	0	Dk. Brown/Black	SV	C	



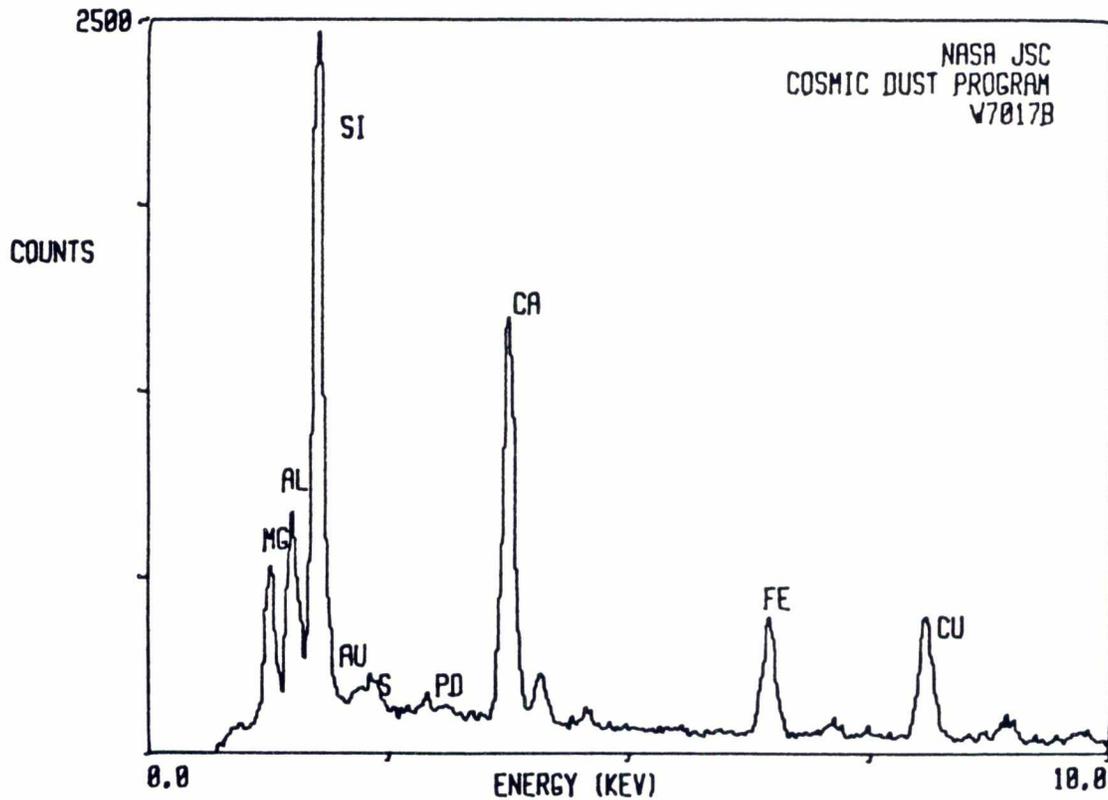
W7017B3



S-81-39959

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
5x6	I	TL	Lt. Yellow	D/SV	C	

β0301

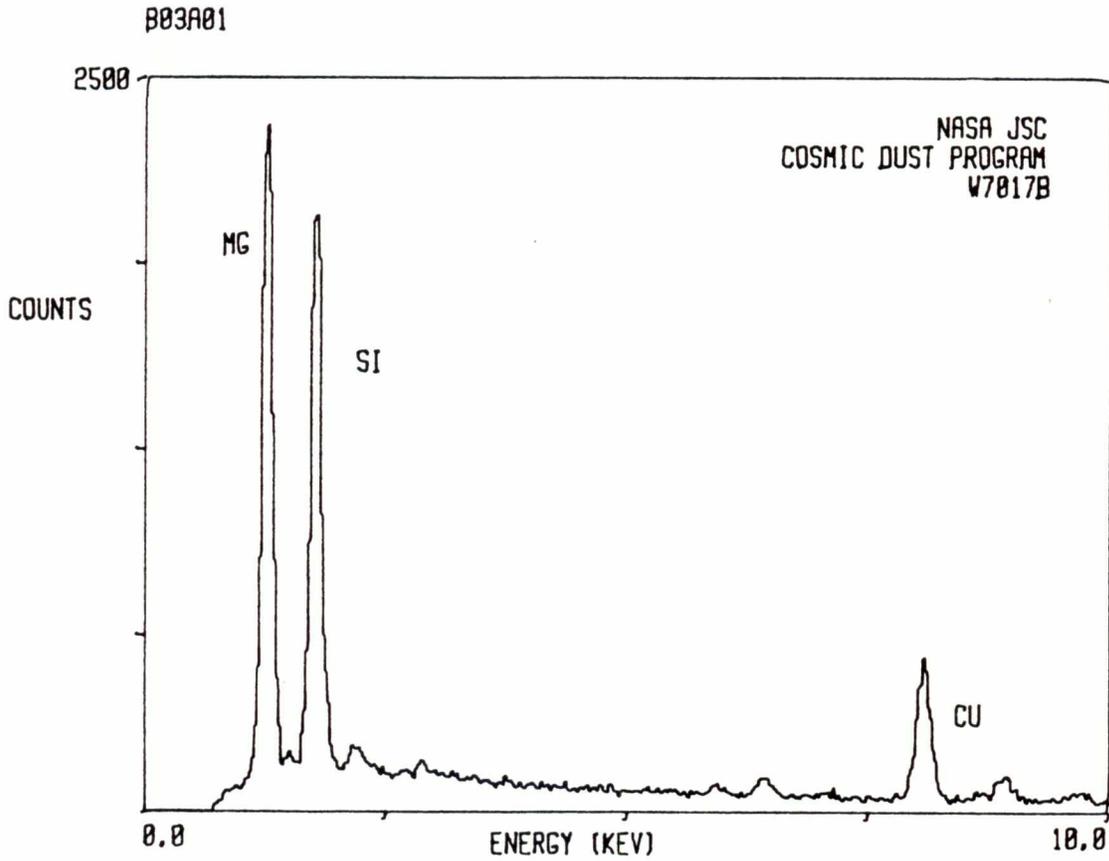


W7017B3-A

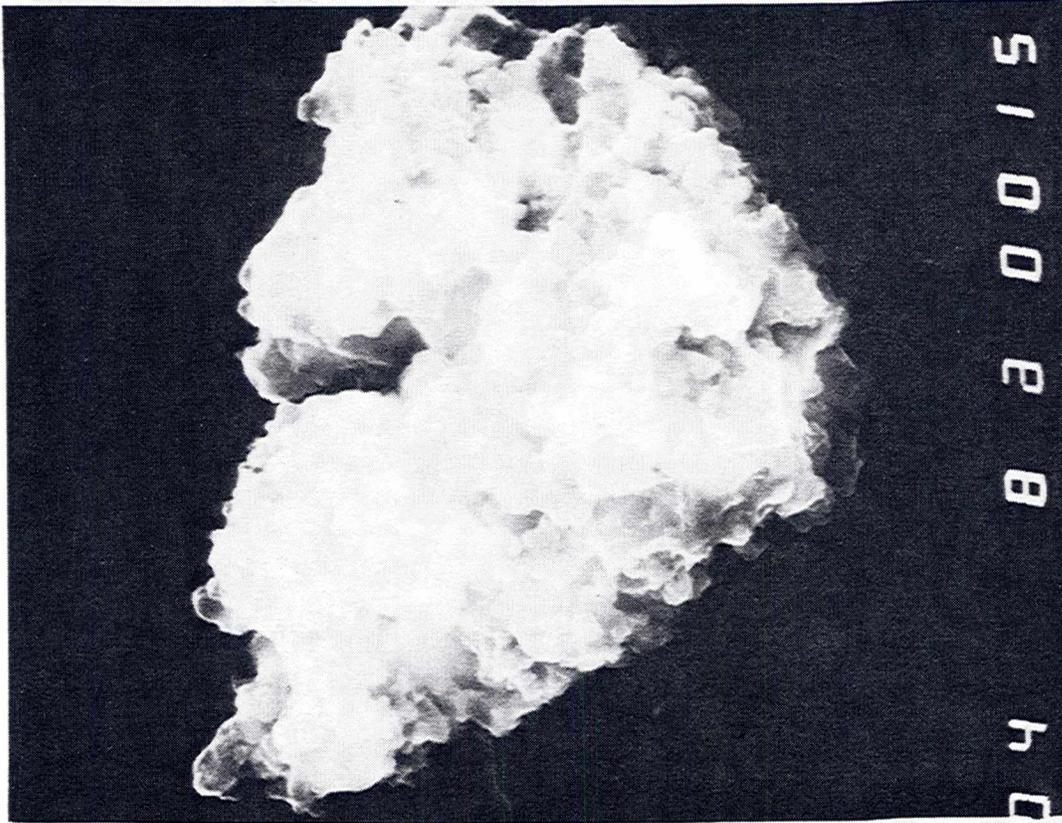
S-81-39958



<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8x12	I	TL	Lt. Yellow	D/SV	C	

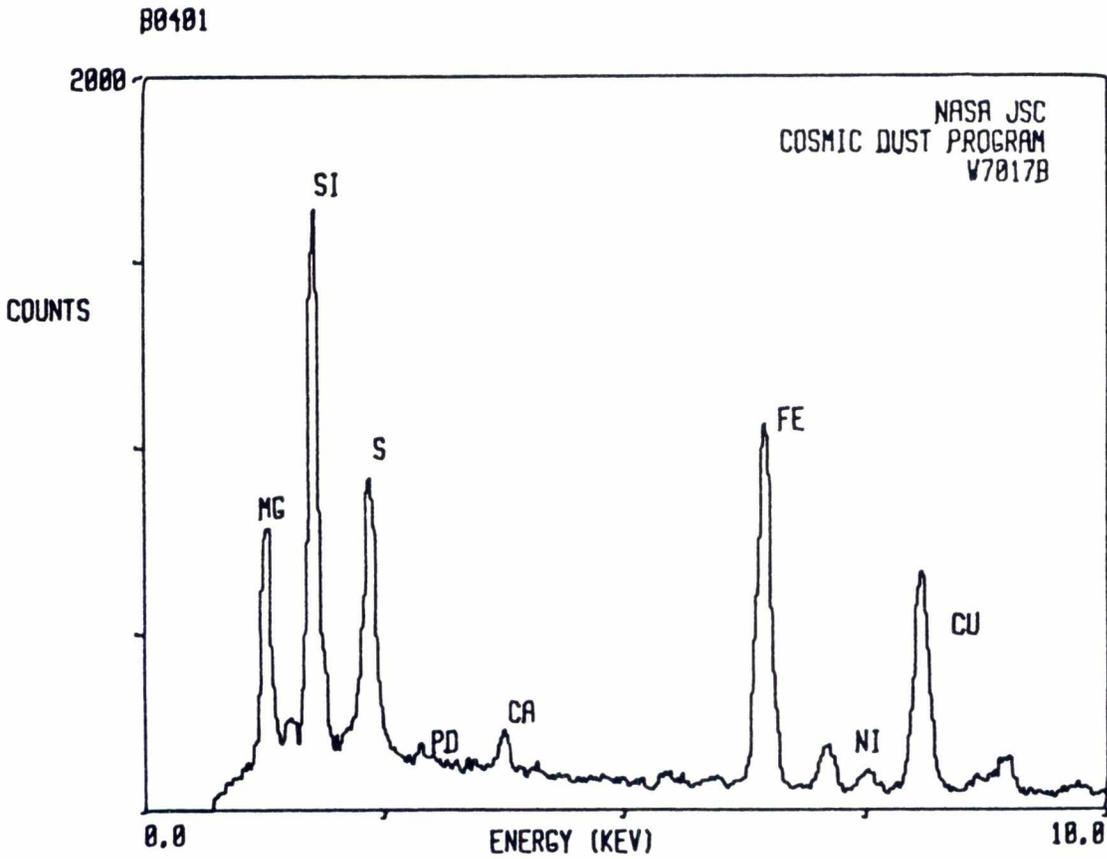


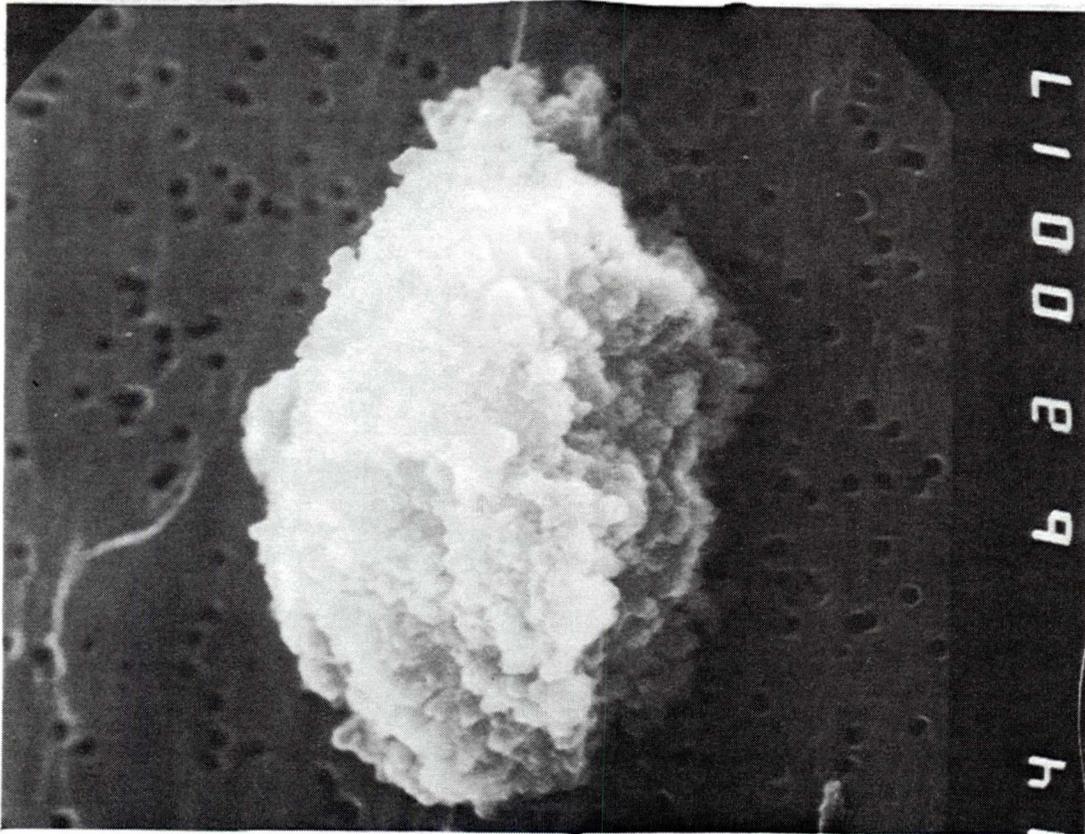
W7017B4



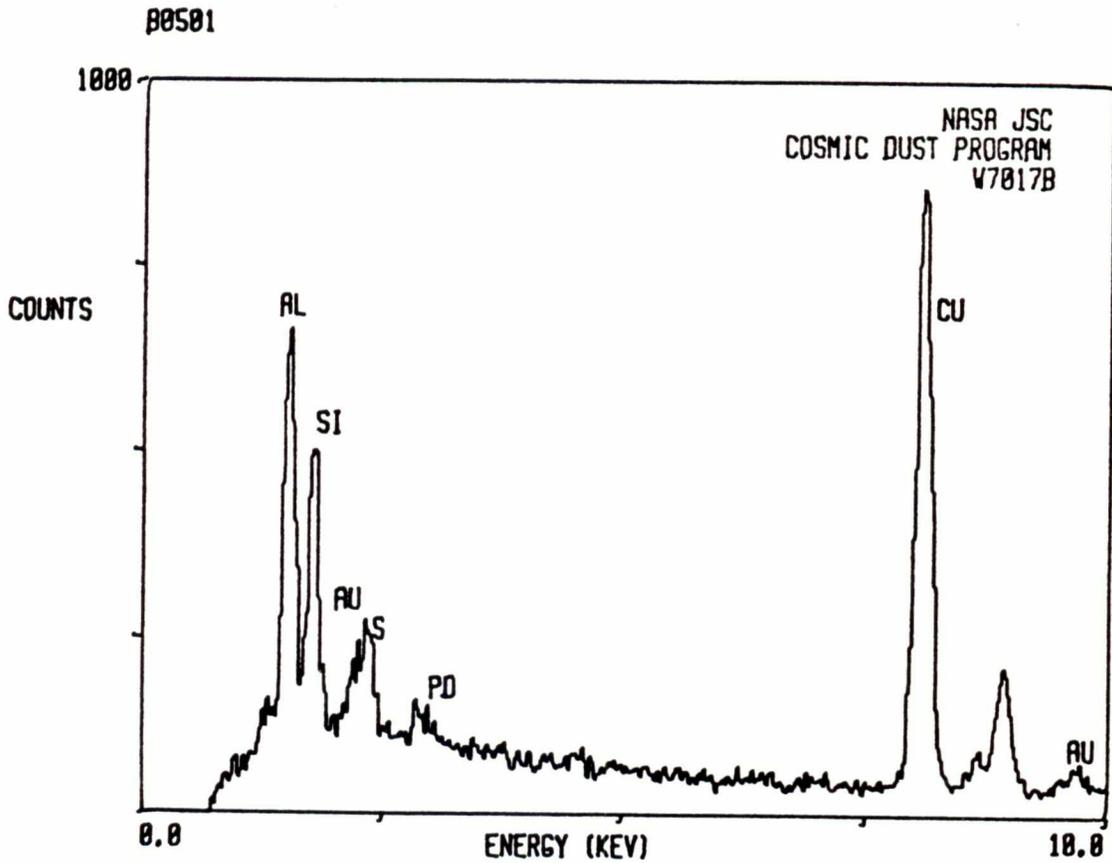
S-81-39957

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8x11	I	0	Black	D/SV	C	

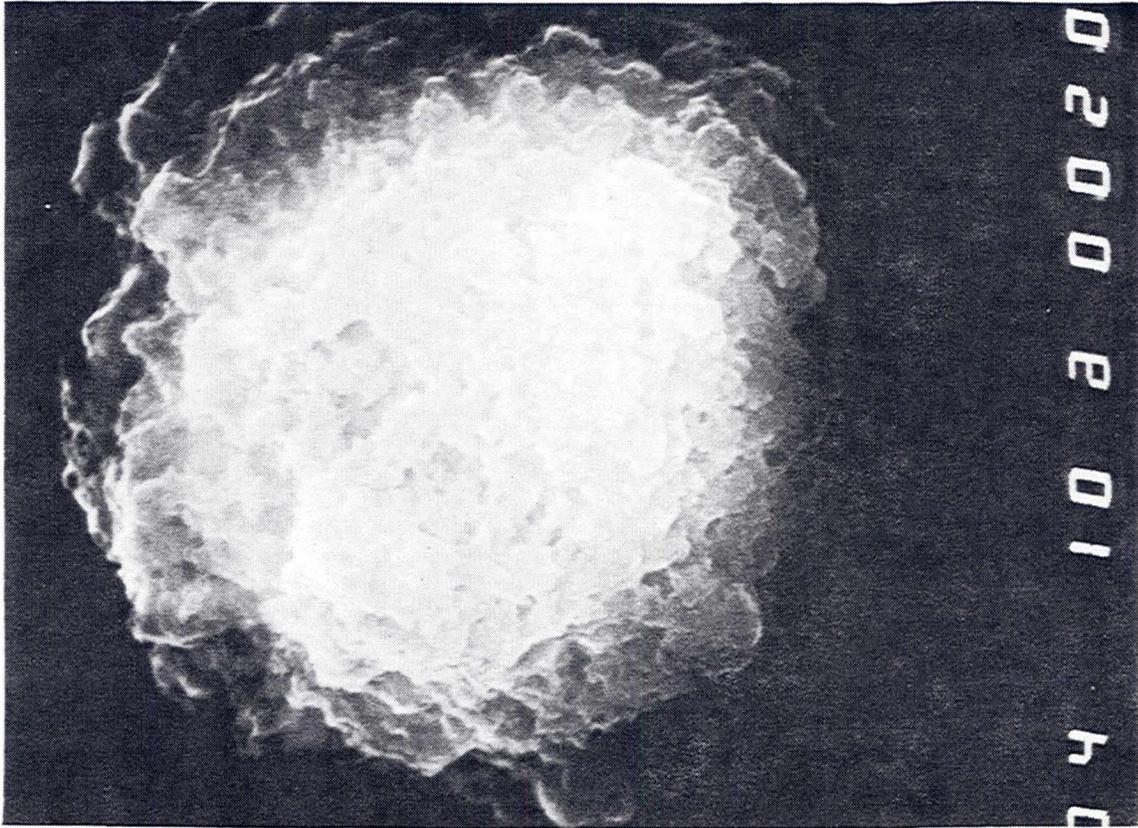




<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8x12	I	0	Black	SV	C?	

