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APOLLO 14 ROCK SAMPLES

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INTRODUCTION

As a result of the Apollo 14 mission, approximately 42,285 grams of lunar material were returned. The samples include particles ranging from dust-size to "Big Bertha" (sample 14321), with a mass of almost 9000 grams. This booklet includes petrographic descriptions of all Apollo 14 samples larger than 1 cm in any dimension. It has been prepared as an intermediate step in the compilation of a new Apollo 14 sample catalog.

The format is different from that in catalogs previously prepared by the curatorial staff because many of the samples in this collection have been extensively investigated. Consequently, rock descriptions were compiled from many sources. First of all, we looked at the original notes taken by members of the preliminary investigation team (PET). Naturally, these descriptions were found to be widely variable, both in detail and in use of terminology. We have attempted to impart uniformity wherever possible; however, words used by different members of PET such as light and dark, coarse-, medium-, and fine-grained, etc., may not be used as consistently as we would have liked. In addition, we have attempted to summarize the petrographic literature, and again, we are faced with non-uniform terminology. A discussion of general nomenclature as applied to lunar breccias by various investigators has been included. Although we have adhered to commonly accepted usages of geologic terms, we have included a list of petrographic terms frequently used in rock descriptions for convenience.

When possible, we examined at least one representative thin section for each generic. Each section we described was photographed (110x) in transmitted light and is included herein. At least one photograph of each sample was selected from among those on file to provide a representative picture of the hand specimen.

The sample description format we follow in this booklet consists of five parts:

1) An introductory section which includes information on lunar sample location, orientation, and return containers taken from the paper by Swann et al. (1977);
2) A section on physical characteristics, which contains the sample mass, dimensions, and a brief description;
3) Surface features, including zap pits, cavities, and fractures as seen in binocular view;
4) Petrographic description, consisting of a binocular description and, if possible, a thin section description (Unless otherwise noted, the description is of the binocular view.);
5) A discussion of literature relevant to sample petrology is included for samples which have previously been examined by the scientific community.

Because the booklet was prepared in this fashion, some samples will be seen to have received more attention than others. Along these same lines, models and geneologies have been made for a few samples and have been included herein according to their availability. We welcome any constructive comments on these efforts, and they will be considered in the preparation of the forthcoming Apollo 14 sample catalog.

Having compiled this booklet, we wish to emphasize that there is no substitute to actually looking at the rock, and ask that investigators report all new or conflicting information on these (or any other) samples to the curator's office for incorporation in data packs kept on each generic.

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We wish to extend our sincerest thanks to the following people, without whom the completion of this booklet could not have been accomplished so easily. Sue Goudie and Jean Leecraft amazed us by translating our handwritten drafts into an error-free typed version in record time. Sherry Feicht took photographs with all kinds of formats made between 1971 and 1977 and made them appear in our booklet to have a consistent format after long hours of cutting and pasting. Catherine King diligently searched all the data packs for photographs of these samples. Dan Anderson took the time to write a computer program to alphabetize the references in Jeff Warner's computerized bibliography. Pat McGee, Chuck Simonds and Bill Phinney enlightened us during several discussions on their interpretation of various thin sections, and the booklet has benefited by Chuck Simonds' review comments. David Twedell and Phil Smith helped us by processing and photographing samples. Chuck Meyer provided us with many useful references as well as his advice and guidance on numerous occasions. Special thanks go to the members of the Apollo 14 PET whose notes we used in compiling these data. The best part was that several of these people did their jobs without complaint, especially Sue Goudie, to whom we gave ample cause. Thanks also go to Lee Smith and the other NSI and curatorial personnel who helped us in our completion of this effort.

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Geologic Setting

After the successful return of numerous basalt samples from the mare regions by the Apollo 11 and 12 missions, it was desirable to sample a different kind of area. For this reason a major objective of the Apollo 14 mission, was to sample material comprising the Fra Mauro Formation, which had been interpreted as being a portion of the ejecta blanket deposited during the impact-formation of the Imbrium Basin (Gilbert, 1893; Eggleton, 1964; Wilhelms, 1970). This event was believed to predate mare formation, and it was hoped that an age for the Imbrian event could be established through successful return of these samples.

The geological formations in the area of the landing site are shown in figure 1. The formations shown on the map are subdivided into four age groups: pre-Imbrian (oldest), Imbrian, Eratosthenian, and Copernican (youngest), in accordance with U.S. Geological Survey usage. Imbrian formations predominate the region of the Apollo 14 landing site. This area is known as the Fra Mauro region, and is a light-colored, topographically high area surrounded by maria.

The Fra Mauro region and the Fra Mauro Formation are named for the crater Fra Mauro, an ancient, eroded, and partially buried crater 70 km south of the landing site. The Fra Mauro Formation is a distinctive ridged and furrowed unit surrounding the Imbrium Basin. This formation had traditionally been interpreted as fragmental ejecta from the Imbrium Basin since the idea was first proposed by G. K. Gilbert in 1893. In recent years, however, this idea has met with some challenge by investigators who point out that much local material excavated by secondary cratering is admixed with the Imbrium Basin material (Morrison and Oberbeck, 1975).

The thickness of the Fra Mauro Formation is not known, and estimates vary by an order of magnitude. Offield (1970) estimates the thickness to be between 100 and 200 meters based on its relation to the local topography, while Kovach (1971) finds it to be only 20 - 70 meters thick, using results from the active seismic experiment by the Apollo 14 astronauts. It is seen to cover 26,000 km^2 in the region of the landing site, feathering to a thin edge in the vicinity of the crater Bonpland approximately 150 km to the south. A northwest-trending ridge, radial to the Imbrium Basin lies about 600 meters east of the smooth terrain of the landing site. At the crest of this ridge is Cone Crater, a relatively young crater 340 meters deep. Here, it becomes important to know the thickness of the Fra Mauro Formation, for some of the material collected at station C_1 (figure 2) is interpreted to be Cone Crater ejecta. The question is whether this material is from the Fra Mauro Formation, or from the underlying material. The relief of the ridge is 90 meters. If Cone Crater is only 70 - 80 meters deep, chances are the ejecta represents Fra Mauro material.

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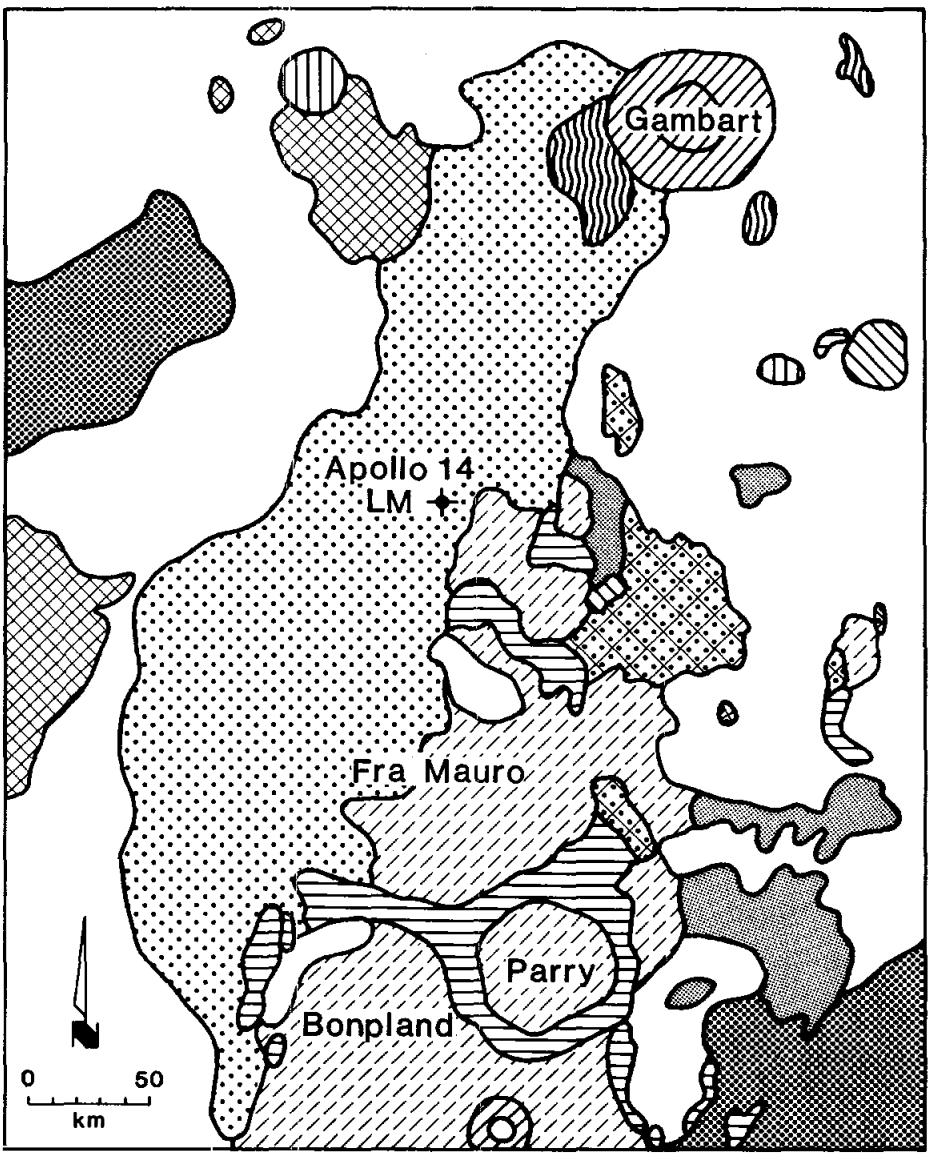
Figure 1a. Fra Mauro region.



CId	Dark Mantling Material	Copernican
Cc	Crater Material	Copernican
Em	Mare Material	Eratosthenian
Ec	Crater Material	Eratosthenian
Im	Mare Material	Imbrian
Ip	Plains Material	Imbrian
It	Crater Material	Imbrian
Ial	Alpes Formation	Imbrian
If	Fra Mauro Formation	Imbrian
IpIt.It	Terra Material	Pre-Imbrian
pIr	Rugged Material	Pre-Imbrian
pIc	Crater Material	Pre-Imbrian

Figure Ib. Geological formations of the Fra Mauro region. [Simplified from Wilhelms and McCauley, 1971, after Marvin, 1976]

The Cone Crater event has been dated by Turner et al. (1971). They show that the surface of the Cone Crater ejecta blanket has been in place for only 26-40 million years. The Imbrian event has been dated as being between 3.75 billion years (Sutter et al., 1971), and 3.94 billion years old (Nyquist et al., 1972). On the basis of terrestrial crater analogs, Gault et al. (1968) suggest that ejecta closest to the rim of Cone Crater must be derived from the greatest depths, and that a mixture of ejecta from different depths occurs in rays extending outward from the crater. Doublet and Triplet craters are situated between the landing site and Cone Crater, and may have penetrated into Fra Mauro material. Samples from Station G and G_1, as well as from the Comprehensive sample, may be representative of ejecta from these events (Table 1, figure 2). More detailed information is available in a recent discussion by Hawke and Head (1977), in summaries by the Imbrium Consortium (1976), and Swann et al. (1972, 1977).

The Apollo 14 Lunar Module (LM) landed in the Fra Mauro region of the moon on February 5, 1971, at latitude 3° 40' 24" S, longitude 17° 27' 55" W. The landing site is located 1,230 km south of the center of the Imbrium Basin and 550 km south of the southern rim crest of the basin (Swann et al., 1977). Figure 2 shows a map of the traverses taken during the Apollo 14 mission.

Three photogeologic map units were traversed during the two EVA's:

1) a smooth terrain unit on which the LM landed,
2) a cratered ridge of the Fra Mauro Formation which has slope angles of 10°-15°, and
3) the blocky rim deposit of Cone Crater, densely strewn with blocky ejecta 1-15 meters in size.

The smooth unit was originally thought to be either highlands volcanic material or a smooth facies of the Fra Mauro Formation that had been ponded in low areas between ridges (Eggleton and Offield, 1970). A primary objective of the mission was to sample the Fra Mauro Formation. Other objectives were the sampling of Cone Crater ejecta and the sampling of the smooth terrain around the LM. During the first EVA, the astronauts set up the Apollo lunar surface experiment package (ALSEP), collected the Contingency, Comprehensive, and Bulk Samples, and two "football size" rocks (FSR) (Table 2). On the second EVA, they travelled to the rim of Cone Crater, taking cores and grab samples enroute. During their return to the LM, more grab samples, cores, and trench samples were collected (Table 2, figure 2).

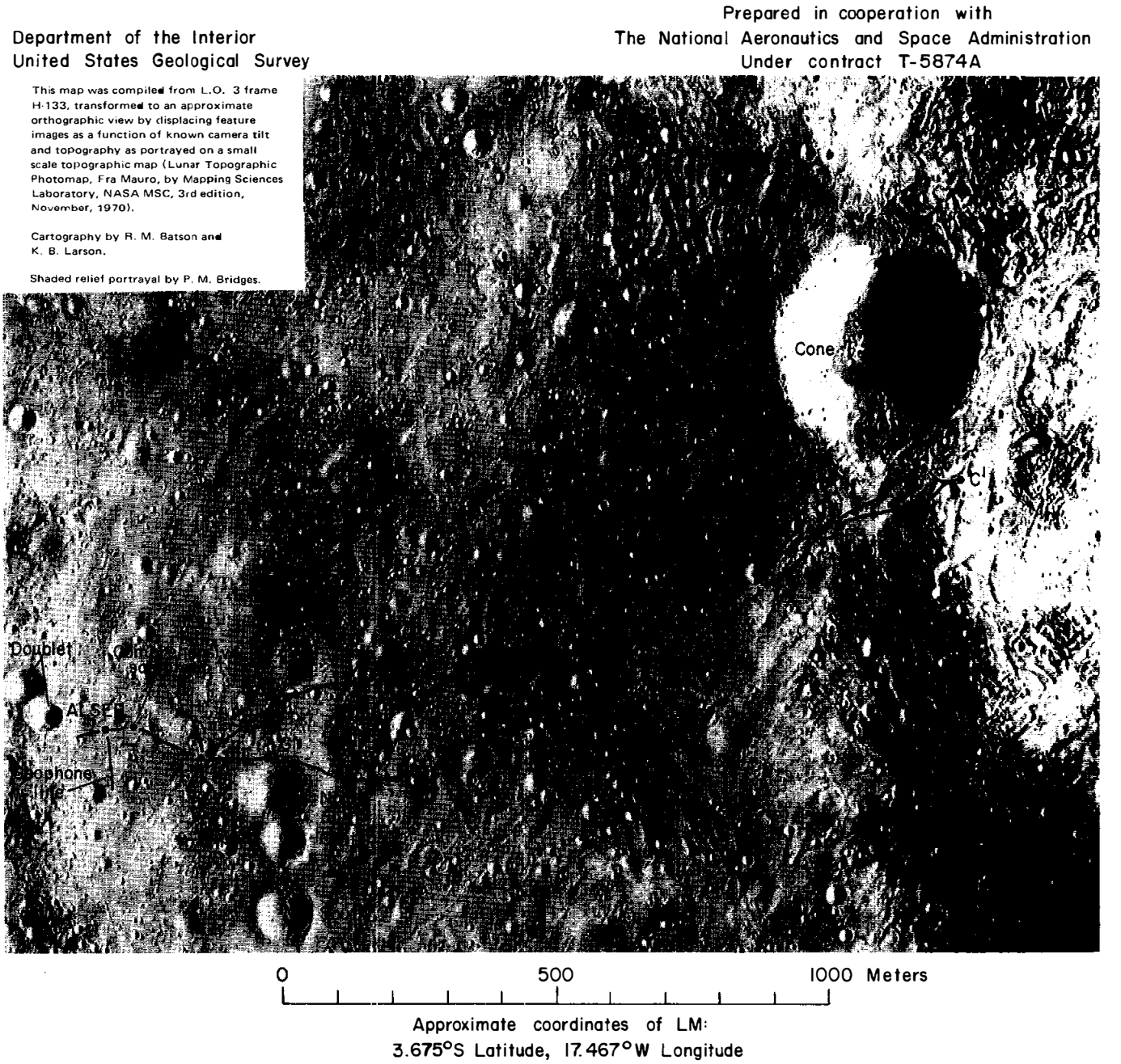


Figure 2. Apollo 14 landing site showing LM location and area traversed by astronauts during EVAS.

Table 1

Sample Locations (Swann *et al.*, 1977)

SAMPLE NUMBER	TRAVERSE STATION
14001 to 14012	Contingency sample, EVA 1
14041 to 14046	A
14047 and 14048	B
14049 and 14050	Bg
14051 and 14052	C'
14053 and 14054	C2
14055 to 14062	E
14063 to 14065	C1
14066 and 14067	F
14068 to 14072	C'
14073 to 14081	G
14082 to 14084	C1
14140 to 14144	C'
14145 to 14156	G
14160 to 14163	Bulk Sample
14165 to 14189	Comprehensive Sample, EVA 1
14190 to 14204	Unknown, Residue in weigh bag 1031, EVA 2
14210 and 14211	A
14220, 14230, 14240	G
14250 to 14289	Comprehensive sample, EVA 1
14290 to 14297	H (?) Residue in weigh bag 1038, EVA 2
14301	G1
14302	EVA 1, part of 14305 FSR
14303	EVA 1, part of 14304 FSR
14304	EVA 1, FSR
14305	EVA 1, FSR
14306	G
14307	G
14308	Dg part of 14311
14309	EVA 2, unknown station
14310	G
14311	Dg
14312	H
14313	G1
14314 to 14320	H
14321	C1
14411	A, core bit
14414	G, core bit
14421	Comprehensive Sample
14222 - 14453	Bulk Sample

Table 2

TRAVERSE STATION LOCATIONS AND DESCRIPTIONS
(Swann *et al.*, 1977)

STATION EVA 1	LOCATION BETWEEN LM AND ALSEP	DESCRIPTION SMOOTH UNIT
A	150 m NW of LM and 90 m N of North Triplet Crater	Fine grained friable breccia
B	330 m NE of LM and 65 m NNW of rim of Weird Crater	Fine grained clastics
C'	1.28-1.29 km ENE of LM and approximately 95-100 m SE of rim of Cone Crater	Fine grained polymict breccia (Cone Crater ejecta)
C1	1.24-1.25 km ENE of LM and 17-30 m SE of Cone Crater rim	White Rock area, breccia
G1	150 m E of LM on north rim crest of North Triplet Crater	Coherent clastic breccia
G	230 m ESE of LM and 50 m E of 50 m E of North Triplet rim crest	Coherent clastic breccia
H	Turtle Rock area, North Boulder Field 70-80 m NW of LM	Coherent clastic breccia

GENERAL PETROLOGY

Although systems of rock classification should not be based on sample genesis, their interpretation generally is based on some underlying model of how samples were formed. In the case of lunar samples, this model is relatively simple, but the resulting samples can be extremely complex. Primitive lunar crust is assumed to have been coarse-grained igneous material. Coarse-grained igneous lunar samples have old ages (most have crystallization ages older than 4.0 billion years ago), hypidiomorphic-granular texture with a grain size generally greater than 1 mm, anorthositic compositions or high Mg/Fe ratios suggestive of a cumulate origin, low rare-earth values and positive Europium anomalies, and have low-siderophile element concentrations (Warner et al., 1974).

This primitive coarse grained material is assumed to be older than most of the fine-grained igneous material. This fine-grained material includes mare flood basalts and volcanics with associated pyroclastics. These samples have igneous textures, lack mineral and lithic clasts, have low-siderophile concentrations, and contain relatively little metallic iron (Warner et al., 1974).

The primary geologic process acting on this primitive material has been meteroid bombardment. The major phase of this bombardment was accomplished before the emplacement of the flood basalts, but has continued up to present times. Meteoroid bombardment constitutes the major weathering and rock forming agent acting on the lunar surface. Lunar soils and breccias form as a result of meteoroid impact, but there has been much debate over the actual lithification process. Because of the close chemical and mineralogic resemblance LSPET (1969) believed lunar breccias to be shock lithified soil. Two schools of thought emerged, with investigators such as King et al. (1970), Mason et al. (1970), Quaide and Bunch (1970), Shoemaker et al. (1970), Wood et al. (1970) favoring shock welding and Smith et al. (1970), McKay et al. (1970), and McKay and Morrison (1971) preferring thermal welding as the lithification process responsible for breccia formation. Chao et al. (1971) believed breccias formed by low level shock compaction of the soil near the base of the regolith. He felt that this would occur at some distance from the impact. Studies of Apollo 14 breccias indicated thermal metamorphism to be the most reasonable model for breccia lithification (Warner, 1972; Jackson and Wilshire, 1972; Wilshire and Jackson, 1972; Chao et al., 1972). More recently, using SEM techniques, Simonds et al. (1977) and Phinney et al. (1976) suggested that breccias form when hot silicate melt welds the relatively cool clastic fragments together during meteorite impact.

The collection of rocks returned by the Apollo 14 mission consists of breccias, most of which are compound (or polymict) in their nature, and a few basalt samples. This is consistent with the idea that the Apollo 14 landing site was on the Fra Mauro Formation. A breccia is a rock consisting of angular coarse-grained fragments in a fine grained matrix. Commonly, in the case of lunar breccias, there is no definite distinction between "matrix" and "clasts" because of the seriate texture of the rock. In these cases, we refer to fragments larger than 1 mm as clasts and those smaller than 1 mm as matrix to be consistent with the practices of the curatorial staff.

Breccias have a higher siderophile element concentration than do lunar rocks of igneous origin implying that they contain some admixed meteoritic material. They contain both mineral and lithic clasts and have more metallic iron than do either the fine-grained or coarse-grained igneous rocks.

The return of so many breccias as a result of the Apollo 14 mission made it important to devise a breccia classification scheme, and many investigators have done so. Wilshire and Jackson (1972) chose a simple descriptive means of classification which enables the rocks to be placed in categories (F1-F4) primarily on the basis of the color index of their clasts and the sample's coherence, a useful classification allowing the rocks to be categorized on the basis of hand specimen examination (Table 3).

TABLE 3

Basic Breccia Classification Scheme
of Wilshire and Jackson (1972)

	FRIABLE	COHERENT
LIGHT CLASTS	F_1	F_2
DARK CLASTS	F_3	F_4

Following more extensive observations, it was possible to invent more elaborate schemes, and a debate arose over the classification as well as over the origin of these breccias. Much of the debate stemmed from the lack of agreement on the stratigraphic history of the landing site (see General Geology). Most researchers had accepted the Fra Mauro Formation as being an ejecta blanket associated with the Imbrian event, and, there is undoubtedly a sizable contribution of material from the many post-Imbrian cratering events. This contribution could be merely a thin veneer mixed with Imbrium ejecta or it could even be a thick regolith developed on Fra Mauro basalts as was suggested by Schonfeld and Meyer (1973). Many workers now accept the arguments of Chao (1972), Morrison and Oberbeck (1975), and Head and Hawke (1975) that the high degree of thermal effects in the rocks is more consistent with their origin by nearby smaller, pre-Imbrian events. This has recently been reviewed by Hawke and Head (1977).

Almost as many methods of classifications of these breccias were developed as there were articles written about them. Some, such as Chao et al. (1972), formed groups on teh basis of the clasts, thereby deriving genetic relationships. Chao's classification system is based on fragment population, nature of matrix, grain size and porosity, metamorphic history, and bulk chemical composition. He divided the Apollo 14 breccias into regolith microbreccias, Fra Mauro breccias, and spherule-rich microbreccias (Table 4).

TABLE 4

Breccia Classification System
of Chao et al. (1972)

1. Regolith microbreccias
   a. Unshocked, porous
   b. Compact, nonporous
   c. Shocked
2. Fra Mauro breccias
   a. Unannealed or slightly annealed, feldspathic breccias
   b. Moderately annealed breccias
   c. Strongly annealed (thermally metamorphosed) breccias
      Unshocked
      Shocked
3. Spherule-rich, transported microbreccias

This classification is roughly comparable to that of Jackson and Wilshire (1972). Their F_1 is equivalent to the unshocked, porous regolith microbreccia of Chao et al. (1972); F_2 resembles the compact or shocked regolith microbreccia; F_3 is analogous to unannealed (Fra Mauro) friable feldspathic microbreccia, and F_4 resembles the strongly annealed (Fra Mauro) breccias of Chao et al. (1972).

The distinction between shocked and unshocked samples in the classification of Chao et al. (1972) is mainly on the basis of the presence or absence of microfractures that cause the microbreccias to break across, rather than around, grain boundaries. Other shock features include shock-induced lamellar twinning in ilmenite grains, low porosity, and glass coating on the microbreccia chips. Compact regolith microbreccias that show no evidence of shock features were also observed (14313).

The gradation between unannealed to annealed breccias is analogous to that of Warner's (1972) low to high metamorphic grades. This model included three metamorphic grades, low, medium, and high. He was able to form eight groups (1-8) corresponding to these grades. These were formed on the basis of abundance of matrix glass, abundance of glass clasts, and matrix texture. It was suggested that with increasing temperature, glass clasts and spherules devitrify and lose identity, while pyroxene and feldspar recrystallize developing more euhedral crystals, until, at the highest temperatures, the matrix melts. These 8 groups were correlated with temperature by Williams (1972) who found the range from 500°-1100°C to be sufficient to produce the observed features. Magnetic properties of the Apollo 14 samples correlate well with the metamorphic classification of Warner (1972). All observed magnetic characteristics can be attributed to the increase in grain size

of interstitial iron from the 100 Å range in Warner's lowest metamorphic grade samples to grains larger than 1 μm in the highest grade samples (Gose et al., 1972)

Quaide and Wrigley (1972) saw three groups: regolith breccias, white rock breccias, and annealed breccias. Others believed the matrix provided a good classification standard. Von Engelhardt et al. (1972), using glass content as a criterion, divided breccias into 3 groups, each matched by a proposed origin:

I. Glass-rich breccias - produced by meteorite impacts on regolith

II. Glass-poor breccias - produced by impacting solid rock

III. Glass-poor breccias with a crystalline matrix - produced by recrystallization of a base surge deposit or an impact melt

Christie et al. (1973) emphasize textural features, forming two groups (A & B) on the basis of the presence or absence of evidence of recrystallization, and Lindsay (1972) formed two groups, I and II, on the basis of the presence or absence of glass.

Later, more detailed studies of the matrices of the Apollo 14 breccias using the SEM indicated that the texture of Warner's group 1-7 is "heterogeneous and intermingled on a scale of millimeters" (Simonds et al., 1977). Based on these studies Simonds et al. (1977) have identified 3 breccia groups, which bear some resemblance to the groups of von Engelhardt et al. (1972). The three groups they propose are:

Crystalline matrix breccias (CMB) - those with coherent holocrystalline matrices, at least vestiges of clasts, and meteorite contamination (evidenced by high siderophile content).

Vitric matrix breccias (VMB) - impactites with a definite fragmental texture and abundant glass, glass-bearing clasts, and low melting point clasts.

Light matrix breccias (LMB) - friable, porous, fragmental breccias, with little glass, lacking in recrystallization effects, and more feldspathic than the other two categories.

Simonds et al. (1977) further subdivide their crystalline matrix breccias into 3 subgroups:

(1) Clast-free impact melts (14310, 14276)

(2) Clast-bearing impact melts - 1-15% clasts (14068)

(3) Fra Mauro breccias - more than 15% clasts (all other Apollo 14 CMB's)

Indeed, many of the Apollo 14 breccias are described by them as being crystalline matrix breccias of the Fra Mauro type.