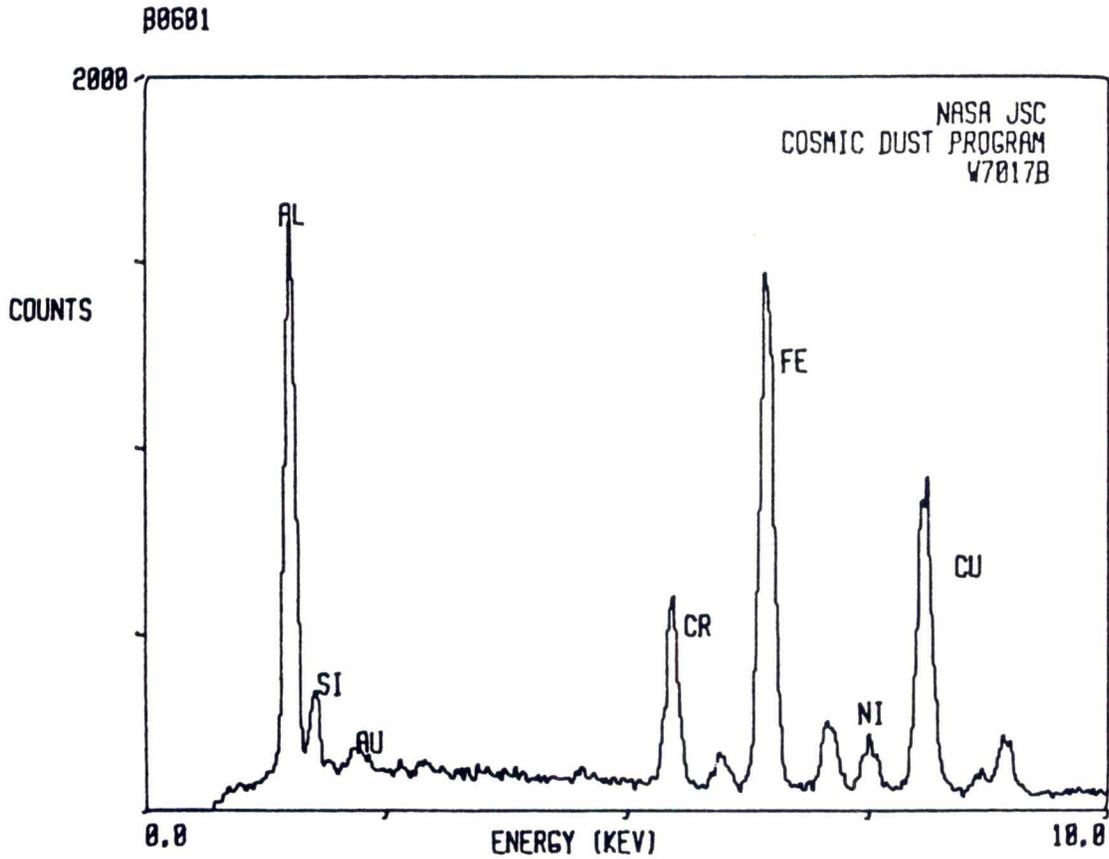


W7017B6

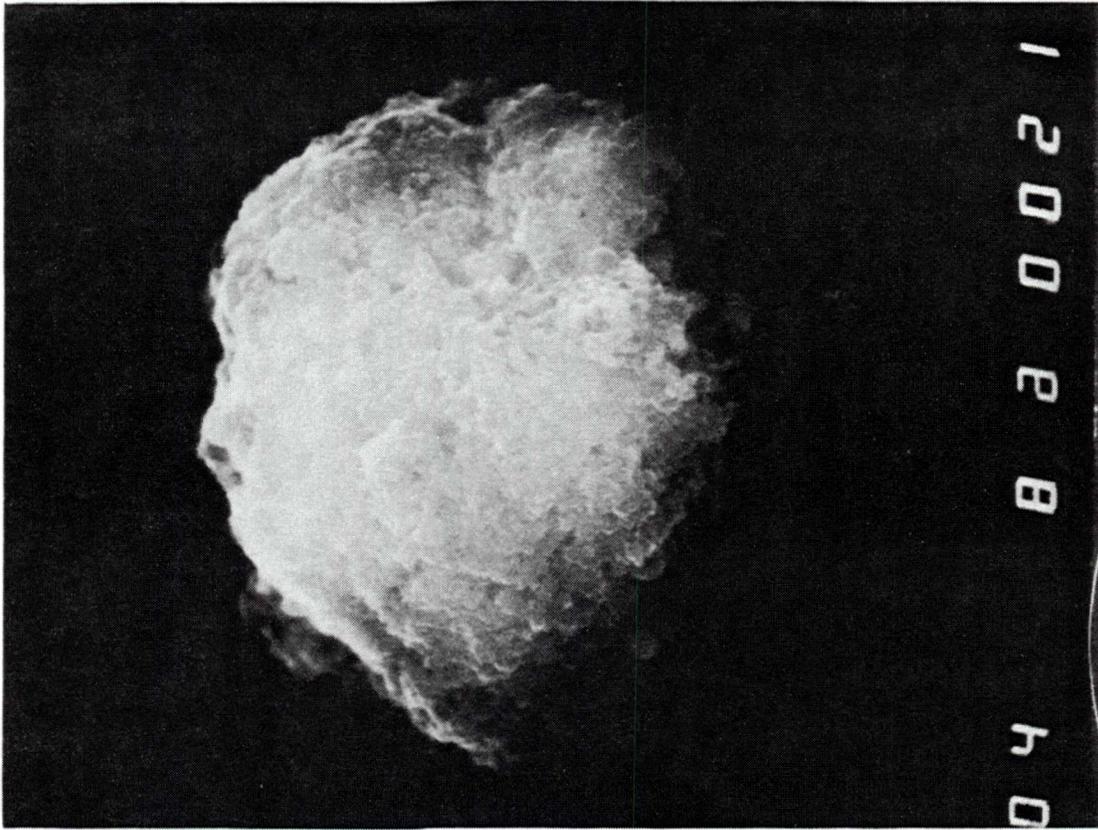


S-81-39956

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8	E	0	Black	SM	TCA	

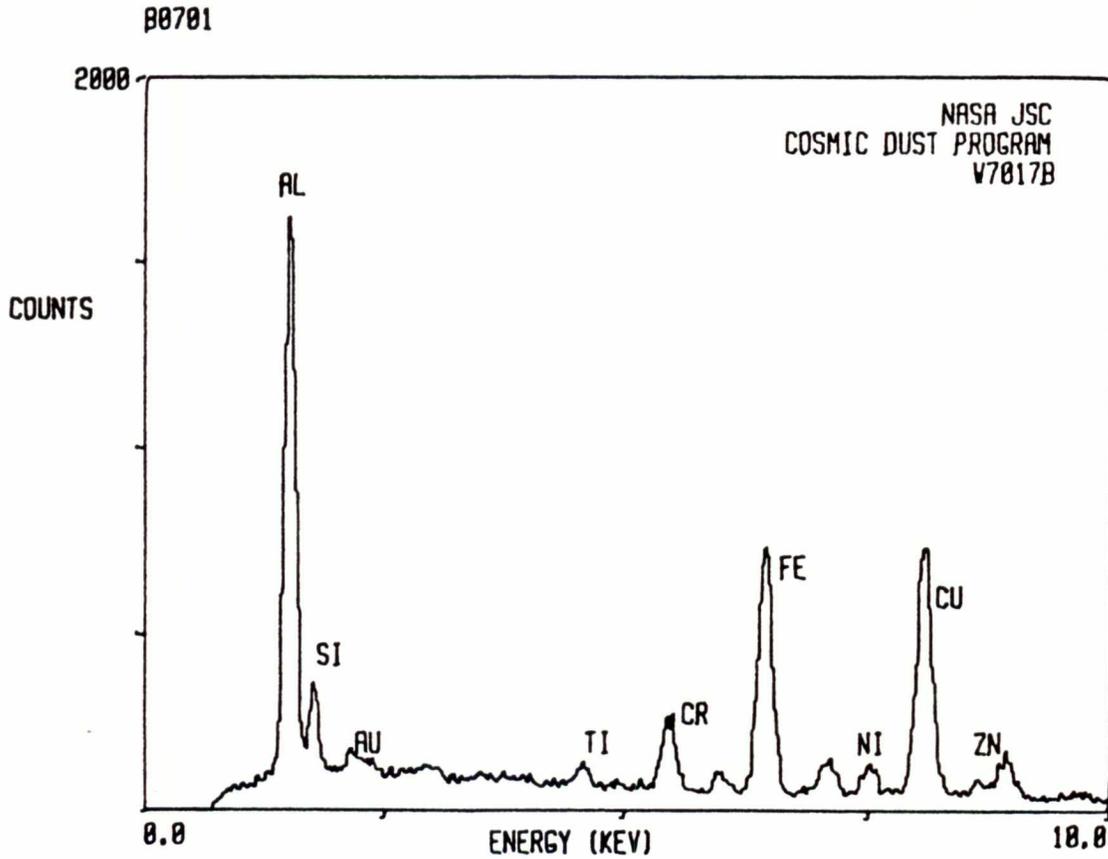


W7017B7

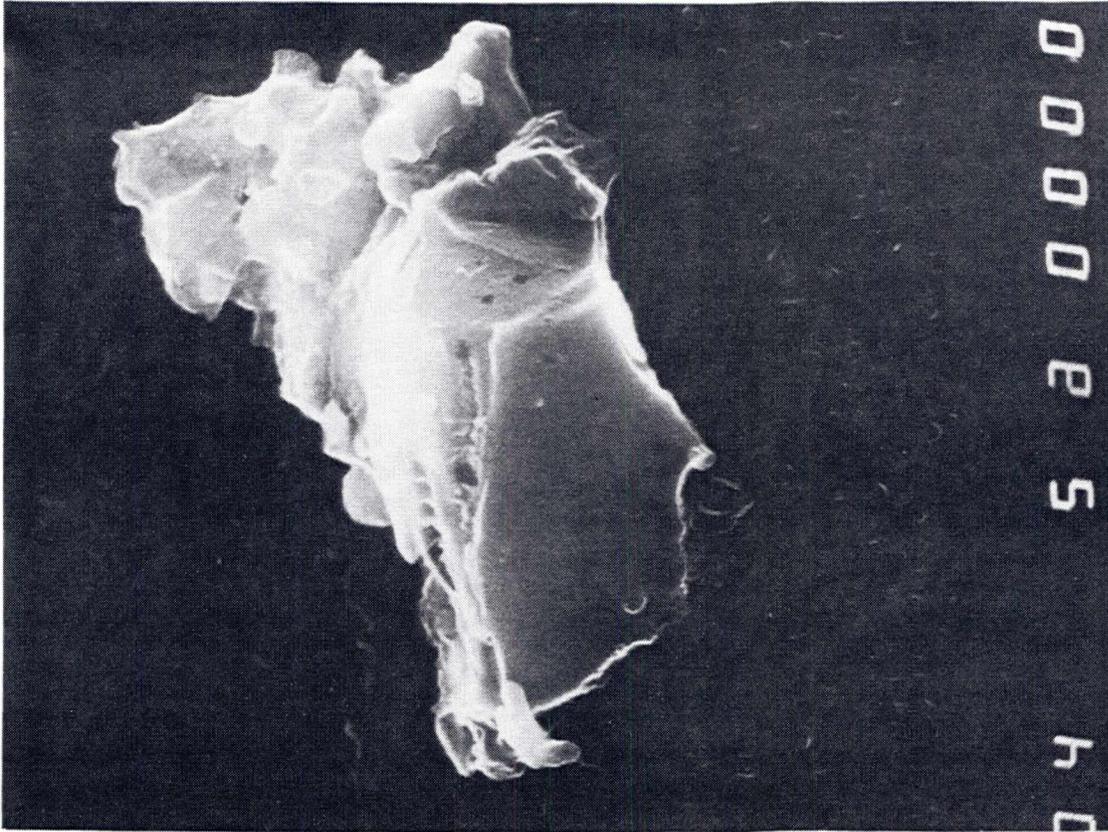


S-81-39955

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
7x8	E	0	Dk. Brown/Black with Gold Tint	SM	TCA	

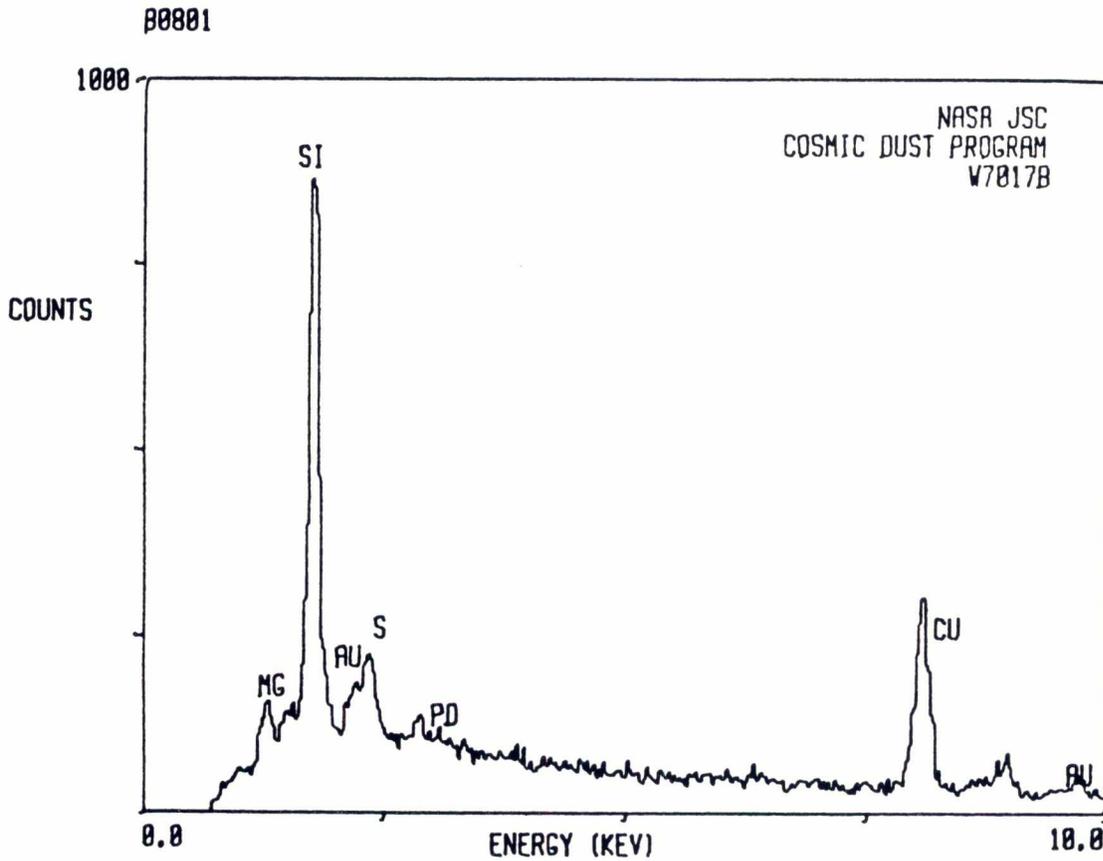


W7017B8

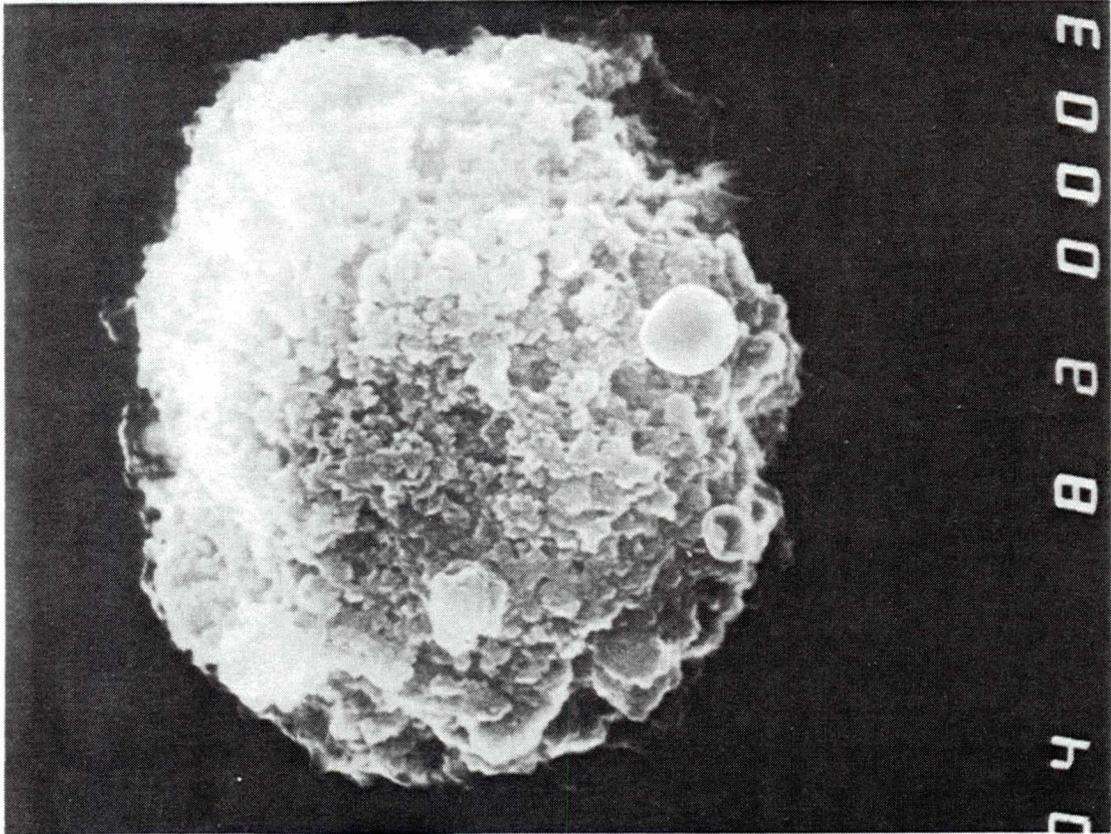


S-81-39950

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
7x14	I	0	Black	SV	TCN	

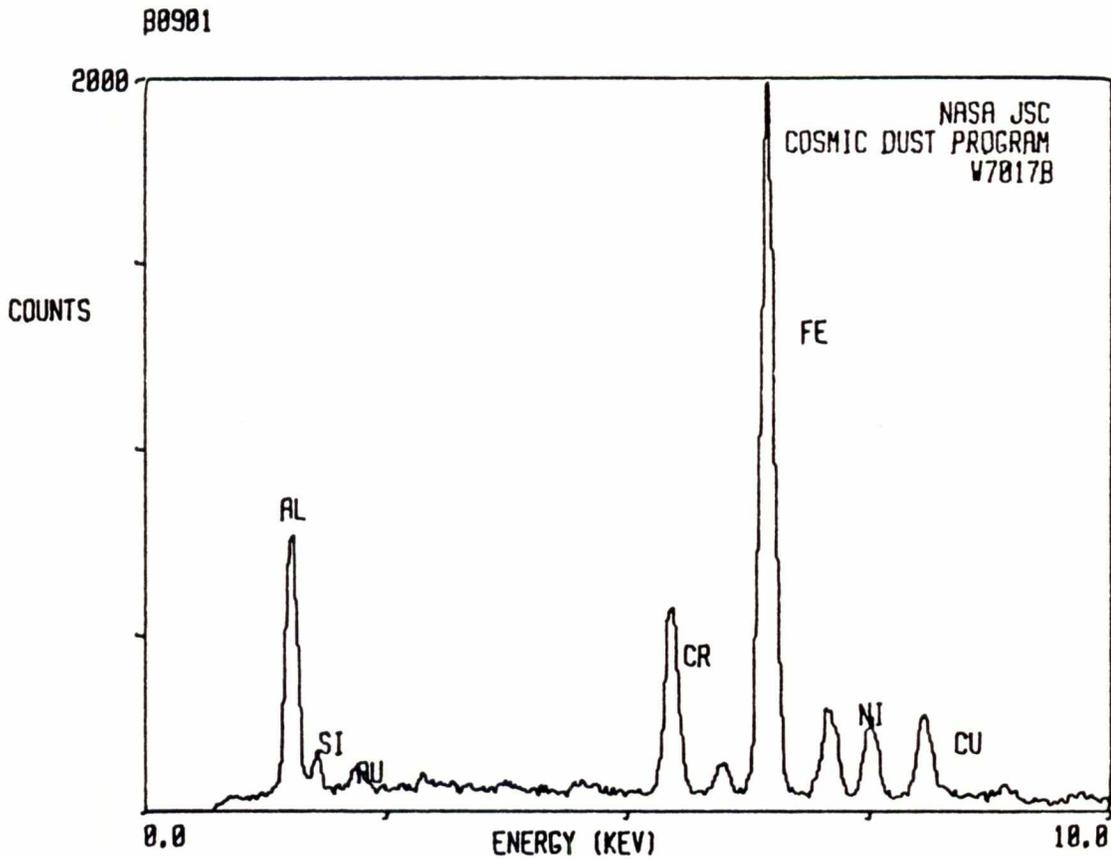


W7017B9

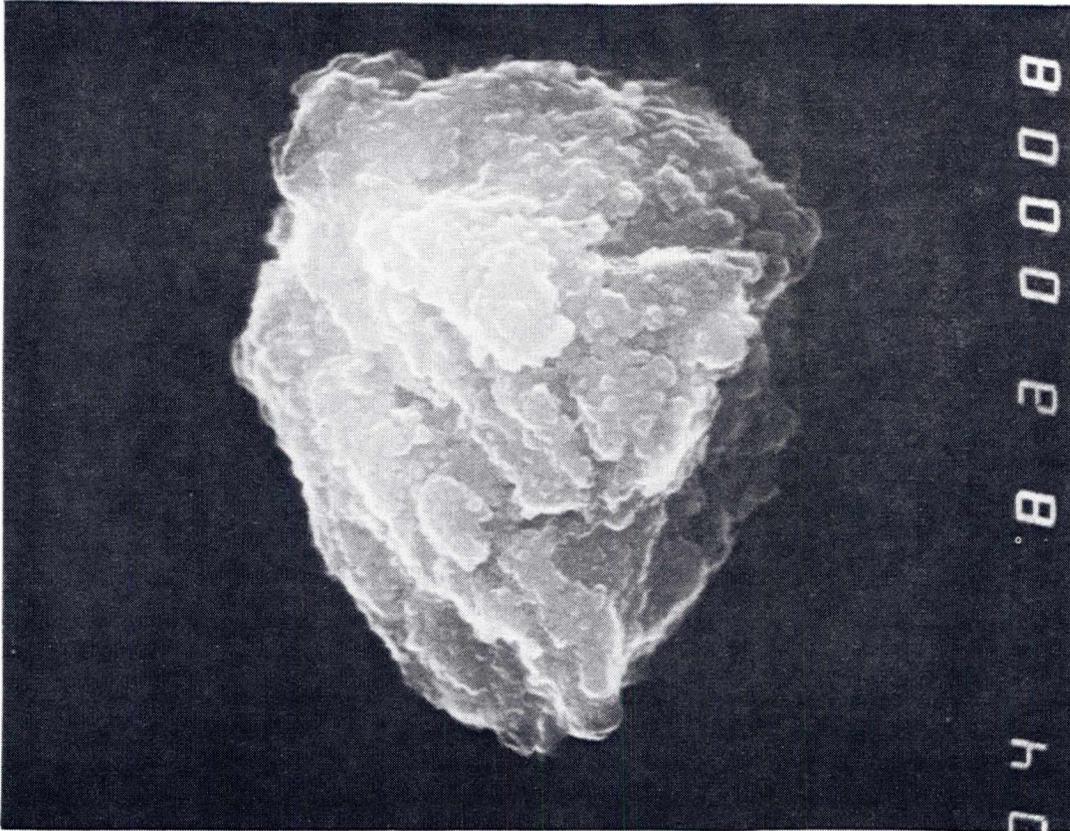


S-81-39951

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8	E	0	Dk. Brown to Black	D	TCA	

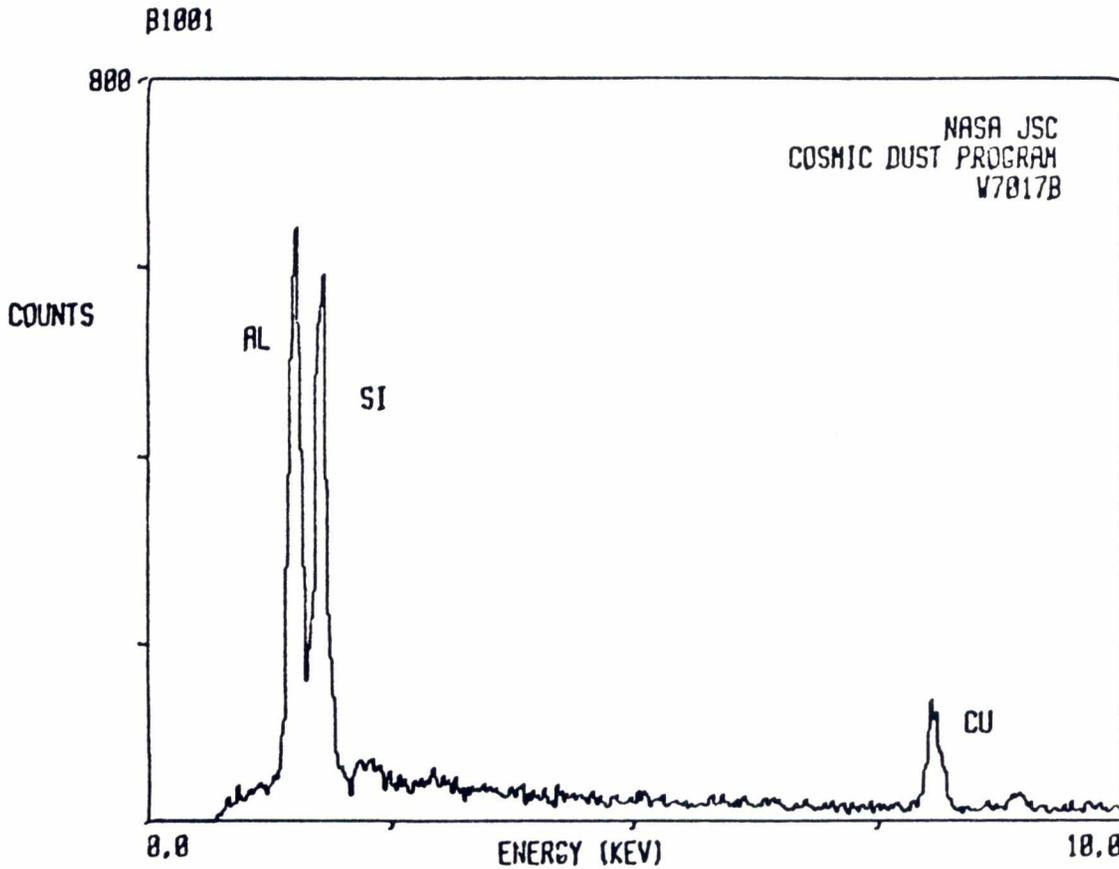


W7017B10

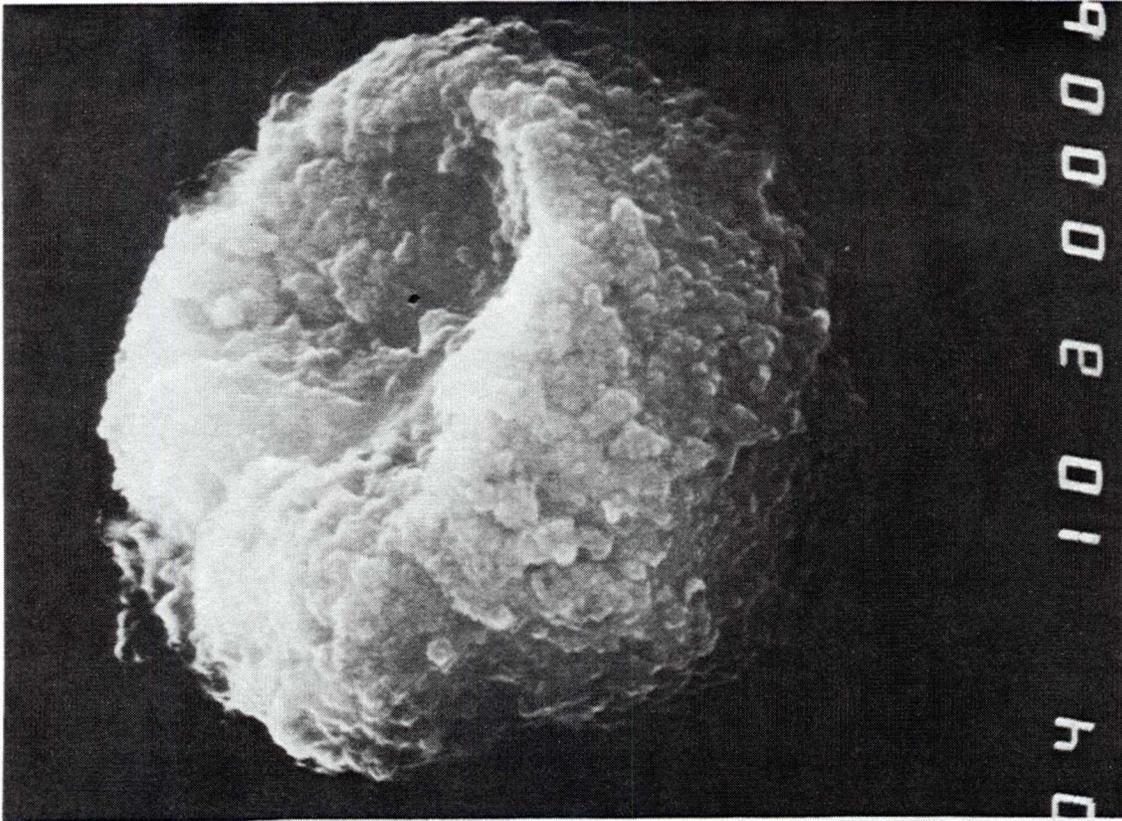


S-81-39962

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
7x9	I	0	Black	D	?	

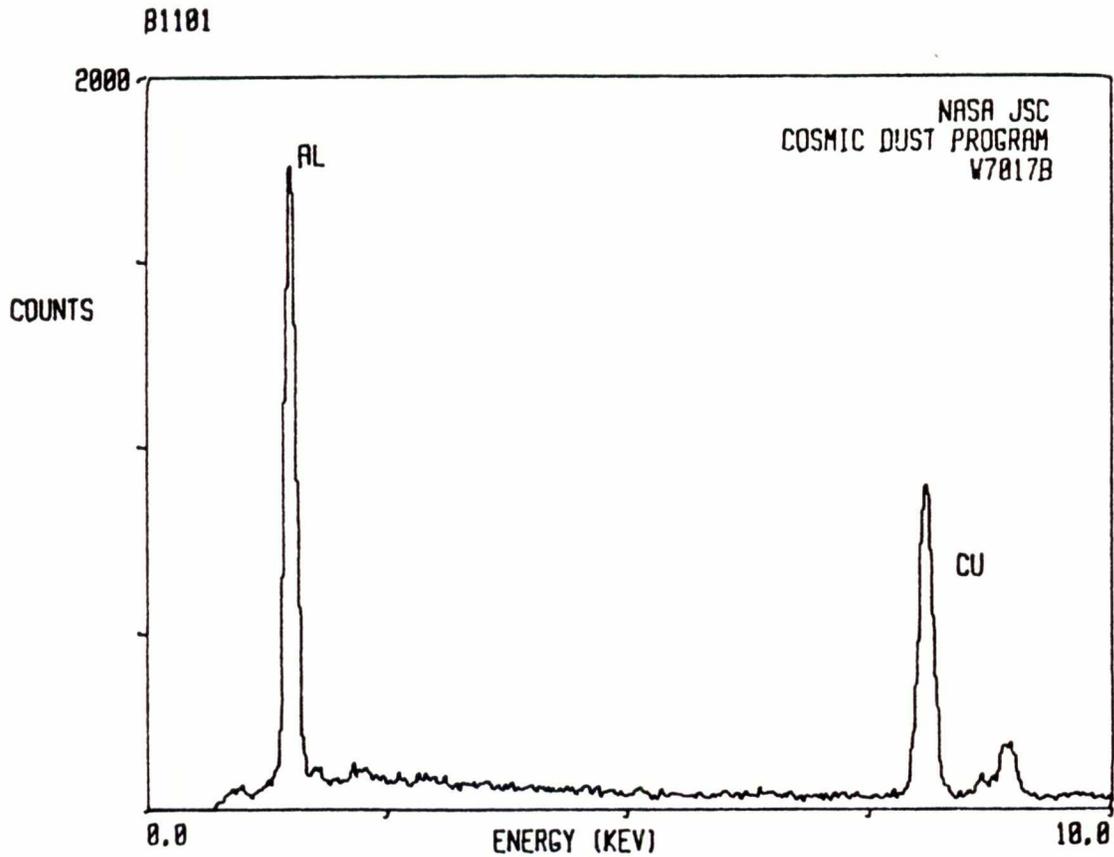


W7017B11

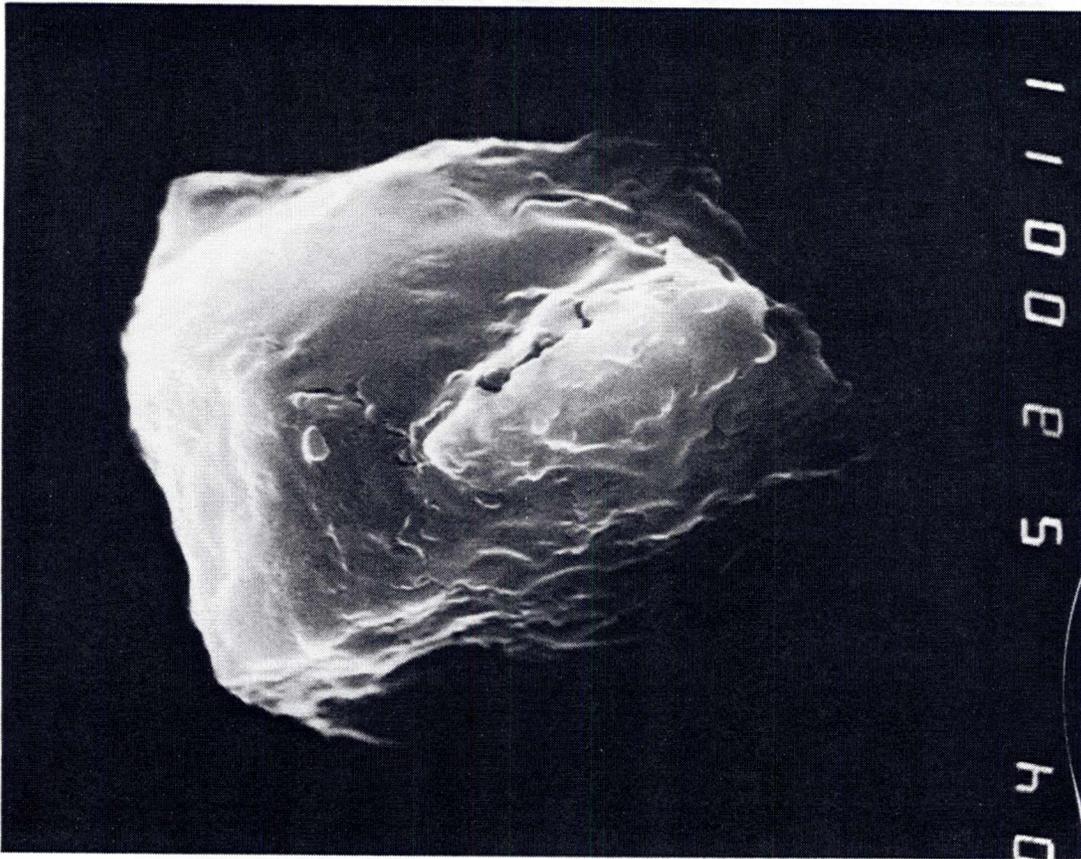


S-81-39952

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
9	E	T	Lt. Yellow	?	AOS	A1' Grain



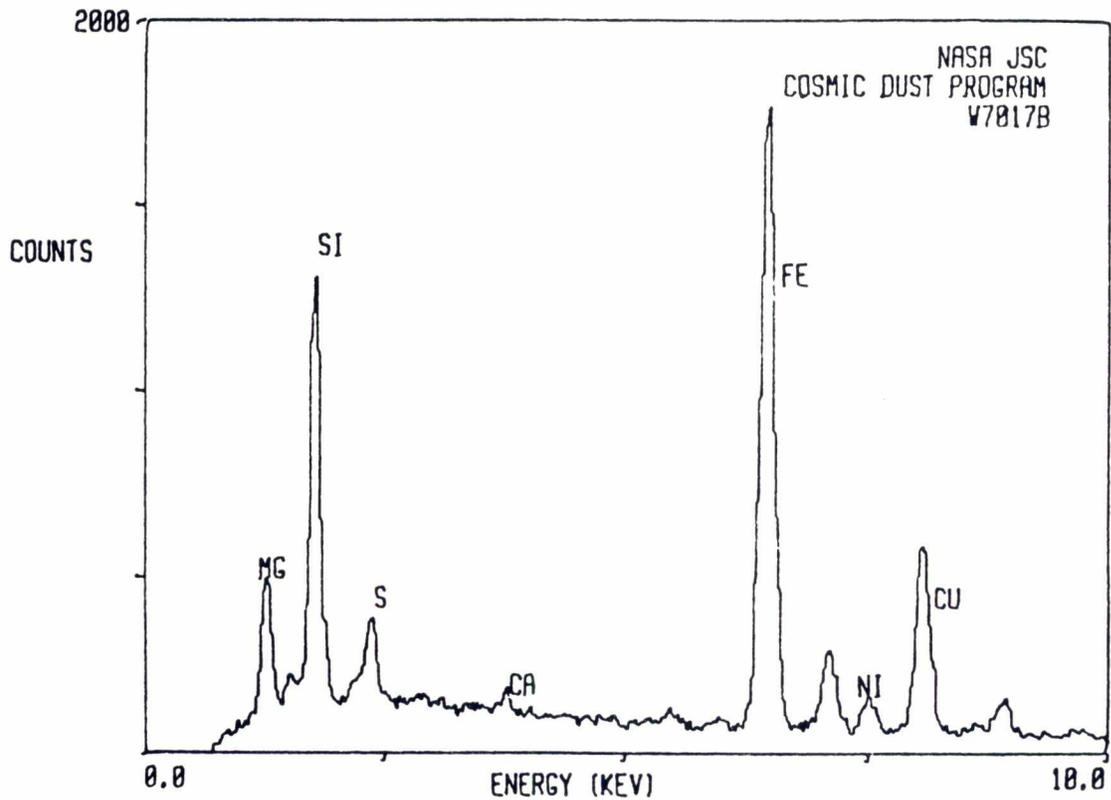
W7017B12



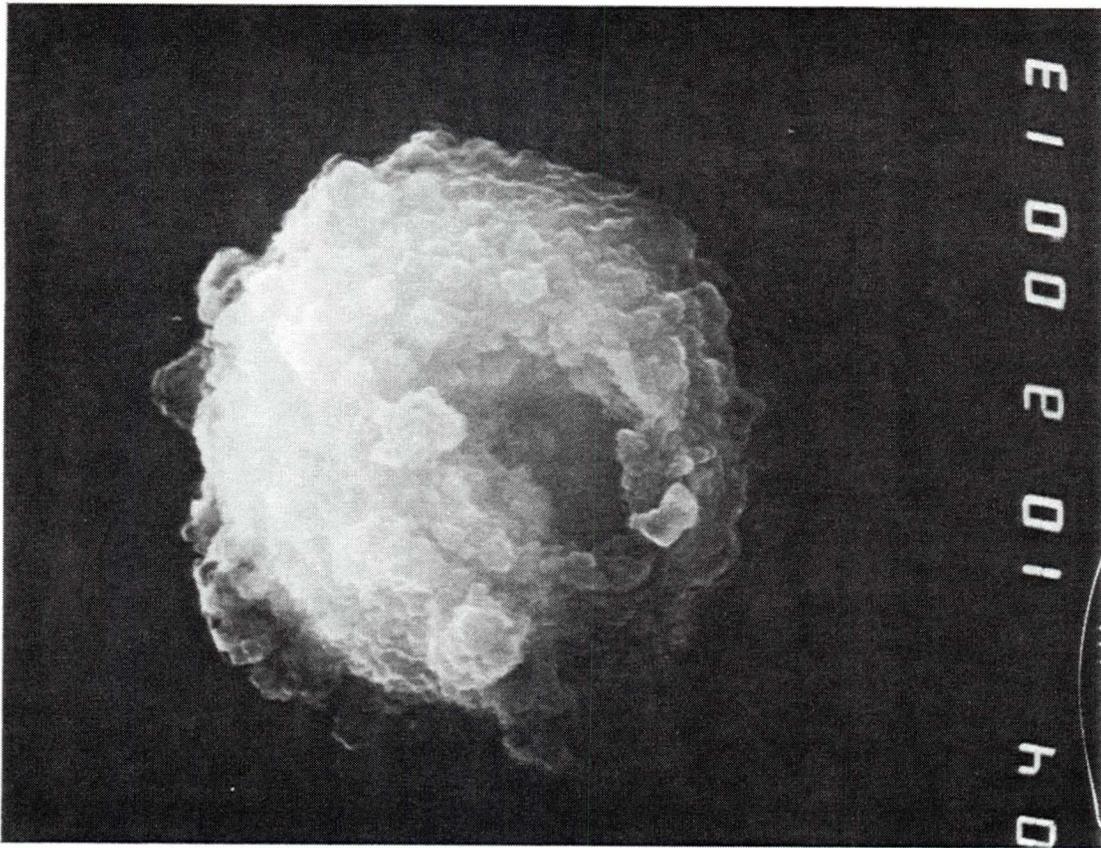
S-81-39963

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
12x13	I	0	Black	V	C	Oil on Grain?