Table 5 contains a list of Apollo 14 rocks and their classification by various investigators. The following observations can be made based on samples classified by the various schemes suggested:

TABLE 5
COMPARISON OF VARIOUS BRECCIA CLASSIFICATION SCHEMES

Sample	Mass (g.)	Wilshire and Jackson (1972)	Warner (1972)	Chao et al. (1972)	Quaide and Wrigley (1972)	von Engelhardt et al. (1972)	Simonds et al. (1977)
14006	12	C	high (6)	2c unshocked	Annealed Breccia	Glass poor crystalline matrix	CMB
14066	510	F4	high (7)	2c shocked	Annealed Breccia	Glass poor crystalline matrix	CMB
14169	78.66	F4					CMB
14171	37.79	F3	med (4)	2c shocked			CMB
14172	32	F4					CMB
14270	25	F4	high (7)	2c unshocked			CMB
14274	15	C					CMB
14303/304	3397	F4	high (6)	2c shocked	Annealed Breccia		CMB
14305/302	2497	F4	high (6)	2c shocked			CMB
14311/308	3200	F4	high (5)	2c unshocked 2c shocked	Annealed Breccia	Glass poor crystalline matrix	CMB
14312	299	F4	high (7)	2c shocked			CMB
14314	116	F4	high (7)	2c shocked			CMB
14319	211	F4	high (7)	2c shocked			CMB
14320	64.9	F4	high (6)	2c shocked	Annealed Breccia	Glass poor crystalline matrix	CMB
14321	9000	F4	med (4)	2b	Annealed Breccia	Glass poor crystalline matrix	CMB
14306	872	F4	med (4)	2c shocked	Annealed Breccia		CMB
14063	135	F3	med (3)	Fra Mauro Breccia 2a	White Rock Breccia	Glass poor with fragmental matrix	LMB
14064	107	F3					LMB
14083/82	79	F3	med (3)	2a		Glass poor with fragmental matrix	LMB

Sample	Mass (g.)	Wilshire and Jackson (1972)	Warner (1972)	Chao et al. (1972)	Quaide and Wrigley (1972)	von Engelhardt et al. (1972)	Simonds et al. (1977)
14041/42	270	F1	low (1)	Regolith micro-breccia unshock-ed la Porous			VMB
14045	65	F1					VMB
14047	242	F1	low (1)	Regolith micro-breccia unshock-ed la Porous			VMB
14049	200	F1	low (2)	Regolith micro-breccia unshock-ed la Porous		Glass rich rego-lith breccia	VMB
14055	111	F1	low (1)	Regolith micro-breccia unshock-ed la Porous	Regolith Breccia	Glass rich rego-lith breccia	VMB
14255	22	F2					VMB
14264	117	F4					VMB CMB clasts
14265	66	F2					VMB
14269	17	F2					VMB
14271	97	F2					VMB
14275	13	F2					VMB
14301	1360	F2	low (2)	Regolith micro-breccia unshock-ed la Porous			VMB
14307	155	F2	low (1)	1c shocked		Glass rich rego-lith breccia	VMB
14313	144	F2	low (1)	1b compact	Regolith Breccia		VMB
14315	115	F2	med (3)	3 spherule			VMB
14318	600	F2	med (3)	3 rich	Regolith Breccia	Glass rich rego-lith breccia	VMB

- All CMB's are F_4 except 14171 (F_3)
- All LMB's are F_3
- All VMB's are F_1 or F_2 except 14264 (F_4)
- Twice as many VMB's are F_2 as F_1
- All CMB's are Warner's grade 4 or higher except 14171 (3)
- All LMB's are Warner's grade 3
- All VMB's are Warner's grade 3 or lower

In fact, the groups formed by von Engelhardt et al. (1972) contain the same members as the groups proposed by Simonds et al. (1977) without exception (Tables 5 and 6).

TABLE 6

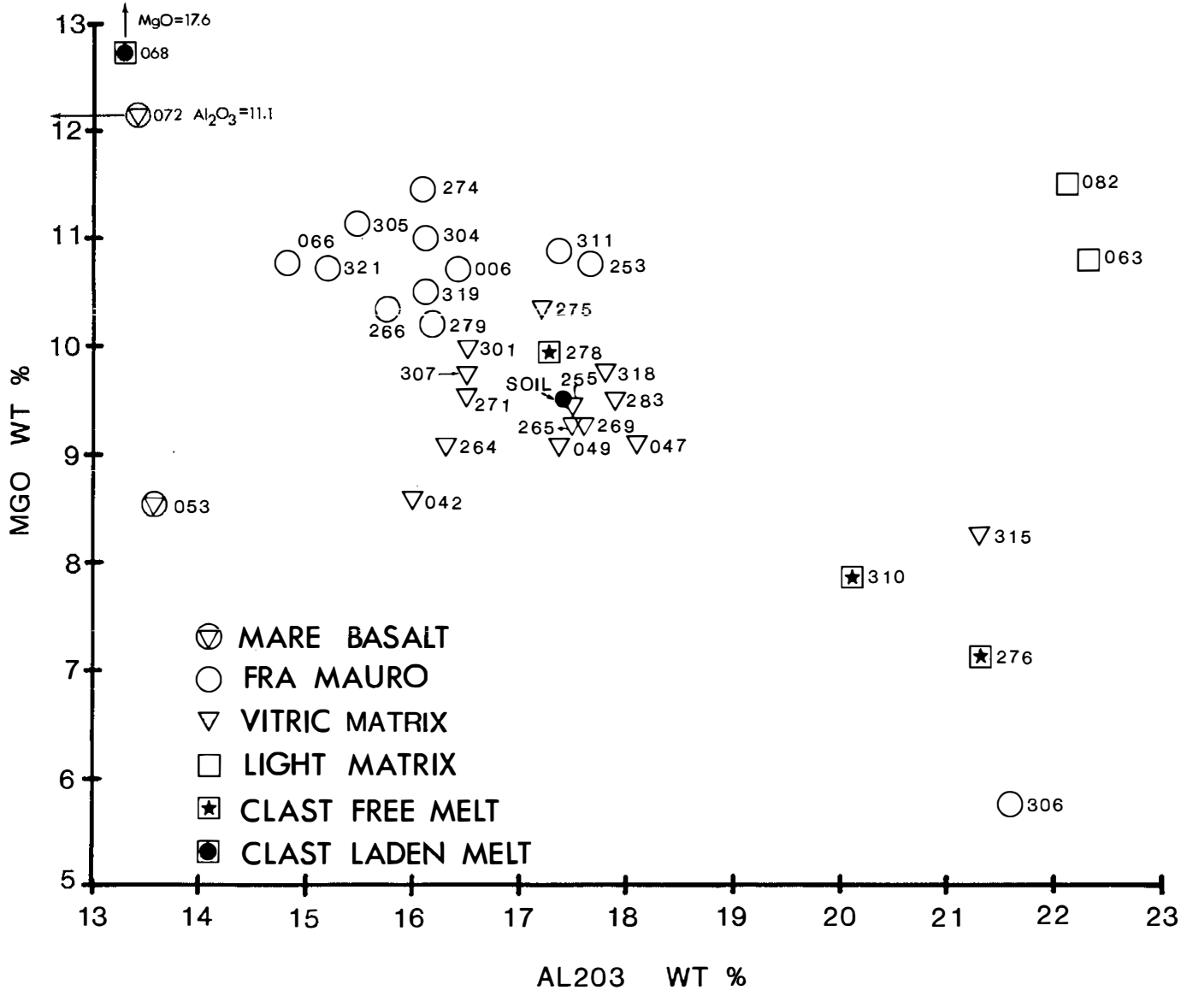
Comparison of the Classifications
Simonds et al. (1977) and von Engelhardt et al. (1972)

Simonds et al., 1977	von Engelhardt et al., 1972
CMB	Glass poor with crystalline matrix
LMB	Glass poor with fragmental matrix
VMB	Glass rich regolith breccia

It is not so easy to relate the classification of Chao et al. (1972) to the others because his was based on clasts, but all CMB's studied by Chao were placed in his group 2c except 14321, which was classified as a 2b. Moreover, all the 2c breccias are CMB's and F_4's except 14171 which is a F_3. An interesting feature noted by our group in observing clast populations is the association of chondrules or chondrule-like bodies with the larger samples of the 14300 series. Smaller samples contain more amorphous "glassy" masses and matrix glass.

It is interesting to note the numerous similarities that must exist among those groups of breccias for there to be so few exceptions when attempts are made to correlate different classification schemes. This suggests that there are natural groupings of breccias and/or there might be something fairly unusual about samples that are exceptions to these groupings, such as 14171, 14264, and 14321. For the purposes of this booklet, we will rely on criteria recognized by von Engelhardt et al. (1972) and Simonds et al. (1977) as being effective in forming groups among the lunar breccias. Differences among these groups are relatively uncomplicated and distinctive. In addition, the small but important difference in chemical composition (Mg and Al) noticed by Simonds et al. (1977) (figure 3) for CMB, VMB and LMB types is persuasive evidence of their basic difference. Unlike Simonds et al. (1977), however, we will tend to refer to samples such as 14310 and 14276 as melt rocks rather than "clast-free impact melt crystalline matrix breccias."

Figure 3. MgO vs Al_2O_3 plot for Apollo 14 samples. [After Simonds et al., 1977.]



A basalt is a fine grained, usually dark colored, igneous rock which commonly is extrusive in origin. It is composed primarily of calcic plagioclase, pyroxene, and other mafic minerals such as olivine. Lunar basalts differ from terrestrial basalts chiefly in their minor element composition. Lunar basalts typically contain more TiO_2, rare earth elements, and zirconium, and less nickel than their terrestrial counterparts. The plagioclase is more calcic in lunar basalts, being An_{80} or more in composition while terrestrial basalts are more likely to be in the labradorite range of plagioclase composition.

It was anticipated from early data on the large ion lithophyle (LIL) element-rich or KREEP basalts from the Apollo 12 site that Fra Mauro samples would have similar characteristics. Hubbard et al. (1972) establish the similarities among other KREEP basalts and Apollo 14 basalts. Using Al_2O_3 and FeO as discriminating factors, Hubbard et al. (1972) show that mare basalts are distinguished from non mare basalts (KREEP and low-k) by higher FeO (> 14%) and lower Al_2O_3 (< 12%) concentrations.

Some disagreement exists regarding the classification of crystalline lunar rocks. Of the crystalline rocks returned during the Apollo 14 mission, very few are regarded as basalts by virtually all investigators. As we pointed out previously, samples 14310 and 14276 are classified as crystalline matrix breccias of the clast-free impact melt variety by Simonds et al. (1977).

When we can recognize remnant clasts or other criteria suggesting that a sample was once a soil or a breccia, we will simply refer to it as a melt rock. Obviously, many samples duplicating basaltic texture and composition may have had their origins as something other than extrusive or intrusive melts, but we do not feel that the name "basalt" must necessarily carry genetic connotations. These samples are referred to merely as crystalline rocks.

Glossary of Terms Used in Petrographic Descriptions

anorthite - triclinic plagioclase feldspar with the composition (Ca_{90-100}, Na_{10-0}) $Al_2Si_2O_8$

anorthosite - rock name for an igneous rock (or lithic fragment) composed almost entirely of plagioclase (usually calcic plagioclase). Lunar anorthosites have a granulitic texture.

basalt - a fine grained, usually dark colored, igneous rock which commonly is extrusive in origin. Composition of basalt, ordinarily, includes primarily calcic plagioclase, pyroxene, and other mafic minerals, such as olivine.

breccia - a clastic rock with angular and broken rock fragments in a finer grained matrix. For purposes of this catalog, breccia fragments larger than 1 mm are designated as clasts, and those smaller than 1 mm are referred to as matrix.

clast - fragmental part of a breccia larger than 1 mm. A clast may be lithic, mineral, or glass in lunar breccias.

coherent - consolidated; not friable; doesn't crumble easily

crystallite - a broad term applied to grains or crystals which are too small for identification

dendritic - minerals that have crystallized in a branching or feathery pattern, commonly in a glassy matrix

devitrified - said of a glass which has converted to a crystalline texture after its solidification

fragmental rock - any clastic rock; rock composed of fragments of other rocks, minerals, or glass; includes breccias and microbreccias

friable - said of a rock that crumbles naturally or is easily broken; poorly consolidated; poorly cemented; not coherent

gabbro - coarse grained equivalent of basalt, commonly intrusive in origin

"glass" - a term used in optical petrographic descriptions to denote amphorous and/or cryptocrystalline material

leucocratic - light colored; applied to a light-colored igneous rock relatively poor in mafic minerals

matrix - smaller or finer grained material filling interstices between the larger grains or particles of a rock; for purposes of this catalog, portion of a breccia smaller than 1 mm in size

melanocratic - dark colored; usually applied to dark colored igneous rock rich in mafic minerals

melt rock - igneous rock which is neither intrusive nor extrusive in origin, but formed by melting during meteoroid impact. These rocks resemble basalts, but have "ghost clasts," or small areas of textural homogeneity enclosed in a fabric of a different texture; occasionally these exhibit remnant clasts, which appear as xenocrysts

mesocratic - composed of subequal amounts of light and dark constituents; applied to igneous rocks intermediate in color between leucocratic and melanocratic

mesostasis - the last-formed interstitial material, either glassy or aphanitic, of an igneous rock

microbreccia - a breccia with no clasts larger than 1 mm; a clast of a breccia from previous generation within another breccia

norite - a coarse grained plutonic rock containing calcic plagioclase and orthopyroxene

ophitic - texture of a holocrystalline, hypidiomorphic rock in which lath-shaped plagioclase crystals are partially or completely enclosed by pyroxene crystals

phenocryst - a term used for a large crystal in a porphyritic igneous rock

poikilitic - igneous rock texture in which small crystals of one mineral (e.g. plagioclase) are irregularly scattered without common orientation in a larger crystal of another mineral (e.g. pyroxene)

polymict - said of a breccia containing fragments of differing composition

seriate - texture in which grain size varies gradually or in a continuous series from large to small

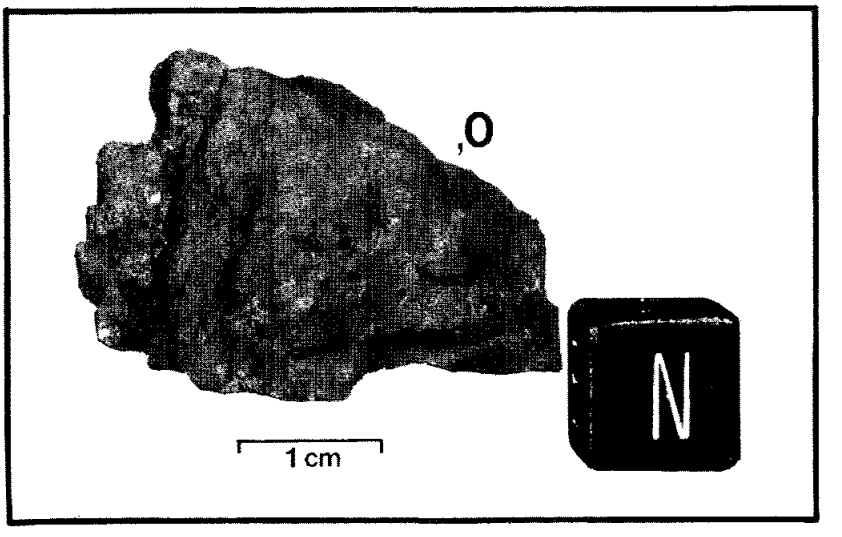
subophitic - said of the ophitic texture of an igneous rock in which the feldspar crystals are approximately the same size as the pyroxene and are only partially enclosed by them

troctolite - a coarse grained plutonic rock containing calcic plagioclase and olivine, with little or no pyroxene

zap pit - micrometeoroid impact crater on a lunar sample; commonly lined with glass

APOLLO 14 ROCK SAMPLE DESCRIPTIONS

14006

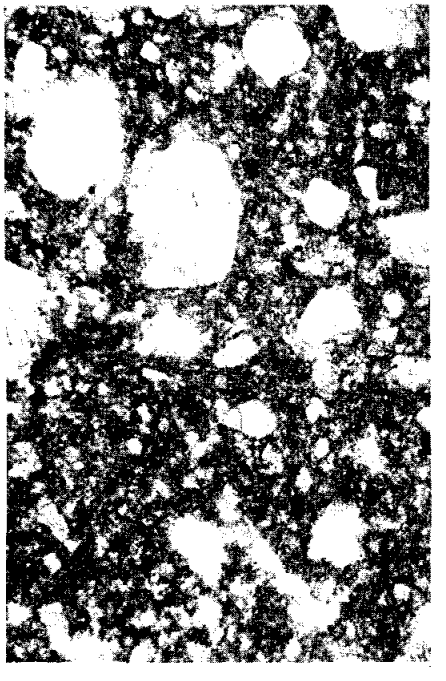


S-71-25297

14006, 5

.1mm

14006, 21



Note: Variation in glass content.

Sample 14006 was collected as part of the contingency sample during the first EVA in the vicinity of the lunar module. It was returned in weigh bag 1039 along with the rest of the contingency sample.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
12.13 g	3.0 x 2.0 x 1.3 cm

This rock is a coherent, dark medium gray breccia with leucocratic clasts comprising less than one percent of the sample. Thin section examination reveals the sample to be inhomogeneous with respect to glass content.

SURFACE FEATURES

Sample 14006 is pitted with one fresh surface. The pits are glass lined and vary in size from 0.3 to 0.7 mm. Pit density is very low.

Vugs are present, covering less than 5% of the surface of the sample. They range in size from 0.1 to 0.5 mm and are spaced approximately 4 mm apart. They are irregular to subcircular in shape, and are homogeneous in distribution. Plagioclase crystals projecting from the walls are clear to gray, but were not observed in thin section. One non-planar fracture cuts the rock. The fracture surface texture appears typical of that of the rest of the sample.

PETROGRAPHIC DESCRIPTION

In thin section 14006 is a fine grained, texturally heterogeneous, fragmental rock. Less than one percent of the rock is composed of 1 mm clasts. These are composed of plagioclase cumulates with minor olivine (40%), pale yellow pyroxene (10%), gray pyroxene (50%), and scattered opaque minerals. The matrix is very fine grained with some glass. There are small masses of a reddish-orange glass present as distinct units in the matrix. The matrix is nearly opaque and shows gradation of size from very fine-grained up to rather coarse-grained. The grains that comprise the matrix material appear to be single crystal fragments to small lithic fragments.

Vugs are round to irregular and comprise approximately 5% of the sections. The size of the vugs vary from 0.1 mm up to 0.5 mm. There are no crystals projecting into any of the vugs.

The clasts (> 1 mm fragments) consist of a wide variety of lithic fragments as well as single mineral grains. Among the lithic clasts present are the following: plagioclase cumulates with olivine; fine-grained polymict breccias; and a few devitrified glass fragments. The remainder of the clasts consist of single crystal fragments of plagioclase and pyroxene. Many of the pyroxene grains show reaction rims. Most of the mineral grains show well developed cleavage patterns. Many of the larger plagioclase grains are multi-twinned.

The fragments throughout the sections show little to no shock effects. Some of the plagioclase forms radiating bundles which may be a devitrification feature. Several "ghost" clasts are present which are clasts that blend in with the matrix in such a manner as to make their distinction very difficult. These clasts, however, are distinct in texture and composition as to distinguish them one from another. Localized pods of fine grained matrix occurs intermingled with stringers of coarser grained matrix surrounding it.

DISCUSSION

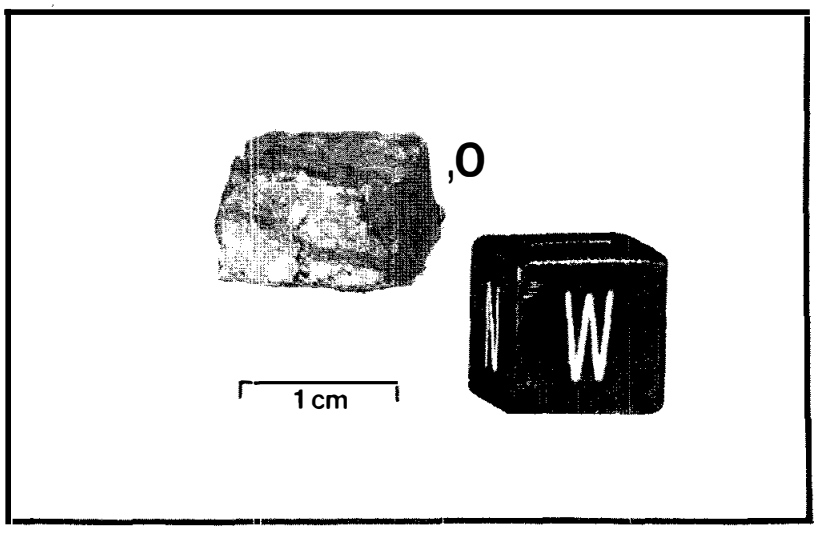
Sample 14006 is one of the rocks studied by Warner (1972), Wilshire and Jackson (1972), Chao et al. (1972), Quaide and Wrigley (1972), von Engelhardt et al. (1972), and Simonds et al. (1977). They agree that it is a glass poor breccia with a crystalline matrix. Chao et al. (1972) classify it as unshocked strongly annealed Fra Mauro breccia (2c). Warner (1972) and Chao et al. (1977) list it as having been thermally metamorphosed. Simonds et al. (1977) classify it as a CMB (see Table 4, p.). Simonds et al. (1977) studied sample 14006,5. Our group examined 14006,7 and 14006,21 and found the matrix to consist of 5 - 6% glass. These sections appear to be more like the LMS's of Simonds et al., or the glass-poor with a fragmental matrix rocks of von Engelhardt et al. (1972). They do not have enough glass to be classed as a VMB, but neither sample 14006,7 nor sample 14006,21 is a CMB. On the other hand, the thin sections show the clear cut difference from one thin section to another -- 14006,5 appears to have a crystalline matrix with little or no glass visible.

Phinney et al. (1976) studied sample 14006,6 and described it as a tough, crystalline breccia with 15 - 20% vugs and vesicles. The matrix is described as consisting of 10 - 20 μm plagioclase and clinopyroxene, with 5 μm ilmenite and smaller than 5 μm interstitial potassium feldspar. Grains are mostly equigranular and interlocking, but some are subhedral in shape.

Sample 14006 is said to have the typical major and trace element chemistry of Apollo 14 basaltic breccias of KREEP composition (Hubbard et al., 1972) except that both have low K and Rb concentrations accompanied by increases in K/Rb ratios (Gibson and Hubbard, 1972).

Scanning electron microscope studies (McKay et al., 1972) reveal that 14006 has vapor phase deposited minerals lining cavities. A limit at 1050°C has been placed on the temperature to which this sample was heated, because the sample has been depleted in K and Rb but not Na, and because of the vapor phase deposition (Gibson and Hubbard, 1972).

14007



S-71-25324

Sample 14007 was collected as part of the contingency sample during the first EVA in the vicinity of the lunar module. It was returned in weigh bag 1039 along with the other contingency samples (14001-14012). (Sample 14012 consists of residue fines from 14001-14011.)

PHYSICAL CHARACTERISTICS

Mass:	Dimensions:
3.67 g	2.4 x 1.1 x 0.6 cm

This sample is a moderately coherent, gray, polymict breccia.

SURFACE FEATURES

Sample 14007 contains no zap pits and has a blocky, relatively smooth surface.

A possible remnant of a glass sheet is present in a fracture. This planar fracture transects clasts.

PETROGRAPHIC DESCRIPTION

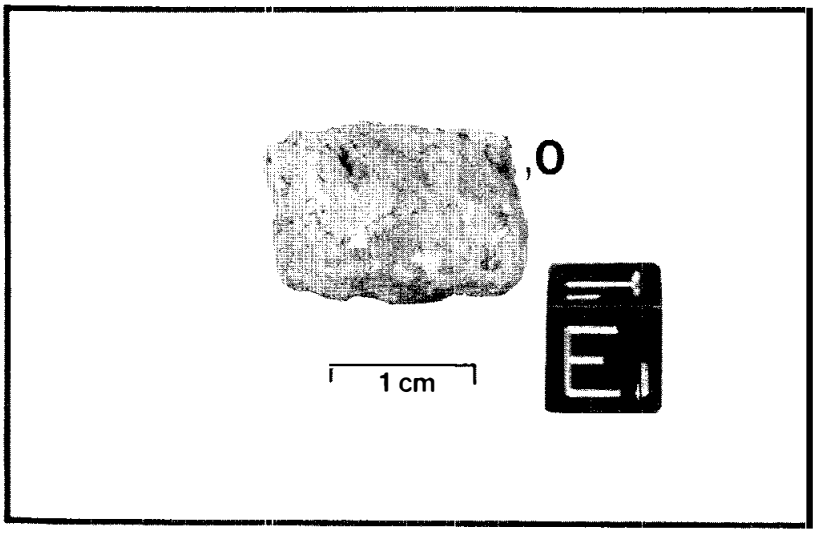
The sample is fine-grained with an average grain size of 0.1 mm. It appears to be texturally homogeneous, but mineralogically inhomogeneous. The sample consists of 20% clasts larger than one mm, and 80% matrix. Of these clasts, 90% are leucocratic and 10% mesocratic lithic fragments. The mesocratic fragments consist mainly of olivine, with possible accessory pyroxene. The leucocratic clasts are of two varieties. One is 60% plagioclase and 40% brownish gray pyroxene, and the other is 90% plagioclase and 10% olivine. The largest leucocratic clasts are 8 mm in size.

The matrix consists of 65% medium gray pyroxene and 35% plagioclase. The plagioclase seems to be somewhat lath-shaped. Traces of opaques and a pinkish orange mineral (spinel?) are also present in the matrix.

DISCUSSION

Sample 14007 is classified by Wilshire and Jackson (1972) as an F_2.

14008



S-71-25325

Sample 14008 was collected from the LM vicinity during the first EVA as part of the contingency sample. It was returned in weigh bag 1039 along with the rest of the contingency samples (14001-14012).

PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.35 g	2.3 x 1.4 x 0.9 cm

Sample 14008 is a medium gray, friable, breccia with only one visible clast larger than 1 mm.

SURFACE FEATURES

Some deep zap pits are present with an average size of 0.6 mm. No vugs or fractures can be seen on this fragment. The lunar top cannot be accurately determined because the sample appears to have been broken (probably in transit).

PETROGRAPHIC DESCRIPTION

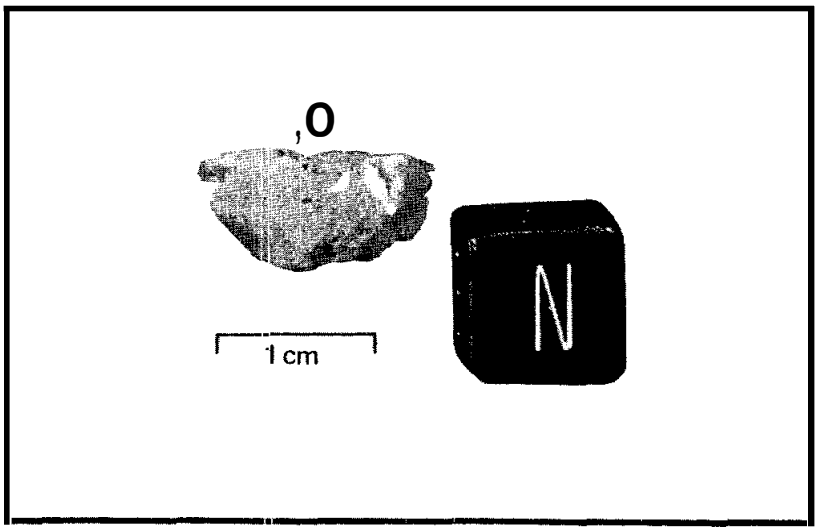
Sample 14008 is a fine grained fragmental rock with an average grain size less than 0.1 mm. It is texturally and mineralogically homogeneous.

The one clast larger than one mm is a black angular fragment. Visible components of the matrix include plagioclase, olivine, pyroxene, glass, and lithic fragments. Lithic fragments are mesocratic with a large proportion of feldspar. Pyroxene accounts for up to 50% of the fragments, while 10% are composed of pyroxene and olivine. Glass is present both as spheres and angular fragments.

DISCUSSION

Wilshire and Jackson (1972) tentatively identified it as an F_1, but it is too small to chip for thin section determination.

14009



S-71-25329

Sample 14009 was collected as part of the contingency sample during the first EVA. It was collected, along with the other contingency samples (14001-14012) from the vicinity of the LM and these were returned in weigh bag 1039.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.09 g	0.7 x 0.9 x 1.3 cm

This is a medium gray, friable, polymict breccia with 3-5% clasts larger than 1 mm.

SURFACE FEATURES

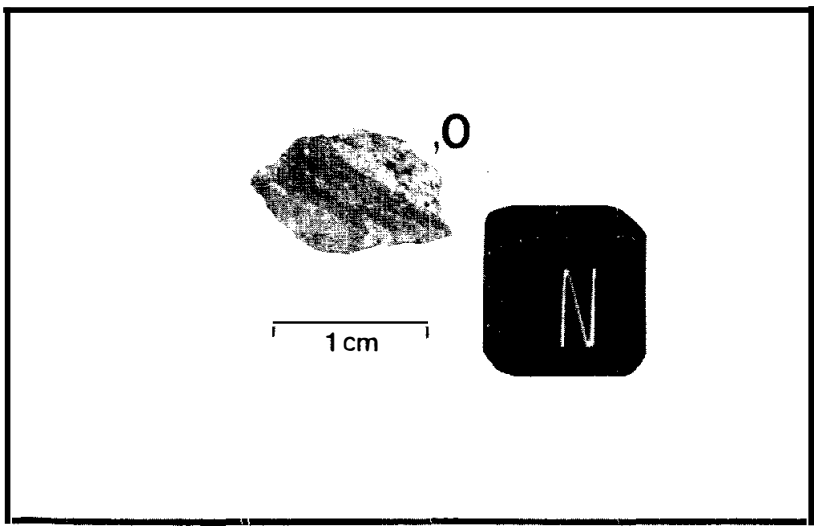
There are no zap pits or cavities present. Two planar fractures occur parallel to one another spaced 1 mm apart.

PETROGRAPHIC DESCRIPTION

This polymict breccia is texturally and mineralogically inhomogeneous. It is fine grained with an average grain size of less than 0.1 mm. Clasts larger

than 1.0 mm comprise 3-5% of the rock and are all leucocratic. The largest clast is 3 mm across and contains milky feldspar and an unidentified yellow mineral. This clast may exhibit shock features but no thin section is available due to the small size of the sample. Both angular and spherical dark brown glass fragments account for 2-3% of those in the 0.2-1.0 mm size range. Four percent of the fragments in this range are cinnamon brown pyroxene, and 45% are leucocratic lithic fragments. The rest appears to be olivine.

14010



S-71-25337

Sample 14010 is one of those collected as part of the contingency sample during the first EVA in the vicinity of the LM. It was returned in weigh bag 1039 along with the rest of the contingency sample (14001-14012).

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.00 g	2.4 x 2.5 x 0.5 cm

This sample is a friable, gray, polymict breccia with 10% clasts larger than 1 mm.

SURFACE FEATURES

No zap pits are present on the surface, but there are small splashes of yellowish white glass covering less than 1% of the surface. One non-planar fracture cuts this sample.

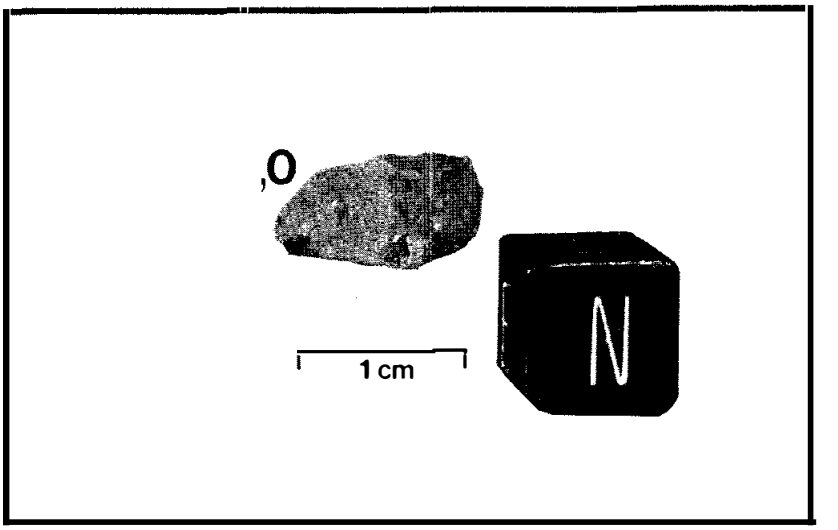
PETROGRAPHIC DESCRIPTION

Sample 14010 is a friable fine-grained polymict breccia with an average grain

size of 0.05 mm.

Ten percent of the fragments are larger than 1 mm and 90% are matrix. Mineral fragments of feldspar, pyroxene, and possibly olivine comprise 70% of these clasts. Thirty percent are lithic fragments of crystalline rocks. The largest clast is 10 mm in size. White clasts consist of 60% feldspar, 10% greenish-yellow mineral (olivine?), 2% ilmenite, and 25% brown mineral (pyroxene?). The matrix contains smaller fragments of the clast components and some glass.

14011



S-71-26096

Sample 14011 was collected during the first EVA from the vicinity of the LM as part of the contingency sample. It was returned in weigh bag 1039 along with the rest of the contingency sample (14001-14012).

PHYSICAL CHARACTERISTICS

Mass	Dimensions
0.68 g	0.6 x 0.8 x 1.2 cm

This is a medium gray, blocky, friable, polymict breccia with 1% clasts larger than 1 mm.

SURFACE FEATURES

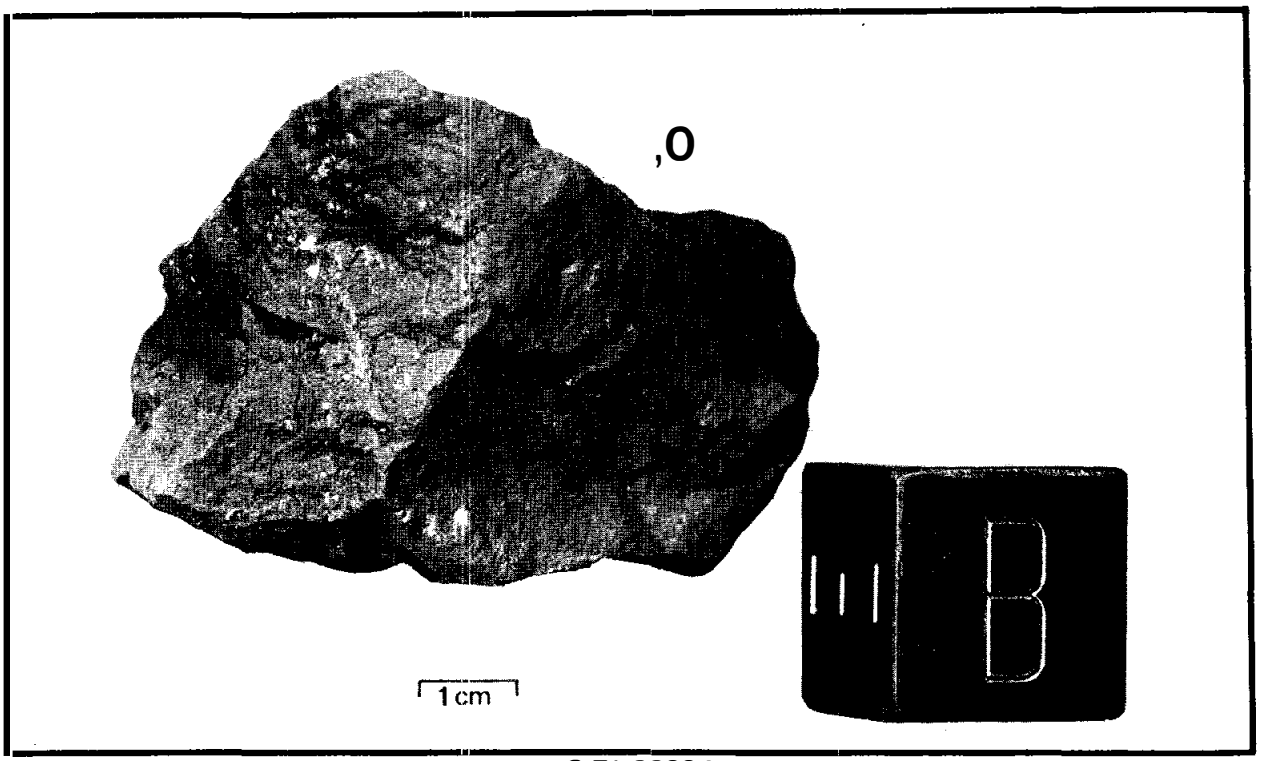
Dust filled zap pits are very sparsely distributed over the surface. They average 1 mm in size and do not appear to be glass-lined.

PETROGRAPHIC DESCRIPTION

This friable, polymict breccia has 1% clasts larger than 1 mm and 99% matrix. Clasts consist of both lithic fragments and mineral fragments in subequal

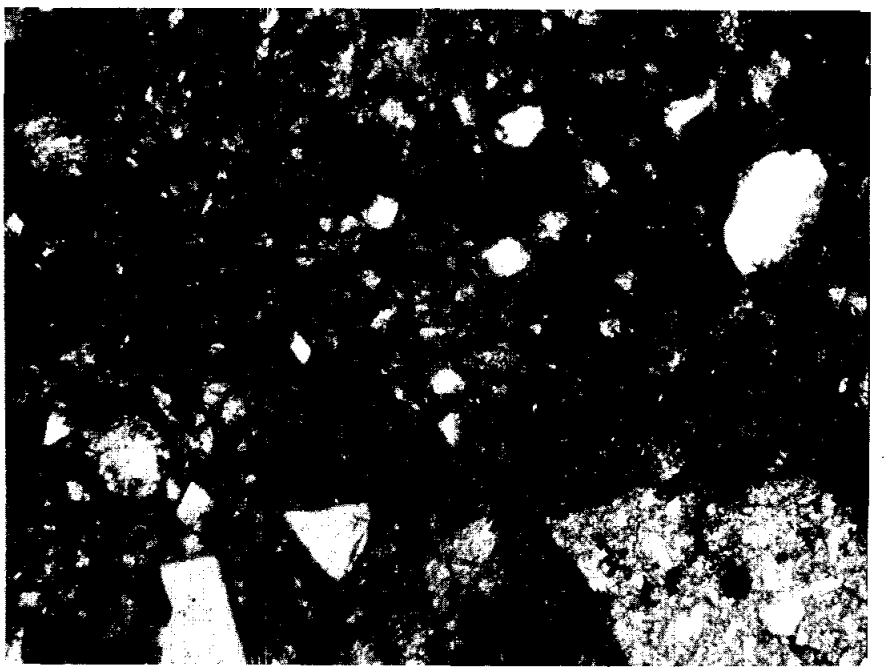
proportions. One clast is 1.5 mm in size and consists of subangular chalky white plagioclase which contains a cross-cutting glass vein. One 1.0 mm fragment is angular, deep brown pyroxene which shows some cleavage. One melanocratic clast contains 10% white plagioclase, 5% brown pyroxene and 1% leucocratic rock fragments. The matrix contains 5% glass, 10% plagioclase, 5% brown pyroxene, 1% leucocratic lithic fragments, and the remainder is too fine to resolve.

14041

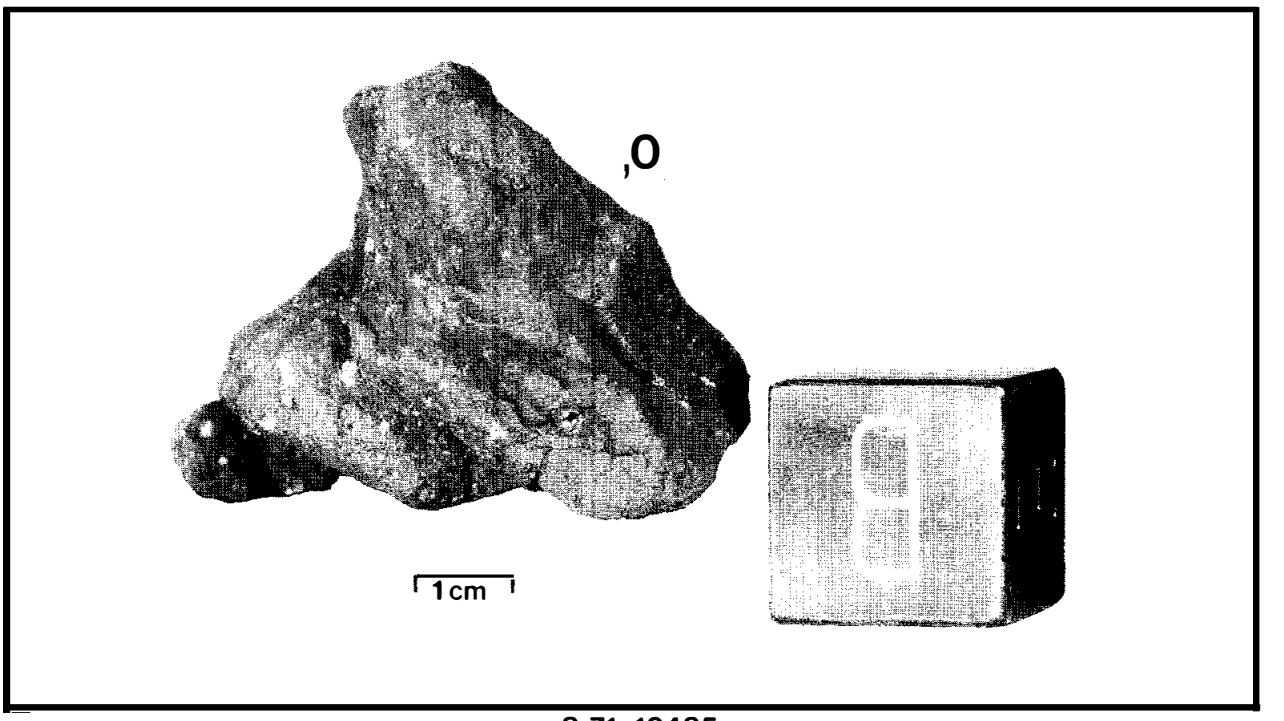


S-71-33224

14041,6

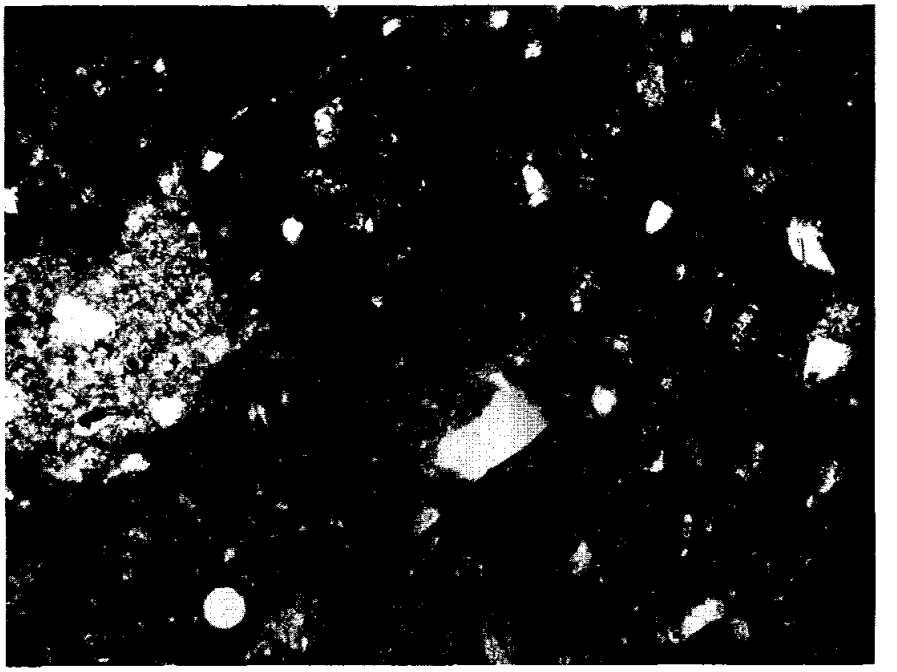


14042

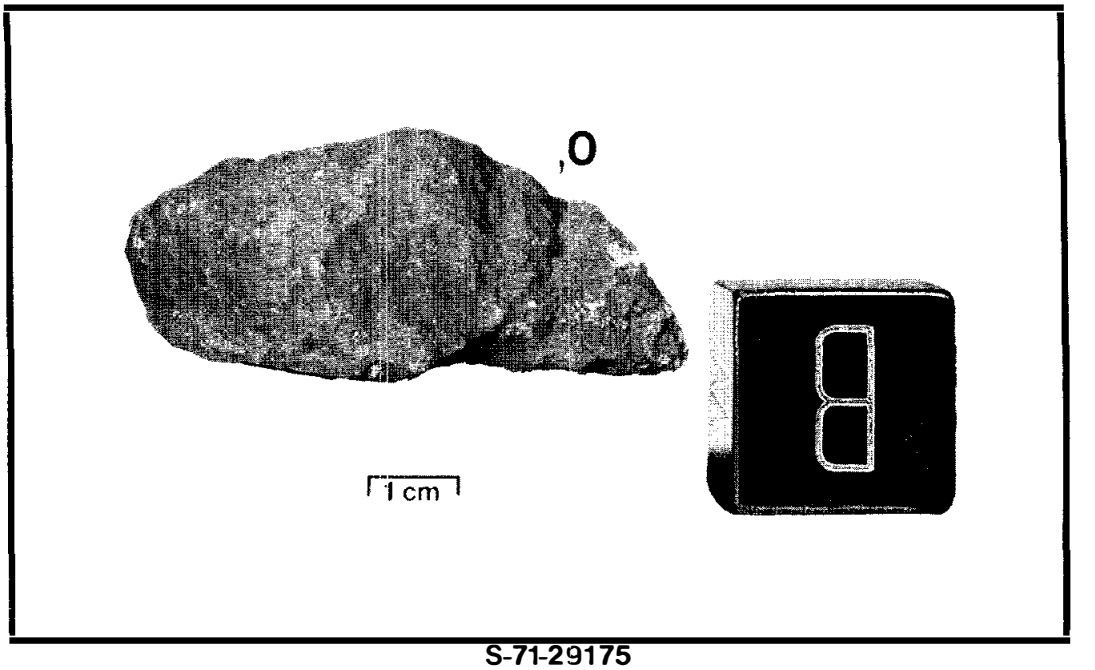


S-71-19485

14042,18

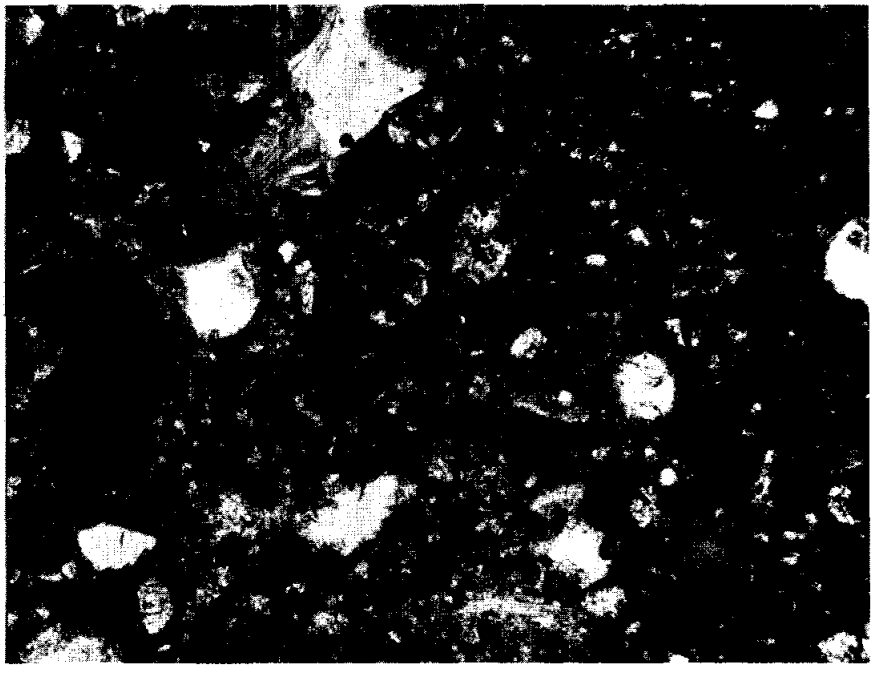


14045



S-71-29175

14045,8



.1 mm

14043

No photo available

Samples 14041 - 14046 are fragments from a fractured clod that broke apart when it was collected by Astronaut Mitchell. They were collected from Station A, 150 m NW of th LM and 90 m N of North Triplet crater. Samples 14041, 14042, 14043, and 14045 are large enough to be considered rocks. Sample 14044 is residue and sample 14046 is composed of chips and fines. They were placed in documented bag 3N and returned in ALSRC 1006.

PHYSICAL CHARACTERISTICS

	Mass	Dimensions
14041	166.3 g	8.0 x 5.0 x 4.0 cm
14042	103.2 g	5.5 x 4.0 x 4.2 cm
14043	5.9 g	3.5 x 1.8 x 1.8 cm
14045	65.2 g	7.0 x 4.0 x 3.0 cm

These rocks are all part of a friable fine-grained clastic rock with less than 5% clasts. Sample 14043 has a considerably higher proportion of clasts but is otherwise similar.

SURFACE FEATURES

Glass-lined microcraters cover the exterior faces of the rocks. Glass spatter covers 5% of the surface on one end of sample 14041. A small clod (4 x 5 mm) is welded to this glass coating. Some zap pits are visible in the glass coating. Glass coating is also present on 1 - 2% of the surface of 14042. Sample 14042 has pits from 1 - 6 mm in size with a density of 1 or 2 pits per square centimeter, which is approximately 10 times the abundance on sample 14041. Pits are also present on sample 14043 and 14045, occurring on rounded surfaces.

Numerous fractures are present on all these rocks.

PETROGRAPHIC DESCRIPTION

These rocks are very friable and have an average grain size of less than 0.1 mm with very few clasts. Mineral as well as lithic fragments occur, with white feldspar, cinnamon brown pyroxene, and pale yellow olivine fragments recognizable in all but 14043. Opaques are rare (less than 1%) with ilmenite and metallic iron present up to 100 μm in diameter. Lithic clasts contain ilmenite, blebs of metal, and one or two contain troilite to about 15 μm diameter as observed under the binocular microscope.

Thin section 14041,6 is glass rich, and would be classified as a VMB using the classification of Simonds et al. (1977). There are only two clasts (> 1 mm) present in the section. Both clasts are plagioclase-rich breccias with a partly glassy matrix. The first type has distinct plagioclase crystal fragments and shows only minor shock effects. The second type has no distinct plagioclase fragments and the crystals all show moderate to strong shock effects. In the second type the pyroxene crystals show some microfaulting.

The matrix of the rock consists of approximately 50% of a yellowish brown glass which is nearly opaque. There are numerous gray glass spherules scattered throughout. There are also several large blocky masses of glass present which show minor devitrification. The remainder of the matrix is composed of crystal fragments of plagioclase and pyroxene with minor lithic fragments. Most of the crystal fragments contain abundant inclusions. Approximately 1/3 of the matrix is lithic fragments and 2/3, crystal fragments. Most of the lithic fragments resemble the second type of clast described previously. A few scattered chondrule-like bodies are also present. Almost all of the matrix material shows some shock effects.

Samples 14042,18 and 14042,19 are similar to 14041,6. These thin sections contain abundant spherical glassy clasts and are VMB's using the classification of Simonds et al. (1977). Only small mineral and lithic clasts are present in these sections. Sample 14042,18 has a much higher glass content and fewer clasts than does 14042,19. Clasts are all small and most are lithic. Rock types recognized include basalt with an intersertal texture, anorthositic

breccia, and devitrified rock fragments. One basalt clast with a coarse grained diabasic texture is present in 14042,19. Several pyroxene clasts are present and are scattered throughout the sample. All of the pyroxene grains have many inclusions. More glass clasts are present in sample 14042,18 than in 14042,19. Sample 14042,12 was studied by Phinney et al. (1976) who describe it as containing 2 - 3% matrix glass with 35% porosity. It is described as friable, with some shattered grains. Matrix glass has a filamental texture with many 5 - 10 μm size grains. Most matrix grains fall in the 1 - 5 μm size range, with many smaller than 1 μm. Grains are angular to subangular in shape.

Sample 14045 also contains glass in the matrix. Thin section 14045,8 contains approximately 20% matrix "glass". In addition, there are large areas of devitrified glass present and some very small crystalline fragments. A few glass masses exhibit signs of flowage.

Almost all the fragmental glass occurs as shards, with few spheres and spherical fragments visible. One small crystalline breccia clast is present. It is composed of pyroxene with minor plagioclase. All clasts are microbreccia fragments with included mineral fragment shards and 5% amorphous material in the matrix.

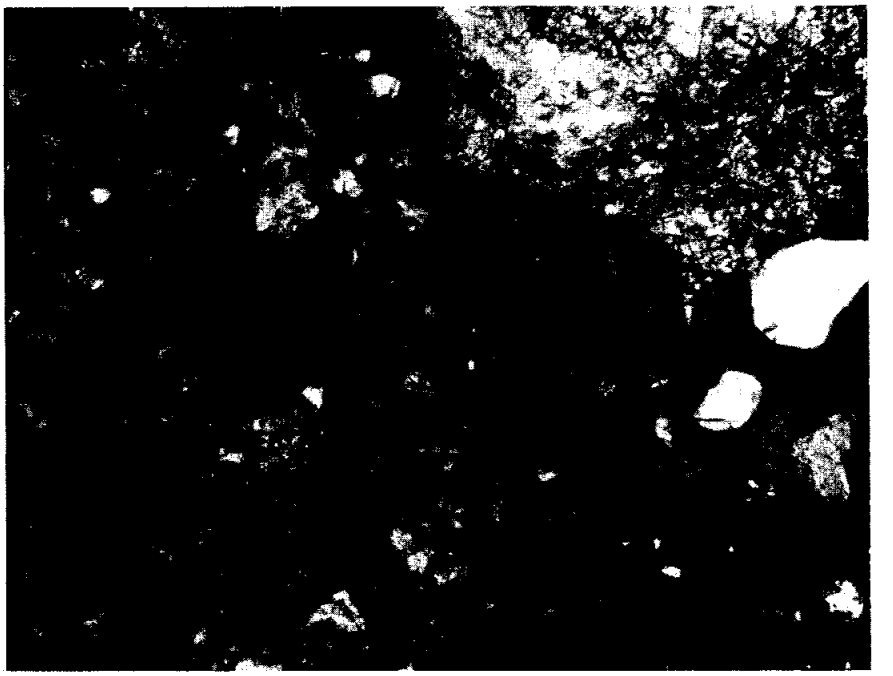
DISCUSSION

Samples 14041, 14042, and 14045 have recently been classified as VMB's by Simonds et al. (1977), and were classed as F_1's by Wilshire and Jackson (1972). Sample 14042 was placed in Warner's (1972) metamorphic grade 1 and classified by Chao et al. (1972) as a regolith microbreccia which is unshocked and porous (1a).

14047

S-76-23341

14047,53



1 mm

Sample 14047 was collected at station B, 330 m NE of LM and 65 m NNW of the rim of Weird Crater. It was placed in documented bag 5N and returned in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
242. g	5.0 x 5.5 x 10 cm

This sample is a brownish-gray, blocky, subangular, fine-grained clastic rock with a hackly surface. One side is concave. The rock is very friable and fragile.

SURFACE FEATURES

Approximately 30% of the irregular surface of sample 14047 is covered with glass spatter, which appears to be the cementing agent of the hackly fragments on the surface. There are no microcraters on the glassy spatter, but they are present elsewhere on the surface, ranging in size from less than 0.1 to 1.5 mm. Glass lined zap pits have small raised rims.

The rock is highly fractured, with approximately twenty non-planar fractures

occurring in two sets. The fractured segments are held together in part by glass spatter.

Only the pits on the rounded side of the rock have a glass lining. The fractured side may be the bottom of the rock.

PETROGRAPHIC DESCRIPTION

This rock crumbles easily when handled. It has a homogeneous texture with an average grain size of less than 0.1 mm. One of the leucocratic lithic clasts on the N face is 14 mm in size (S-76-23341).

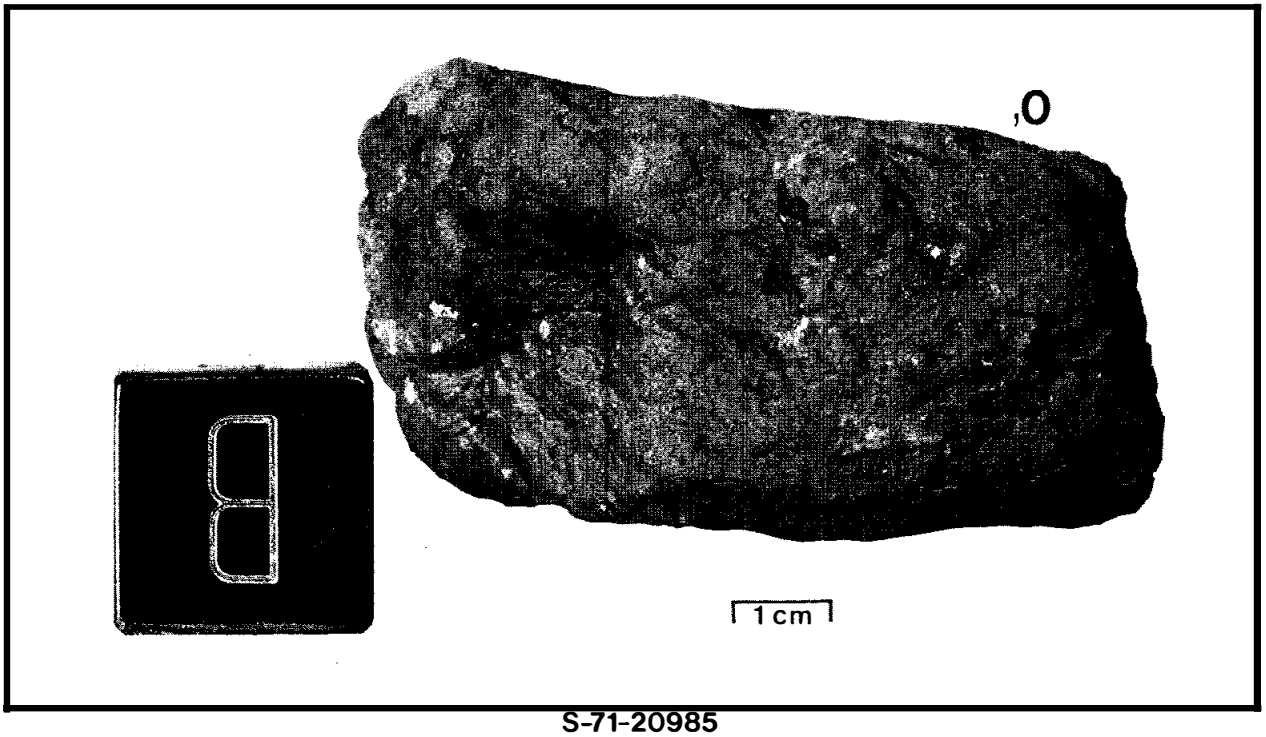
Thin section 14047,53 shows two main types of clasts. The first is a crystalline breccia with large pyroxene and plagioclase shards. The second type is large shards of partly devitrified to fresh yellowish glass. Where devitrification has taken place the crystals are dendritic and scattered along fractures and near the boundary of the glass. One large mass of glass shows residual pyroxene granules showing a skeletal pattern isolated in the glass. In hand specimen there appears to be no glass or mineral fragments present, however, in thin section they are abundant. In the thin section, there is approximately 30% glass in the matrix. The glass is a "dirty" yellow brown and discontinuous. Several spheres of yellow glass are also present. The unusual feature of the section is the large amount of fresh glass.