B1201

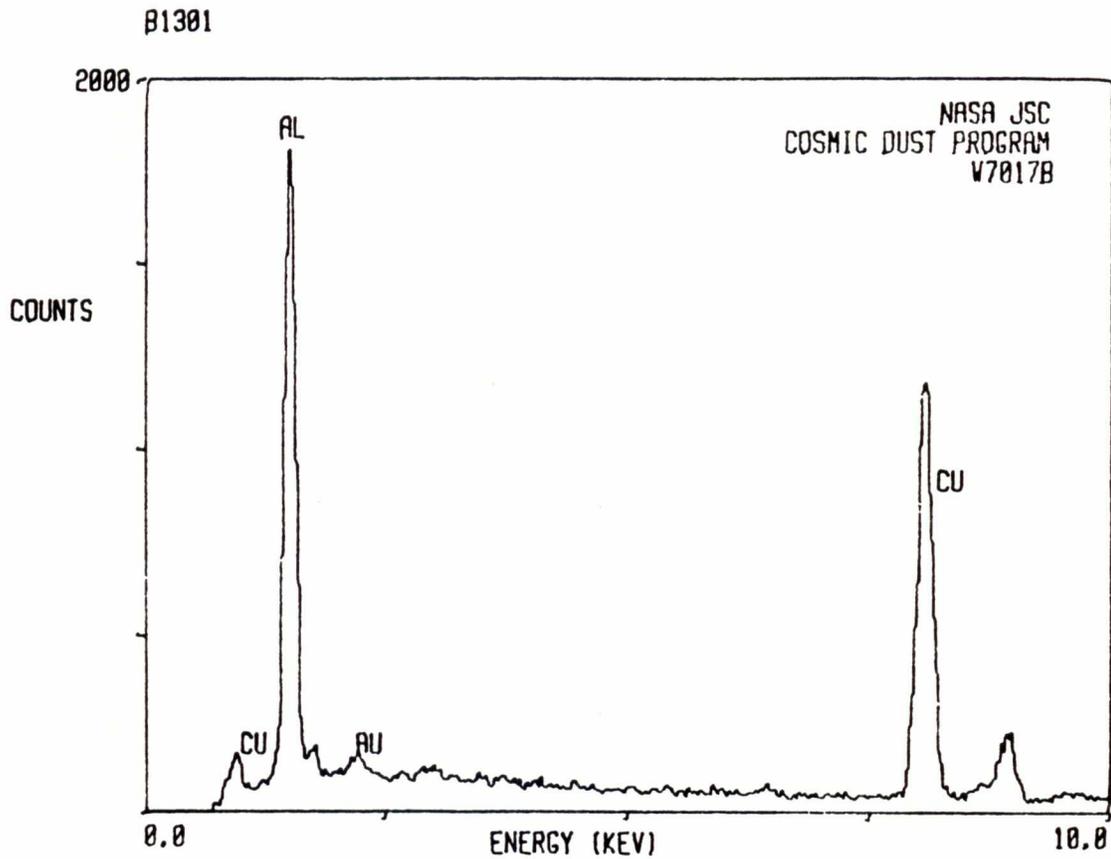


W7017B13

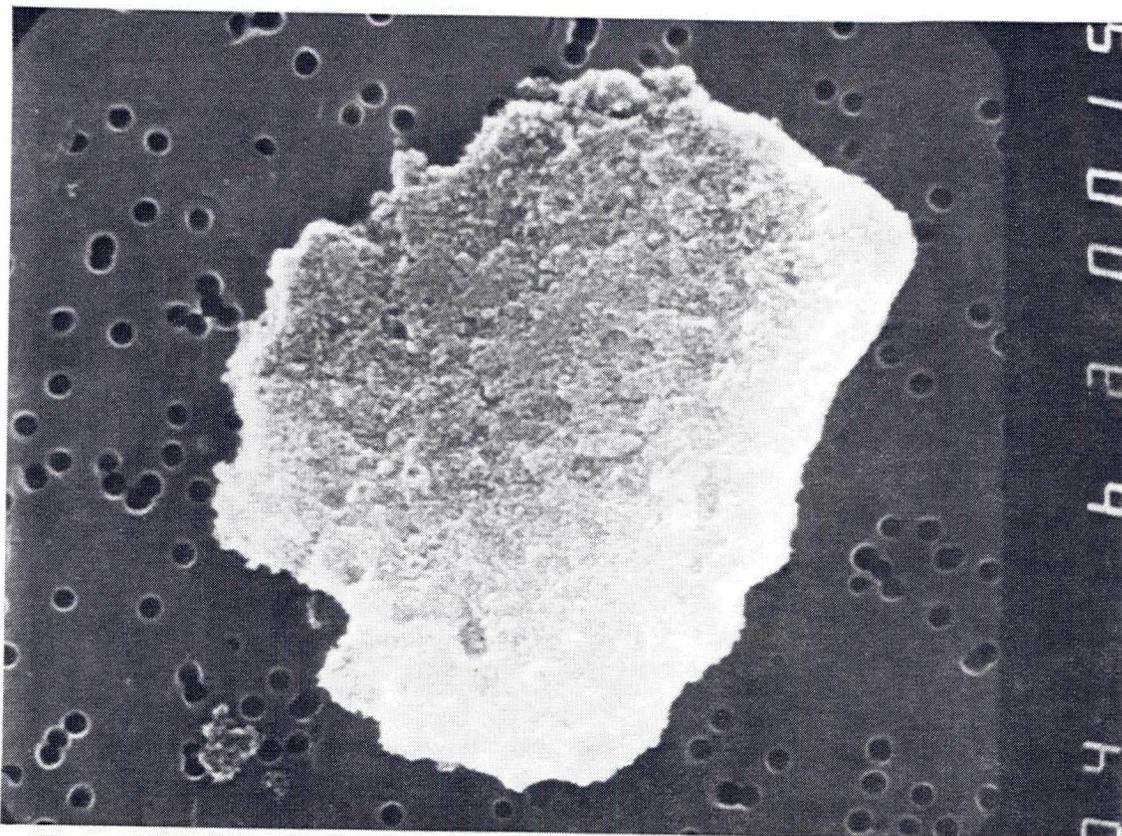


S-81-39964

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
6	S	O/T(?)	?	D/V(?)	AOS	A1' Grain

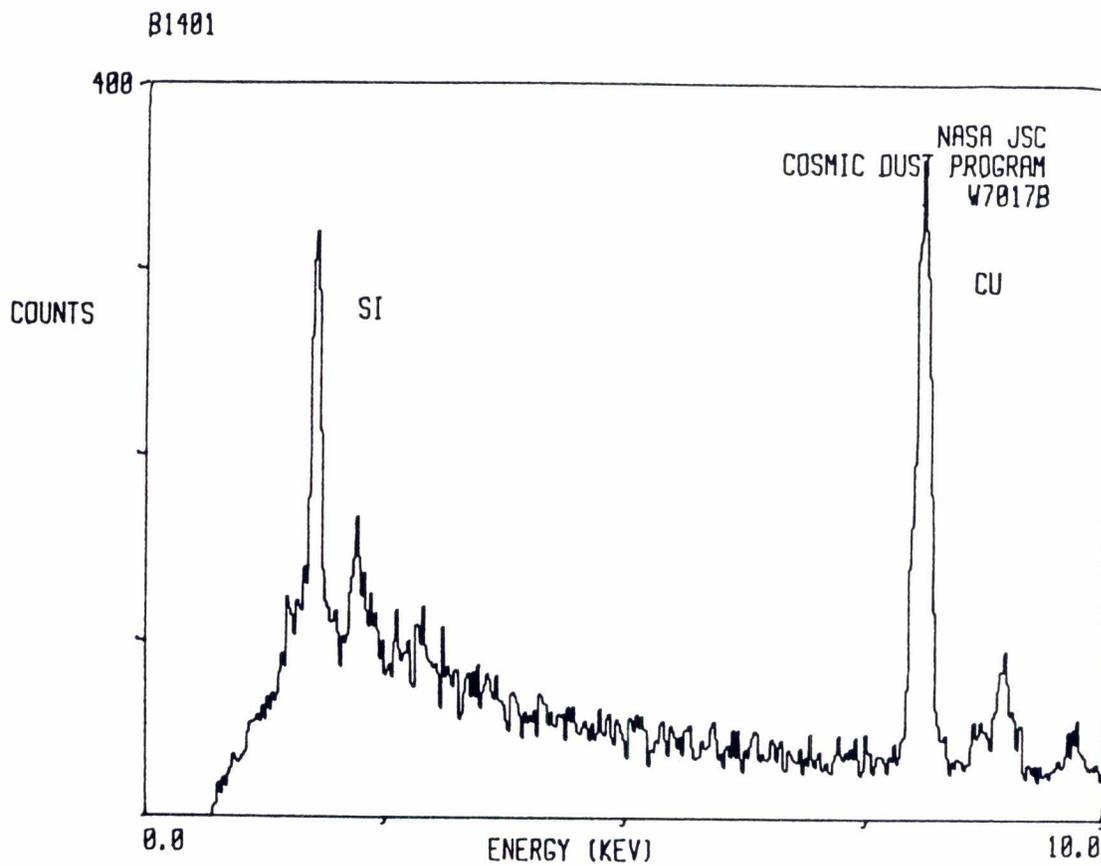


W7C17B14

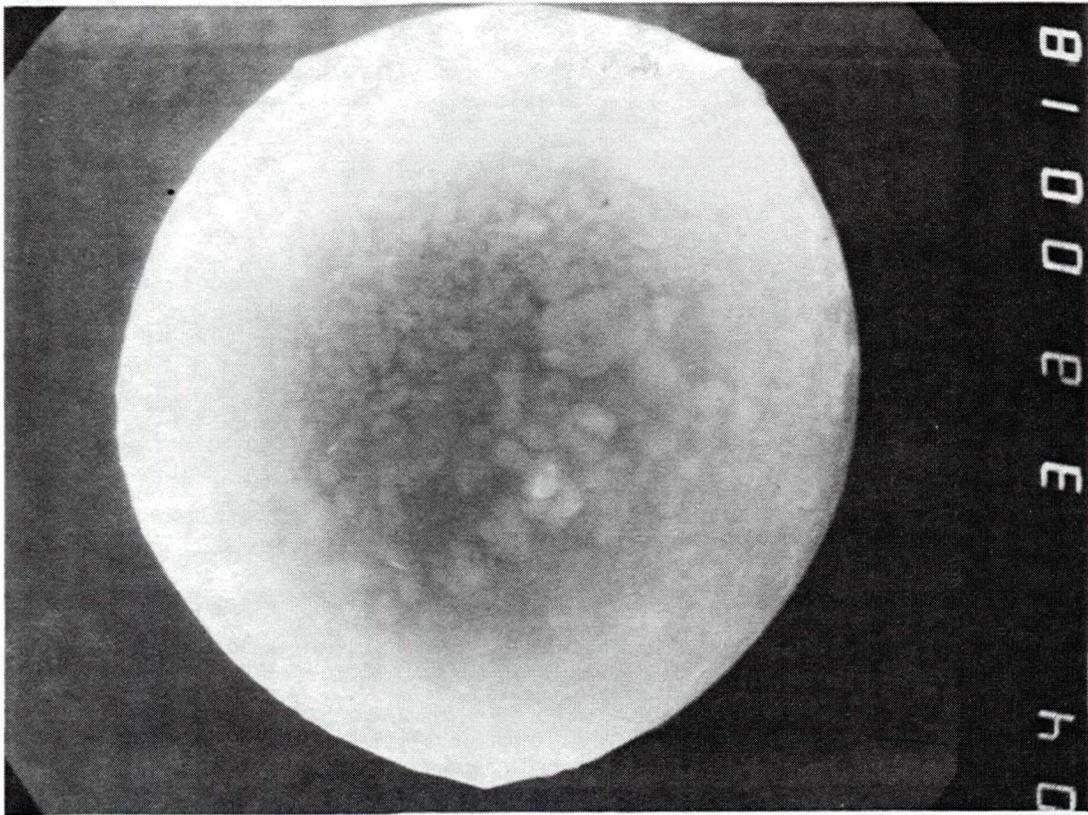


S-81-39954

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
9x11	I	0	Black	D/SV	TCA	



W7017B15

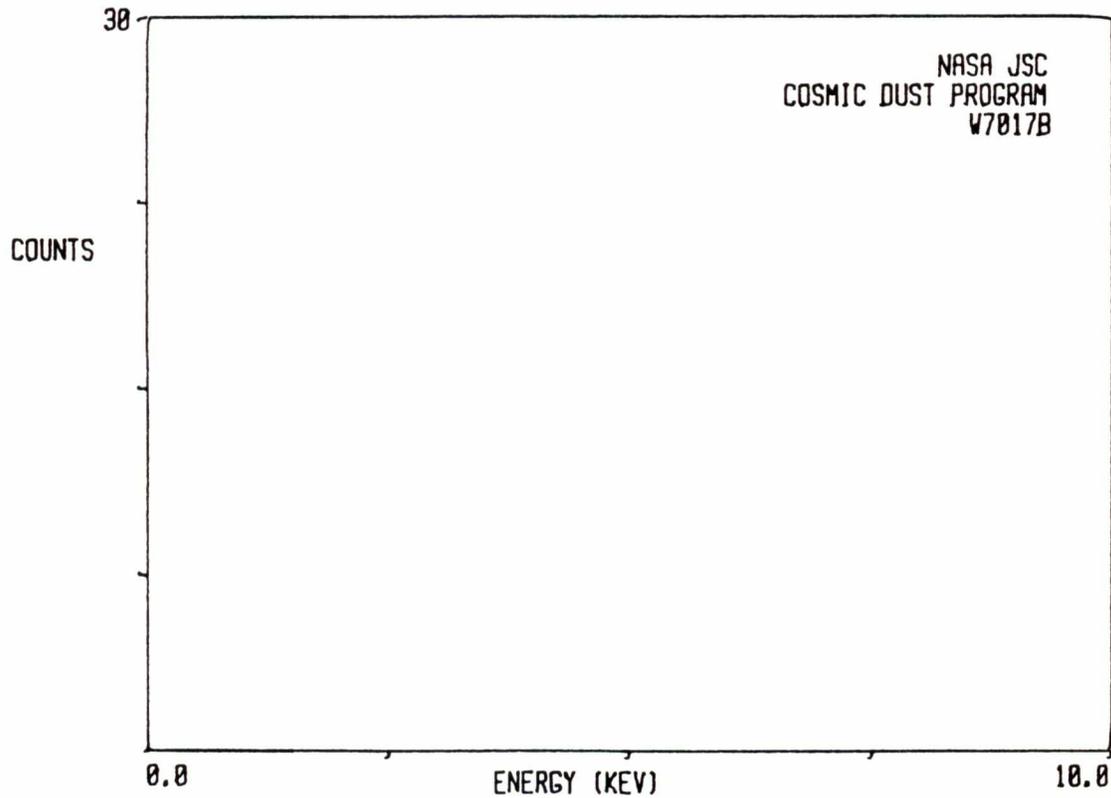


S-87-39966

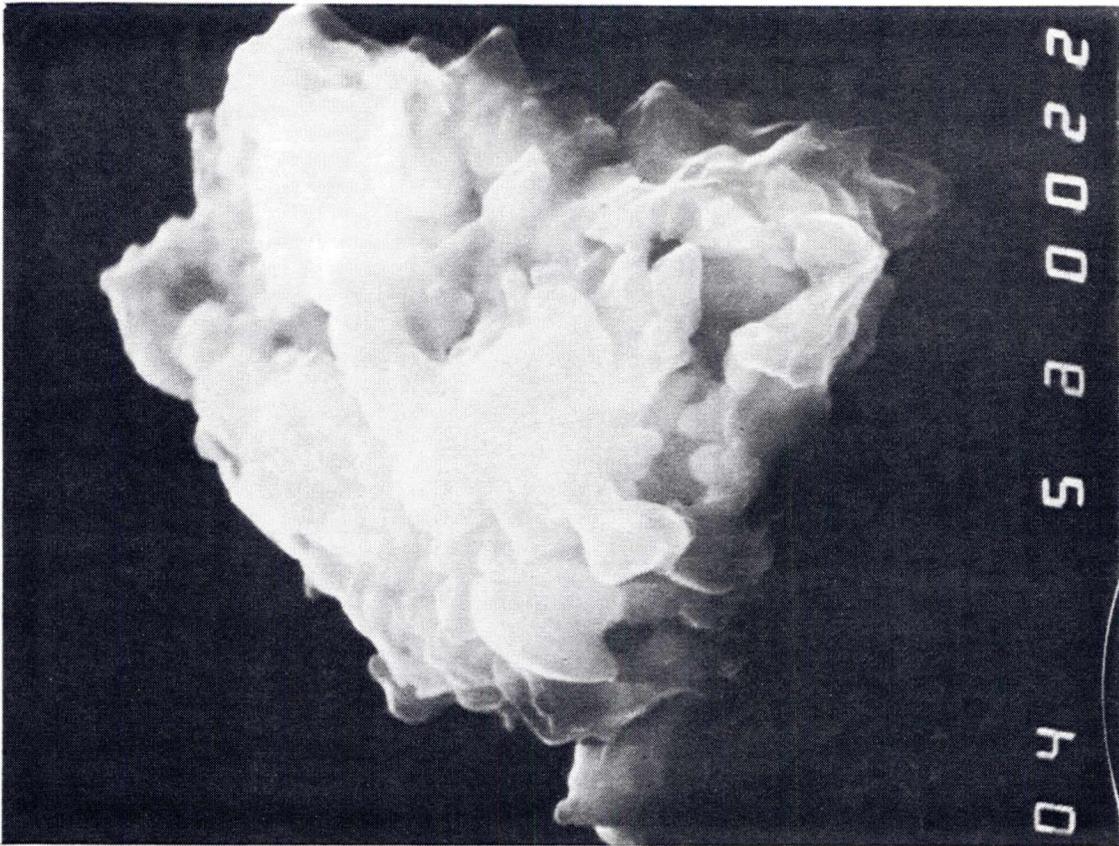
<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
24	S	0	Black	V	TCA	Lost