Megascopically, 1% of the fragments are greater than 1 mm. Leucocratic lithic fragments compose 20% of the rock. These white fragments have olive brown spots. (Not so abundant in thin section.) The opaque content is extremely low, consisting of angular to subrounded clasts of ilmenite with subordinate metallic iron in a fine grained silicate matrix. In order of decreasing abundance, ilmenite, metal, troilite and a few small (10 μm) grains of chromian spinel are present.

DISCUSSION

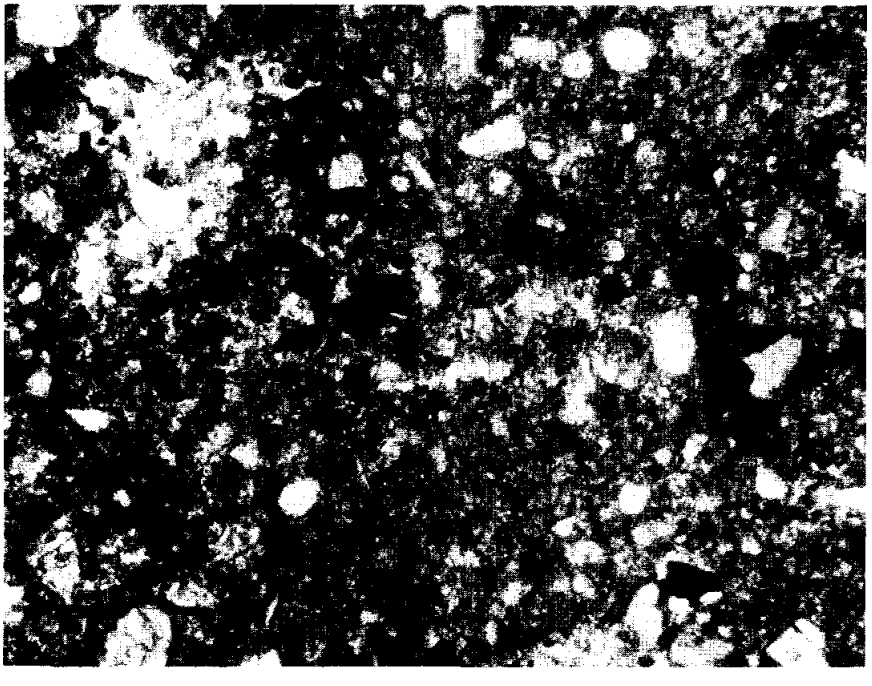
Sample 14047 was described as friable with leucocratic clasts and placed in their F_1 category by Wilshire and Jackson (1972). It was described as being low grade metamorphic and placed in group 1 of Warner (1972). Chao *et al.* (1972) described it as an unshocked porous regolith microbreccia, placing it in his 1a category. Simonds *et al.* (1977) classify it as a VMB. Silver (1972), Laul *et al.*, (1972), and Wakita *et al.*, (1972) suggest that 14047 is merely compacted soil; however, the agglutinate content is very low for even a submature surface soil (Simonds, 1978, Personal Communication).

14049



S-71-20985

14049,40



Sample 14049 was collected during the second EVA from station Bg. It was placed in bag 6N by the astronauts who said they collected it from a crater rim. The lunar location and orientation are not documented by lunar surface photographs.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
200.13 g	8.0 x 5.0 x 4.0 cm

This fragmental rock has less than 1% subrounded leucocratic clasts in a medium gray matrix and is extremely friable and soft.

SURFACE FEATURES

Sample 14049 is lacking in zap pits and has no cavities or fractures visible on the surface.

PETROGRAPHIC DESCRIPTION

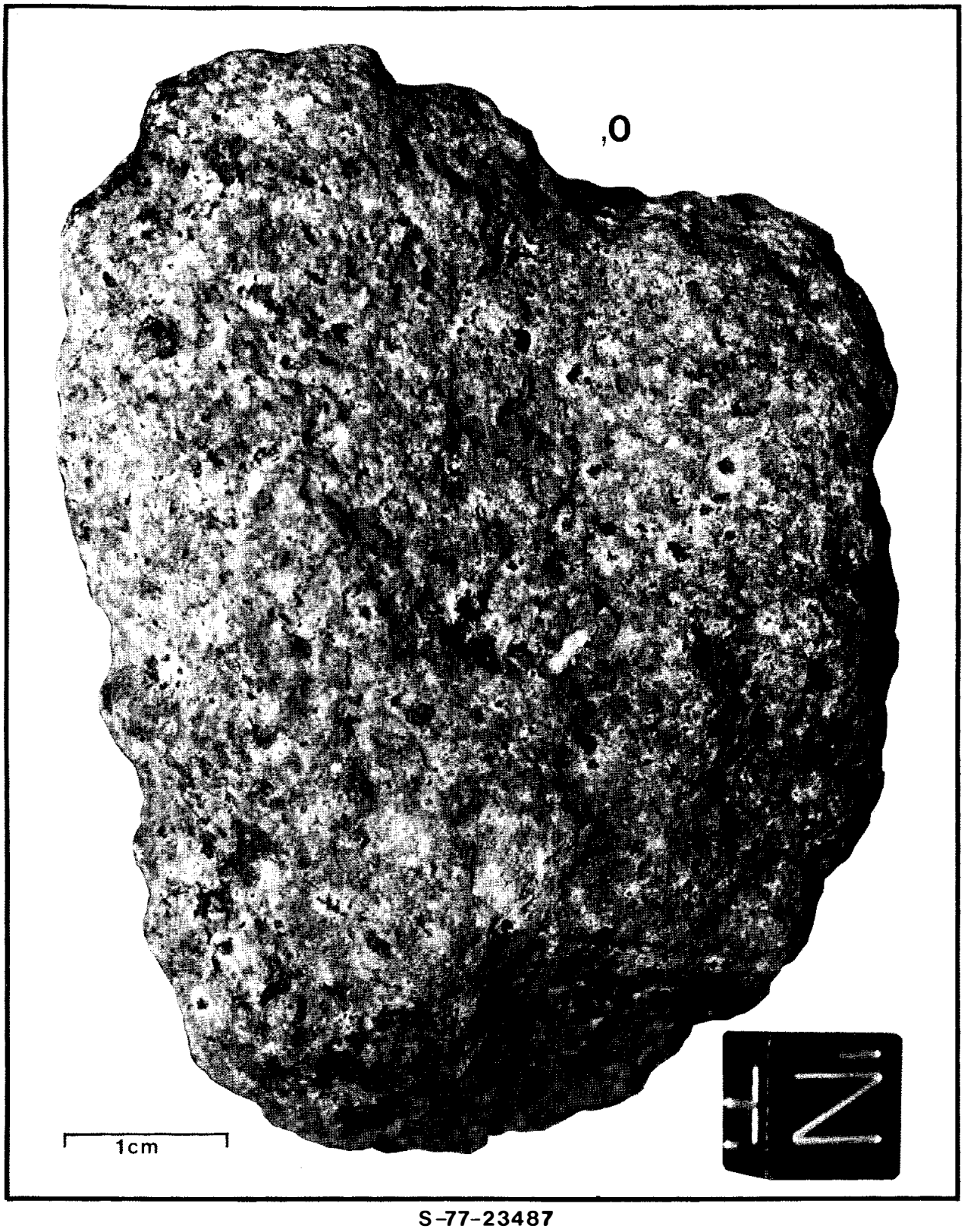
The rock is very fine grained and appears homogeneous. Mineral grains that were identified include transparent feldspar, greenish and brownish glass, and one dark brown spherule. No fragments are greater than 1 mm. There are no opaques in the matrix except for several ragged metal grains up to 100 μm in diameter.

Thin section 14049,0 is somewhat similar to 14047,53 in that there is a large amount of fresh glass shards in the matrix. There is approximately 20% yellow glass in the bonding material that holds the clasts and fragments. There is one large elongate glass glob with several rounded and eroded pyroxene crystals in it. There are no lithic or mineral clasts present. There is at least two different matrix fabrics present with a sharp dividing line between them. Unlike 14047,53, some of the glass has undergone some devitrification. The only lithics present are plagioclase-rich microbreccias and pyroxene-rich microbreccias. The mineral fragments are about equal amounts of pyroxene and plagioclase.

DISCUSSION

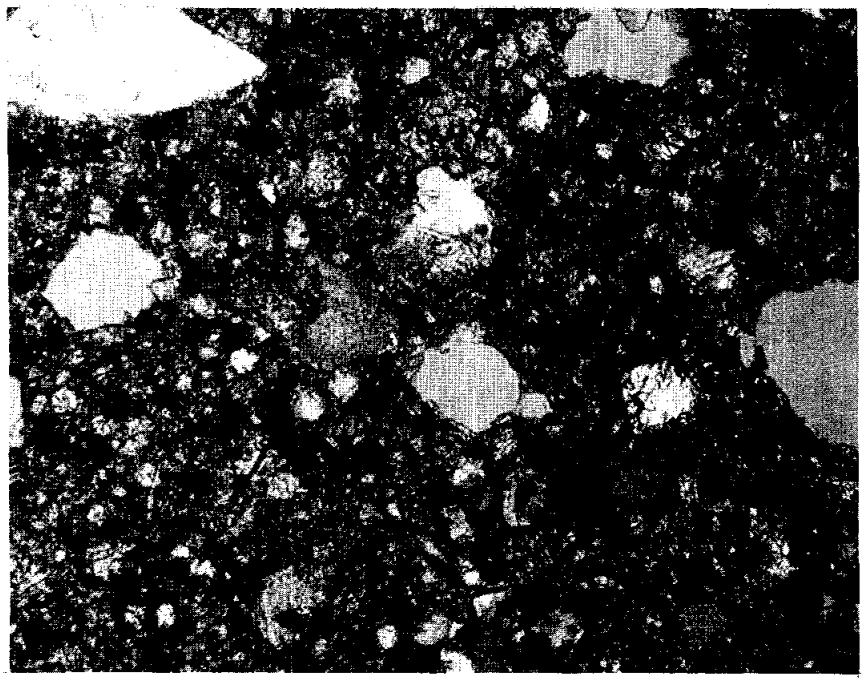
This is one of the softest rocks of the Apollo 14 mission. A shocked basaltic fragment consisting of diaplectic plagioclase glass and pyroxene with lamellae were found in sample 14049 and reported by von Engelhardt et al. (1972), who classify the sample as a glass rich regolith breccia. It is classified as an F_1 by Wilshire and Jackson (1972) and as Warner's group 2 (Warner, 1972). Chao et al. (1972), describe it as an unshocked porous regolith microbreccia. Simonds et al. (1977), classify the rock as a vitric matrix breccia (VMB). Sample 14049 has the greatest agglutinate content (3% by volume) of any Apollo 14 breccia that they studied.

14051



S-77-23487

14051, 6



.1 mm

Sample 14051 was collected at station C' which was located 1.29 km ENE of LM and approximately 95 m SE of the rim of Cone Crater. The sample was collected on a gentle southward slope and was partly buried. The area was characterized by abundant fragments ranging from the limit of resolution up to 1.5 m blocks. The sample was returned in documented bag 7N in ALSRC 1006.

The general area where the sample was collected is characterized by abundant 5 to 70 cm craters. Most are moderately subdued and have abundant ejecta around several of the 50 - 70 cm craters.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
191.3 g	3 x 3.5 x 6 cm

The sample is a pale brown, blocky to subrounded, fragmental rock.

SURFACE FEATURES

Approximately 1% of the rock surface is covered with 0.5 to 2.0 mm pits. They are irregular, elongate, hemispherical and circular. Few pits are rectangular,

and these appear to be holes which originated when feldspar cleavage fragments fell out. Pit density is about equal over the entire surface of the rock. Pits are spaced about 5 to 20 mm apart. Seventy-five percent of the S_1 surface contains vugs up to 3 mm in size (Twedell et al., 1978).

There are no apparent fractures and there are no obvious shock features. The rock is moderately coherent with a softer surface. Since the orientation of the pits seem random, the rock is not orientable.

The grain size is predominately smaller than 1 mm and the texture and mineralogy are homogeneous (except for scattered clasts).

PETROGRAPHIC DESCRIPTION

14051 is a pale brown to tan, very fine grained, clastic rock with scattered clasts. The rock is polymict, with fragments larger than 0.5 mm in size making up less than 1% of the rock. The matrix is composed almost entirely of leucocratic, very fine grained, crystalline fragments. This represents a typical crystalline matrix breccia (CMB) (Simonds et al., 1977).

Clasts larger than 0.5 mm are white and appear to have been derived from a fine grained, feldspar-rich rock. Matrix grains are mostly clear and very pale brown. Some clear grains have good cleavage up to 0.5 mm in size.

In thin section the rock appears nearly holocrystalline with small scattered clasts. The rock is rather vuggy with 1 - 2 mm vugs. The mineral clasts consist primarily of single crystals of pyroxene and plagioclase with some devitrified material. Some secondary growth is present on many of the plagioclase crystals. Some free glass is present as spherules.

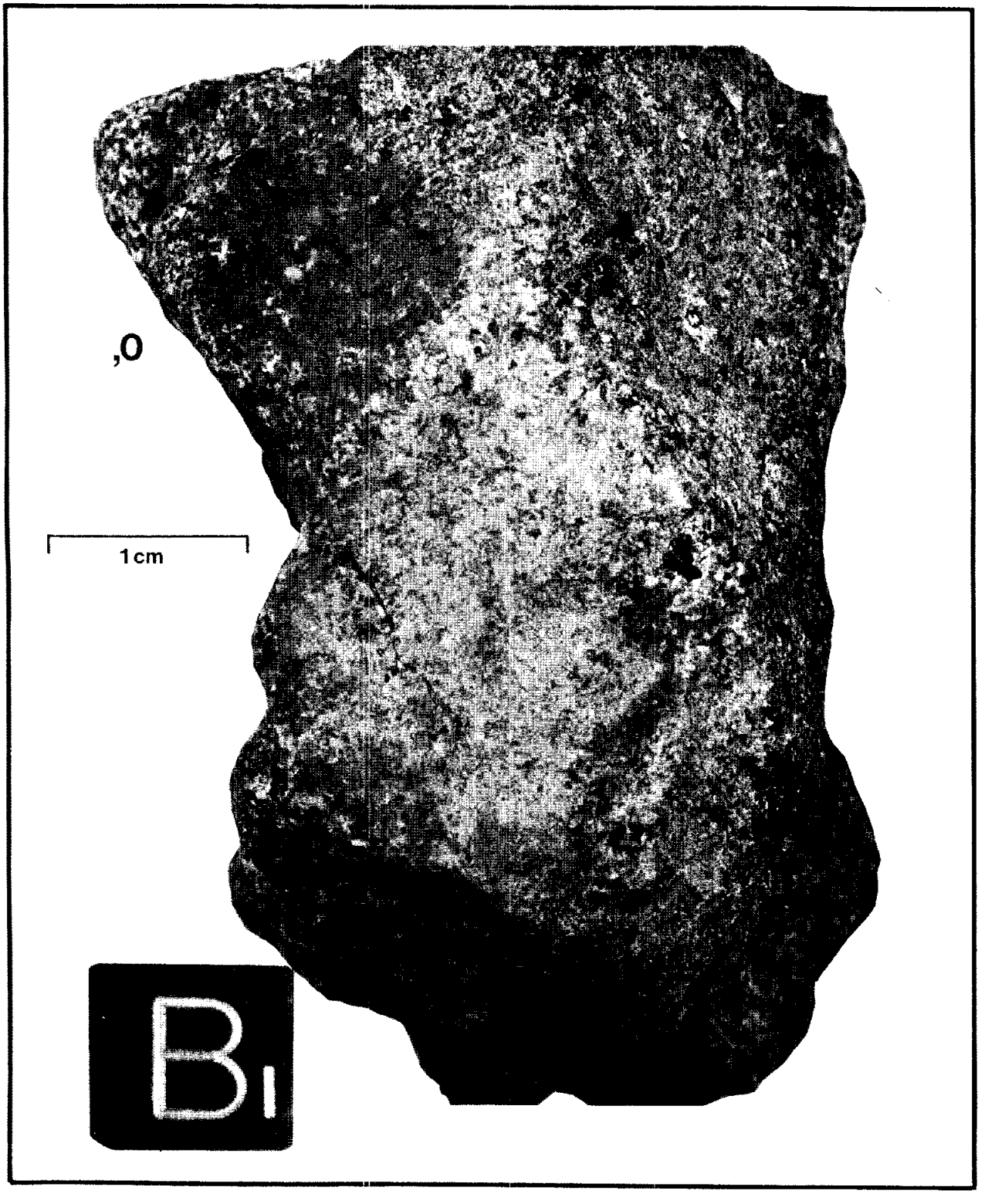
DISCUSSION

Swann et al. (1977) feel that this rock represents an ejecta fragment from Cone Crater. They also feel that the rock was not as deeply buried as other rocks in the same area because of its heavily pitted and rounded nature.

Wilshire and Jackson (1972) tentatively grouped 14051 in their F_2 classification.

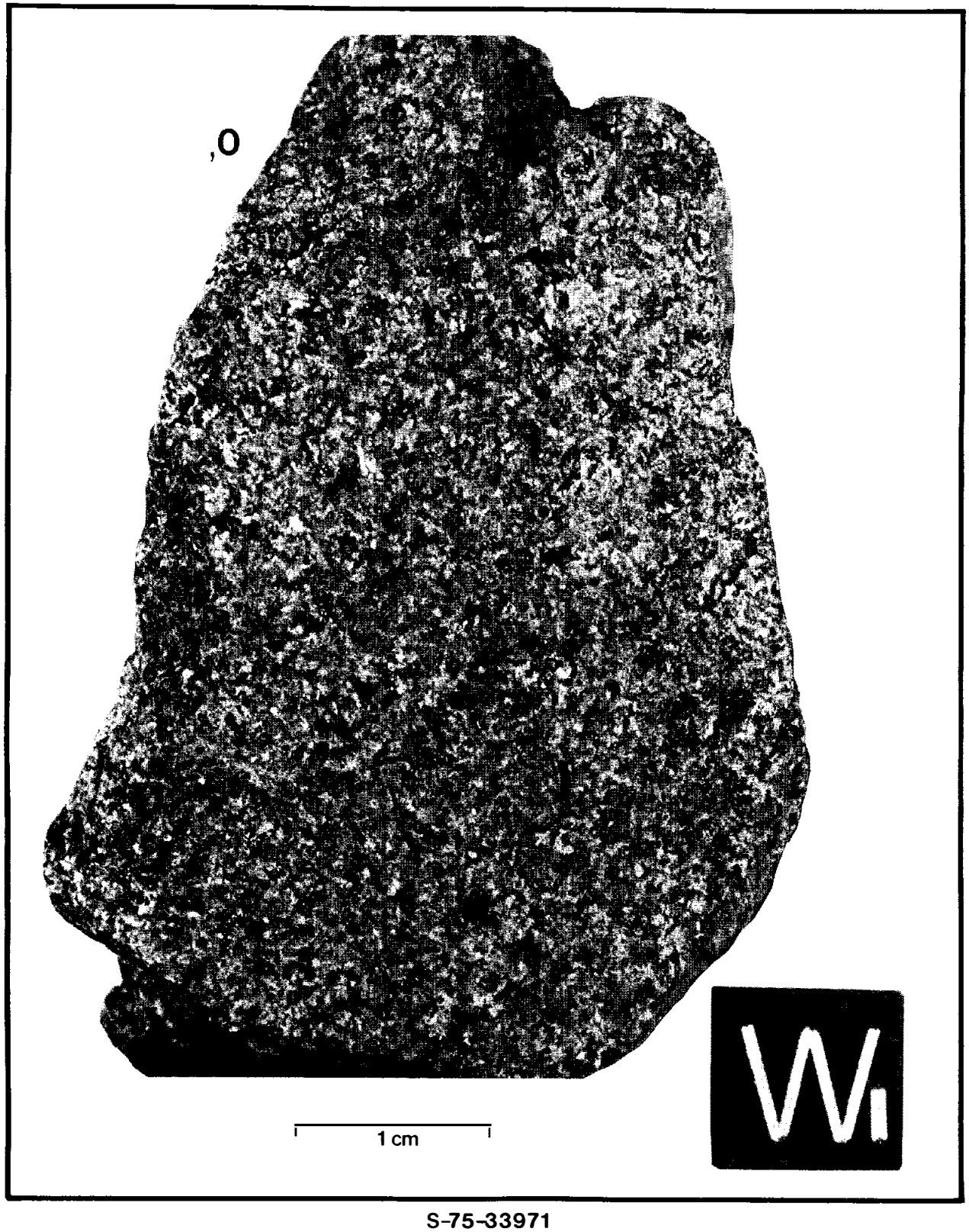
Sample 14051 is one of those mapped by Twedell et al. (1978).

14053



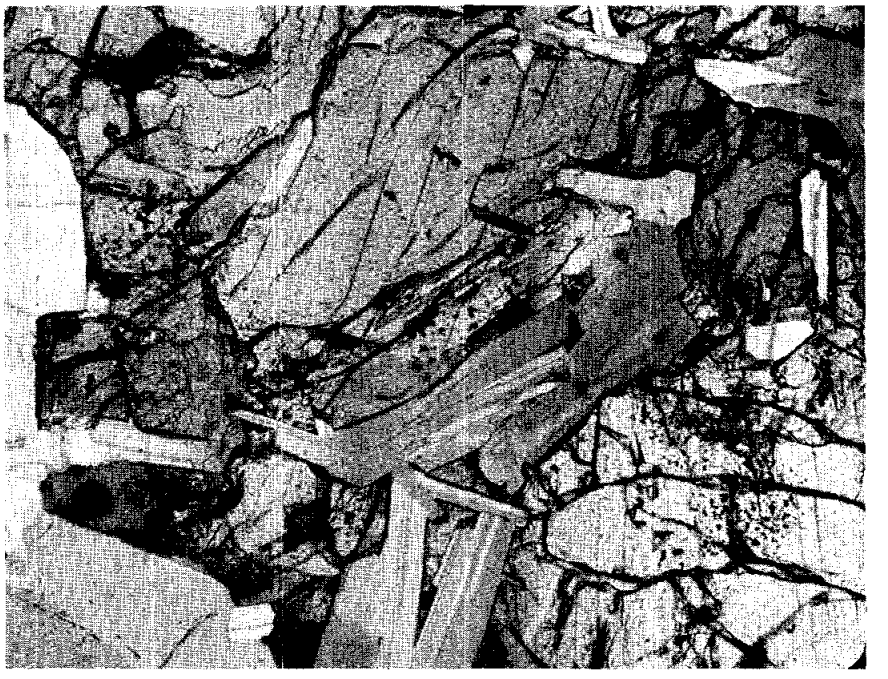
S-75-33972

14053



S-75-33971

14053,6



1 mm

Sample 14053 was collected at station C2 approximately 1.21 km ENE of LM and approximately 130 m south of the rim of Cone Crater. The area where the sample was collected is characterized by a 10-15° southward slope away from Cone Crater. The area is moderately covered by blocks ranging from the limit of resolution up to 2.5 m. The larger boulders are rounded while the smaller ones are more angular to rounded.

Abundant small irregular craters (< 10 cm) are present in the general area of the sample locale. Very few distinct 15 to 30 cm craters are present. The whole area appears to be in the continuous ejecta blanket of Cone Crater.

The sample was returned in documented bag 14N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
251.3 g	8.0 x 6.0 x 3.0 cm

The sample is slabby, with rectangular to rounded corners. One side has been freshly broken and unweathered. The exposed surface displays rounding and microcraters.

SURFACE FEATURES

The flat, relatively fresh surface is unpitted. The convex surface has gentle relief with some prominences of approximately 1-3 mm in height. These features are not abrupt but rounded. Pits appear on the convex surface but not on the flat surface. Pits are glass lined and have a size range from 0.5-3.0 mm. Average pit size is 1 to 2 mm. Density of pits is approximately 10 pits per square centimeter.

Cavities are both vesicular and vuggy. Irregular vugs range from 1-2 mm in size. Small vugs (0.5 mm diameter) and vesicules (1 mm in diameter) contain feldspar and orthopyroxene crystals.

There are three planar and four non-planar fractures appearing in two sets. Fractures have an irregular orientation. There are numerous hair-like cracks a few millimeters long. The entire fracture pattern is somewhat irregular.

There are fragments of what appears to be soil clinging to the B_1 surface (NASA photo # S-75-33972).

PETROGRAPHIC DESCRIPTION

14053 is a holocrystalline, fine-grained, equigranular mare basalt. Approximately 30% of section 14053,6 consists of plagioclase laths, and the remainder is pyroxene. There are, as is seen in hand specimen, two types of pyroxene present. The higher value assigned to feldspar (60%) in hand specimen may be due to the inhomogeneous nature of the rock. In texture and mineral proportion this rock appears different from Apollo 11 and 12 basaltic rocks. There is abundant cristobalite (5-10%) and a small amount of olivine present in the thin section.

Upon close examination the rock appears to be inhomogeneous in hand specimen. Some areas display relative concentration of olivine and pyroxene. These inhomogenities are on a 1-2 cm scale.

DISCUSSION

Sample 14053 is listed as a basalt by Wilshire and Jackson (1972) and by Quaide and Wrigley (1972) and as a mare basalt by Simonds et al. (1977). Many, including Swann et al. (1977), believe that 14053 is a clast from a larger breccia boulder. Crystalline rocks are rare in the Apollo 14 collection. In a 1971 memo D. Morrison notes that fragments of soil clinging to the bottom may actually be the remanents of breccia matrix which once enclosed the rock.

Sample 14053 is described by Hubbard et al. (1972) as a mare-like basalt, with FeO > 14%, but the Al_2O_3 concentration is more like that of KREEP basalts (> 12%), making 14053 intermediate in composition. Sample 14053 also has low REE values, but an intermediate K/U ratio. Ridley (1975) concluded that the sources of aluminous mare basalts such as 14053, are

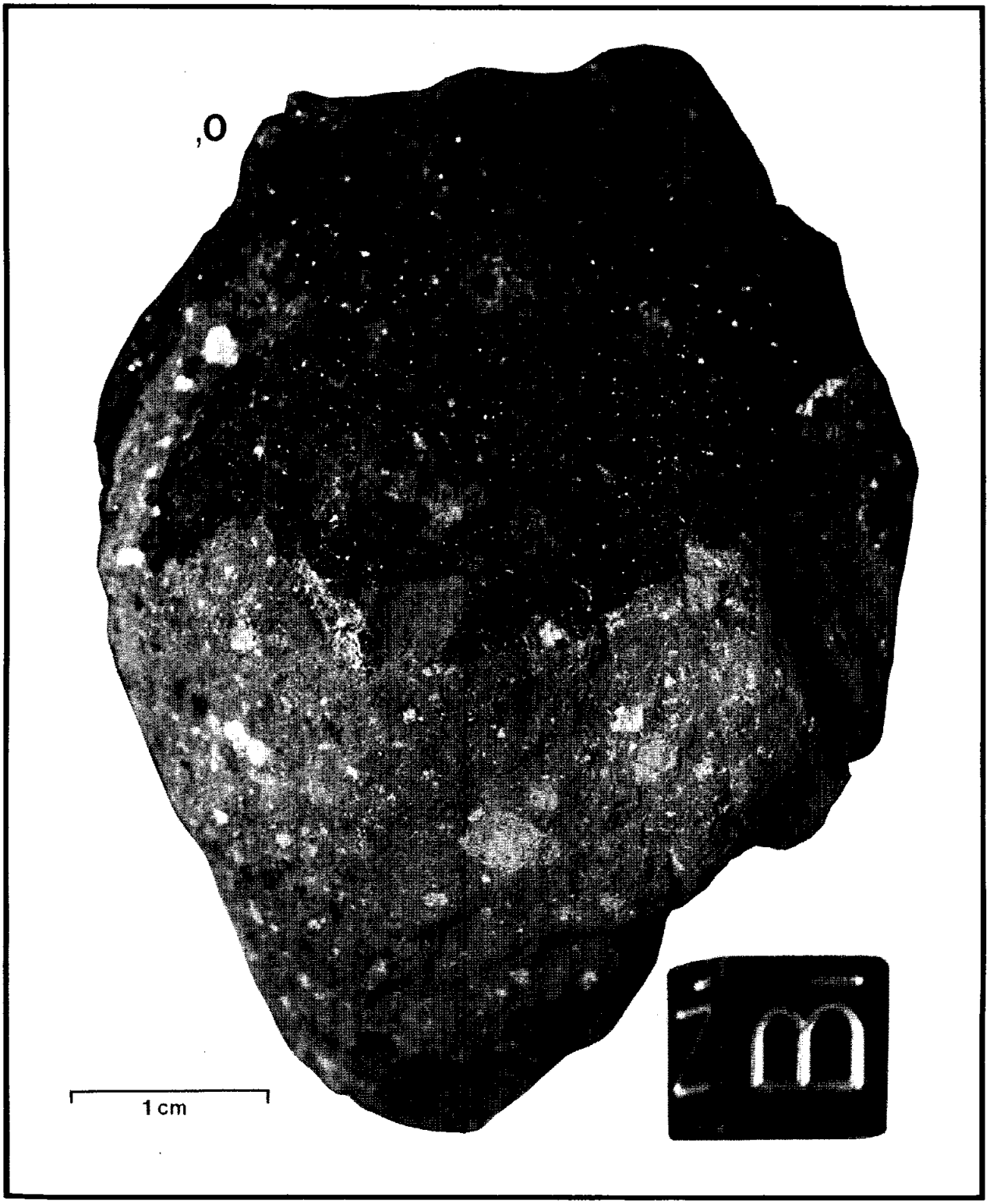
not significantly different from the sources of the common mare basalts. He felt that slight chemical changes in the lunar mantle was more important in producing aluminous mare basalts than pressure.

Papanastassiou et al. (1971) determined the Rb-Sr age to be 3.96 ± 0.04 x 10^9 years for sample 14053. The $^{38}Ar_{sp}/^{37}Ar$ thermal release patterns allowed Husain et al. (1972) to assign an exposure age of 21 ± 5 x 10^6 years to sample 14053,34, while the age of formation is given by them as 3.92 ± 0.08 x 10^9 years based on $^{40}Ar/^{39}Ar$ plateau. Age data also suggest that formation of aluminous mare basalts was not a unique event, but occurred over a 0.5 b.y. period. During this time the zone of incipient melting moved to progressively higher pressures, but the composition of aluminous mare basalts occupies a relatively narrow range, supporting Ridley's (1975) claim that the chemical changes in the heterogeneous mantle is the significant factor in aluminous basalt production.

Wenk et al. (1972) determined the average plagioclase composition to be $An_{91.3}$ in sample 14053 using thin sections 14053,11; 14053,19; and 14053,61. Czank et al. (1972) found An content of 14053,45 to be 89-94 using the U-stage, and 85-93 using index of refraction.

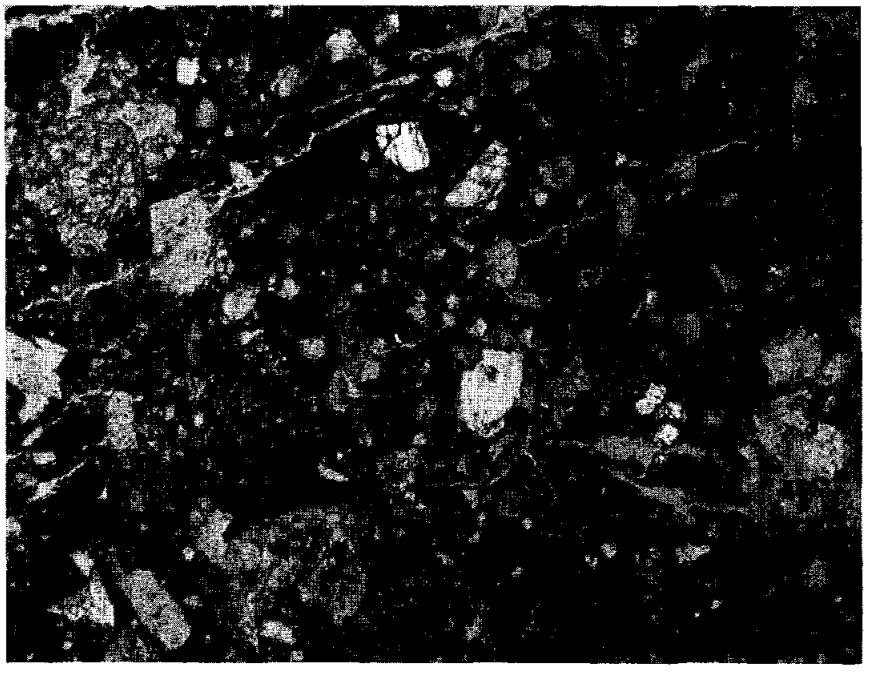
Ghose et al. (1972) studied clinopyroxenes of samples 14053,44. They found that the sample had been quenched quickly at a temperature higher than 1000°C. Morgan et al. (1972) indicate that 14053 has a low siderophile content (Au 0.11 ppb). Finger et al. (1972), on the basis of their pyroxene studies, concluded that the original cooling rate of sample 14053,116 must have been very slow, and that it had been reheated afterwards to a temperature greater than 840°C and then coolec down rapidly.

14055



S-77-23605

14055,11



1mm

Sample 14055 was collected at Station E on the second EVA. The sample was collected along with 14056-14061 near a 40 to 50 m crater. The rocks are very friable and fall apart. It is possible that 14056-14061 may all be pieces of 14055 (Swann et al., 1977).

Sample 14055 was returned in documented bag 15N in ALSRC 1006. Because the rocks were very friable 27.50 gm or residue were generated (14062).

PHYSICAL CHARACTERISTICS

Mass	Dimensions
111 g	2.0 x 5.0 x 4.5 cm

The sample is a blocky subangular to subrounded rock lightly covered with glass-lined zap pits. The sample is a very friable fine-grained clastic rocks with 5 to 15% of the sample consisting of subrounded light-colored clasts in brownish-gray matrix.

SURFACE FEATURES

Approximately one-third of the sample is glass-coated. This coating is 1 - 5 mm thick and exhibits fluidal and vesicular texture.

Pits are glass lined and range in size from 0.1 to 0.75 mm. Pits cover 25% of one side of the rock. There is a low pit density in the glass coating. The only cavities present in the glass spatter are collapsed vesicles which range from 0.1 mm to 1.5 mm and are hemispherical in shape with a homogeneous distribution. Glass covers 30% of sample 14055.

There are two sets of non-planar fractures. The first has an orientation of 40° to the long axis. The second set includes many randomly oriented member with spalled surfaces. These irregular fractures are adjacent to the glass spatter. One surface of 14055 is a fracture surface.

PETROGRAPHIC DESCRIPTION

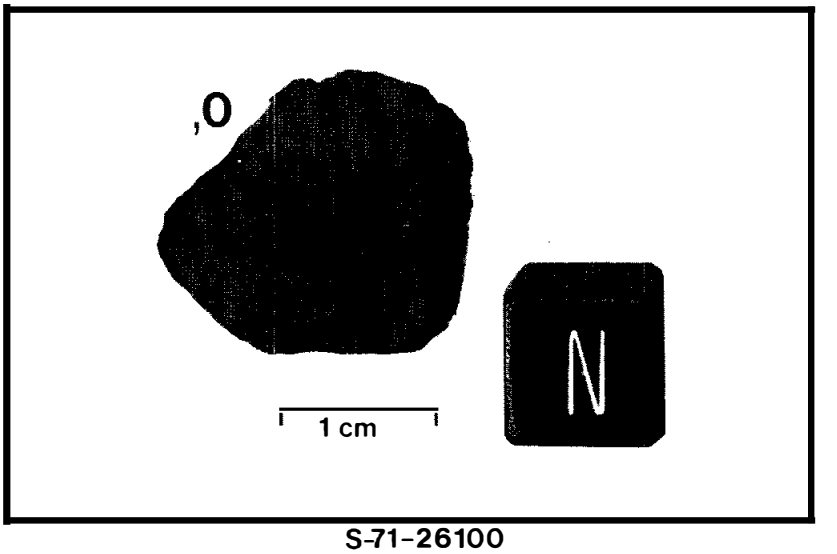
14055 is a medium gray clastic rock with 5% clasts larger than 1 mm and 95% matrix. The matrix contains milky white feldspar, cinnamon brown to reddish pyroxene, and several other mafic minerals.

Thin section 14055,11 shows that the rock is inhomogeneous in that there are two distinct textures in the matrix as in 14049,40. There are abundant glass fragments, both shards and spheres, many of which have undergone some devitrification. There is approximately 20% glass in the matrix. There are no clasts, but numerous mineral fragments. Most of the mineral fragments are pyroxene. Clasts are all lithic leucocratic crystalline rocks. Most clasts have associated traces of glass. There are no dark lithic clasts. The average grain size is less than 0.1 mm.

DISCUSSION

Only limited work has been done on this sample. Wilshire and Jackson (1972) describe sample 14055 as an F_1 breccia (friable with light clasts). It was placed in Warner's (1972) group 1 (low grade metamorphic) and classified as a porous unshocked regolith microbreccia by Chao et al. (1972), and as a glass rich regolith with breccia (von Engelhardt et al., 1972) and a vitric matrix breccia (VMB) by Simonds et al. (1977). This is one of the samples mapped by Twedell et al. (1978).

14056



S-71-26100

Sample 14056 was collected from station E during the second EVA. It was returned in bag 15N along with samples 14055-14062.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
6.38 g	2.2 x 2.1 x 1.5 cm

This sample is extremely friable and appears to be a coherent soil clod. It is medium brownish gray in color.

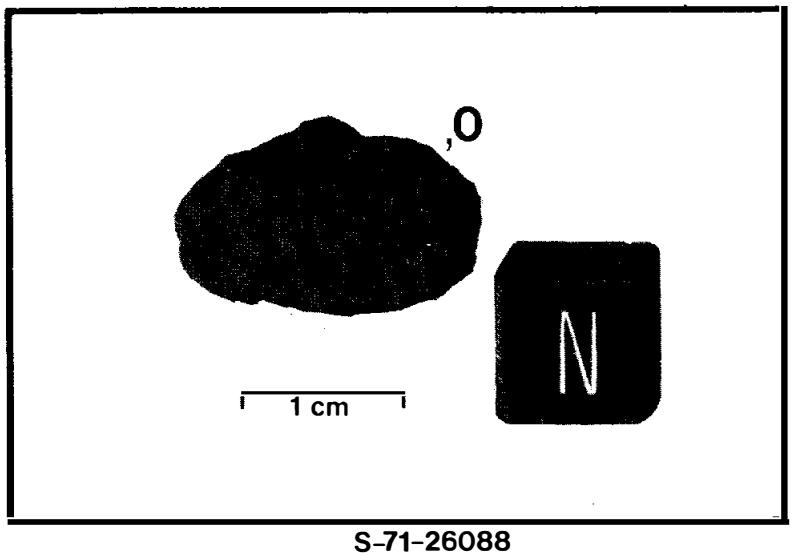
SURFACE FEATURES

Sample 14056 is a soil clod with no visible pits, cavities, or fractures.

PETROGRAPHIC DESCRIPTION

Sample 14056 is fragmental, composed of less than 2% fragments larger than 1 mm and 98% matrix less than 1 mm. Clasts are leucocratic lithic fragments with subrounded shapes. No thin sections have been made of 14056 due to its extreme friability.

14057



S-71-26088

Sample 14057 was collected from station E during the second EVA. It was returned in bag 15N in ALSRC 1006 along with samples 14055-14062

PHYSICAL CHARACTERISTICS

Mass	Dimensions
5.51 g	2.5 x 1.7 x 1.2 cm

The sample is very friable and is brownish gray in color.

SURFACE FEATURES

A few glass-lined zap pits are visible.

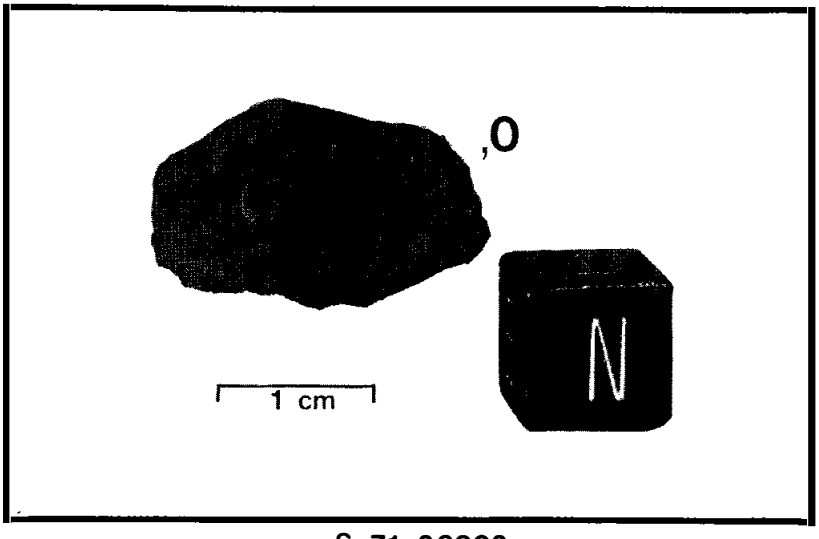
PETROGRAPHIC DESCRIPTION

This rock is so soft and friable that depressions caused by handling are present. It is composed almost entirely of matrix grains smaller than 1 mm. The few clasts larger than 1 mm are light colored laths of plagioclase. Some leucocratic lithic fragments smaller than 1 mm are visible. Dark glass spheres are visible in the matrix.

DISCUSSION

This sample is very friable and is noteworthy for the glass spheres present in the matrix. It is similar to 14056 and 14055.

14058



S-71-26092

Sample 14058 was collected from station E during the second EVA. It was placed in bag 15N and returned in ALSRC 1006 along with 14055-14062.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.53 g	2.5 x 2.0 x 1.5 cm

This sample is a subangular, elongate rock which is tapered at one end. It is olive gray in color and is fine-grained with fragments larger than 1 mm comprising 15% of the rock.

SURFACE FEATURES

Irregular clasts form sharp points above surface level. No zap pits were observed.

PETROGRAPHIC DESCRIPTION

Sample 14058 is a polymict fragmental rock with 15% clasts larger than 1 mm. Crystalline rock fragments which are light gray in color account for the majority of clasts. These clasts are composed of 70% white powdery mineral

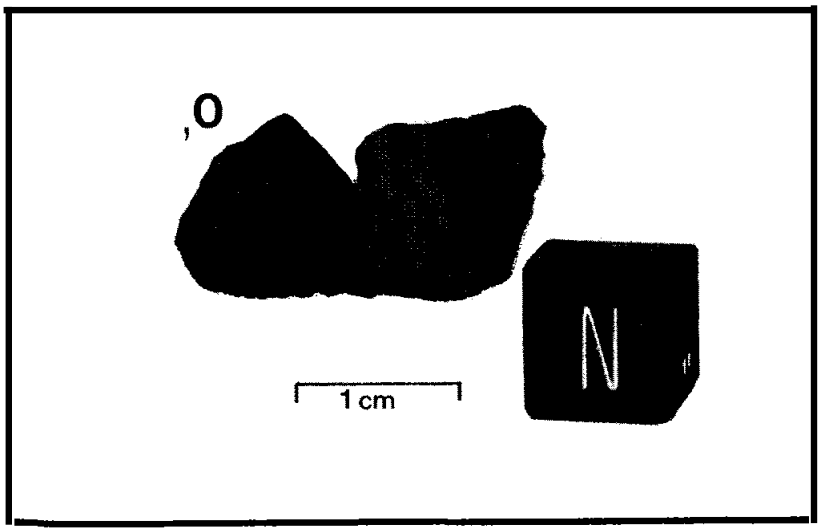
(feldspar?), 20% lath-shaped feldspar crystals with albite twinning, and 10% opaques (probably ilmenite). The feldspar crystals exhibit a preferred orientation parallel to the long axis of the clasts.

Clasts of equant black finely crystalline material are present in lesser amounts. Feldspar clasts and spherical as well as angular black glass fragments are also present. A powdery brownish-red mineral is present in patches. Black glass fragments compose 20% of the rock, lithic fragments compose 60%, and mineral fragments compose 20%.

DISCUSSION

The sample is extremely friable and cannot be cut for thin sectioning without impregnation. It is probably a piece of 14055.

14059



S-71-26080

Sample 14059 was collected during the second EVA from station E. It was placed in bag 15N by the astronauts, and returned in ALSRC 1006 along with samples 14055-14062.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
8.68 g	1.2 x 1.2 x 1.0 cm

This sample consists of two pieces, the larger of which is very irregular in shape and the smaller, subrounded. The dimensions given are those of the larger piece.

SURFACE FEATURES

All surfaces are pitted, but only one glass-lined pit was seen. The pits range from 0.1 to 1.0 mm in size.

PETROGRAPHIC DESCRIPTION

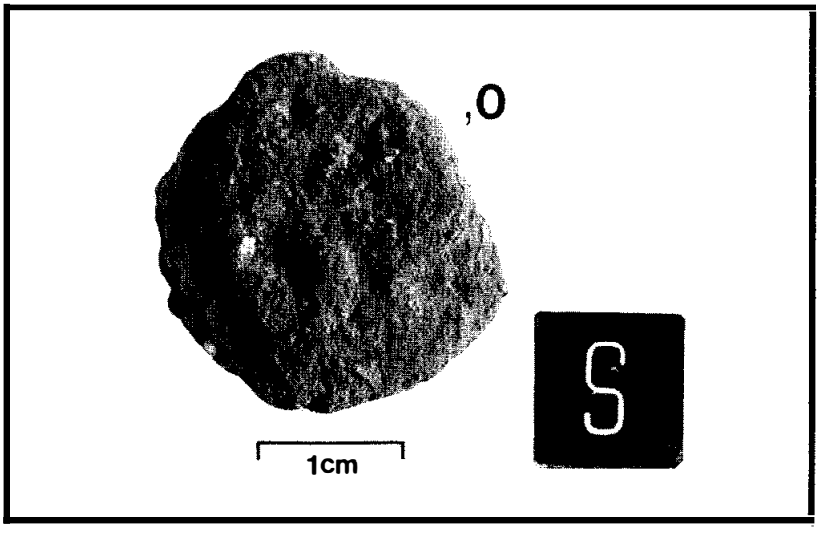
Sample 14059 is fine-grained, with an average grain size of 0.05 mm. It is extremely friable and is homogeneous in texture and mineralogy. It is

medium gray in color and resembles 14056 and 14057. All grains are smaller than 1 mm. The matrix consists of plagioclase laths, mineral fragments, brown and green glass, and leucocratic lithic fragments. The largest lithic fragments are 0.4 mm in size. A possible glass vein cuts one of the samples.

DISCUSSION

The sample is too friable for cutting and can only be sectioned by impregnation.

14060



Sample 14060 was collected from station E during the second EVA. It was placed in bag 15N by the astronauts and returned in ALSRC 1006 along with 14055-14062.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.5 g	1.0 x 1.5 x 1.5 cm

Sample 14060 is a well rounded (almost spherical), friable, fragmental rock and is medium gray in color.

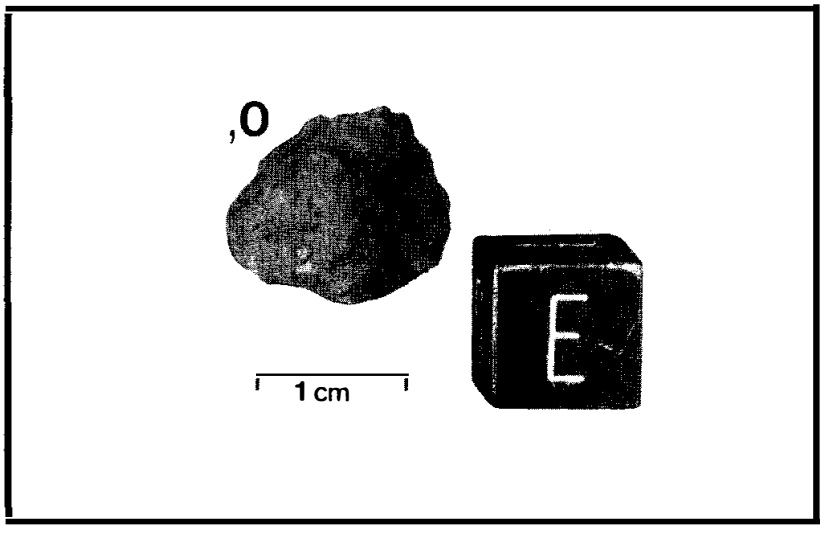
SURFACE FEATURES

Two kinds of pits are present. One type, with a density of approximately 2 pits/cm^2, is small but deep, with diameter to depth ratios of 1:1 or 1:2. The second type is more abundant, with 3 pits/cm^2. These are large (1-4 mm in size) but shallow, with diameter to depth ratios of approximately 3:1. These pits overlap and probably have steady state distribution according to Hörz, who was the PET member describing this sample. The pits are not glass-lined.

PETROGRAPHIC DESCRIPTION

This sample is a fine-grained, friable, almost spherical, fragmental rock. It has less than one percent clasts greater than 1 mm in size. Angular black glass fragments 1 mm in size are present. Feldspar fragments account for less than 1% of the rock.

14061



S-71-26087

Sample 14061 was collected during the second EVA from station E. It was placed in bag 15N by the astronauts and returned in ALSRC 1006 along with 14055-14062. (Sample 14062 is residue.)

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.11 g	1.5 x 1.7 x 1.2 cm

This sample is friable and appears grayish brown in color. It is an equidimensional, subrounded block.

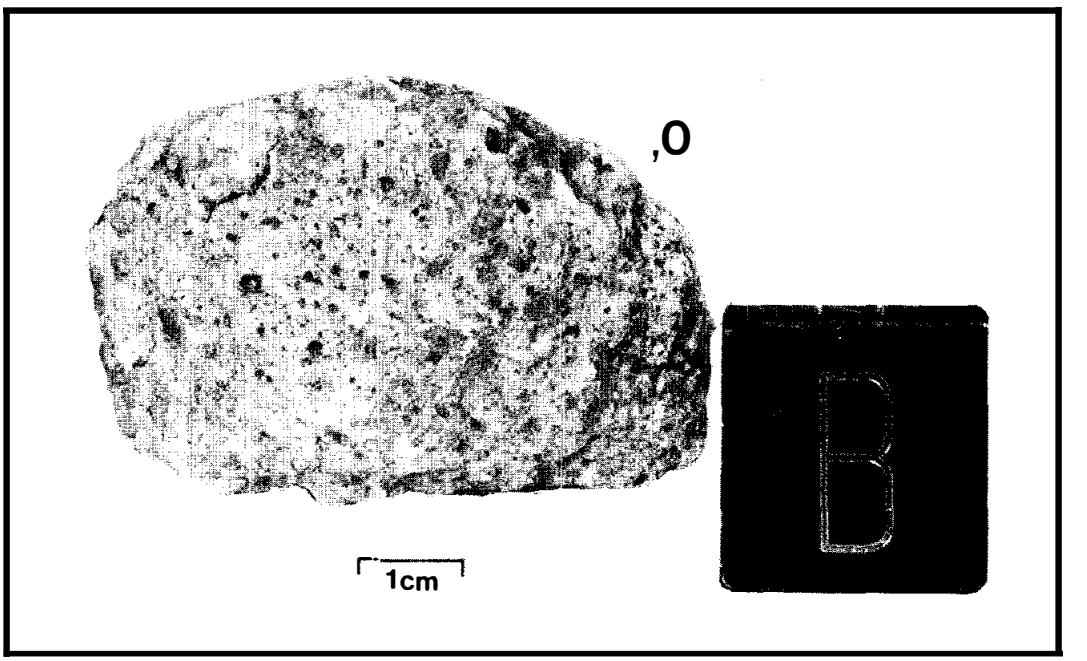
SURFACE FEATURES

The surface features are obscured by a heavy dust cover.

PETROGRAPHIC DESCRIPTION

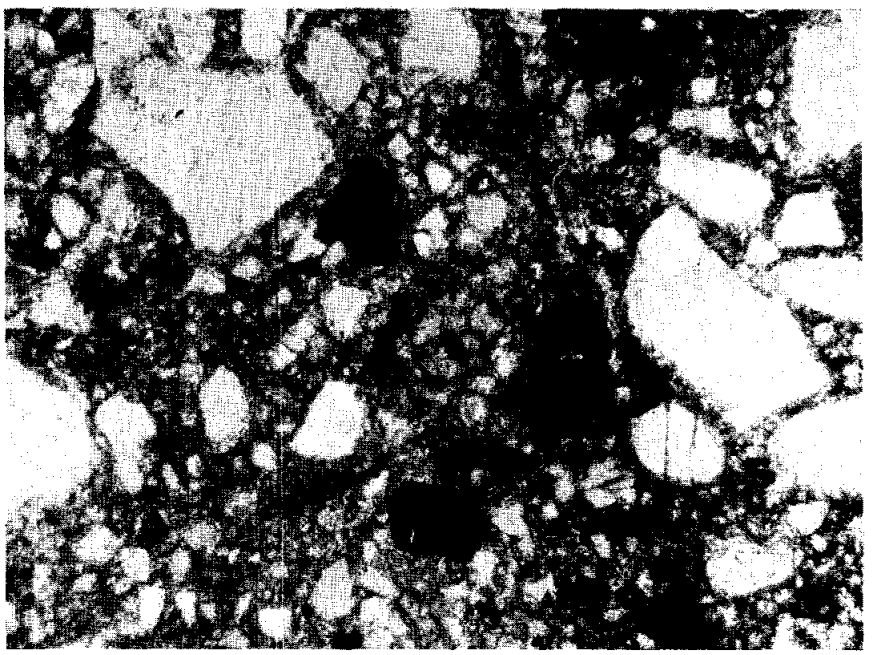
Sample 14061 is a friable, fine-grained fragmental rock with a 1 mm thick dust cover. It appears to be polymict with more than 99% of the grains less than 1 mm. One visible mineral grain appears to be a euhedral plagioclase crystal 5 mm long.

14063



S-71-35866

14063, 56



Sample 14063 is one of the hand-size grab samples collected during the second EVA at station C1 in the White Rocks area. Its exact lunar location and orientation are unknown and there are no lunar surface photographs in which this sample is identified. It was returned along with 14064 and 14065 in bag 16N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
135.55 g	6.0 x 4.0 cm

This sample is shaped like a slightly flattened sphere, broken across one edge. It is a light gray fragmental rock with 20-25% clasts. It is moderately friable.

SURFACE FEATURES

Pits cover 25% of the surface and are < 0.1 to 2 mm in size. Glass lining the pits is dark brown and bubbly. The matrix is very white feldspar-rich so it is difficult to explain why the zap pit linings are dark.

Cavities present are clast molds ranging in size from 0.2 to 8 mm and occur over 15% of the surface area on one side.

One fracture set with planar and irregular fracture surfaces is present with random orientation.

PETROGRAPHIC DESCRIPTION

Sample 14063 is a fine grained, light gray, inhomogeneous, fragmental rock composed of 20-25% clasts and 75-80% matrix grains. Fifty percent of the fragments greater than 0.1 mm in size are mineral fragments and 50% are lithic fragments. A trace of glass is present.

Thin section 14063,59 shows one large glass clast that is highly fractured and has undergone partial devitrification. Scattered throughout the section are shards of glass, most showing some small degree of devitrification. Occasional, almost totally devitrified masses are seen. The only clasts present are glass-rich breccias with remainder being mineral fragments and one anorthositic-type rock with minor pyroxene. There is approximately 1% "glass" in the matrix. Mineral fragments include transparent to cloudy, anhedral to subhedral plagioclase and pyroxene (to 0.9 mm); opaques such as ilmenite present as clasts and in lithic fragments (to 10 μm); iron metal present as clasts and blebs within lithic fragments (< 10 μm); and minor troilite; reddish-brown pyroxene (less than 0.1 mm), yellow-green equant crystals of olivine (to 0.2 mm). The lithic fragments seen in thin section consist of shocked crystalline rocks containing small amounts of glass, glass-rich microbreccia, nearly holocrystalline microbreccia, and feldspar granulitic rocks.

DISCUSSION

Sample 14063 is one of the so-called "White Rocks". It has been described as friable with dark clasts (F_3) by Wilshire and Jackson (1972), placed Warner's (1972) group 3, Chao et al. (1972) list it as an annealed, or slightly annealed, feldspathic Fra Mauro breccia, and Quaide and Wrigley (1972) formed a new group for it, calling it a "white rock breccia". Von Engelhardt et al. (1972) and Simonds et al. (1977) place it in a category intermediate between their glass-rich and crystalline matrix breccias, calling it glass-poor with a fragmental matrix, and a light matrix breccia (LMB), respectively. It was also studied by Anderson et al. (1972).