B1501

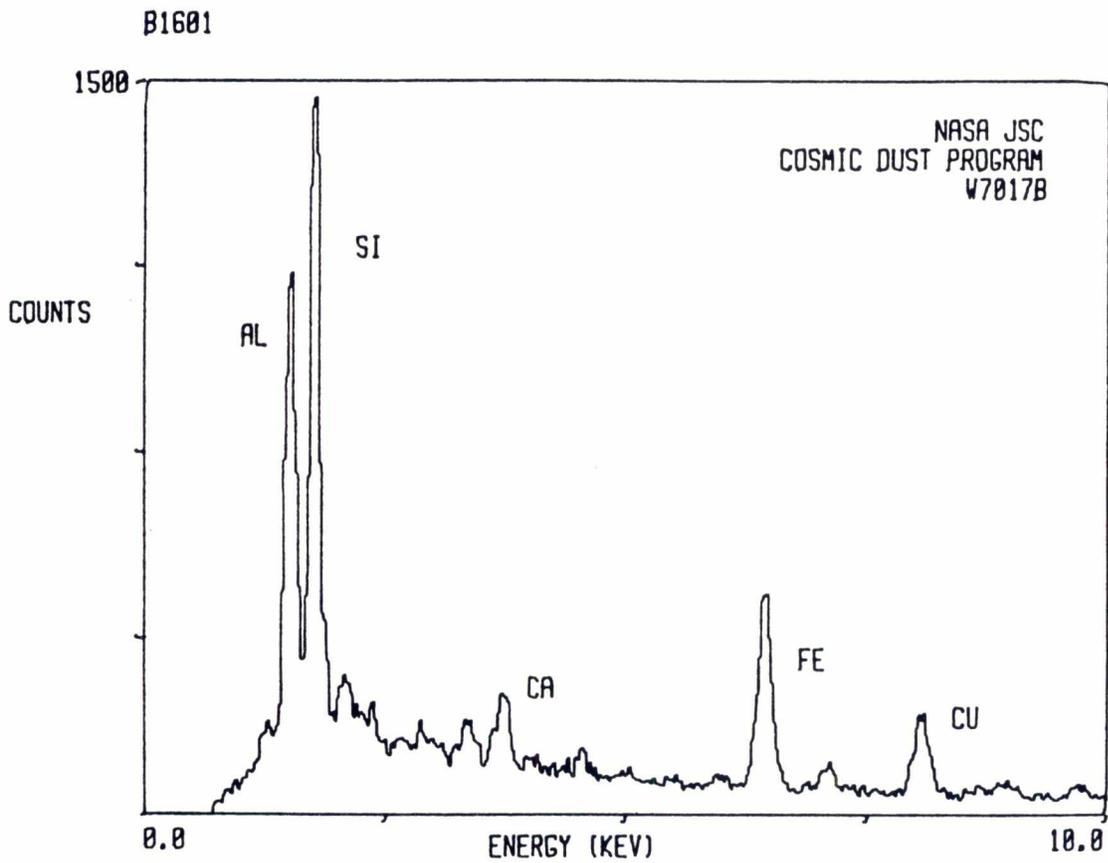
GRAIN MISSING -- 12-17-81



W7017B16



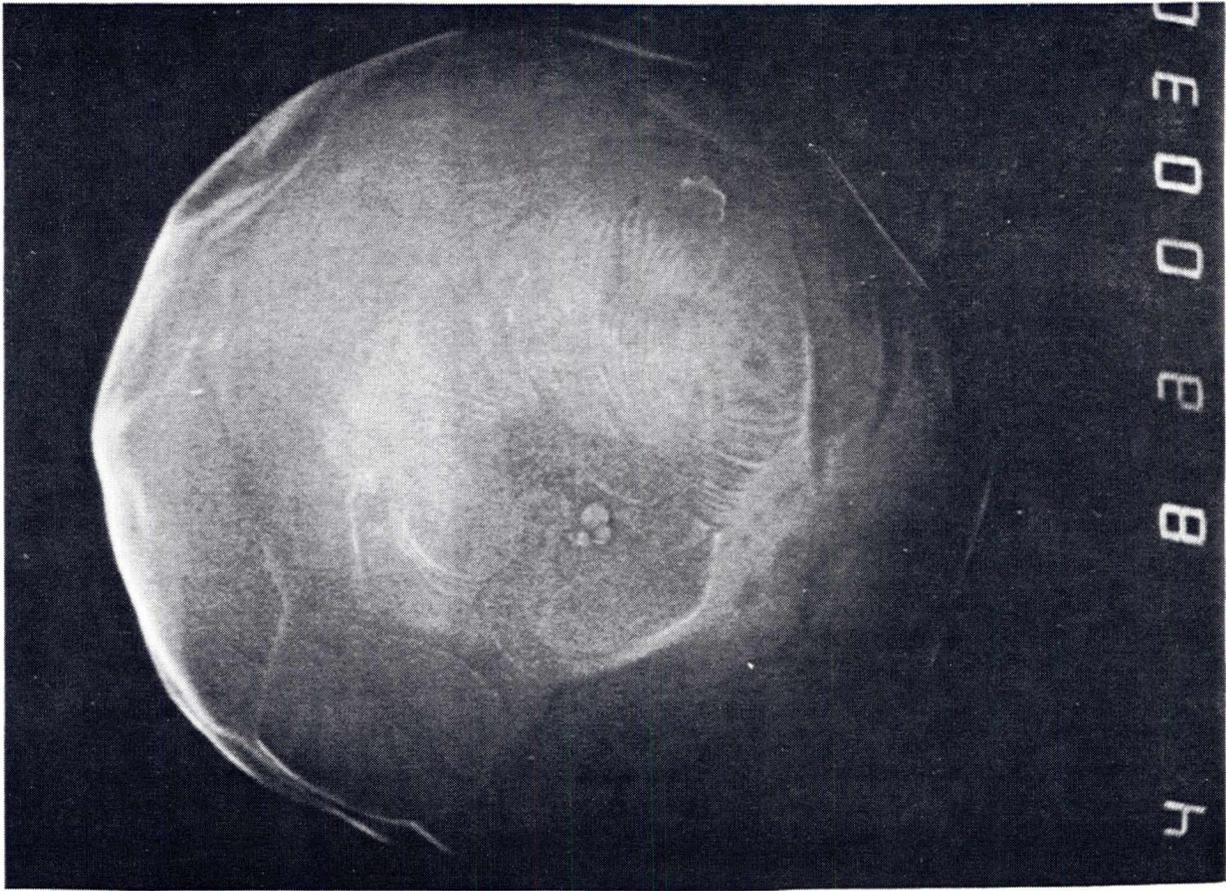
<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
13x17	I	TL	White with Pink-Brown Area	?	TCN	



MOUNT W7017C

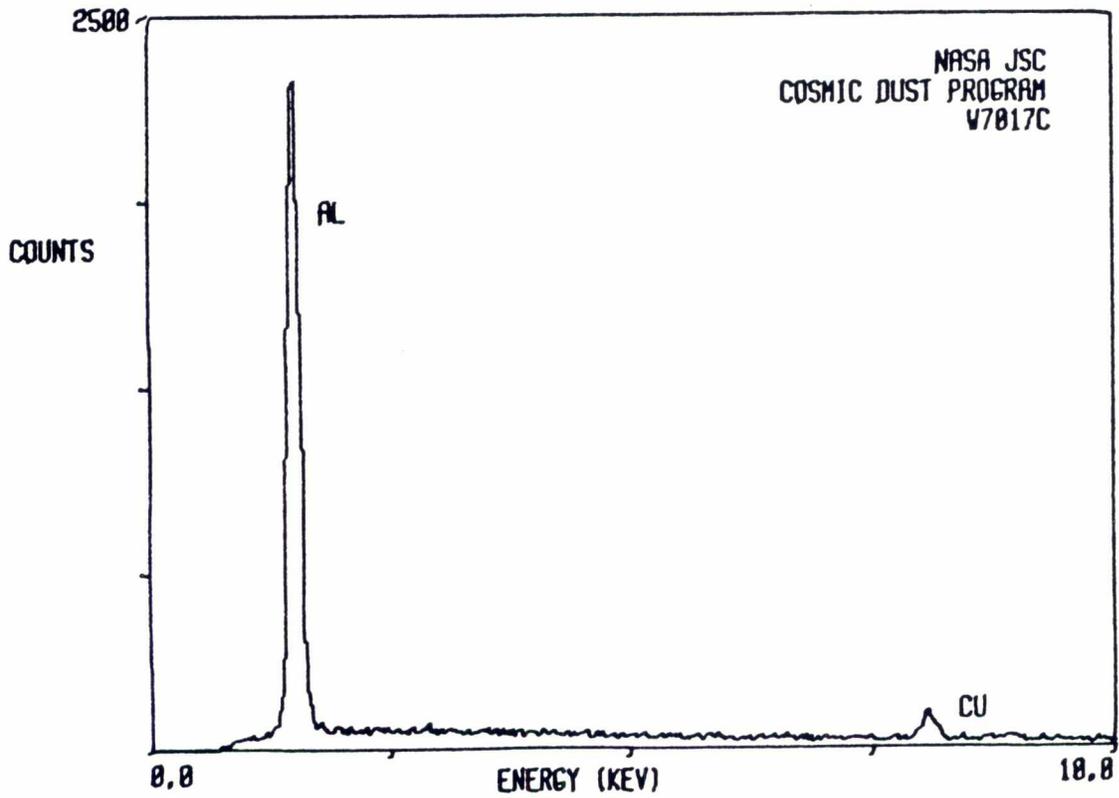
W7017C1

S-81-40486

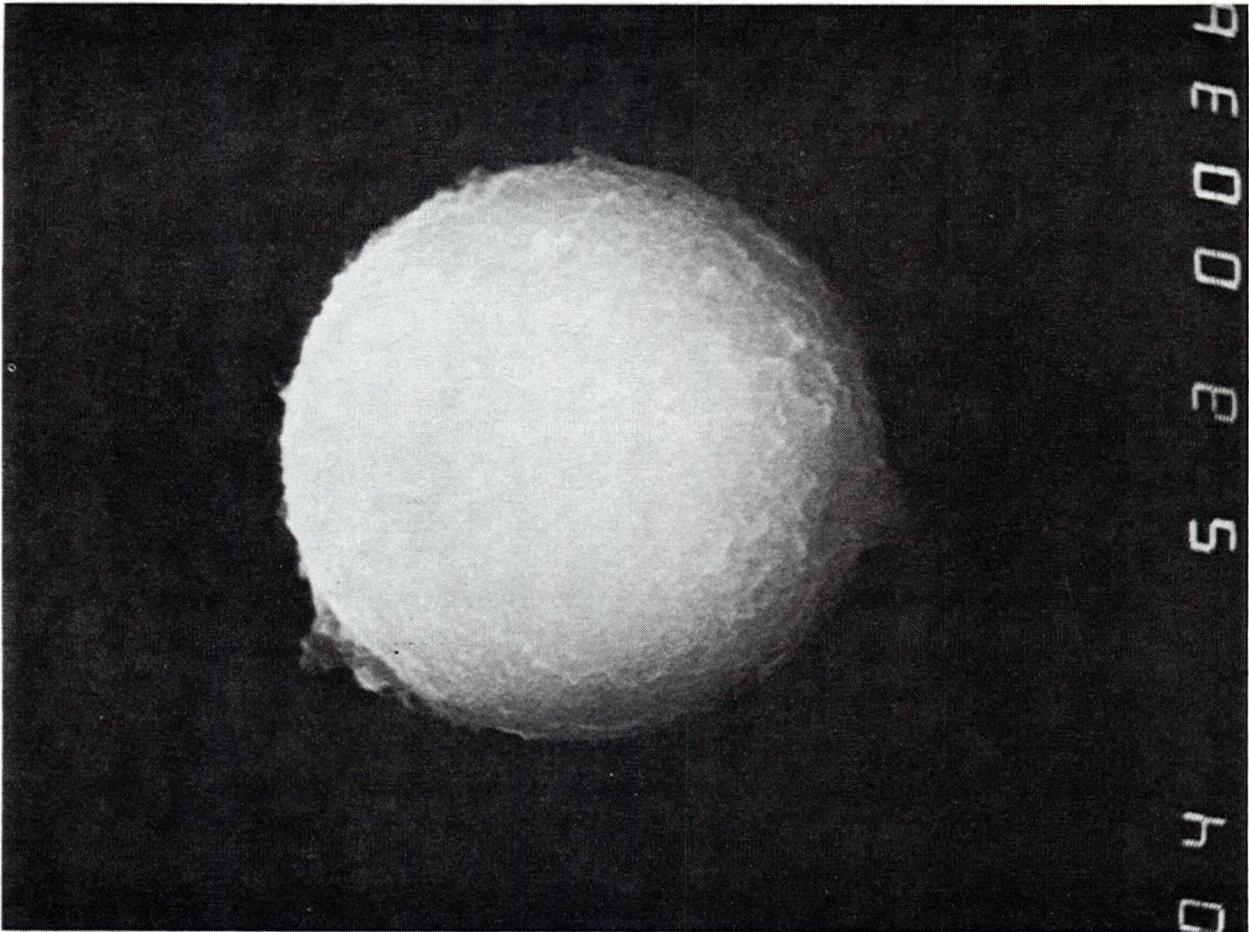


<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
9	S	T	CL/Pale Yellow	V	AOS	