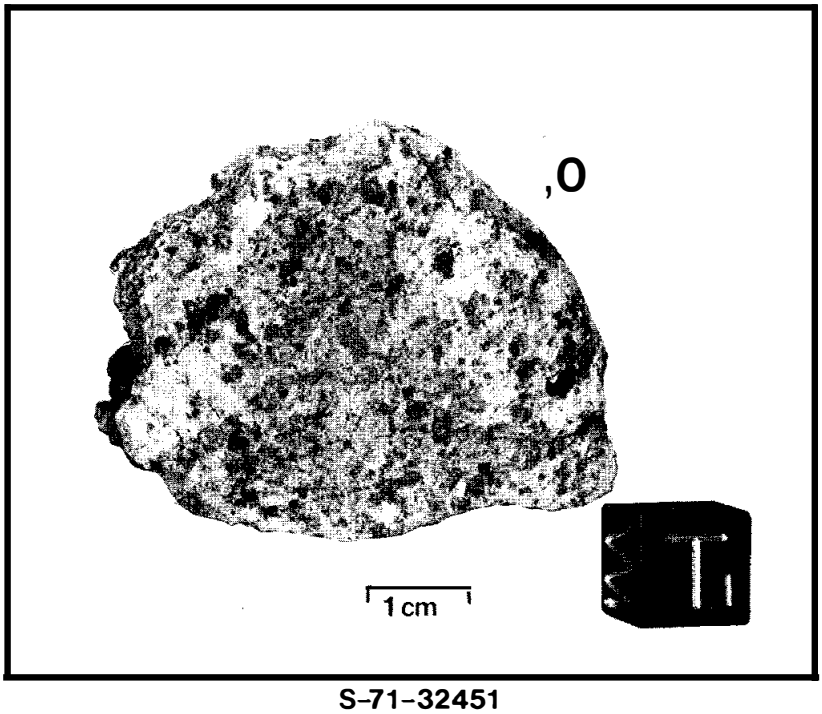
Meyer et al. (1974) believe that there may be a KREEP component in 14063.

Ridley (1975) points out that a group of crystalline clasts in sample 14063 are aluminous mare basalts with higher concentrations of TiO_2, Na_2O, Mg, Fe, and less FeO than other aluminous mare basalts.

One thin section of 14063 was obtained by the Imbrium Consortium during their preliminary work, and Marvin (1976) describes the white rocks as containing gray to dark gray aphanitic clasts. In section 14063,17, clasts are less common than in 14064, and are described as comprising less than 5% of the section (Ryder and Bower, 1976). Ryder and Bower (1976) studied the series of clasts in the Apollo 14 white rocks (14063, 14064, and 14082/83) which show poikilitic texture and KREEP composition. These are interpreted to form as the result of crystallization of silicate melts rather than from metamorphism of breccias. (Most of their data come from sample 14064, however).

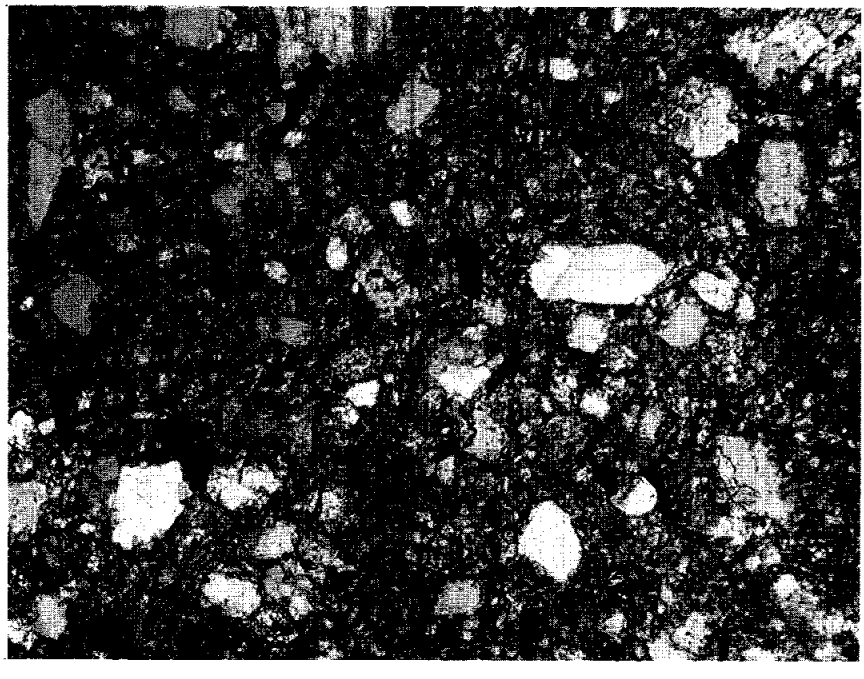
Steele and Smith (1976) found sample 14063,14 to contain at least four distinct lithologies. Contributing mineralogic or rock types were identified as: 1) dunite with minor chromite, very high Mg ilmenite (MgO > 8.2 wt %), and bronzite; 2) spinel troctolite with olivine (Fo_{79}) and Mg-Al spinel; 3) high-Ti, mare-like basalt with high-Mg ilmenite and coarse (exolved?) pyroxene; 4) low-KREEP noritic breccia; 5) anorthosite (?); 6) very Ni-rich (40 wt %) Fe metal. They also identified a mare basalt component as well as other rock types similar to those previously recognized. They believe that the Ni-rich metal possibly formed in equilibrium with olivine early in lunar history. They believe 14063 to be a possible sample of pre-Imbrium regolith bases on the absence of Ti-rich spinel and troilite, the rarity of metal, and the lack of metamorphism sufficient to have devitrified glass or recrystallized dark-matrix clasts.

14064



S-71-32451

14064, 34



Sample 14064 was collected in the White Rocks area at Station C1 and was returned in bag 16 along with 14063 and 14065 (residue) in ALSRC 1006. There was a strong feeling at the LRL that 14064 and 14063 are parts of the same rock because not only do they look very much alike, but 14064 has a protruding 1 cm clast, while 14063 has a 1 cm clast mold. Nobody was able to fit the two together, however, and Cdr. Shepard stated that he had put "a couple" of hand specimens into bag 16, which is what was found. Sample 14064 is one of those studied by the Imbrium Consortium.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
107.5 g	6.0 x 4.0 x 4.0 cm

This sample is pale gray with a leucocratic matrix and contains approximately 40% clasts and 60% matrix. The sample is friable.

SURFACE FEATURES

Pits are glass-lined and occur on 1% of the surface. The sample is very friable and the patina covering the specimen flaked off except for traces around zap pits.

The smoothly rounded surface is pocked with clast molds ranging in size from 1 to 10 mm.

Many fractures occur around clasts and two sets of planar fractures cut the rock.

PETROGRAPHIC DESCRIPTION

Sample 14064 is a fine grained friable "white rock". This rock was studied extensively by members of the Imbrium Consortium (1976) who discussed several clast types in great detail. They found the matrix to consist of monomict breccia zones, as is 14082/83, and 14063, rather than being homogeneous. This distinguishes these so called "White rocks" from other lunar breccias (Imbrium Consortium, 1976).

KREEP-rich melt fragments make up a large proportion of thin sections studied by the consortium. Troctolitic breccia zones are also present, consisting of plagioclase, olivine, and orthopyroxene.

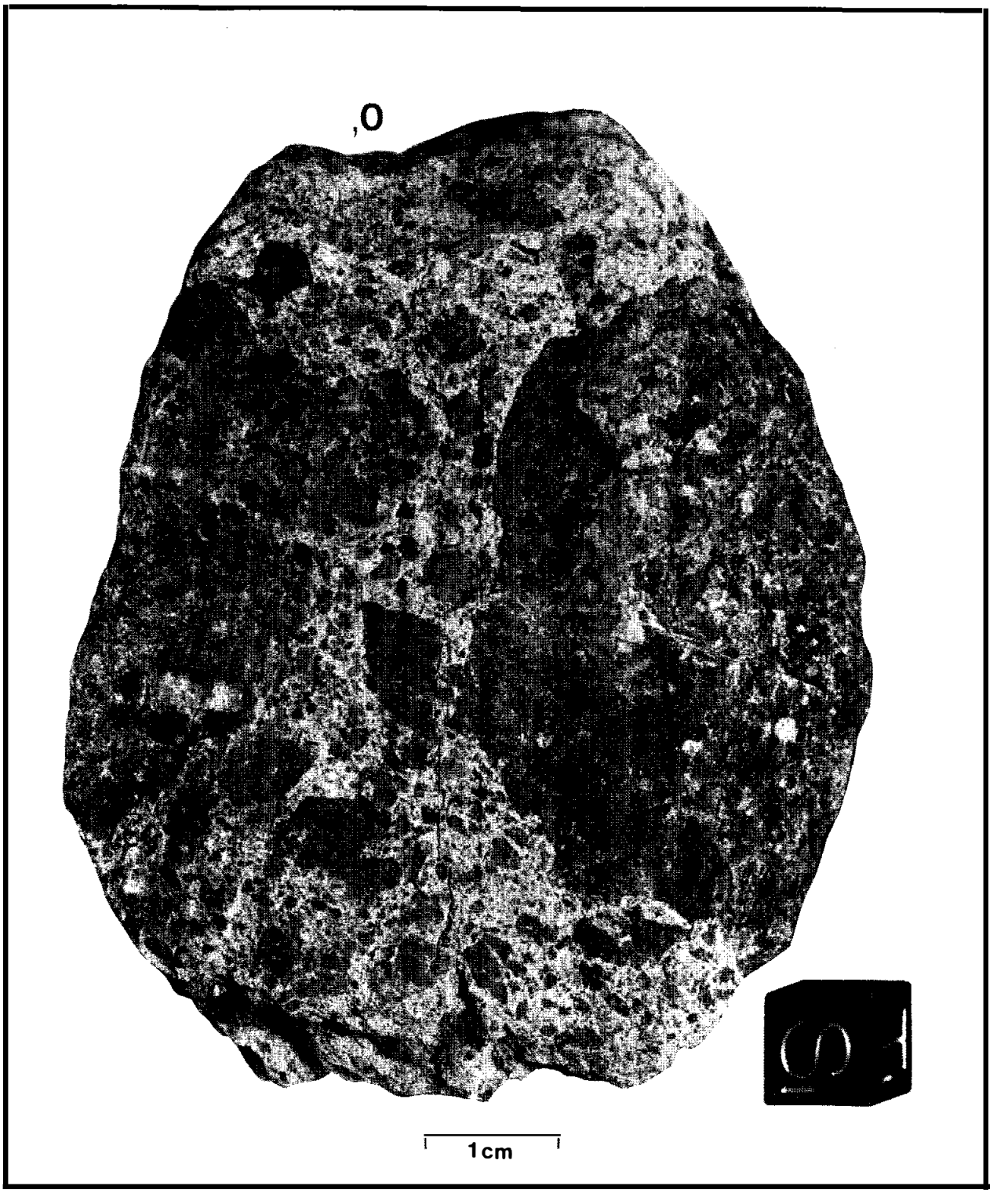
Thin Section 14064,34 is a nearly holocrystalline breccia with large plagioclase clasts. The crystals are slightly shocked and blocky in outline. There are large to small fragments of a turbid brownish phase that was unresolvable. The remainder of the matrix is a seriate mixture of pyroxene and plagioclase fragments.

DISCUSSION

Sample 14064 was classified by Wilshire and Jackson (1972) as F_3 and as an LMB by Simonds et al. (1977). The Imbrium Consortium (1976) studied it extensively, finding most of the clasts to be poikilitic, KREEP-rich melt rocks, and secondarily, plagioclase-olivine-orthopyroxene (troctolitic breccias). These areas occur as zones, distinguishing the "White Rocks" from other lunar breccias.

Ryder and Bower (1976) concluded that the KREEP-rich, fragment laden lithology of 14064, as well as of the other White Rocks (14063 and 14082/83) is a result of the crystallization of a silicate melt containing solid silicate fragments. They felt that it is more likely that this melt resulted from the total melting by meteoritic impact, of a polymict, plagioclase-rich source region, the fragments being picked up as the melt moved outward from the point of impact.

14066



S-77-23485

14066, 37

.1mm

Sample 14066 was collected at Station F on the second EVA. The sample was found in the vicinity of Weird Crater. No orientation or photographic documentation was obtained. The only picture which shows the general area is 64-9137, Pan B, which may contain the exact sample location.

The sample was returned in documented bag 17N in ALSRC 1006. It is essentially a grab sample.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
509.8 g	9.8 x 6.5 x 5.7 cm

This sample is a fragmental rock composed of 25% fragments greater than 1 mm and 75% of fragment less than 1 mm. It is very light gray in color with some large, darker gray clasts. It is moderately friable and it has a blocky subround to subangular surface.

SURFACE FEATURES

The surface of the rock has a high pit density covering approximately 15% of the area. The pits range from 0.5 to 5 mm and are lines with gray botryodial glass. The sample is more densely pitted on one side than it is on the others.

There are several clast molds, making up 5% of the total surface area. These molds are angular to irregular in shape and range from 1 to 4 mm. They occur in clusters at one end of the sample.

There are two sets of fractures with irregular surfaces. One set is subparallel to the intermediate axis of the rock. The second set cuts one end of the rock and resulted in several small chips falling off.

PETROGRAPHIC DESCRIPTION

14066 is a very light gray, medium grained rock with an average grain size of ± 1 mm. Several large, medium gray clasts are scattered throughout the sample. Clasts greater than 1 mm are 98% lithic fragments of crystalline rocks and 2% feldspar mineral fragments. The lithic fragments appear to be parts of a medium gray finely crystalline rock. These clasts are angular and very irregular and are < 1 mm to 5 mm in size. Some fragments have plagioclase phenocrysts set in the fine groundmass. The matrix consists of white, clear, and seriate feldspar and a trace of brown pyroxene, opaque minerals, and olivine. Some of the feldspar clasts have reaction rims suggesting some reaction with the matrix.

In an attempt to characterize the nature of this generic, three thin sections from different parents were chosen for modal analysis of the ≥ 1 mm clasts.

The samples examined with their proper parents designated were:

Sample	Parent	Dominant Clast ≥ 1 mm
14066,34	,20	dark matrix breccia, shocked anorthosite and shocked pyroxene aggregates
14066,49	,26	dark matrix breccia, anorthositic rock, and pyroxene aggregates
14066,50	,25	dark matrix breccia, shocked pyroxene aggregates, and plagioclase vitrophyric rock

In summing the results of this survey and comparing it to the work of Wilshire and Jackson (1972), nominal agreement was found. In this survey little to no noritic type igneous rock was encountered in the ≥ 1 mm clasts. This is the second most common type clast in Wilshire and Jackson's paper.

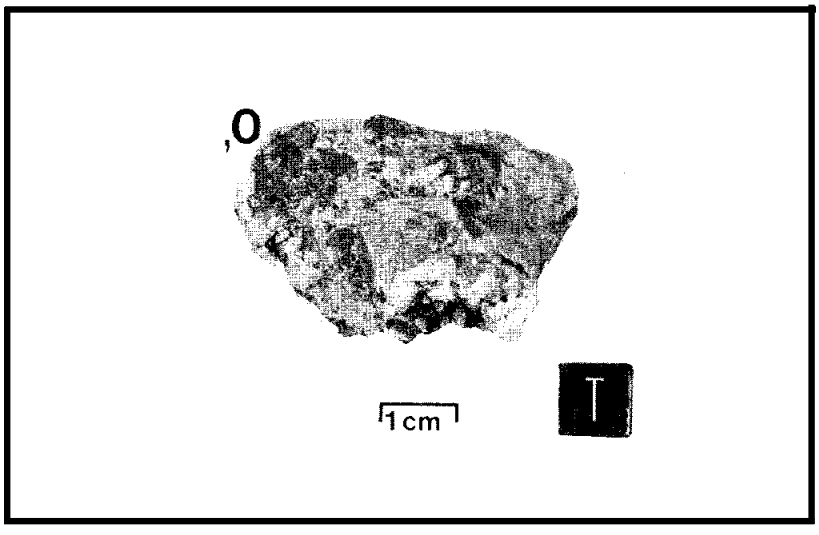
DISCUSSION

14066 is noteworthy for the abundance of clasts of a single lithology (medium gray crystalline rock) and the possible reaction rims on some of the feldspar clasts.

Wilshire and Jackson (1972) classed the rock as an F_4 with a high concentration of dark meta-clastic clasts in the > 1 mm portion. Warner (1972) classified it as being high grade metamorphic (grade 7), and Chao *et al*. (1972) list it as a strongly annealed, shocked breccia. It is listed by quaide and Wrigley (1972) as an annealed breccia, by von Engelhardt *et al*. (1972) as a glass poor breccia with a crystalline matrix, and by Simonds *et al*. (1977) as a crystalline matrix breccia (CMB). Phinney *et al*. (1976) describe 14066,9 as moderately friable with 15 - 20% of the matrix occupied by vugs and vesicles. The sample is highly fractured, with fractures cutting clasts as well as matrix. The matrix is described as being composed of subhedral to anhedral zones plagioclase 5 - 20 μm pyroxene with accessory 5 μm ilmenite arranged in interlocking grains.

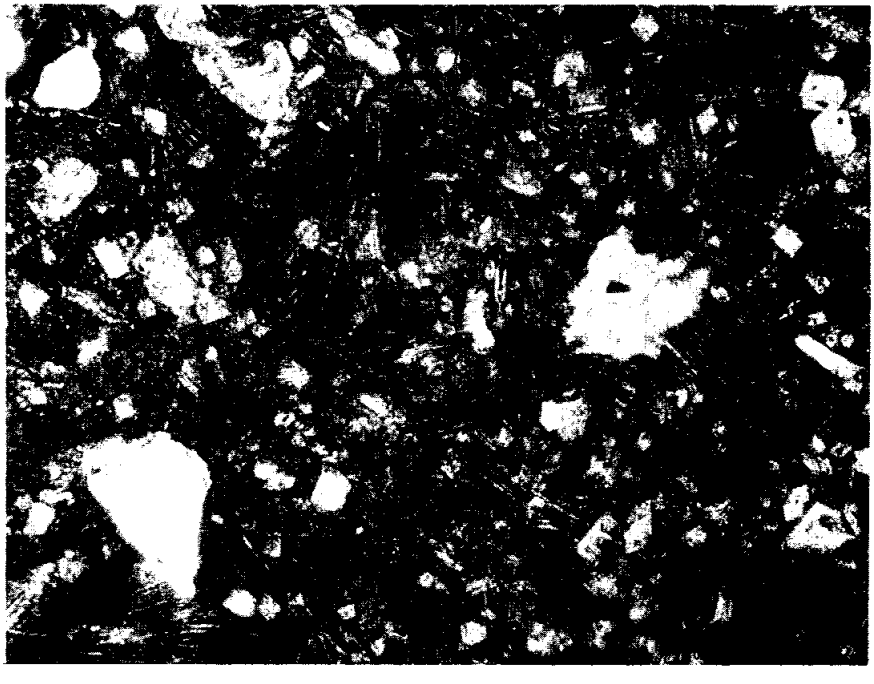
This is one of the samples mapped by Twedell *et al*. (1978).

14068



S-71-30338

14068, 8



Sample 14068 was collected during the second EVA from station C' and placed in bag number 10. It is one of the surface rocks collected while a gray layer, just under the surface, was samples (14140-14143) at station C'.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
35.47 g	4.2 x 3.2 x 2.7 cm

This is a blocky, gray, coherent, holocrystalline, melt rock with less than 5% clasts.

SURFACE FEATURES

The surface contains numerous zap pits ranging in size from 0.1 to 0.7 mm.

The only cavities are those produced by intersecting fractures. Numerous non-planar fractures appear in multiple sets averaging 2 mm in length.

Some vugs or vesicles are visible in thin section.

PETROGRAPHIC DESCRIPTION

Sample 14068 is a walnut-size holocrystalline melt rock with large grains of plagioclase up to 1 mm across making up 5% of the rock. The grain size is very samll, with average grains less than 0.1 mm.

Thin section 14068,8 shows the matrix clusters and fans of devitrification crystals hosting larger, partly eroded mineral fragments. The thin section also shows a high percentage (10-15%) of void areas 0.05-0.2 mm. No crystals extend into the voids and the shape of the voids is irregular to rounded.

DISCUSSION

Sample 14068 has been studied in detail by several investigators. It is the only sample representing Warner's (1972) grade 8, a high grade metamorphic breccia with neither matrix glass nor glass clasts. The large percentage of MgO reported by Hubbard et al. (1972) accounts for the 20% olivine occurring as skeletal crystals in the matrix and as clasts reported by Warner (1972). Warner found no glass in the matrix and rare, partly devitrified glass clasts. Mineral and lithic clasts are described as having ragged borders. The average plagioclase composition is reported by Warner as being $An_{73}Or_{7}$. Pyroxene averages En_{72}, and olivine compositions are reported as Fo_{77} to Fo_{79} for prisms and Fo_{67} to Fo_{84} for clast cores. Warner interpreted 14068 as having been heated to so high a temperature that the matrix melted. Williams (1972) found the temperature required to melt it to be at least 1100°C.

Wilshire and Jackson (1972) classified it as a homogeneous crystalline metabreccia.

It is classified as a clast laden impact melt rock (CMB) by Simonds et al. (1977).

Helz (1972) did an extensive petrographic and chemical study of 14068, which included making a detailed map of 14068,10 and smaller sketches of 14068,7 and 14068,11. She accounts for the observed features with a petrogenetic outline of the history of rock 14068:

(1) The melting, involving temperatures beyond the igneous range, was the result of meteorite impact. The molten bleb produced was fairly small.

(2) The melt picked up plagioclase clasts and nickel-iron blebs. There was sufficient turbulence for the clasts to be mixed throughout the bleb.

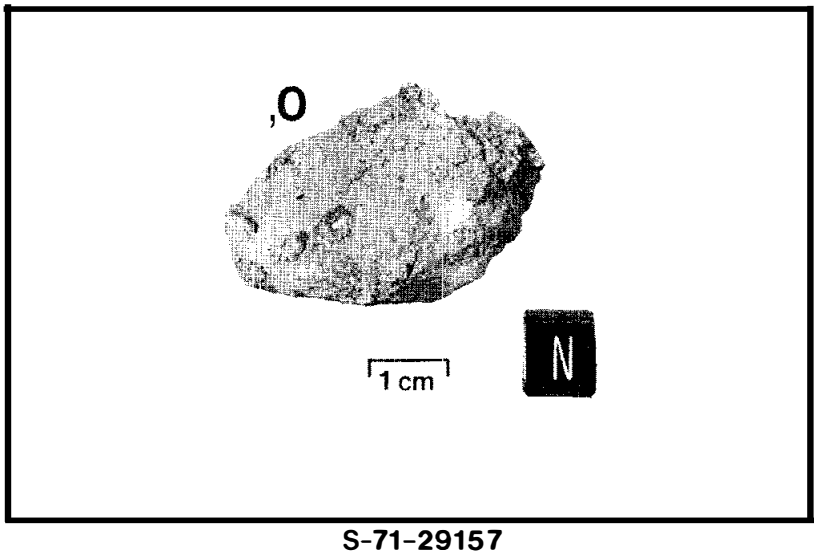
(3) The melt picked up the olivine, orthopyroxene, lithic and glassy fragments. Most of the glassy clasts softened and vesiculated.

(4) The melt made contact with some of the dark breccia ("north" side) while still quite fluid.

(5) The melt made contact with the dark breccia on the "south" side while still plastic, but it was not as fluid as in step 4.

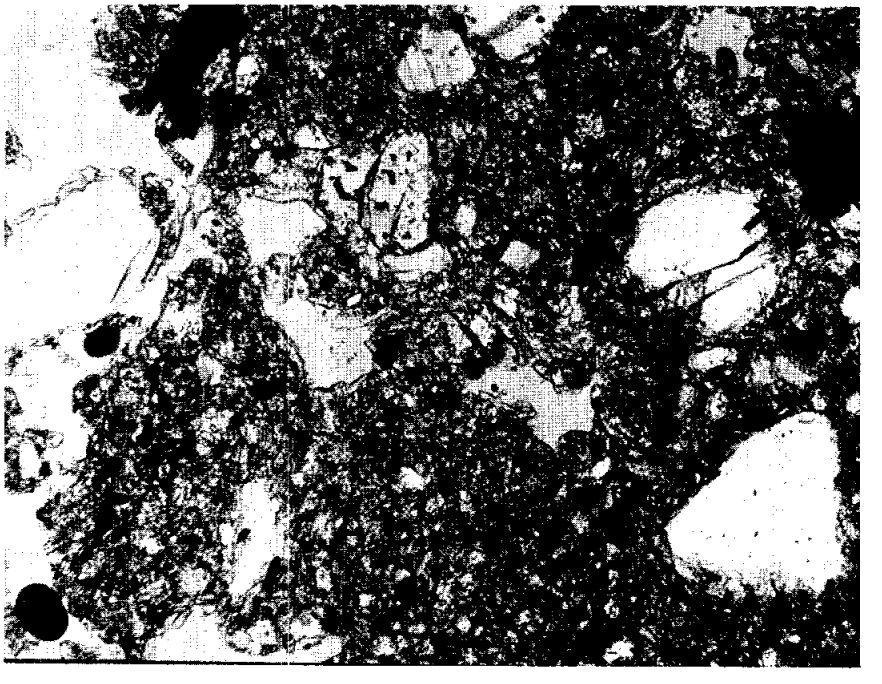
(6) Rock 14068 has not been involved in any major brecciation or thermal metamorphic events since solidification of the olivine-rich groundmass was completed.

14069



S-71-29157

14069, 4



.1mm

Sample 14069 was collected at station C', 1.28 km ENE of the LM and 100 m SE of the rim of Cone Crater during the second EVA. The material at C' appears to be material originally ejected from Cone Crater and re-ejected from a 30 m crater just south of station C' (Swann et al., 1977).

PHYSICAL CHARACTERISTICS

Mass	Dimensions
24.9 g	4.0 x 3.0 x 2.5 cm

Sample 14069 is a blocky, gray, finely crystalline breccia with a sugary texture.

SURFACE FEATURES

The surface is very irregular with no zap pits and 5-15% vugs. Three types of vugs were observed: elongate vugs (1.5 mm x 0.25 mm), spherical vugs (0.7 mm diameter), and an open network (0.5 mm). Clusters of elongate vugs and vuggy openings are 0.5 mm to 2.0 mm apart. Minerals project into the vugs, some at right angles, some at 45°, while others form botryoidal lumps on cavity walls.

Three sets of planar fractures occur: set 1 has one member and is oriented 35° to the intermediate axis of the rock. Set 3 has many members with apparently random orientation, but they may parallel clast edges.

PETROGRAPHIC DESCRIPTION

This rock is crystalline and is composed of colorless to white subhedral plagioclase and red-brown equant pyroxene. A trace of black, equant opaques are present.

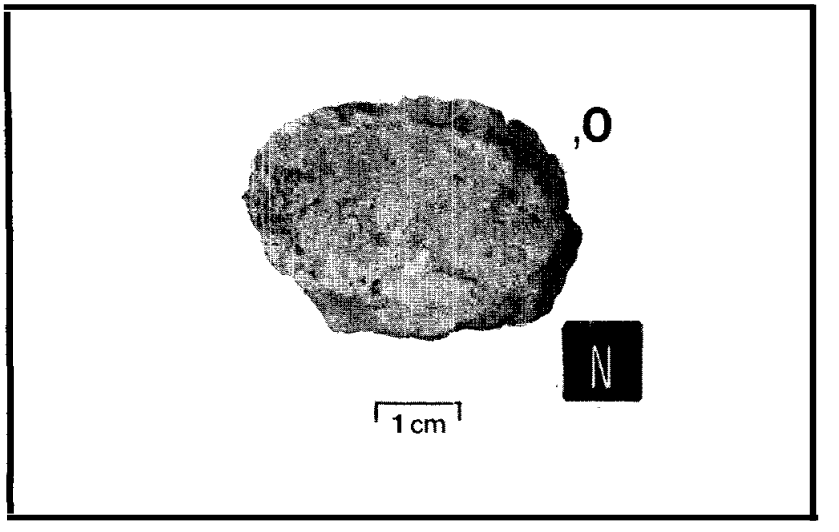
Minerals lining the vugs include feldspar, pyroxene, a green mineral, a black mineral, and a colorless botryoidal silica mineral. The texture of 14069 is fine grained, with grains 0.2 mm average. One 4 x 2 mm plagioclase crystal is present. The sample appears similar to 14070.

In thin section, 14069 is seen to have clasts of pyroxene and plagioclase. Some olivine/pyroxene, plagioclase granulitic rock fragments are present in thin section 14069,4. Sections 14069,4 and 14069,5 both contain small devitrified fragments. Troilite is present in large masses. The samples are composed of 60% plagioclase, 39% pyroxene and 1% olivine. Several pyroxene crystals have reaction rims. The average grain size is less than 0.1 mm.

DISCUSSION

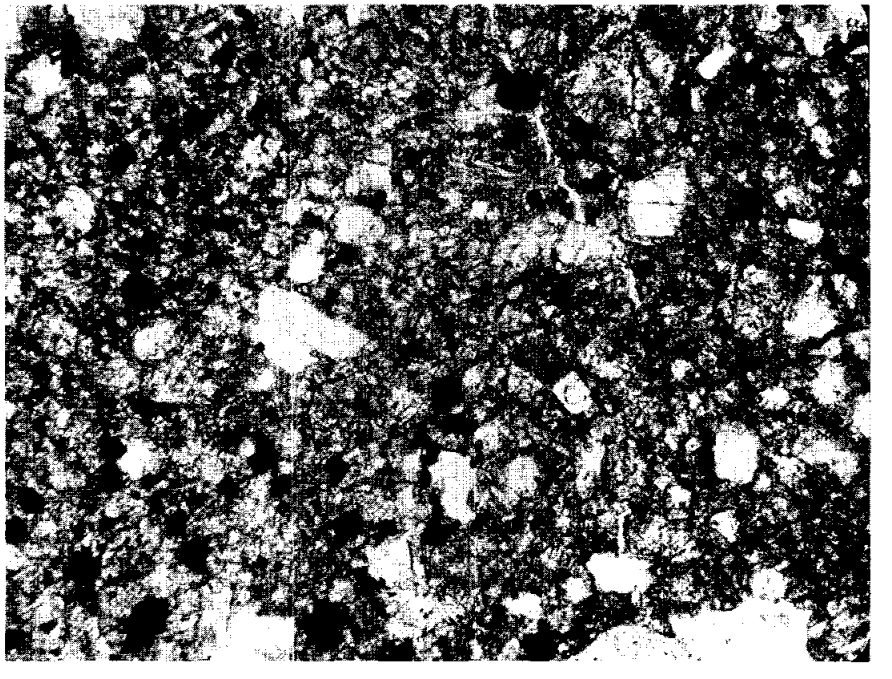
This rock was described by Wilshire and Jackson (1972) as crystalline. Thin section examination reveals 14069 to be a crystalline breccia (or CMB) using the Simonds et al. (1977) classification.

14070



S-71-54218

14070, 3



.1 mm

Sample 14070 was collected from station C', 1.28 km ENE of the LM, and 100 m SE of the rim of Cone Crater during the second EVA. It appears to have been ejecta from Cone Crater that was later re-ejected from a 30 m crater in the vicinity (Swann et al., 1977).

PHYSICAL CHARACTERISTICS

Mass	Dimensions
36.5 g	4.2 x 3.0 x 2.0 cm

This is a blocky, subangular, coherent, light gray, crystalline breccia that is similar to 14069.

SURFACE FEATURES

The irregular surface contains no zap pits, but irregular elongate vugs ranging from 0.2 - 2 mm in size appear in clusters and have inhomogeneous distribution.

A set of planar fractures with three memebers spaced 2 mm to 5 mm apart are oriented 5° to the long axis of the rock. A second set is perpendicular to these and the surface of this set is the same as the rock. Intermediate to these sets is another set and parallel to the intermediate rock axis. The fourth set is parallel to the long axis of the rock and lies 30° to the first set.

PETROGRAPHIC DESCRIPTION

This sample is a very fine grained, almost holocrystalline breccia, with clear plagioclase, cinnamon-brown equant pyroxene (0.2 - 0.5 mm), and yellow-green olivine (0.2 mm).

Larger grains consist of greater than 3 mm grains of plagioclase and olivine (2%). Traces of opaques are present. Plagioclase laths are less well-developed than in 14069.

Thin section 14070,3 is basically that of a crystalline breccia with approximately 5% "glass" in the matrix. The only clasts (> 1 mm fragments) present are those of a mare basalt. The fragments consist of 80% anhedral pyroxene and 20% needle-like plagioclase. The texture is subophitic, but not well defined. One large and one small clast of this type is all that is present.

The matrix (< 1 mm) consists of several large highly shocked to slightly shocked plagioclase grains. These large grains are somewhat grouped but no distinct lineation could be seen. All the grains are twinned and most have some inclusions. The remainder of the matrix consists of a seriate mixture of mineral grains consisting of 70% plagioclase, 30% pyroxene, other fragments, and glass.

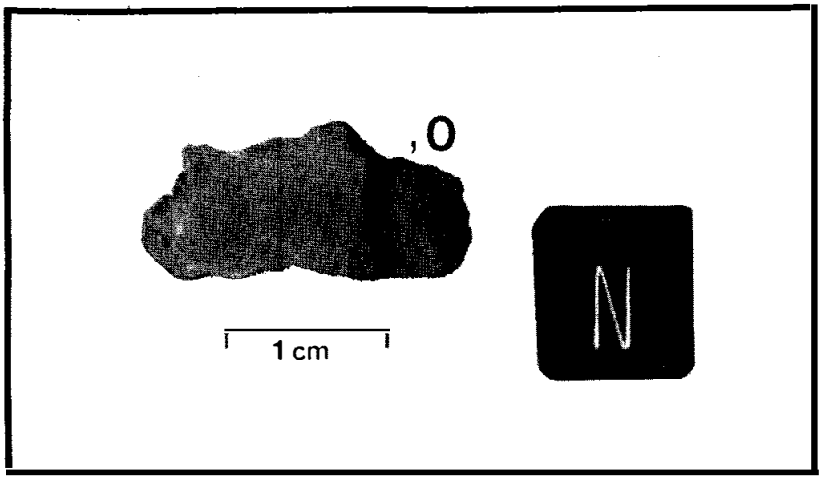
There are small irregular to subrounded vesicles (0.1 - 0.2 mm) present

which are scattered throughout section 14070,3. Some show small crystallites extending into the void area. The rock appears to have undergone some degree of shock, resulting in partial melting and crystal degradation.

DISCUSSION

Wilshire and Jackson (1972) classified this sample as a crystalline rock, but it would, today, probably be classified as a CMB using the classification scheme of Simonds *et al*. (1977).

14071



S-71-26072

Sample 14071 was collected at station C' approximately 1.28 km ENE of LM and 100 m SE of Cone Crater. The area is locally flat with a slight southerly slope. The sample was collected amongst abundant debris ranging in size from the limit of resolution up to 75 cm. The photo-documented area was too disturbed to be able to see any intact craters. The sample was returned in documented bag 10N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.16 g	2 x 0.8 x 0.5 cm

All the samples collected in the vicinity of 14071 are blocky and angular to subrounded with very rough surfaces.

SURFACE FEATURES

No zap pits are present on 14071, but there are small 1 to 10 mm vugs clustered on one side of the rock. The vugs contain small euhedral crystals of pyroxene growing into the cavity; the vugs constitute approximately 2% of the rock volume. There are no apparent fractures.

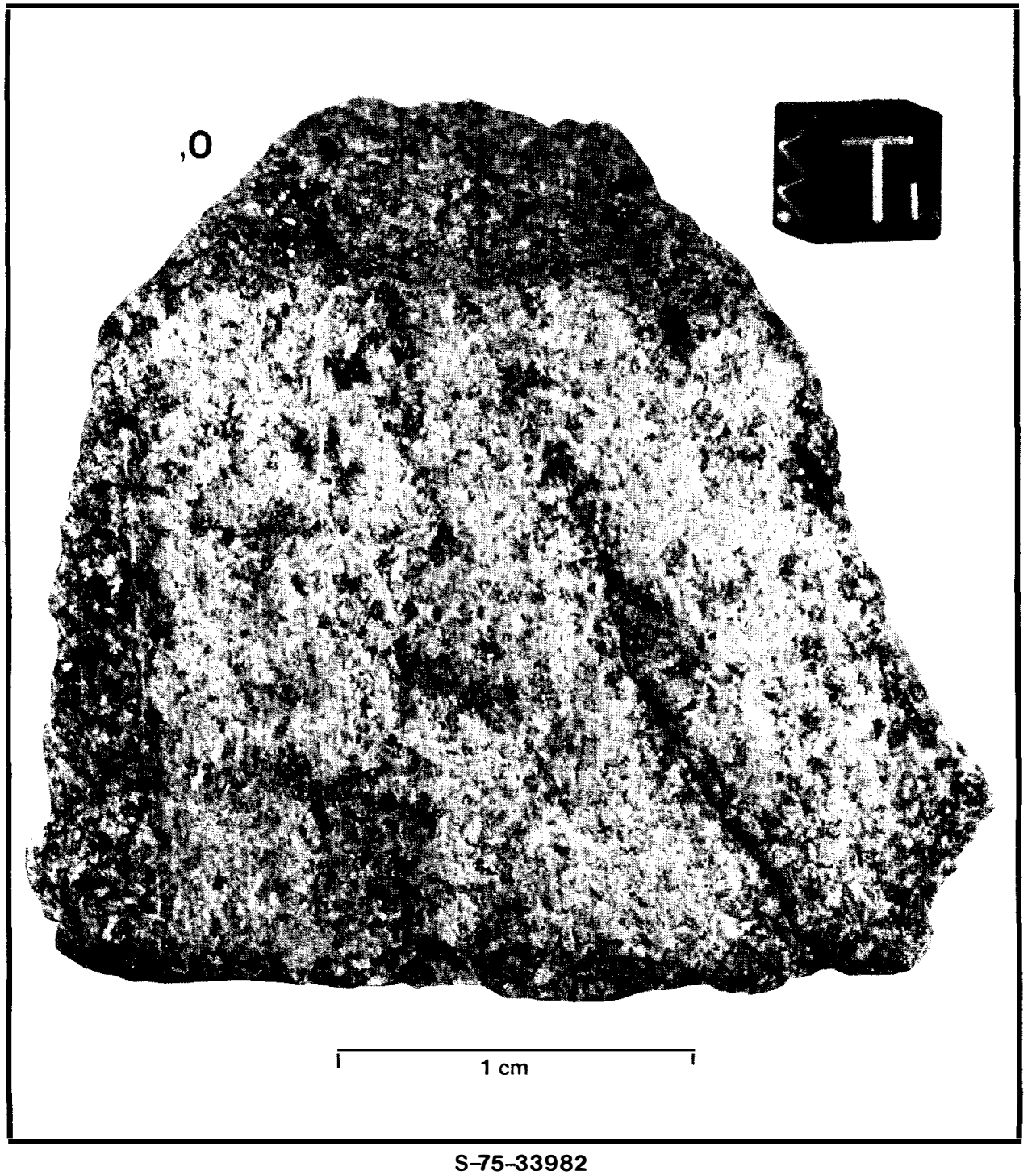
PETROGRAPHIC DESCRIPTION

This small sample is noteworthy due to the free growing pyroxenes in the vugs. The texture of the rock is equigranular and massive. The rock appears to be wholly crystalline. The approximate mineral composition is 43% clear, 0.2 mm, subhedral grains of plagioclase; 55% subhedral, 0.2 mm grains of pyroxene; 2% (approximately 0.05 mm) opaque mineral grains; and approximately 2% mafic minerals (olivine?). The color of the rock is light gray. The rock is often classified as a basaltic crystalline rock (Wilshire and Jackson, 1972).

DISCUSSION

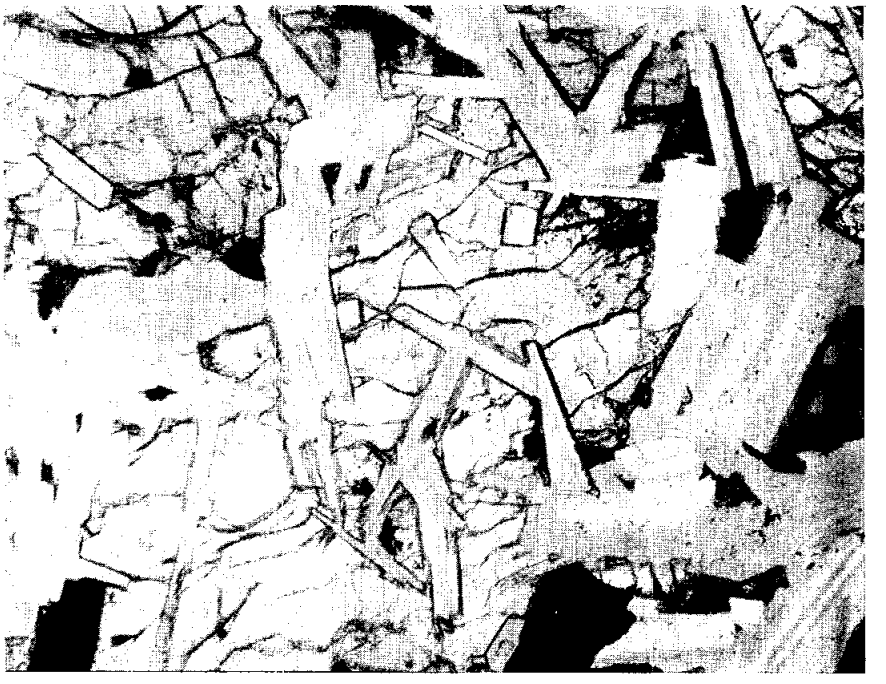
Due to the small size of the sample, no extensive work has been done on the sample except in PET. Swann *et al*. (1977) give a general description of the sample.

14072



S-75-33982

14072,11



1 mm

Sample 14072 was collected at Station C', about 1.28 km ENE of LM and 100 m SE of Cone Crater. The area is locally flat but generally slopes slightly to the south. The area is strewn with debris which ranges from the limit of resolution up to 75 cm. The debris is mainly angular to subrounded. The entire area of photo documentation is too disturbed to see any intact craters.

The sample was returned in documented bag 10N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
45.06 gm	4.1 x 3.4 x 2.1 cm

The sample is a medium light gray basalt and is somewhat smooth in appearance. The shape is blocky to subrounded and the rock is extremely coherent.

SURFACE FEATURES

No zap pits are observed on any of the surfaces. There are small (3 to 11 mm) flattened elliptical vugs that appear in zones. One planar fracture transects the rock at 30° to the long axis.

PETROGRAPHIC DESCRIPTION

14072 is a fine to medium grained, basaltic, igneous rock which is texturally and mineralogically homogeneous. The sample is blocky to subrounded with a relatively smooth surface. The rock consists of light yellow-green olivine, light brown pyroxene, clear plagioclase and small amounts of opaques. Abundant phenocrysts (up to 1.5 mm) occur in the rock.

Thin section 14072,11 shows the rock to be composed of 30% plagioclase laths and masses, 1% light green olivine anhedral crystals, 3% of opaques and mesastasis, with the remainder being large anhedral to subhedral crystals of pyroxene. A few rare scattered masses of cristobalite are also present. Some twinning is present in the pyroxenes. The texture is ophitic to subophitic.

DISCUSSION

The sample is classified as a basalt by Wilshire and Jackson (1972) and is a mare basalt by Simonds et al. (1977). Longhi et al, (1972) described 14072 as a subophitic basalt with large resorbed olivine phenocrysts. There has been a strong post-crystallization reduction in the rock. This is also noted by E. Goresy et al. (1972).

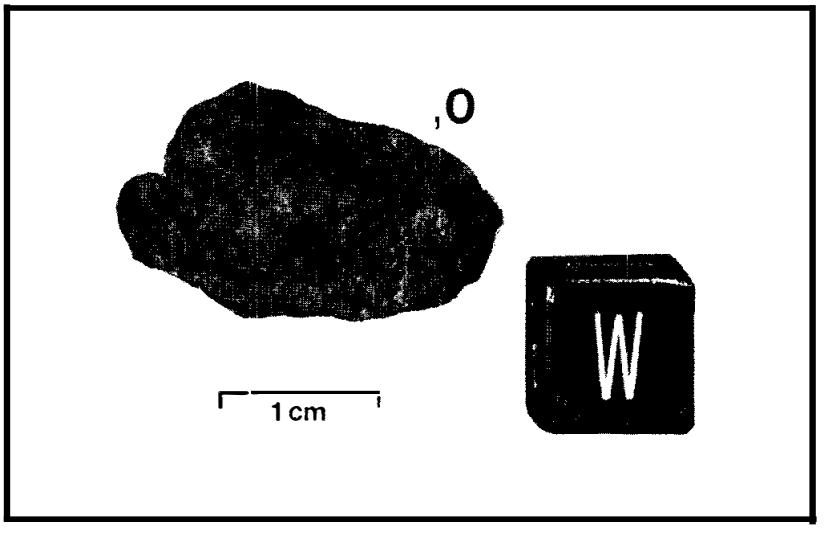
El Goresy et al. (1972) note the textural and mineralogical similarity that exists between 14053 and 14072. They also note the partitioning of MgO between primary ilmenite and ulvospinel vs "exsolved" ilmenite and co-existing ulvospinel indicates that the reduction processes represented are a closer approach to equilibrium than initial crystallization. Native iron-nickel metal also occurs in their sample. The sideraphile content is extremely low (Au content 0.089 ppb) Hughes et al. (1973).

Taylor et al. (1972) consider 14072 to be similar to Apollo 12 basalts.

Helmke et al. (1972) report REE concentrations similar to Apollo 12 basalts.

Clayton et al. (1972) have determined the oxygen isotope concentration in 14072 and Compston et al. (1972) have determined the Rb-Sr mineral isochrons for the rock and suggest the age to be approximately 4 billion years old. York et al. (1972) have found the approximate ^{38}Ar cosmic ray exposure age to be 21 m.y. for 14072.

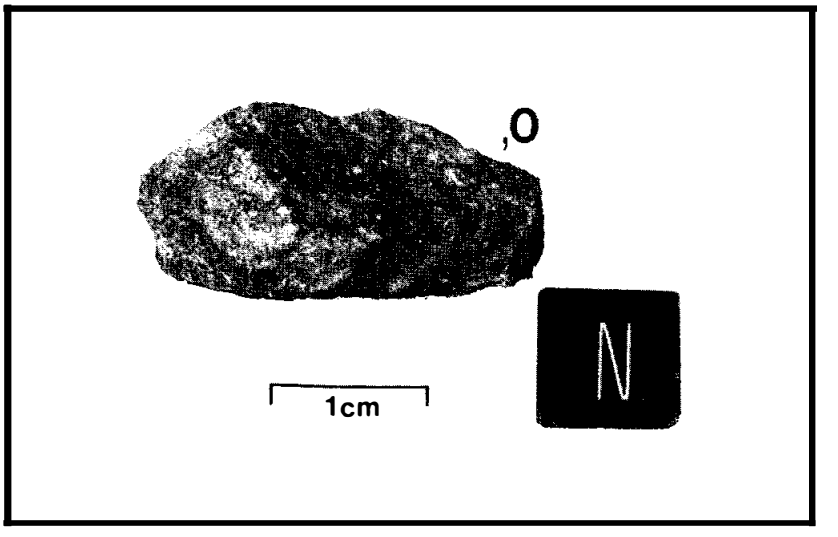
14073



S-71-26079

14073,7

14074



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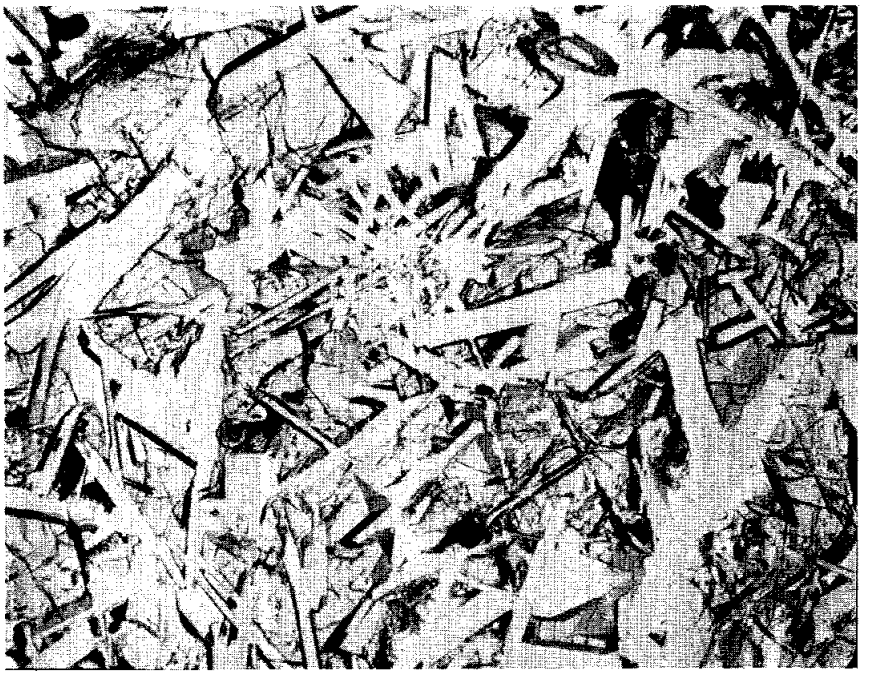
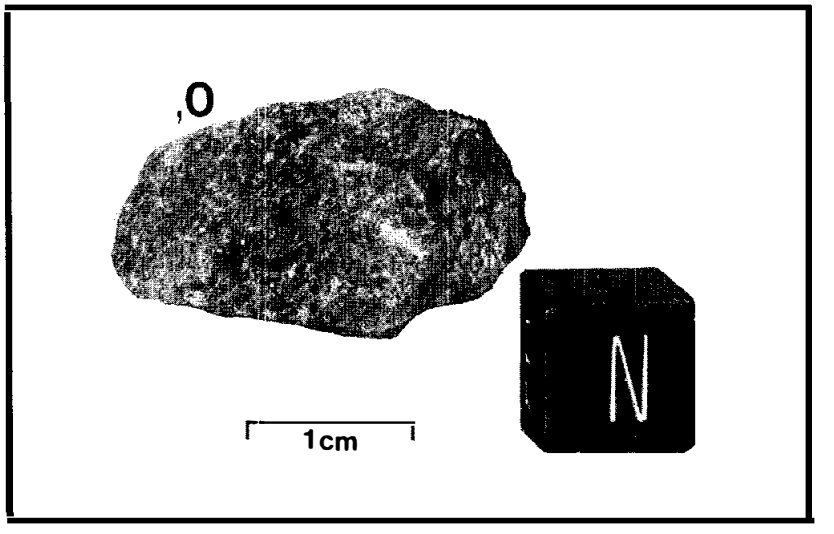
14074, 4



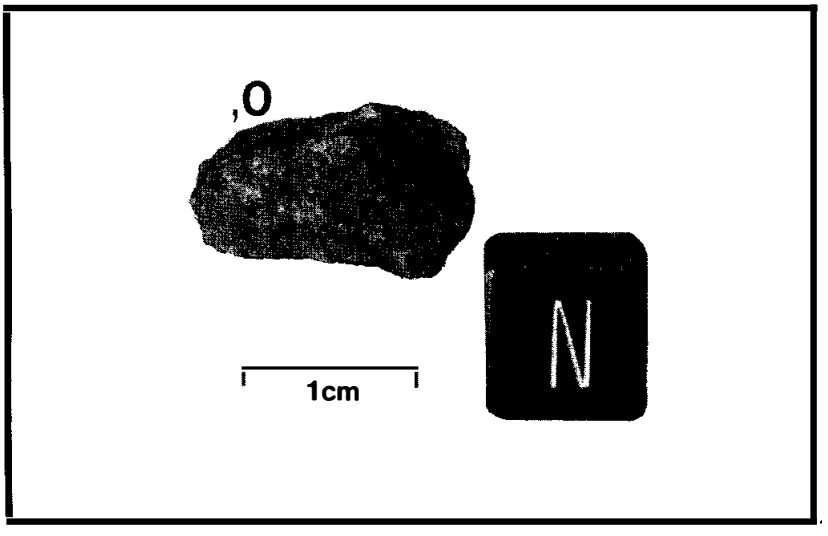
14078



S-71-26046

14078,4

14079



S-71-26050

All of the samples came from the bottom of the trench taken at Station G, 230 m ESE of LM and 50 m E of North Triplet rim crust.

The area is marked by a nearly level terrain with a sparse amount of debris scattered throughout. The debris ranges in size from the limit of resolution up to 60 cm. There is a moderate abundance of subdued 20 to 50 cm craters in the area.

All samples were returned in documented bag 20N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Sample Number	Mass	Dimension
14073	10.4 g	2.8 x 2.0 x 1.5 cm
14074	5.2 g	1.0 x 1.5 x 2.5 cm
14078	8.3 g	2.9 x 1.5 x 1.2 cm
14079	3.2 g	1.6 x 1.2 x 0.6 cm

These samples are very light gray, very coherent, holocrystalline, melt rocks.

SURFACE FEATURES

Originally only sample 14074 had zap pits on any surface. Even on this sample they were very few and widely scattered. Where present, they were described as being glass lined and ranging in size from 0.5 to 1.0 mm. The pits had good halos around them, but no pits are visible on the sample anymore.

All of the samples contain cavities or vugs. Most of the cavities are irregular to elongate and range in size from 0.5 to 1.5 mm and most fall in the 1-1.5 mm size range constituting around 1% of the volume of the rocks. Many contain protruding crystals of plagioclase. Some small clusters of cavities can be seen.

Sample 14073 and 14074 each have fractures present while 14078 and 14079 have no surface fractures.

The fractures in 14073 have one set which makes a 30° angle to the long axis of the sample. The fractures in 14074 are non-planar and occur in two sets of one member each. One set is diagonal to all surfaces and the other makes an angle of 20° to the other. Neither fracture surfaces can be seen.

PETROGRAPHIC DESCRIPTION

All samples are light gray in color and equigranular in texture with a grain size of approximately 0.25 mm to 0.5 mm. These samples are all holocrystalline and basaltic in nature. The observable minerals are plagioclase, pyroxene, olivine and opaques. Some of the feldspar is poikilitic. The major minerals are plagioclase and pyroxene with lesser amounts of olivine and a small amount of opaques.

Thin section 14073,10 shows an interlocking network of plagioclase laths with large anhedral crystals of pyroxene unevenly distributed throughout the section. Several large masses of pyroxene have only minor plagioclase associated with them while other masses are interspersed in the tightly grouped plagioclase network. There appear to be two generations of plagioclase. Plagioclase comprises approximately 60% of the section and pyroxene, 40%. Minor amounts of brown mesostasis and opaques are also present.

Thin section 14074,4 is a typical crystalline rock composed of plagioclase and pyroxene in a diabasic texture. The long bladey to wide laths of plagioclase enclose the much smaller anhedral masses of pyroxene. The plagioclase shows well developed twin planes. The pyroxene shows some zoning with numerous inclusions and some of the pyroxene crystals show cleavage traces. All show some shock effects.

It is apparent that at least two generations of plagioclase are present. There are some very small short bladey crystals, in addition to the two types of larger crystals, suggesting that there may be three generations present. A late stage plagioclase crystallization appears to have occurred, resulting in small masses of anhedral plagioclase and a small amount of mesostasis.

The rock consists of approximately 60% plagioclase and 40% pyroxene with only small amounts of opaques and mesostasis.

Section 14078,4 is also crystalline, with a subophitic texture. It contains slightly more pyroxene than plagioclase (60:40), and some mesostasis is present. Most of the crystals show some evidence of shock.

There are at least two generations of plagioclase crystals present. The pyroxene crystals are anhedral in shape, occurring as masses. Some twinning is present. All samples are similar in appearance to 14310.

The major constituents of 14078,3 are plagioclase (64.4 volume %) and low Ca pyroxene (22.2 volume %) the later is primarily pigeonite but one large orthopyroxene crystal was observed. Olivine (6.5 volume %), augite (3.3 volume %), Sl- and K- rich mesostosis (2.3 volume %), and ilmenite (0.5 volume %) are minor constituents reported by McKay et al. (1978). They also observed traces of calcium phosphate, K-feldspar, troilite and metal. The texture of 14078,3 as reported by them is similar to 14310 ranging from subophitic to intergranular. They observed a suggestion of "textural heterogenity" which they describe as a few small (smaller than 0.5 mm) fine-grained patches resembling the fine-grained areas in 14310 reported by James (1973).

DISCUSSION

The only samples which have been studied are 14073 and 14078. Gancarz et al. (1971) and El Goresy et al. (1972) have described the general petrology and geochemistry of 14073 as being similar to that of 14310. They have described several of the opaque minerals which are present in the sample.

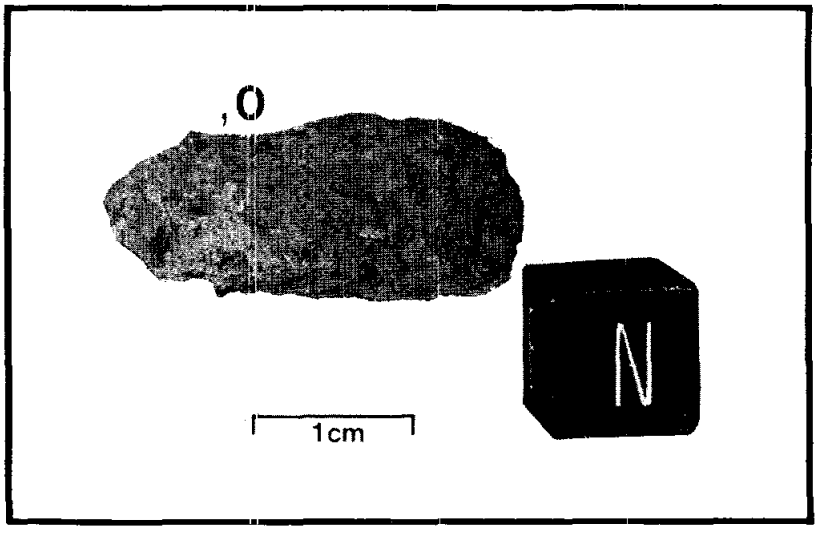
Clayton et al. (1972) have done oxygen isotopic studies and conclude that 14073 show typical "igneous" values.

Age determinations for 14073 have been performed by Papanastassiou and Wasserburg (1971), Tera and Wasserburg (1972) and Turner et al. (1972). The Ar^{40}-Ar^{39} age has been determined as 3.88 ± 0.05 AE and an exposure age of 113 million years.