C0101



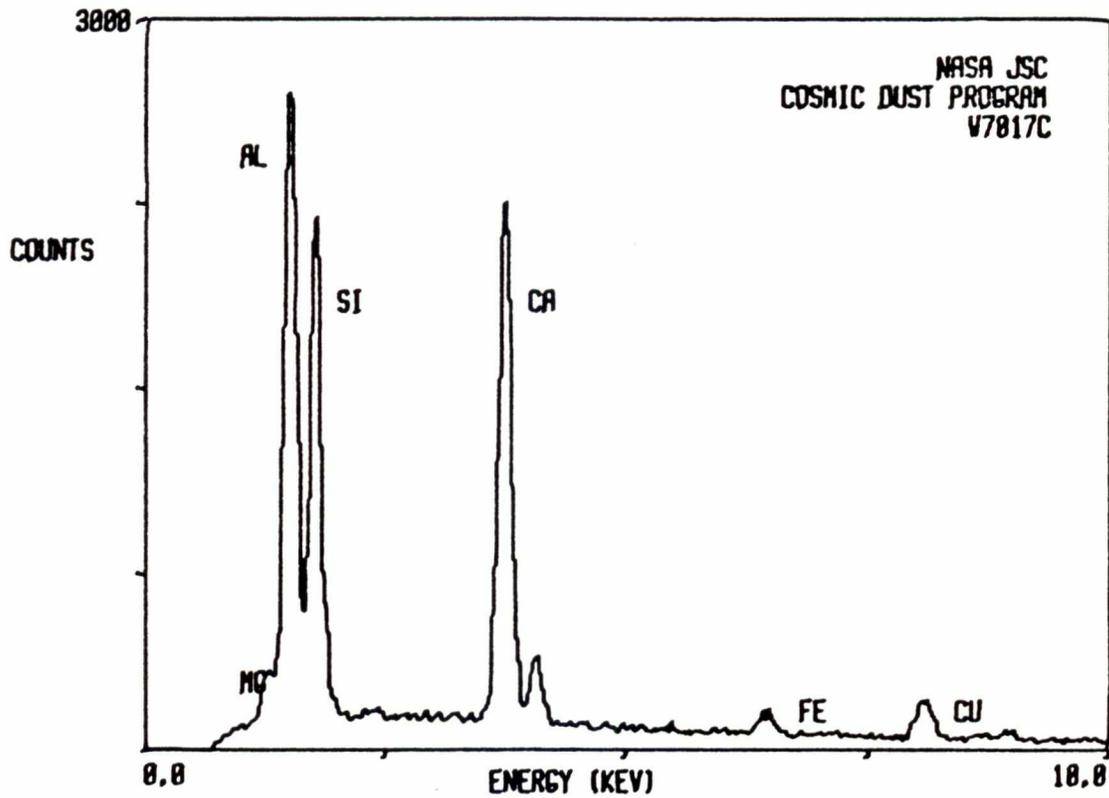
W7017C2



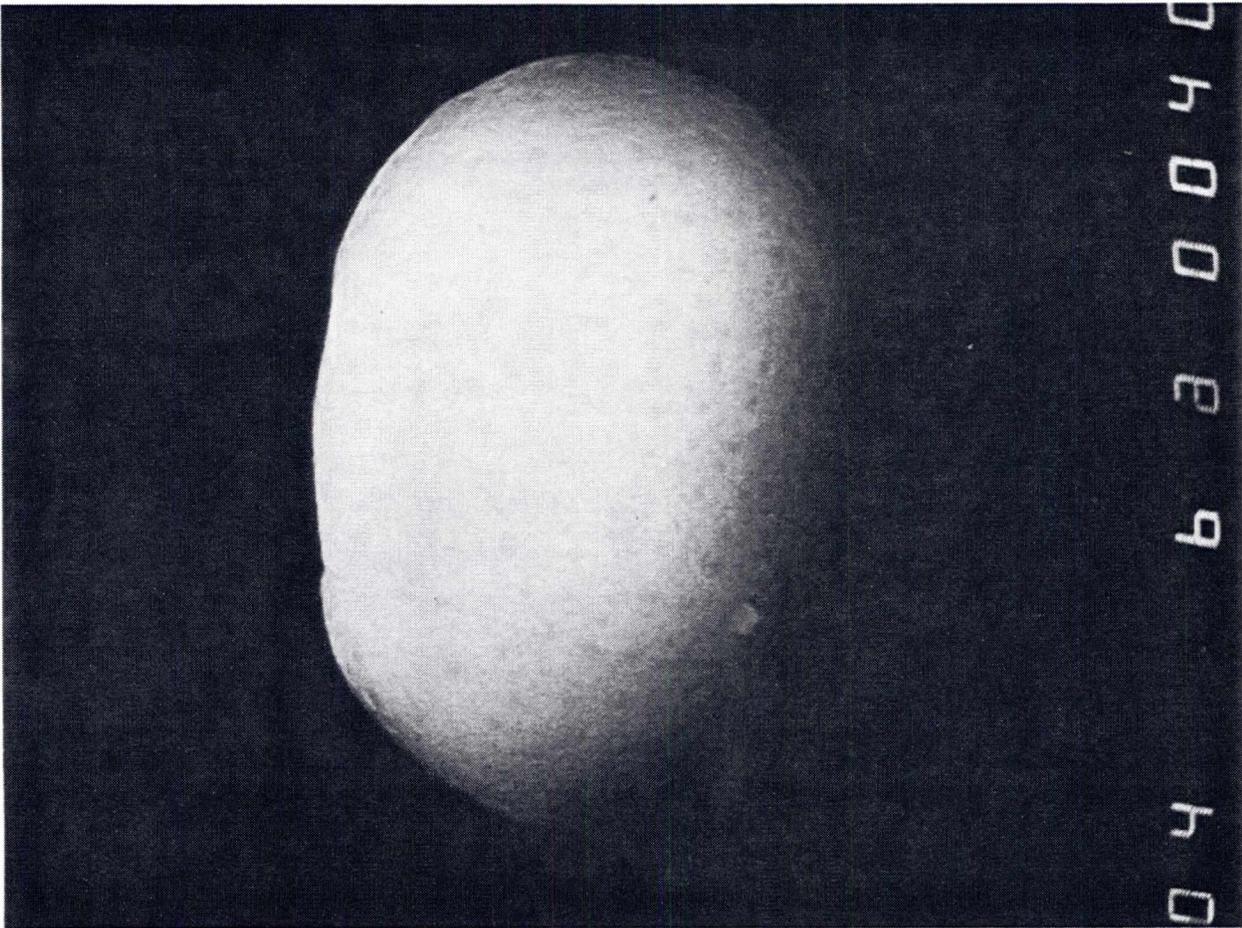
S-81-40485

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
10	S	T	CL/Pale Yellow	V	C	

C8201

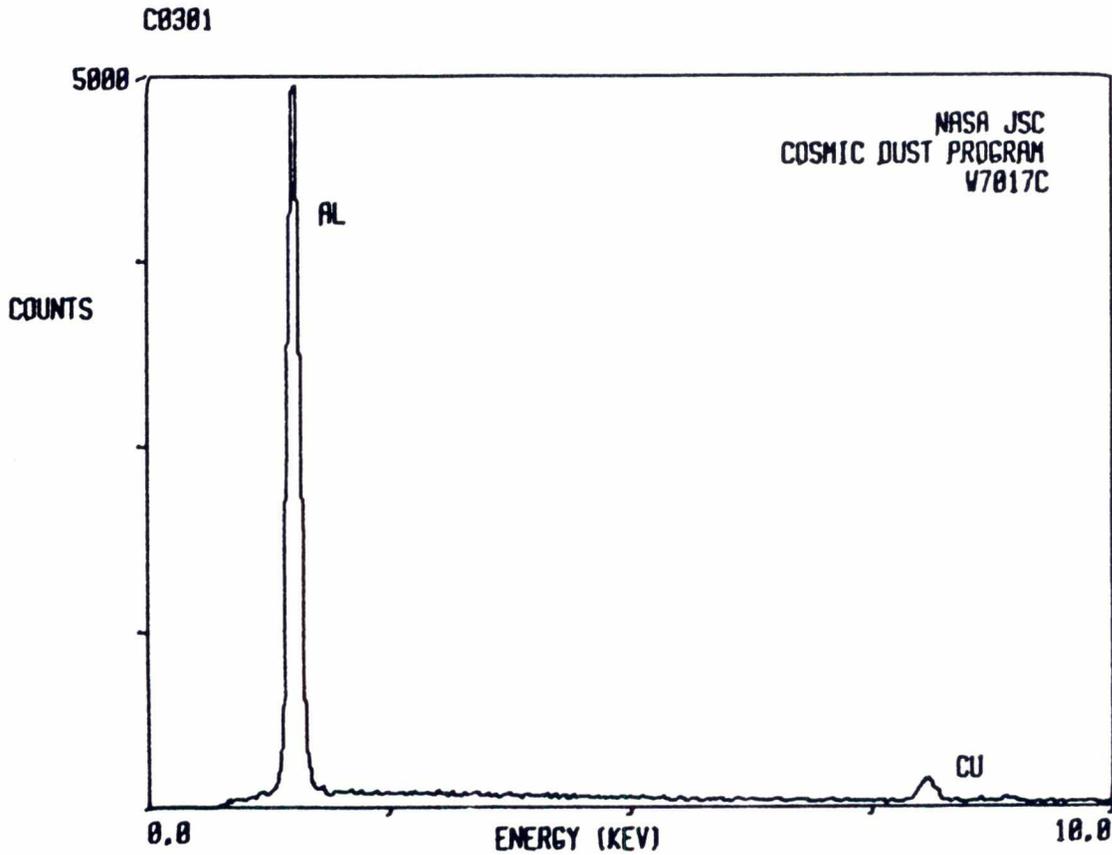


W7017C3

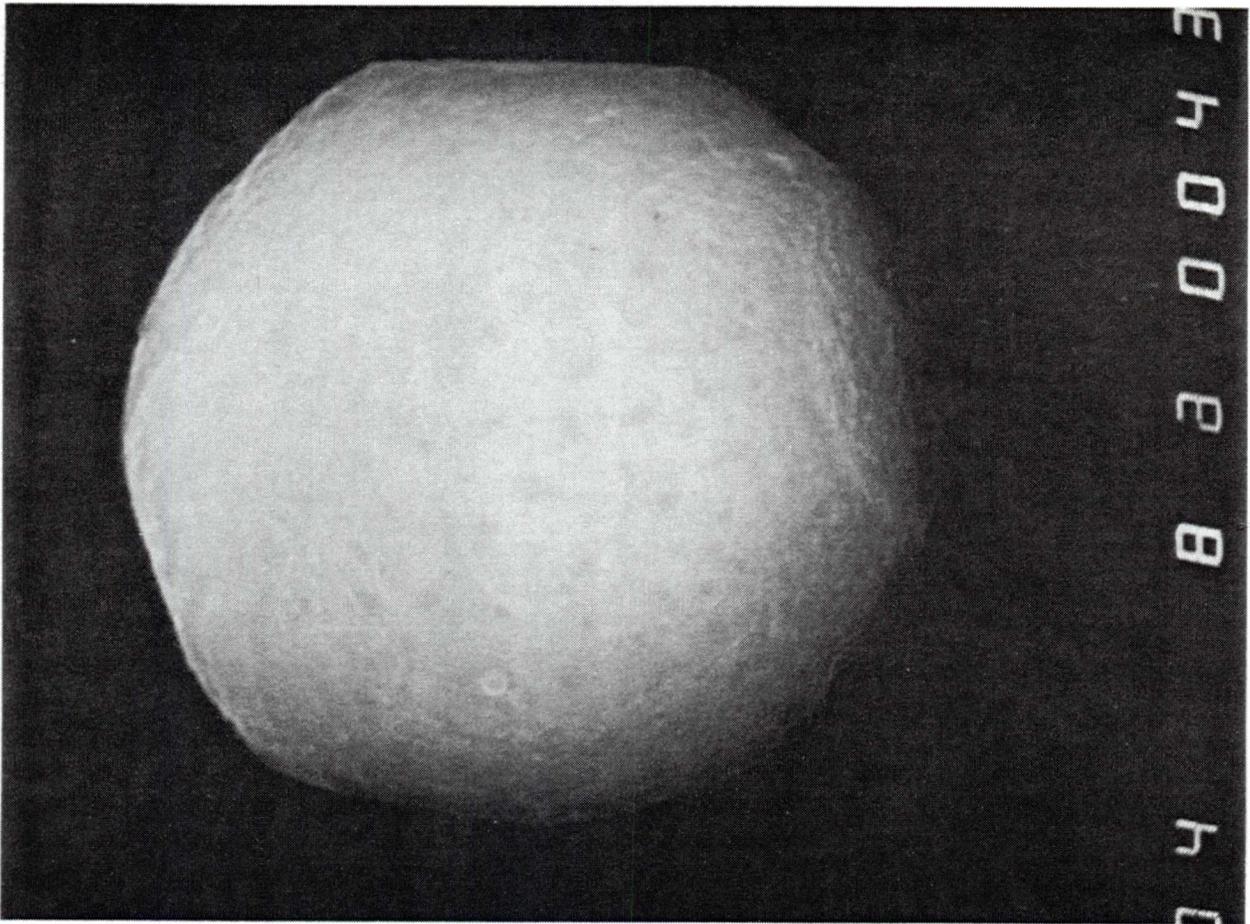


S-81-40467

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
7x10	S	T	CL/Pale Yellow	V	AOS	

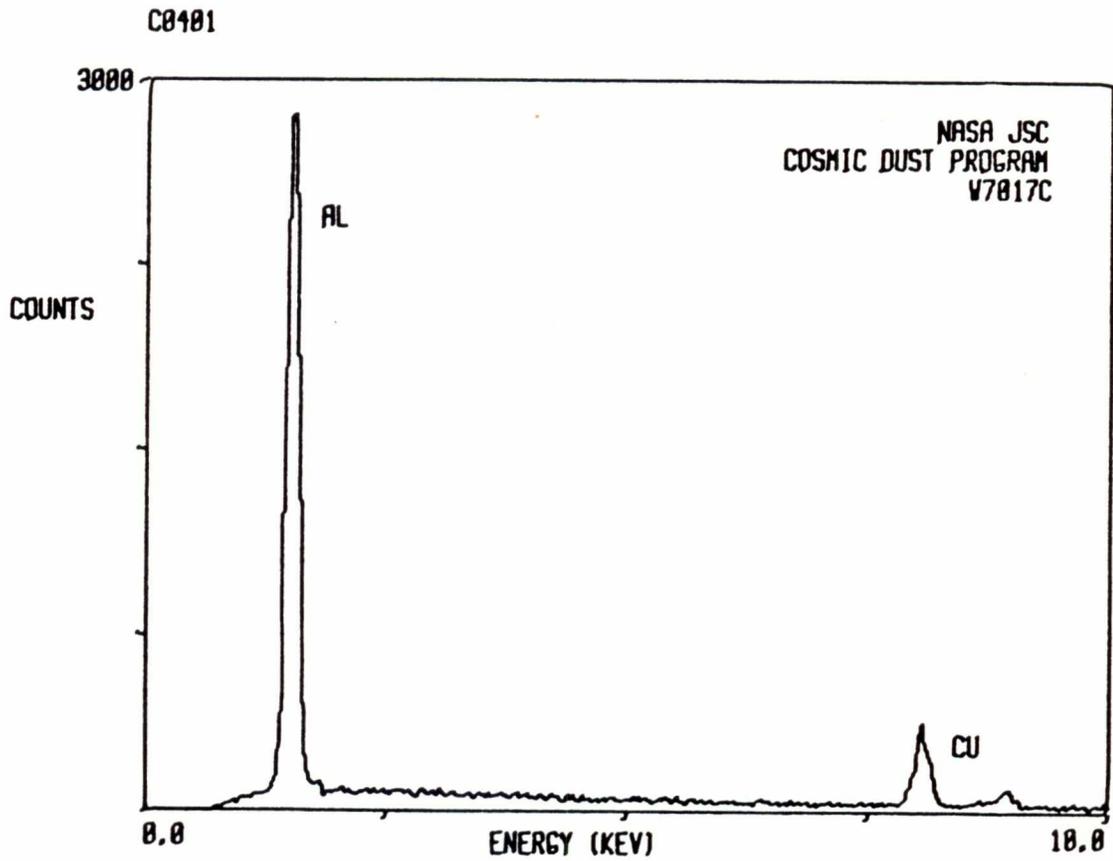


W7017C4

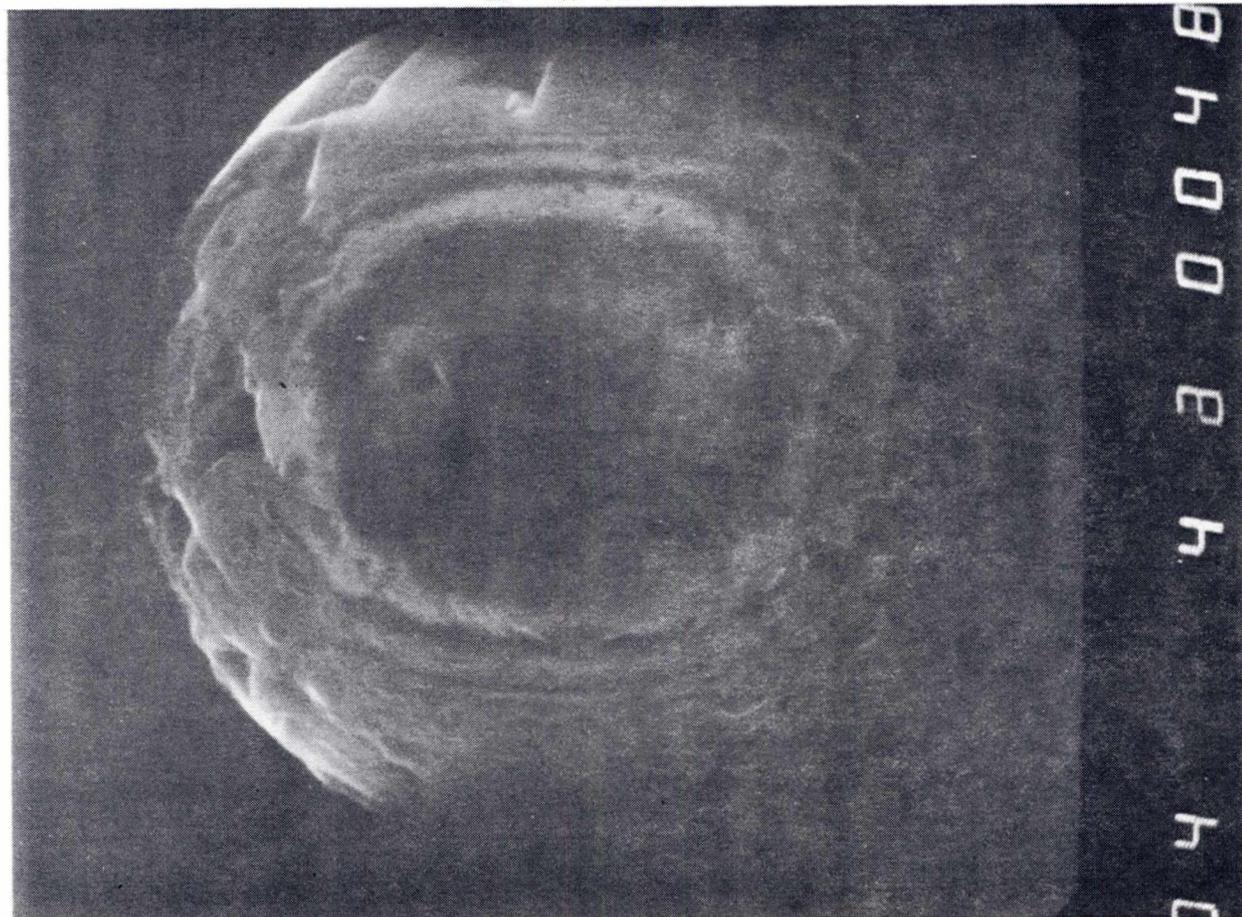


S-81-40488

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8	S	T	CL/Pale Yellow	V	AOS	



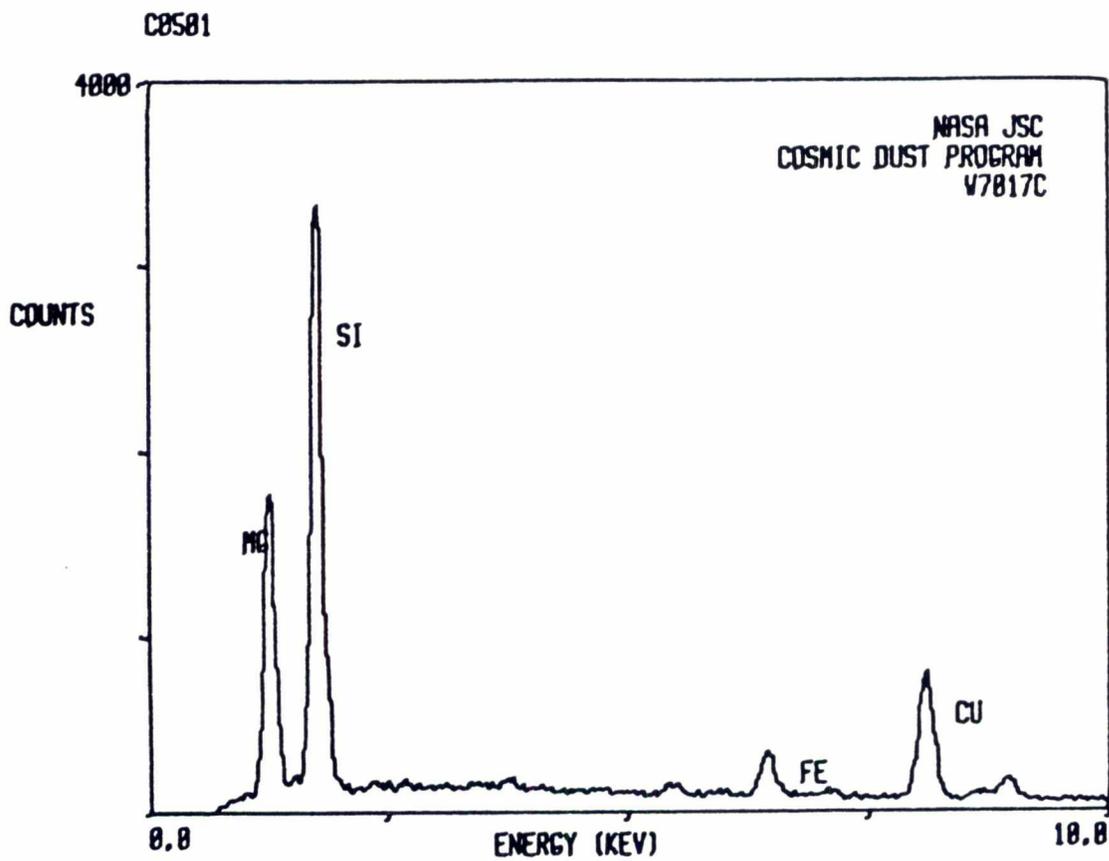
W7017C5



S-81-40489

04 4 3 0048

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
18	S	T	CL/Pale Yellow	SV	C	



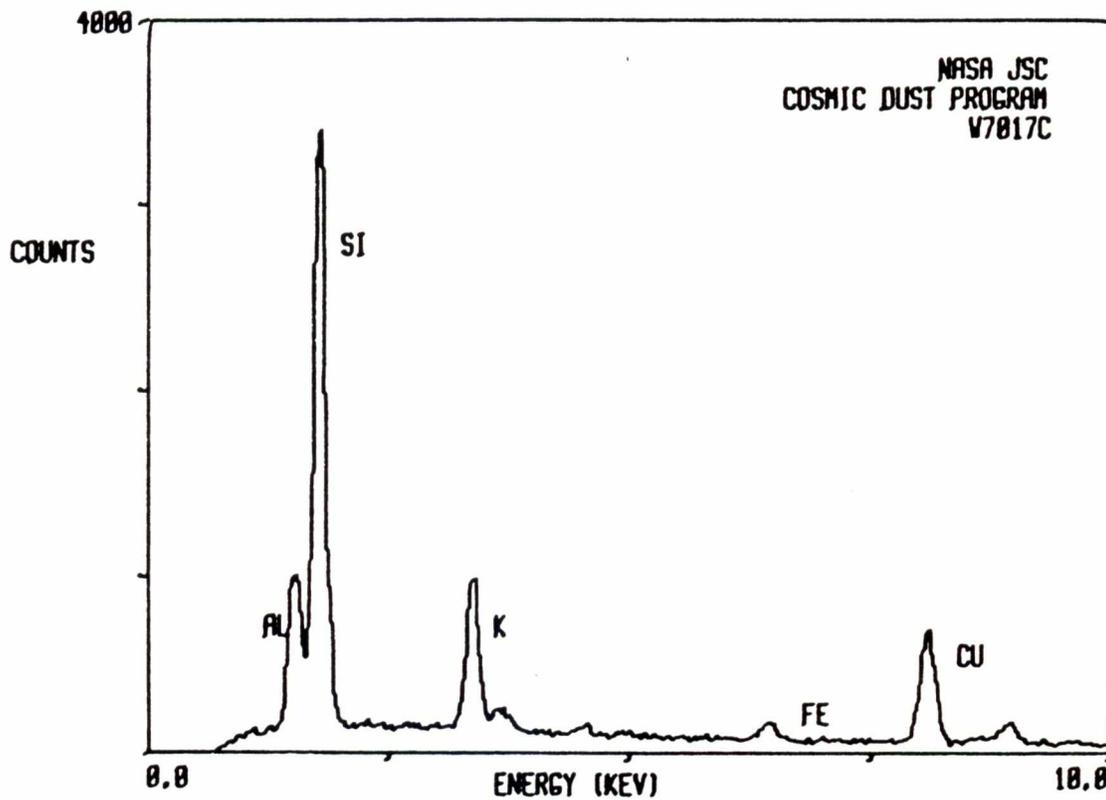
W7017C6



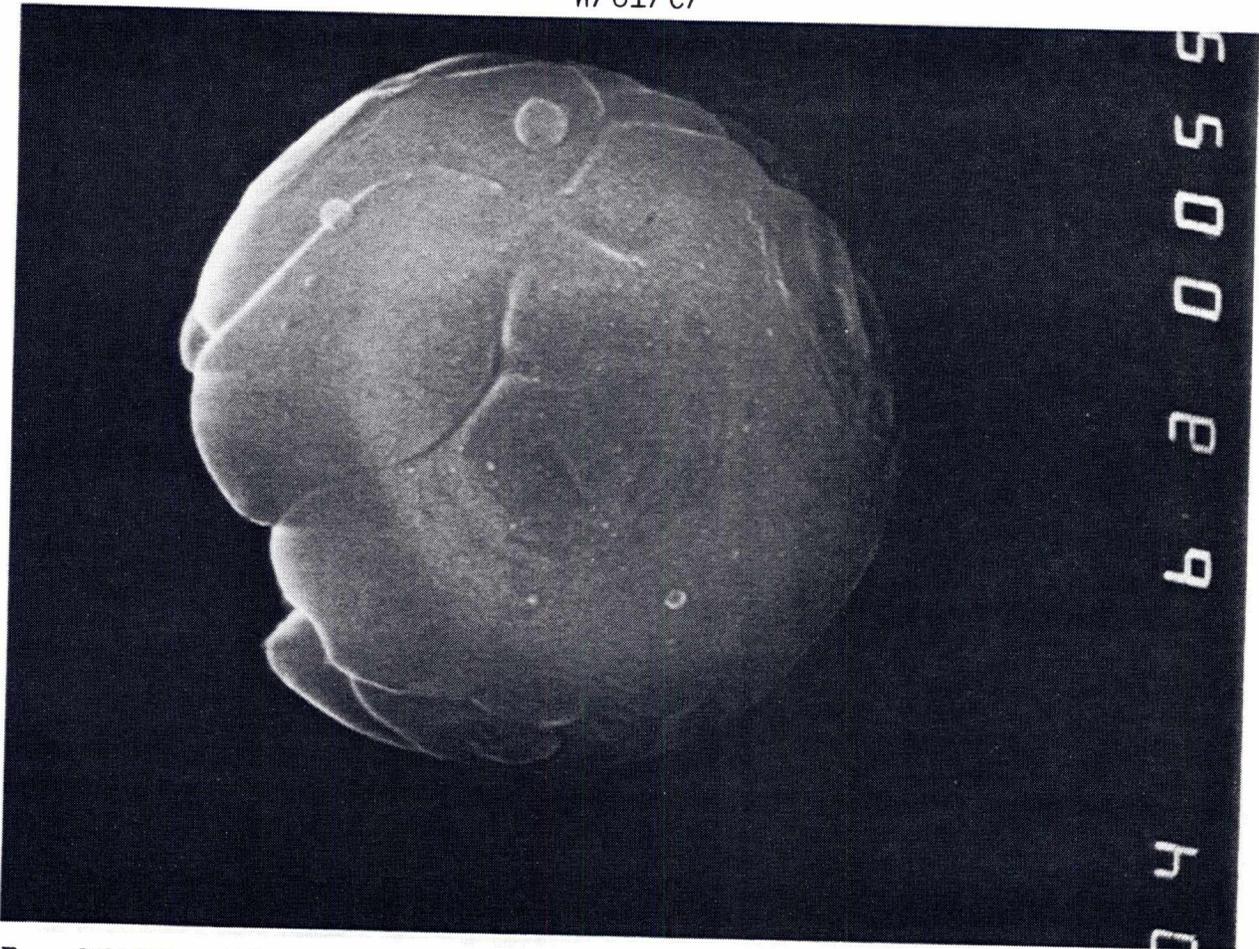
S-81-40490

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
12x15	E	TL	CL/Pale Yellow	V	TCN	

C0601



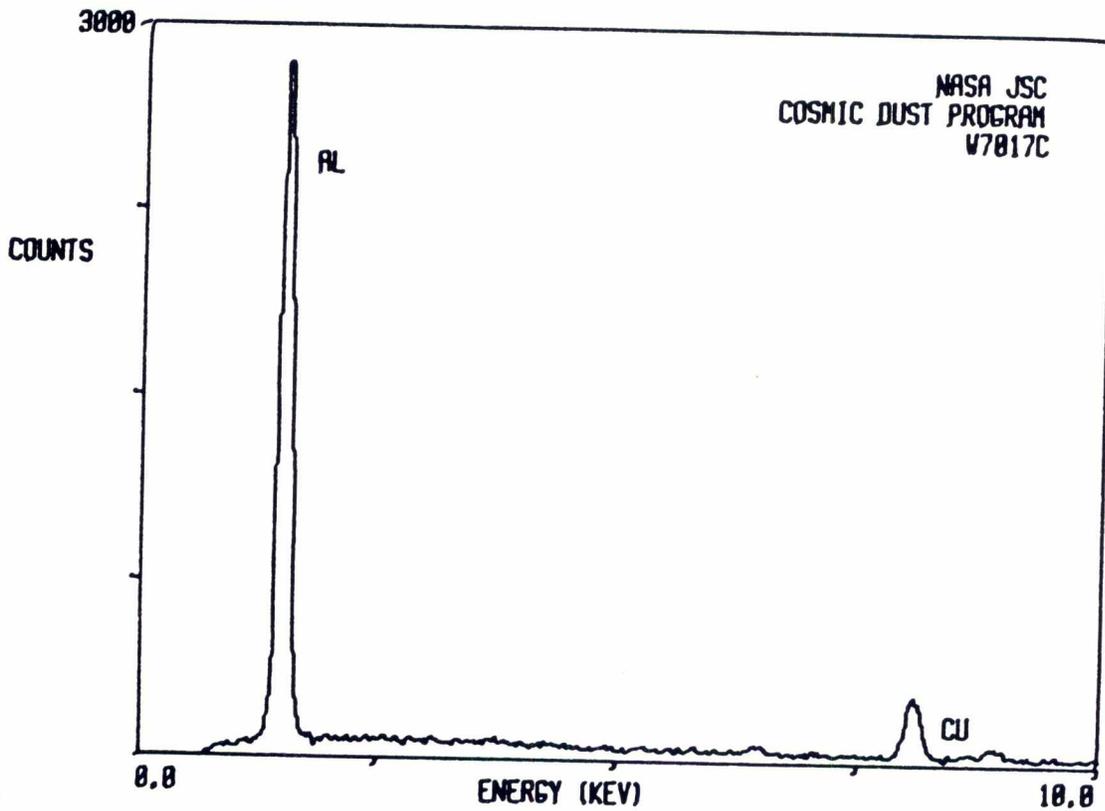
W7017C7



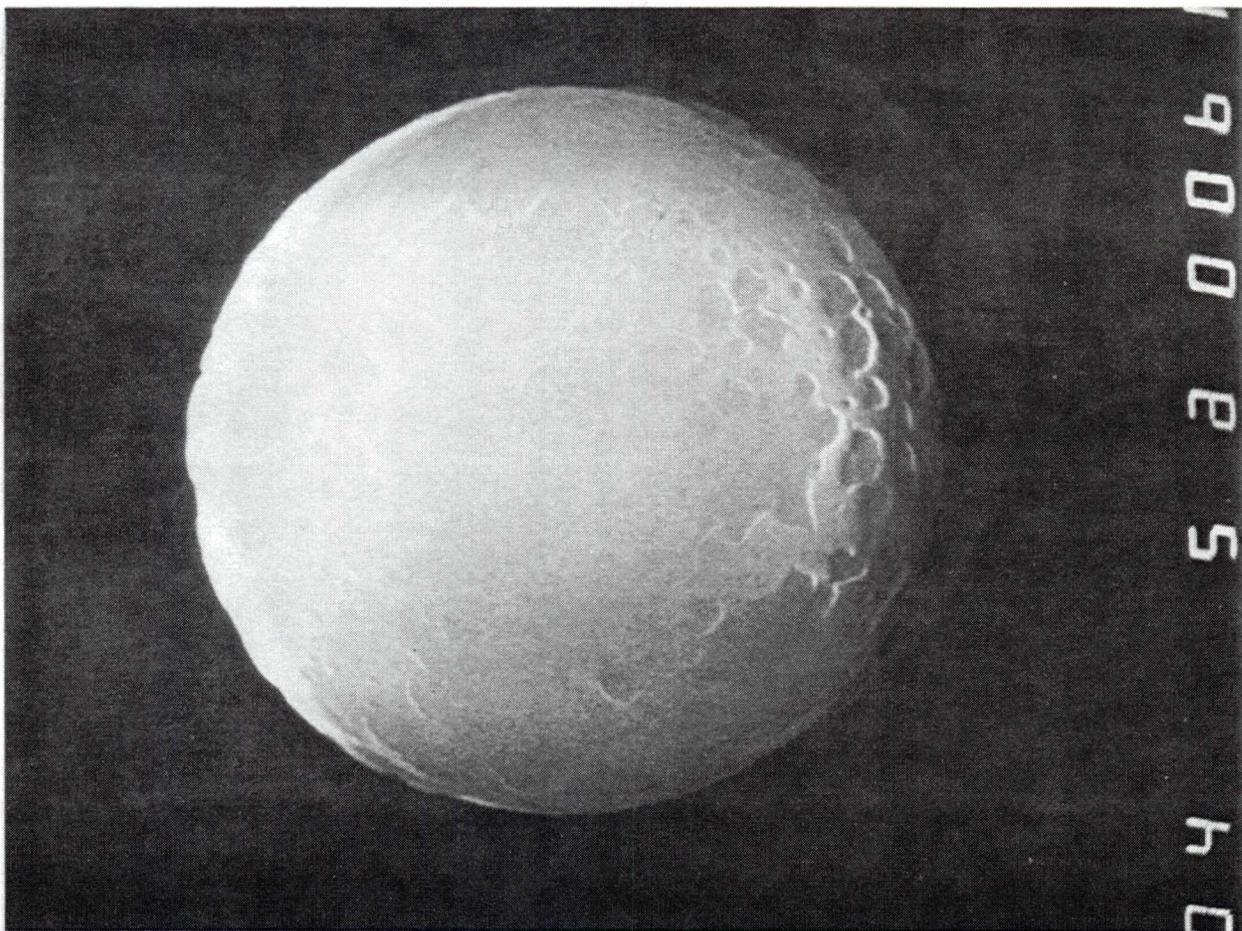
S-81-40491

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
10	S	TL	CL/Pale Yellow	SV	AOS	

C8781



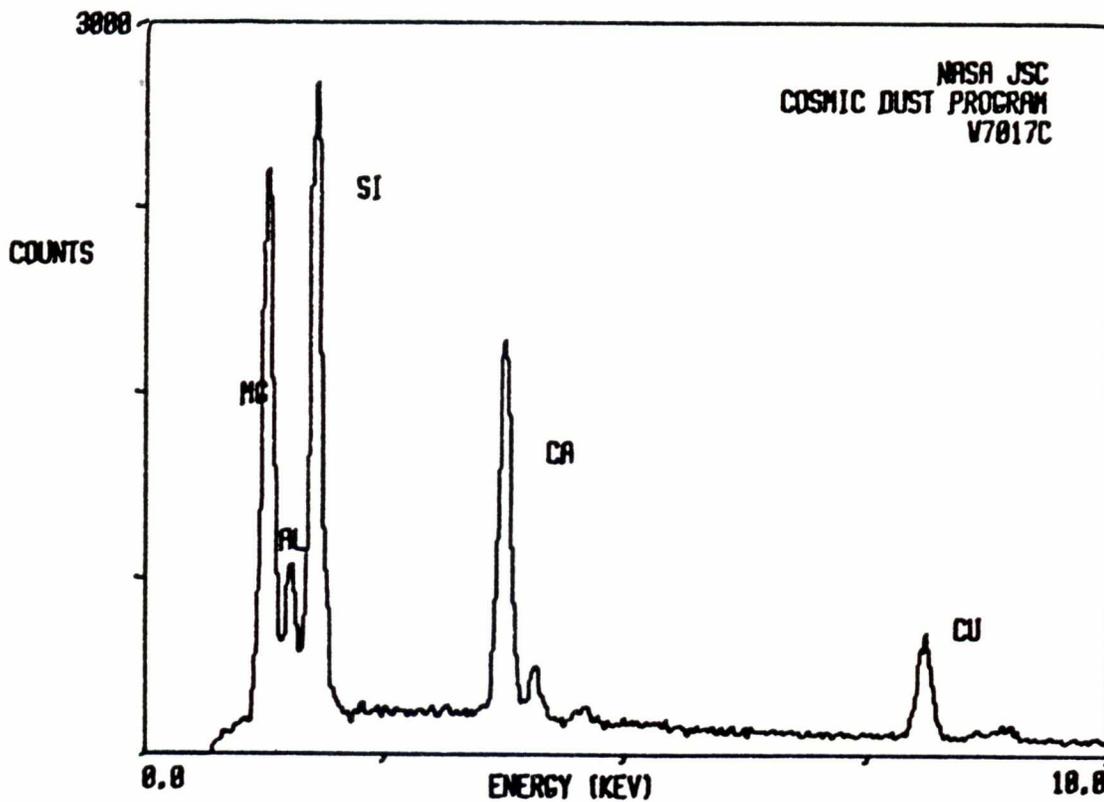
W7017C8



S-81-40492

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
12	S	T	CL	V	C	Lost

C8881



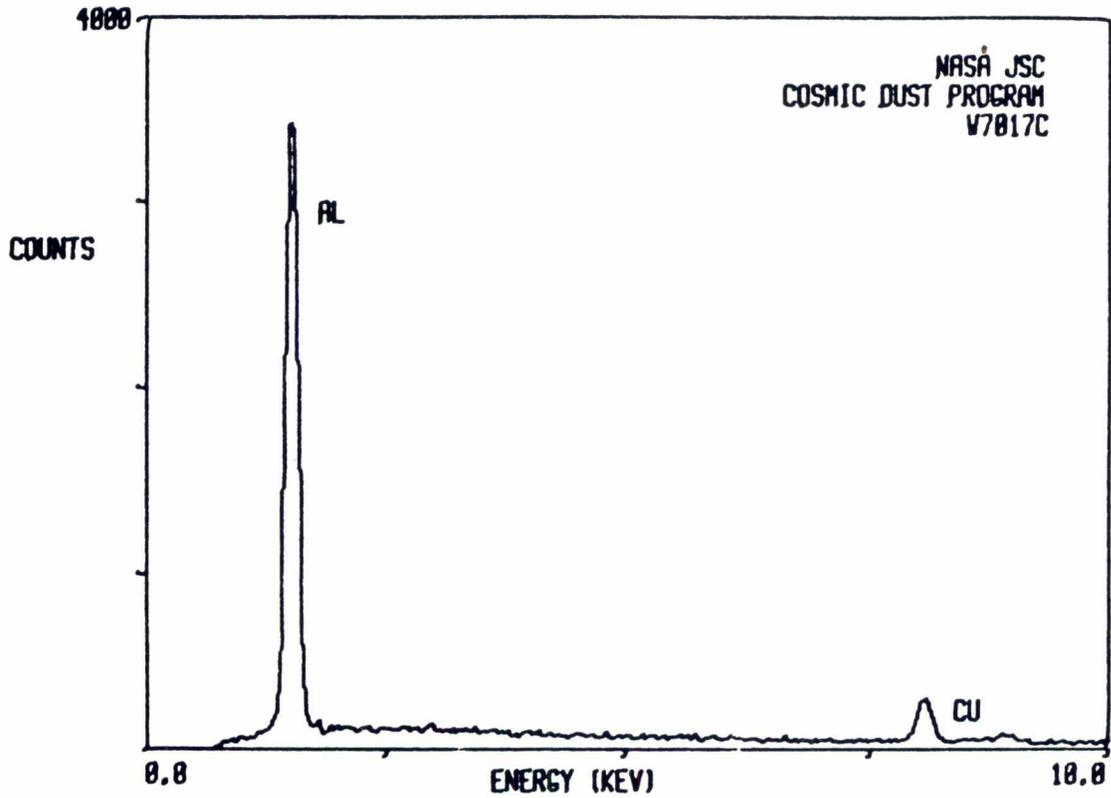
W7017C9



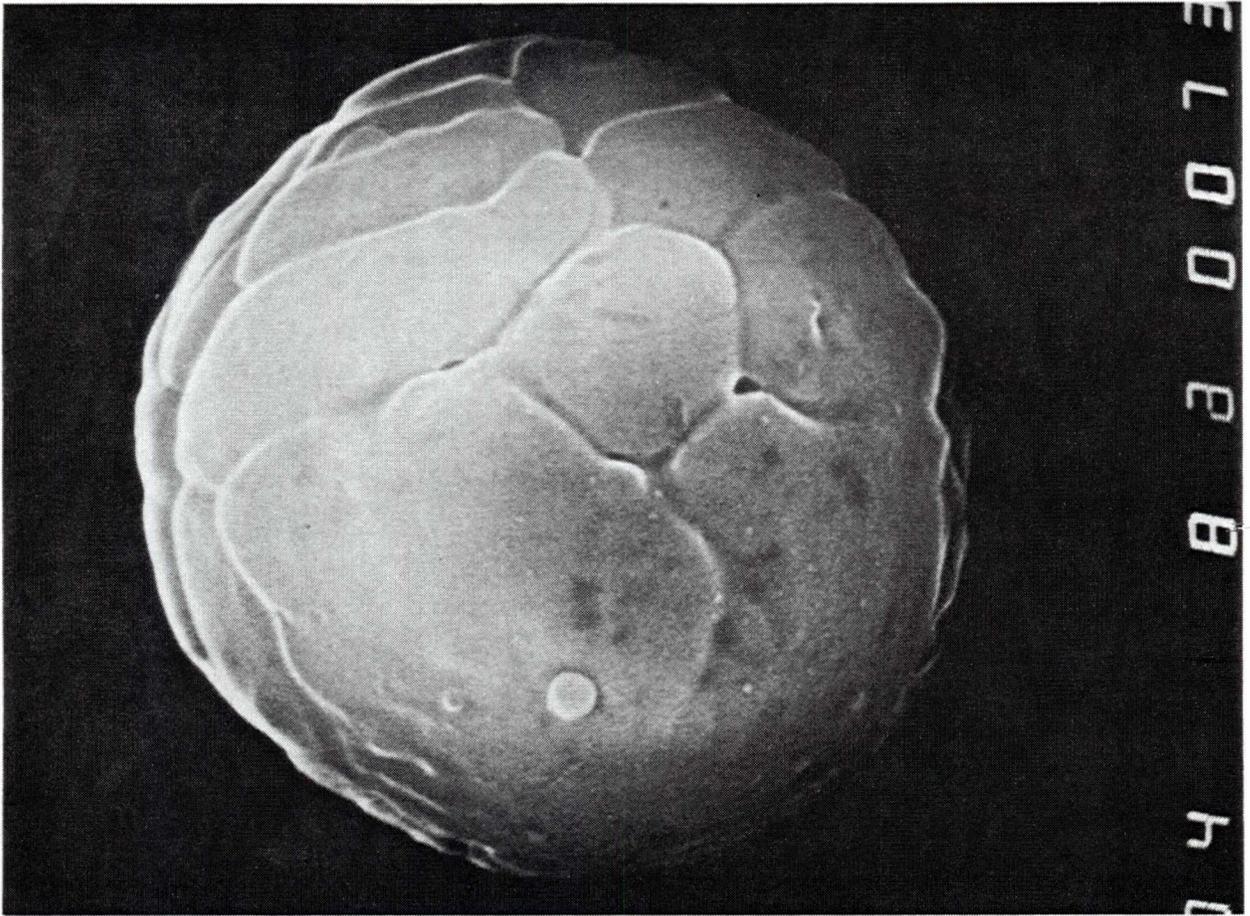
S-81-40493

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
8	S	T	CL/Pale Yellow	SV	AOS	

C8981



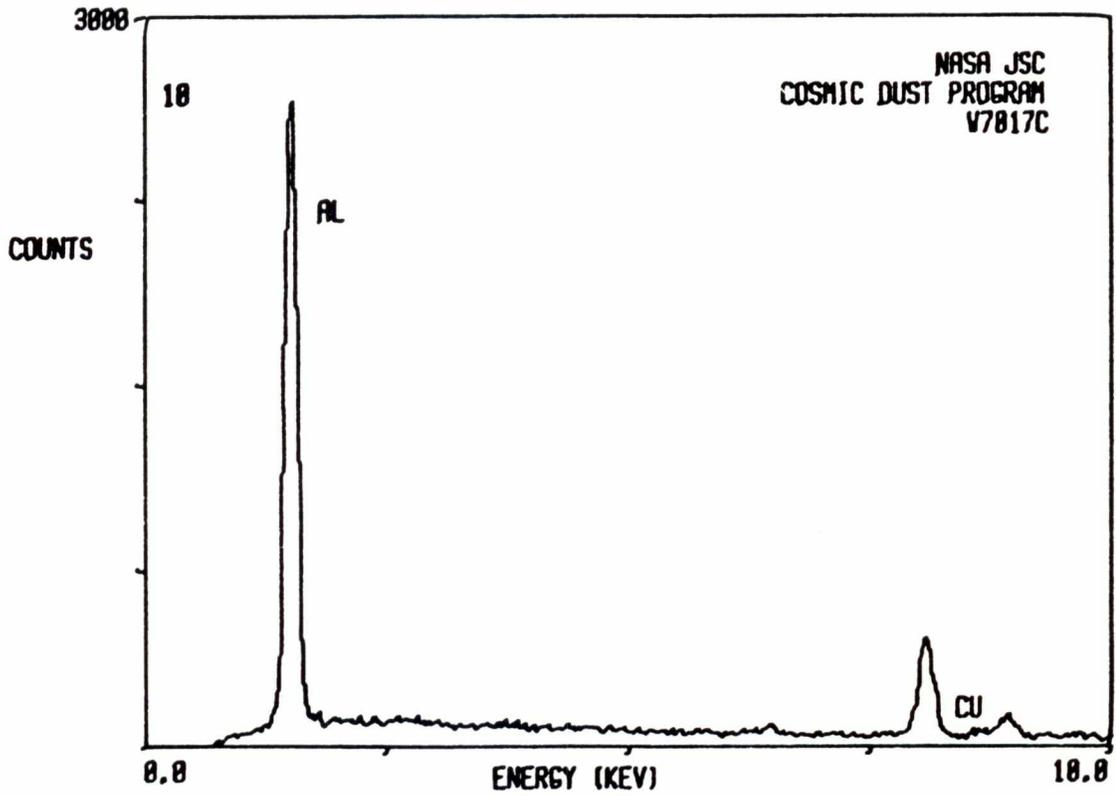
W7017C10

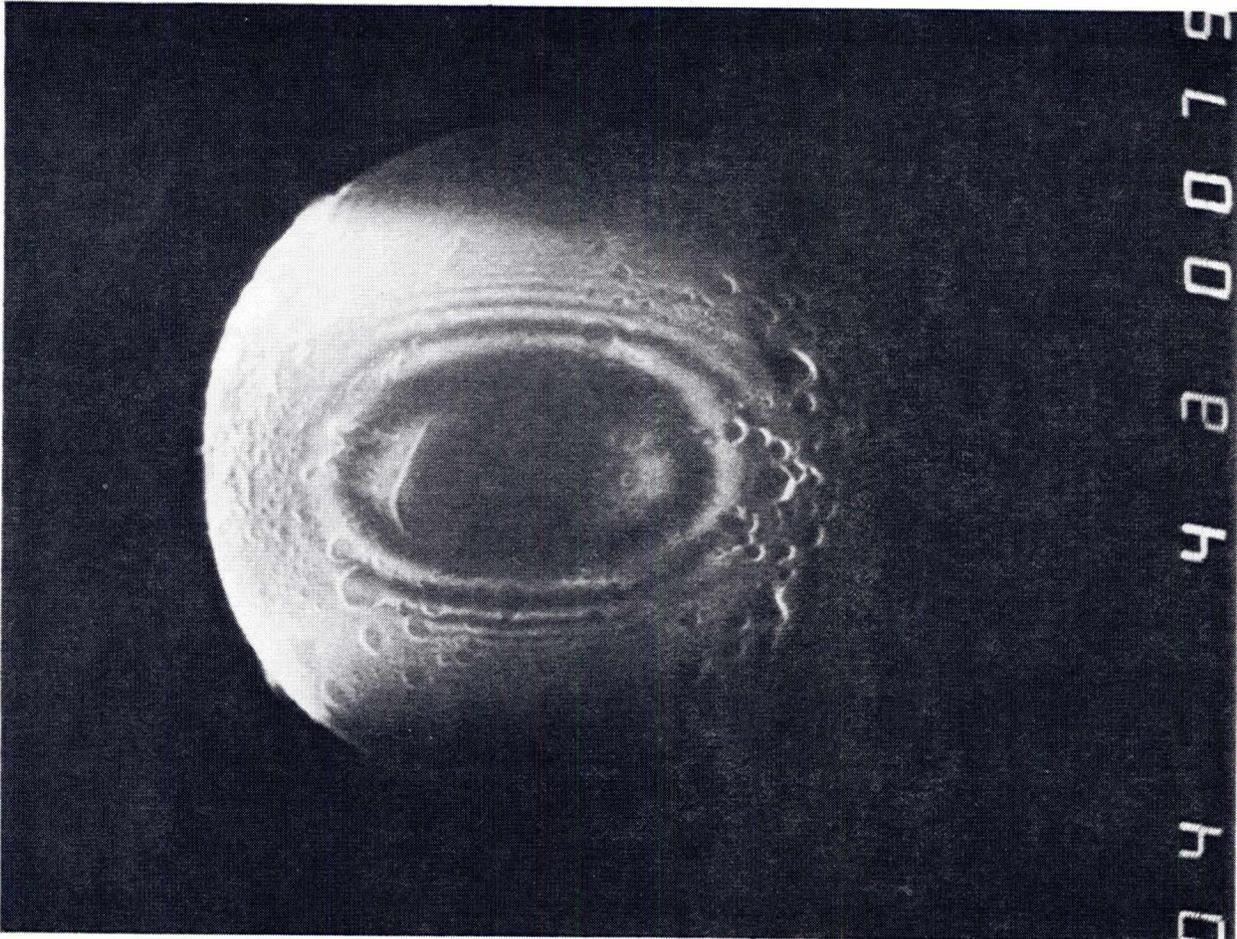


04 8 3 0073
 S-81-40494

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
9	S	TL	CL/Pale Yellow	SV	AOS	

C1001



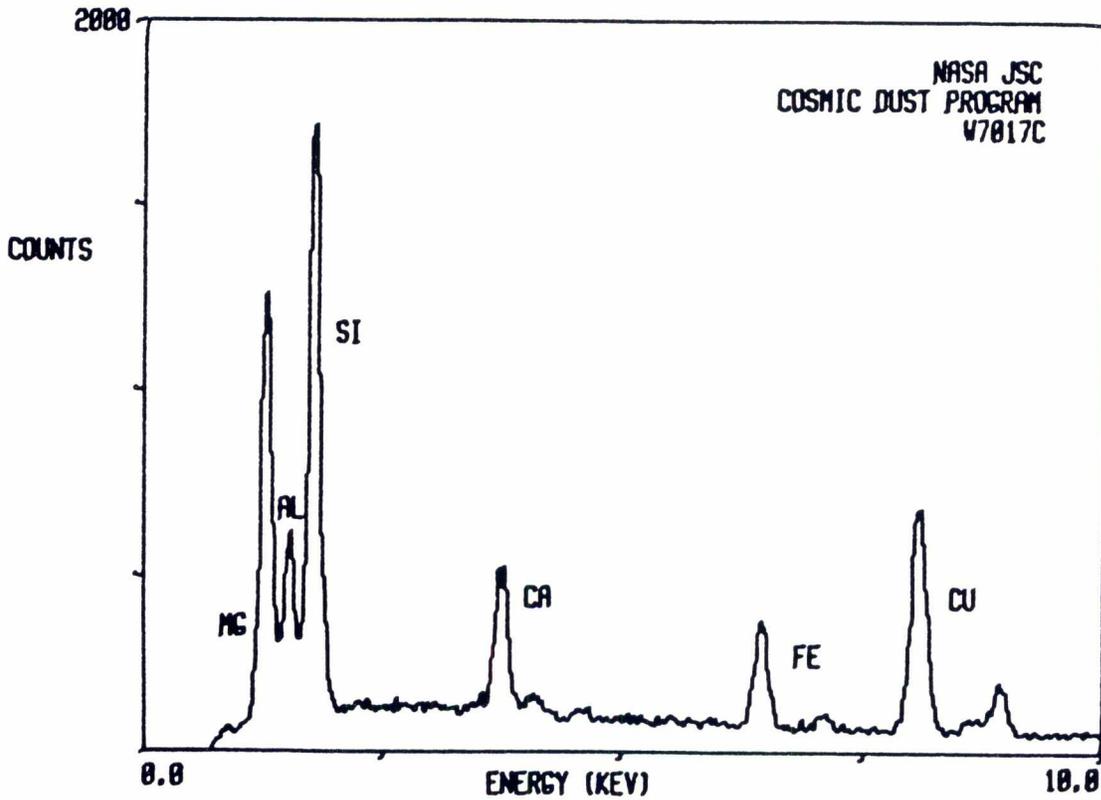


04 4 8 0 0 7 9

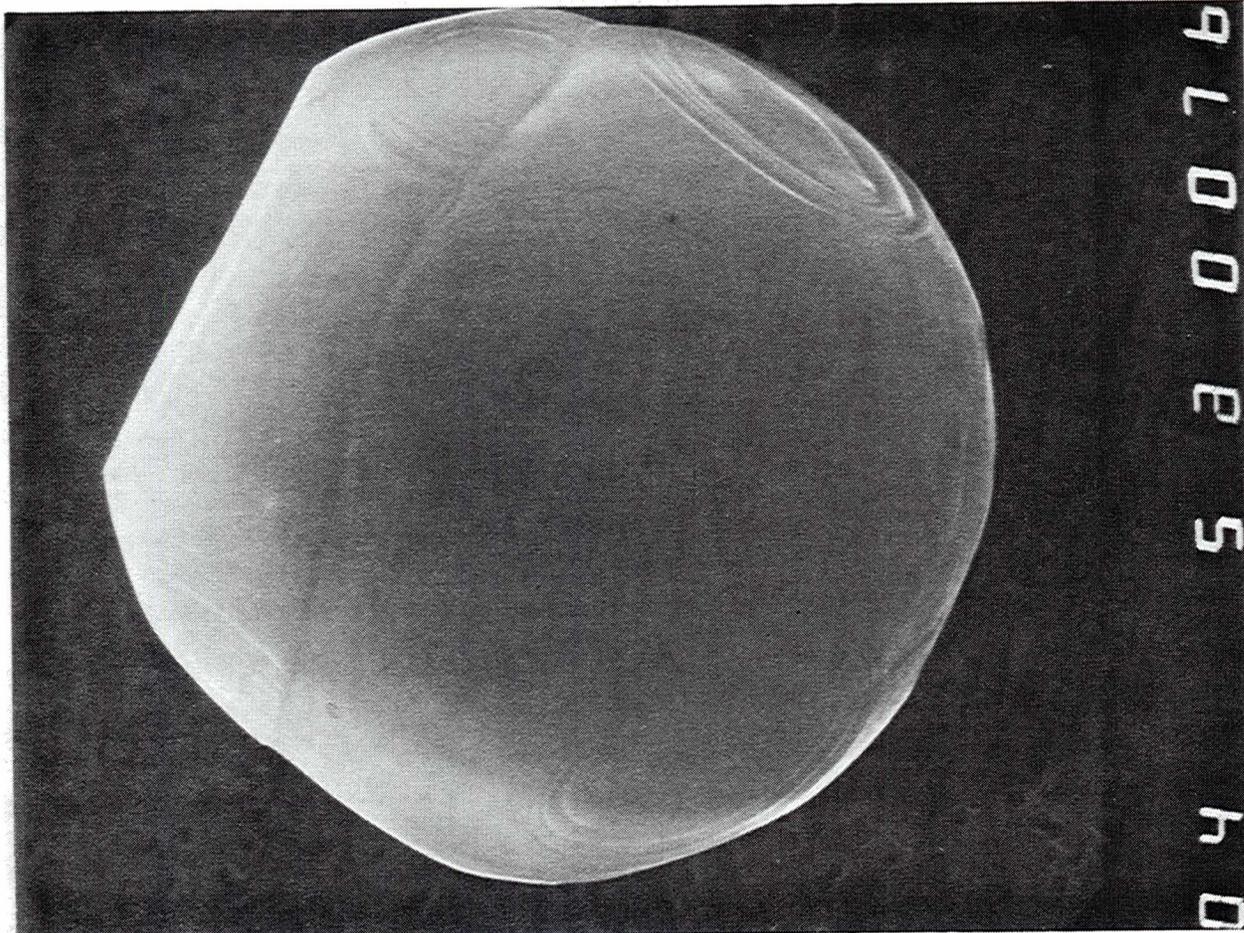
S-81-40495

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
15	S	T	CL/Pale Yellow	V	C	Lost

C1101



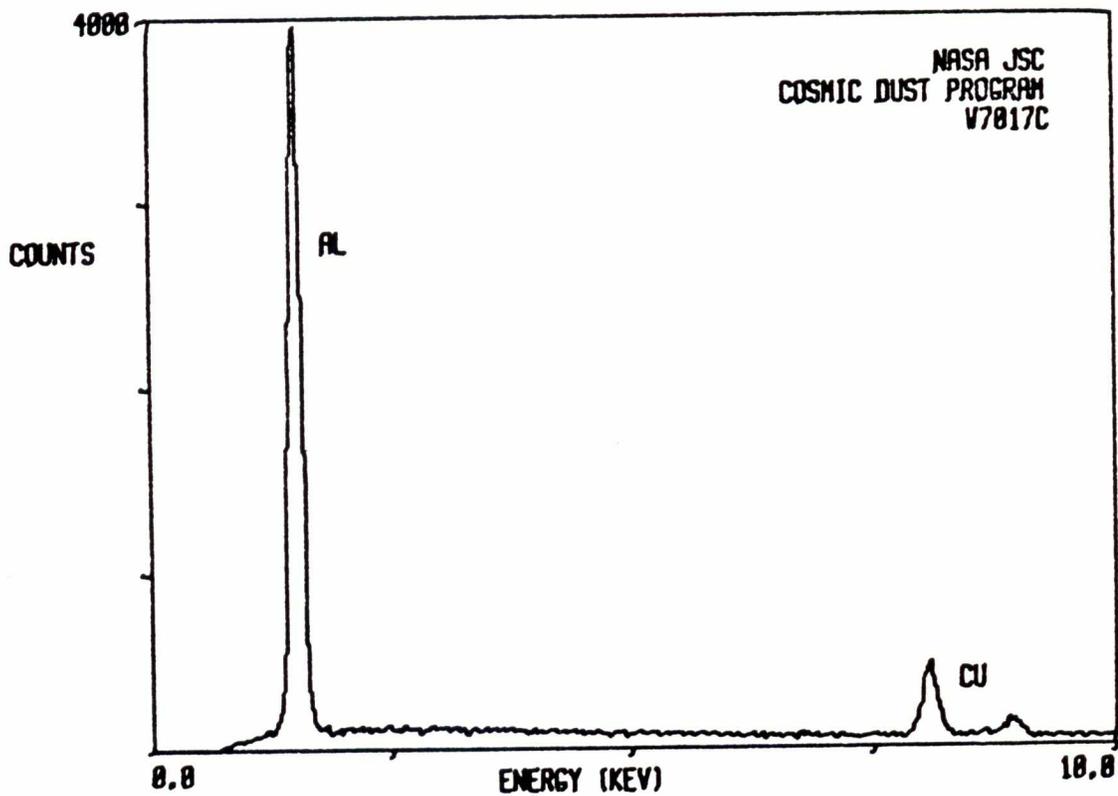
W7017C12



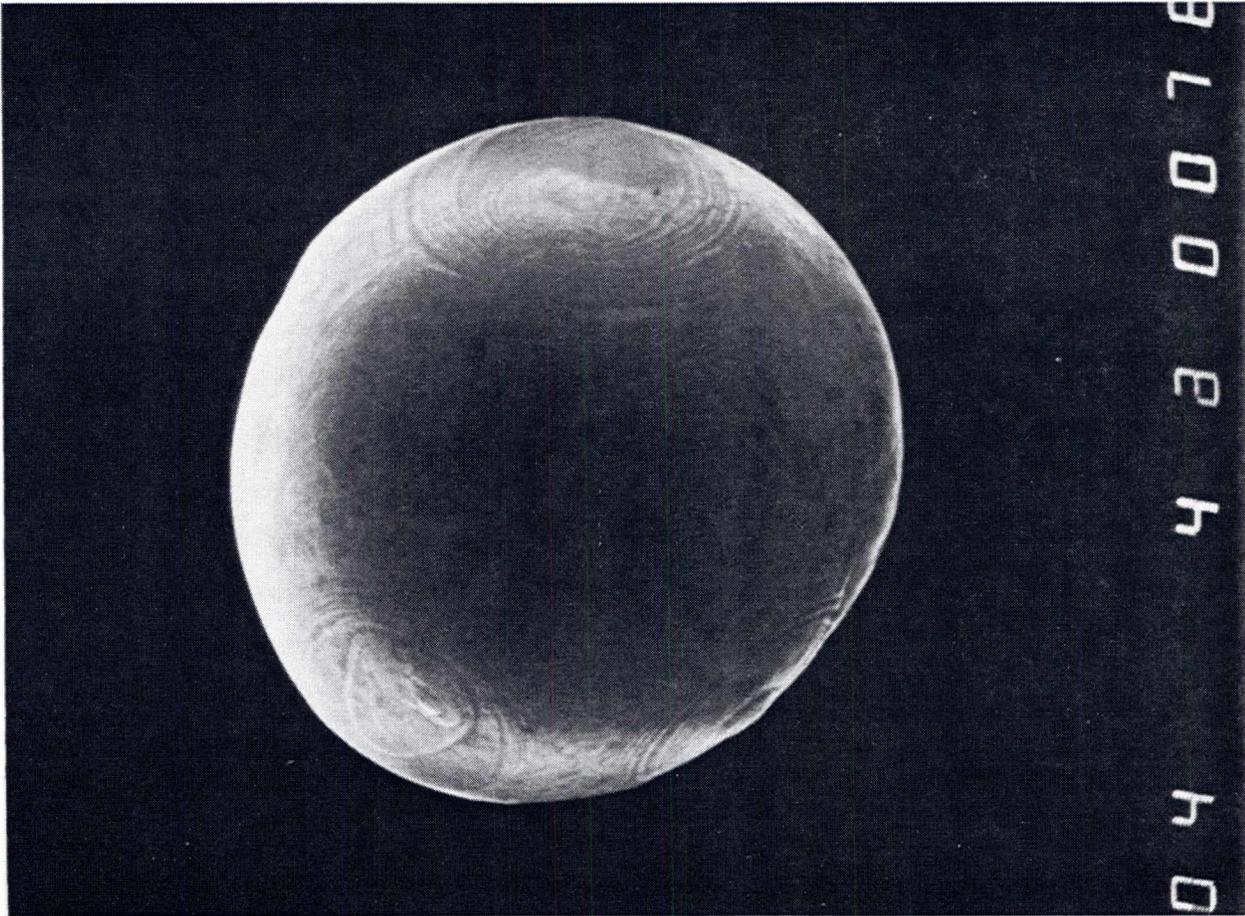
S-81-40496

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
15	S	T	CL(?)	V	AOS	

C1201



W7017C16



S-81-40497

<u>SIZE</u>	<u>SHAPE</u>	<u>TRANS.</u>	<u>COLOR</u>	<u>LUSTER</u>	<u>TYPE</u>	<u>COMMENTS</u>
12	S	T	CL/Pale Yellow	V	AOS	

C1681