Wilshire and Jackson (1972) have classified the samples as Group B (basaltic) crystalline rocks. Simonds et al. (1977) classify 14073 as a CMB of the clast ladened impact melt variety. McKay et al. (1978) have described recently the general petrology and geochemistry of 14078. They report:

1) the REE content of 14078 is 10-15% higher than that of 14073;
2) the age of 14078 is 3.89 ± .02 B.Y. old. The initial $^{87}Sr/^{86}Sr$ is 0.70051 ± 5. Therefore, 14073, 14310, and 14001,7,3 are the same age, within the error listed.
3) Petrographic and chemical data permit derivation of these samples, as well as 14152,5,102, from the same liquid.

14075



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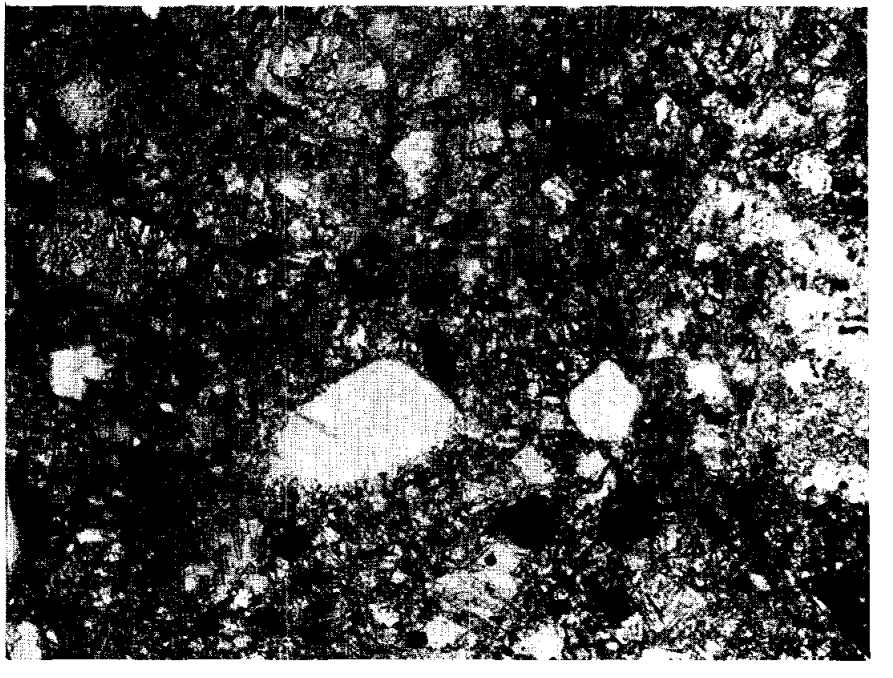
14075,4



Sample 14075 was collected at the bottom of the trench at Station G 230 m ESE of LM and 50 m E of North Triplet rim crust. The area is characterized by a nearly level regolith surface which is sparsely strewn by fragmental debris. The size of the debris varies from the limit of resolution to 60 cm.

There is also a moderate abundance of subdued craters in the 20 to 50 cm range.

This sample was returned in documented bag 20N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.65 gm	1.0 x 1.5 x 2.5 cm

14075 is a small, subangular, blocky, rock chip of a moderately coherent fragmental rock with a moderately smooth surface. The color is a light gray.

SURFACE FEATURES

None of the surfaces show any pits and there are no surface fractures. There are numerous cavities which are angular clast molds with sizes ranging from 0.5 to 3.0 mm having a homogeneous distribution on the surface. These cavities are spaced approximately 3 mm apart.

PETROGRAPHIC DESCRIPTION

This fragmental rock is polymict, composed of 5% fragments > 1 mm and 95% matrix (< 1 mm). The rock is friable but does not crumble easily. The color is light gray and has an average grain size of < 0.5 mm. The largest clast is no more than 4 mm in size. Mineral fragments, which make up 2% of the rock, consist of feldspar and brown pyroxene. Lithic fragments of melanocratic and leucocratic crystalline rocks compose approximately 70% of the rock. Angular black glass fragments make up about 25% of the rock, but not all dark fragments are glass.

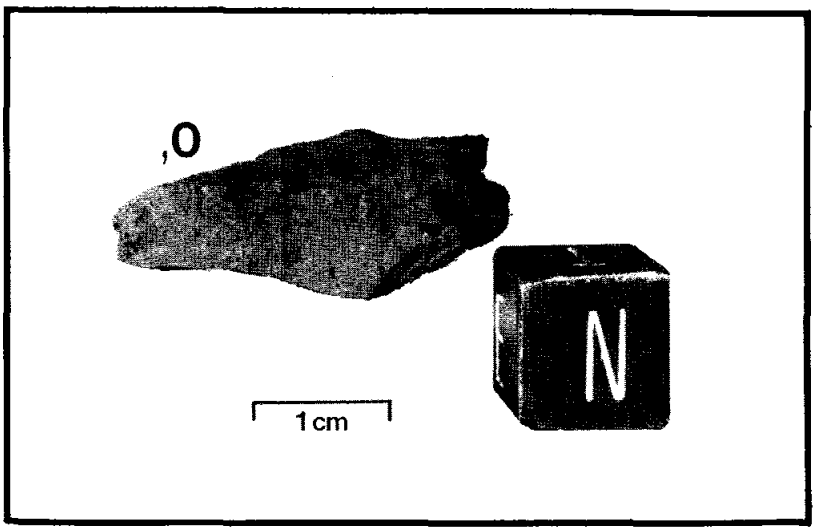
Thin section 14075,4 shows no clasts (> 1 mm) but there are numerous lithic and mineral fragments in the matrix. There is approximately 10% glass in the section represented as small yellowish masses and as turbid "wormy glass" in between the grains. The thin section shows nearly equal amounts of plagioclase and pyroxene fragments. The plagioclase shards are large and mildly shocked, whereas the pyroxene is highly shocked and fractured. Minor olivine occurs in both types of mineral fragments. The lithic fragments represented in the section include crystalline breccias, melt rock, shocked and granulated pyroxene/plagioclase rocks and fine grained microbreccias. Almost all of these mineral fragments are < 1 mm in size.

DISCUSSION

Wilshire and Jackson (1972) classified 14075 as an F_4 fragmental rock.

Due to the small size of the fragment no detailed work has been done on this sample.

14076



S-71-26064

Sample 14076 was collected at the bottom of the trench at Station G, 230 m ESE of LM and 50 m E of North Triplet rim crest.

The area, in general, is nearly level and lightly strewn with debris. The size of the debris ranges from the limit of resolution up to 60 cm. There is a moderate amount of subhedral 20 to 50 cm craters.

The sample was returned in documented bag 20N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.00 g	2.5 x 1.0 x 1.0 cm

14076 is a medium light gray fragmental rock which shows two distinct matrix areas within the same rock fragment. The contact of the two matrices is very sharp. The fragment contains distinct clasts of a light bluish gray crystalline rock. The rock is tough and appears to be welded polymict.

SURFACE FEATURES

None of the surfaces show any zap pits. There are no cavities visible on the surface of the fragments.

There is one set of fractures parallel to the long axis of the rock. This fracture set transects an irregular sharp contact which crosses the rock parallel to the intermediate axis. There are three members each spaced approximately 3 mm apart. The fractures surfaces are planar.

PETROGRAPHIC DESCRIPTION

Sample 14076 is a small elongate, angular, medium gray fragment which is tapered at one end. The surface of the fragment is smooth, planar, and unpitted. The texture is inhomogeneous. The grain size of the matrix is very fine and that of the clasts range from 0.1 to 4 mm.

The rock is tough and shows two distinct matrices in the fragment which are separated by a sharp contact. One half of the rock has 30% visible clasts which consist of mostly elongate and bluish-gray clasts. The second half of the rock has only 5-10% clasts set in a medium brown matrix. This second matrix is slightly coarser than the gray matrix. Mineral fragments constitute 65% of the clasts present and 35% are of the leucocratic crystalline rock fragments.

The following types of clasts occur in the rock:

1) The feldspar-rich, bluish-gray leucocratic lithic fragments which measure up to 3 mm. Feldspar grains compose most of the fragments set in a thin white powdery matrix.

2) Black finely crystalline leucocratic lithic fragments.

3) Patches of coarser gray leucocratic clasts set in a lighter gray matrix.

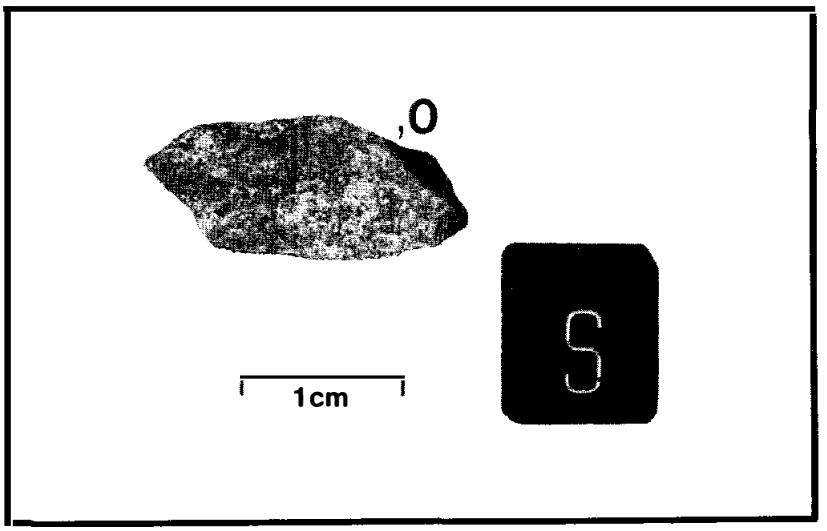
4) Mineral fragments with relative percentages:
   a) Equant, broken milky-white feldspar (20%)
   b) Equant, colorless mineral (18%)
   c) Dark, brownish-black mafic (60%)
   d) Pistachio green olivine in broken crystal (1-3%)

5) Colorless to brown, botryoidal and slabby glass in trace amounts.

DISCUSSION

This rock fragment has not been allocated and no data is presently available. Wilshire and Jackson (1972) classified the fragment as an F_4 type of rock.

14077



S-71-26070

Sample 14077 was collected at Station G located 230 m ESE of LM and 50 m E of North Triplet rim crest. It was collected from the bottom of the trench sample.

The general area is more or less level and sparsely covered with debris. The size of the debris ranges from limit of resolution to 60 cm. The area has a moderate abundance of 20 to 50 cm craters most of which are subdued.

14077 was returned in documented bag 20N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.77 g	2.0 x 1.8 x 0.7 cm

14077 is unusual in that it is a very light gray holocrystalline plagioclase-rich rock. The sample is fine-grained and inequigranular.

SURFACE FEATURES

There are no zap pits present on any of the surfaces. In general, there are two types of cavities present on the sample. These are square-shaped crystal

molds (average size 0.7 mm) and irregular elongate vugs (0.2 to 0.5 mm in size). Few vugs measure 1 mm across. The vugs are homogeneously distributed and are spaced approximately 2 cm apart. The vugs make up approximately 1% of the total volume of the rock.

There are no major fractures in the rock.

PETROGRAPHIC DESCRIPTION

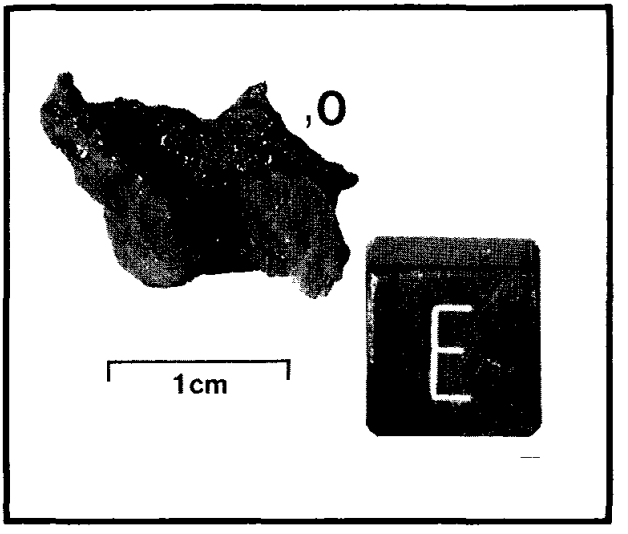
Sample 14077 is a very light gray, holocrystalline, fine-grained, inequigranular rock. It is a blocky and angular rock with an irregular surface. The grain size is < 0.1 mm. It possesses a homogeneous texture and mineralogy dominated by large plagioclase crystals. The rock is very tough and angular.

The rock was described during PET as being composed of 99% feldspar of which there are two types. The first is a clear light gray phenocrystic feldspar (1 mm x 0.5 mm) making up 3% of the whole rock composition. The other feldspar is a clear light gray subhedral type forming the matrix of the rock. The remaining 1% are equant euhedral grains (0.1 to < 0.1 mm) of opaque minerals. No thin section, to date, exists.

DISCUSSION

Wilshire and Jackson (1972) classify this as a homogeneous crystalline metaclastic rock.

14080



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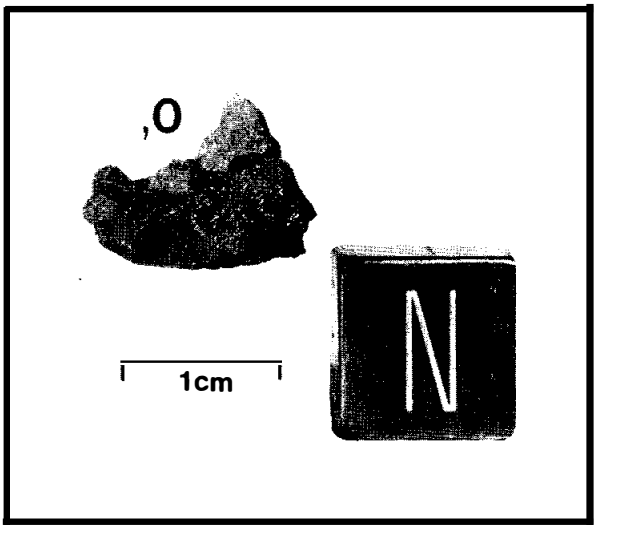
14081



S-71-26042

Samples 14080 -14081 were taken from the middle of the trench at station G 230 m ESE of LM and 50 m E of the Triplet rim crust. The general area from where the sample was taken is characterized by a nearly level terrain sparsely scattered with debris. The size of the debris varies from the limit of resolution up to 60 cm. The area is also characterized by a moderate abundance of subdued 20 to 50 cm craters.

The samples were returned in documented bag 21N in ALSRC 1006.

PHYSICAL CHARACTERISTICS

	Mass	Dimensions
14080	1.94 g	1.6 x 1.3 x 0.8 cm
14081	0.84 g	1.2 x 0.9 x 0.7 cm

Both of the samples are light gray in color and very fine grained. They are both polymicts and contain abundant glass. Both are friable being made up of < 1 mm rock/soil fragments bonded by glass. They could be pieces of the sample but in their present state, they cannot be fitted together.

SURFACE FEATURES

14080 has zap pits which are glass lined, about 0.1 mm in size, and rarely present on the surface. 14081 has no visible pits. The surface of the rock chips are very jagged and uneven. 14080 shows two faint parallel grooves in the vesicular glass on the surface. Both samples are marked by abundant vesicules in the glass. These vesicules are from 0.1 to 0.5 mm in size and are more or less oval in shape. These vesicules are evenly distributed over the samples. The vesicules account for approximately 30% of the glass volume. Most of the vesicules are dust filled. 14080 has an uneven glass spatter over 75% of its surface. 14080 also has numerous non-planar surface fractures which show no orientation.

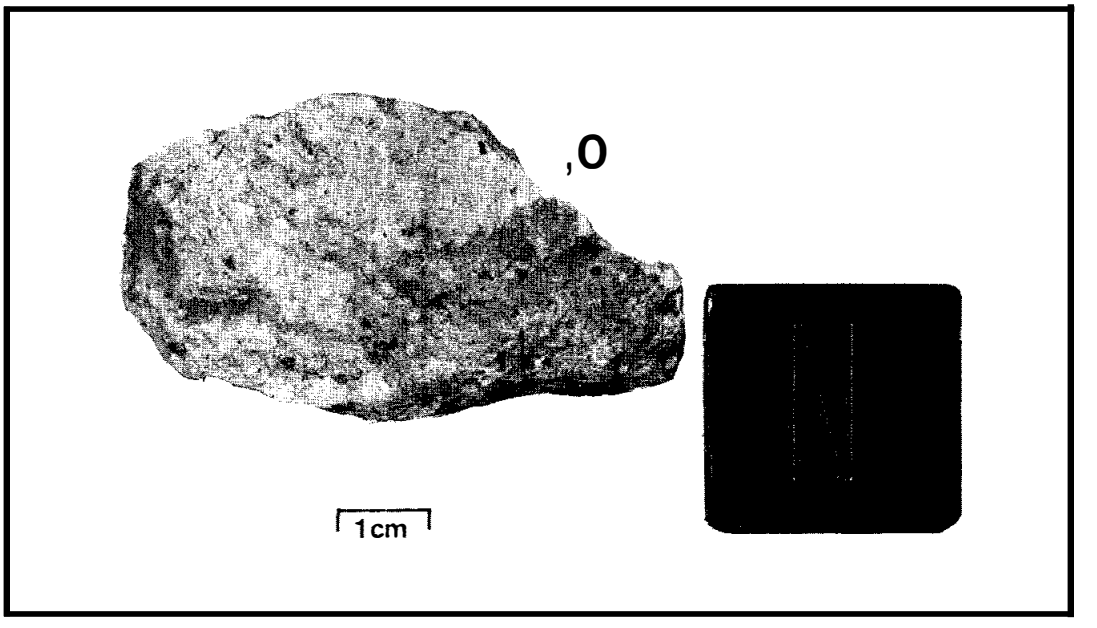
PETROGRAPHIC DESCRIPTION

Both small chips are fine-grained polymicts composed entirely of grains < 1 mm in size. All glass material is also < 1 mm in size. The average grain size is < 0.1 mm. Some very small leucocratic fragments probably occur as some of the small non-glassy fragments. The texture is homogeneous. These rocks may be thought of as glass bonded aggregates of fine-grained clastic fragments.

DISCUSSION

Wilshire and Jackson (1972) has classified 14080 as an F_1 type fragmented rock. Due to their small size, no detailed work has been done on the samples.

14082



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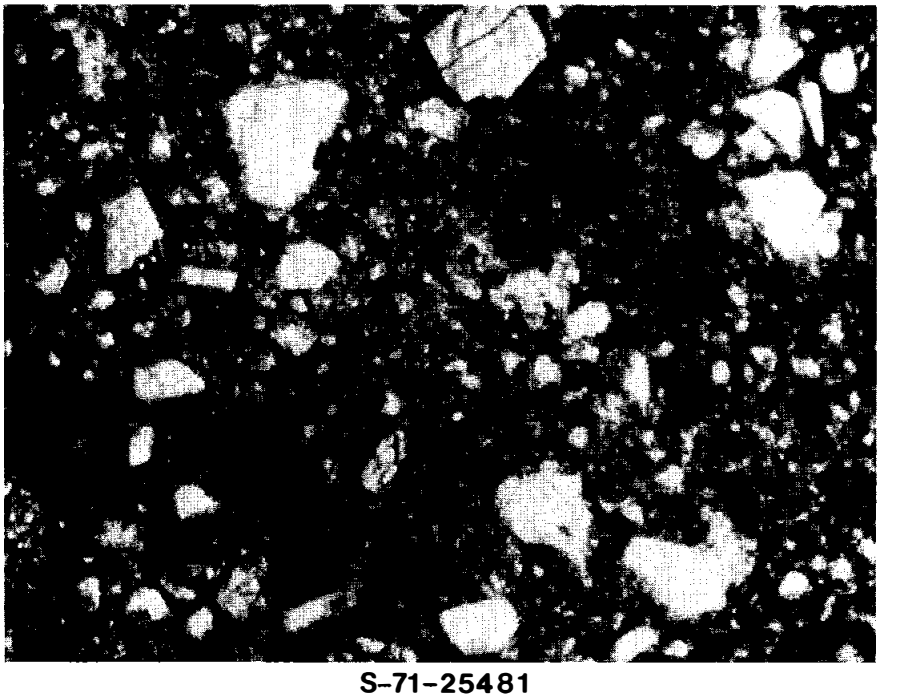
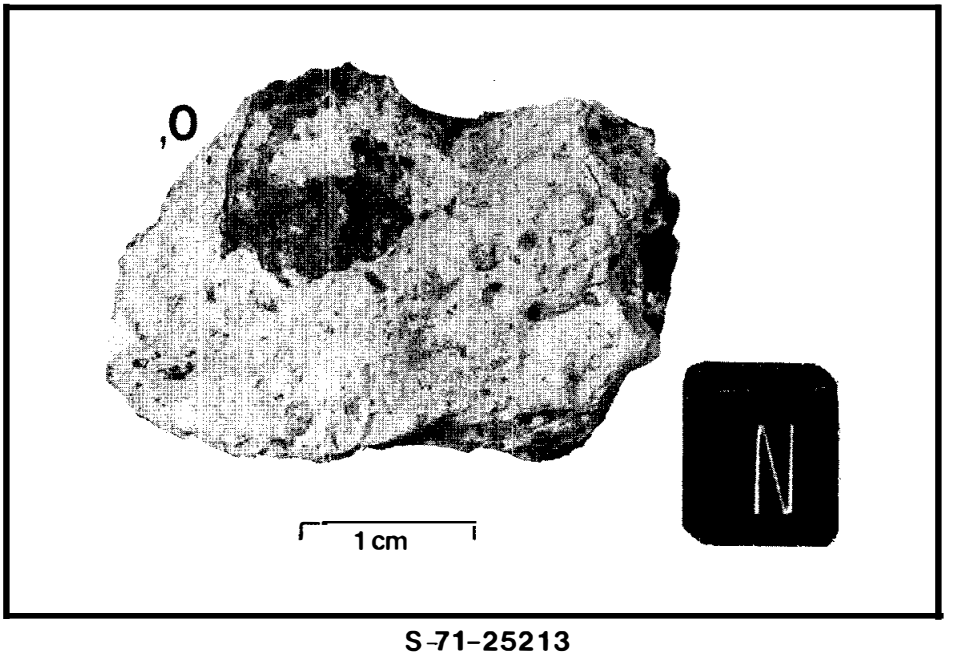
14082, 7



S-71-25481

No scale available

14083



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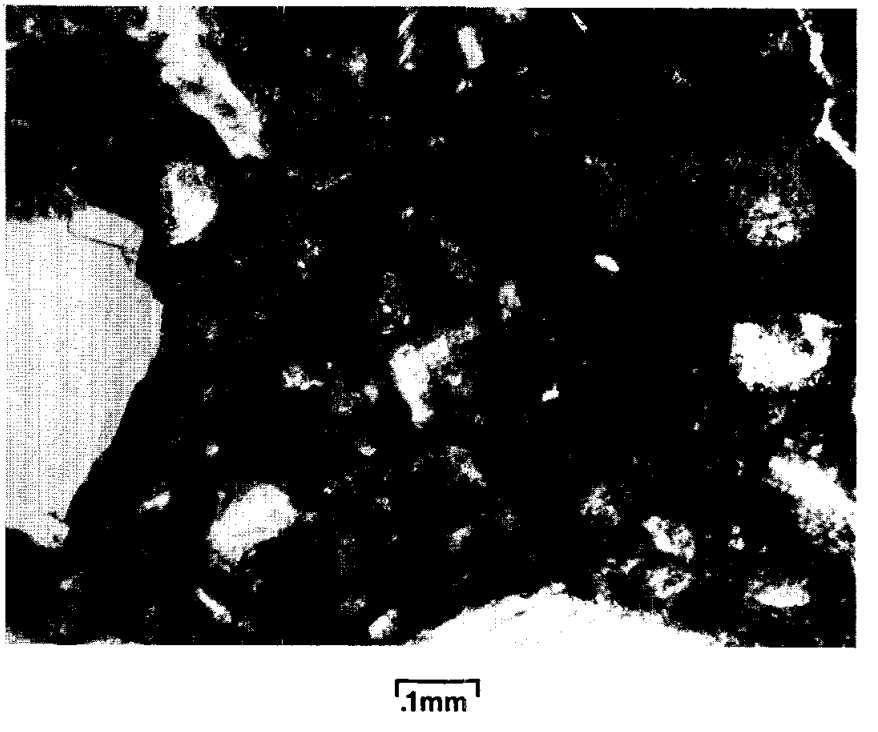
14083, 35



Samples 14082/14083 are white rocks collected at station C1, 1.24 km ENE of the LM and 17 m SE of the rim of Cone Crater. They are representative of one of the major rock types as seen in lunar photo documentation. The sample was chipped from the top of White Rock, a 1 m breccia boulder with conspicuous 1 cm dark and light clasts in a very light gray matrix. This sample was placed in bag 13N and returned in ALSRC 1006. By the time it had arrived at the LRL, it had broken into two pieces and these were numbered 14082 and 14083. Sample 14082 was studied extensively by the Imbrium Consortium, from which much of this information is derived.

PHYSICAL CHARACTERISTICS

	Mass	Dimensions
14082	61.16 g	6.0 x 3.6 x 2.0 cm
14083	13.37 g	3.2 x 1.5 x 2.2 cm

Sample 14082/14083 is one of the white rocks. It is a polymict breccia with a very light gray matrix and darker lithic clasts.

SURFACE FEATURES

Sample 14082 has a rough irregular surface with no glass covering. Only one pit 1.5 mm in diameter was observed by the PET team who describe it as containing dark brown glass forming the shell of the pit and colorless glass forming the filling. The Imbrium Consortium (1976) described all surfaces as pitted.

Sample 14083 contains glass-lined pits ranging from 0.75 mm to 1.0 mm in size. Pits penetrate the dark surface and are confined to one side of the rock. The glass lining is darker on the darker portions of the rock, and lighter on the lighter portions. There are approximately two to three pits per square centimeter.

The only other cavities on these samples are clast molds ranging from 1-3 mm in diameter on 14082, and from 1-2 mm in diameter on 14083.

There are no fractures on either sample.

One corner of 14083 has a dark brown glassy coating which intrudes the white interior.

PETROGRAPHIC DESCRIPTION

Sample 14082 consists of about 90% fine-grained matrix and 10% clasts larger than 1 mm. The matrix is feldspar-rich and grayish-white with some irregular darker gray zones. Fragments of cinnamon brown pyroxene, yellow green olivine, and traces of black opaques down to 0.1 mm in size are visible in the matrix. The matrix has a seriate texture with an average grain size of less than 0.1 mm.

Lithic clasts averaging 2-2.5 mm in diameter are dark gray fragments of very

fine-grained rocks similar to 14076. Lithic clasts make up most of the material larger than 1 mm and light colored anorthositic clasts make up most of the rest, with a few mineral fragments larger than 1 mm.

Sample 14083 has approximately 15% clasts larger than 1 mm and 85% matrix. Of the clasts larger than 1 mm 95% are lithic fragments. These are dark gray very fine-grained seriate clasts ranging from 1-3 mm in size. Some have sparse 0.5 mm plagioclase fragments and some 0.5 mm dark minerals. Most of the lithic clasts are dark but 10% are leucocratic, consisting of ∿ 1% brown pyroxene, 40% dark mineral, and 60% white feldspar.

Mineral clasts are colorless to white equant plagioclase.

The matrix contains clear gray plagioclase, tan pyroxene (?), opaques, yellow-green olivine, and pale pink and orange minerals.

DISCUSSION

Sample 14082/14083 was described by Wilshire and Jackson (1972) as a friable rock with dark clasts, placing it in his F_3 classification. It was classified as Warner's (1972) metamorphic grade 3, and Chao et al. (1972) called it an anannealed slightly feldspathic Fra Mauro breccia (2a). It was listed as being glass-poor with a fragmental matrix by von Engelhardt et al. (1972). Simonds et al. (1977) consider it to be representative of their LMB (light matrix breccia) group.

The surface of 14082 was mapped by the Imbrium Consortium (1976) who studied certain clasts and matrix samples. They describe 14082 as similar to 14064, with abundant pore space in the matrix.

Pyroxene and plagioclase fragments in the matrix are described by the Imbrium Consortium (1976) as being of similar dimensions, but the composition of the pyroxene varies, suggesting that it was derived from various sources. Pyroxene exsolution is common and was studied by Papike and Bence (1972). They interpreted what they termed "inverted pigeonites" to be samples of plutonic rocks that have been blasted out of the Imbrium Basin.

Limited chemistry of 14082/14083 can be found in an article by Rose et al. (1972). The white rocks (14082/14083, 14063, and 14064) are believed to have been ejected from a dark-light stratified bedrock unit at station C_1 by the Cone Crater impact (Sutton et al., 1972; Swann et al., 1977).

Ryder and Bower (1976) concluded that the KREEP-rich, fragment laden lithology of the White Rocks is a result of the crystallization of a silicate melt containing solid silicate fragments. They believe that it is more likely that this melt was the result of the total melting of a polymict, plagioclase-rich source by meteoroid impact, the fragments being picked up as the melt moved outward from the point of impact.

Comprehensive Sample (14169-14188, 14250-14299)

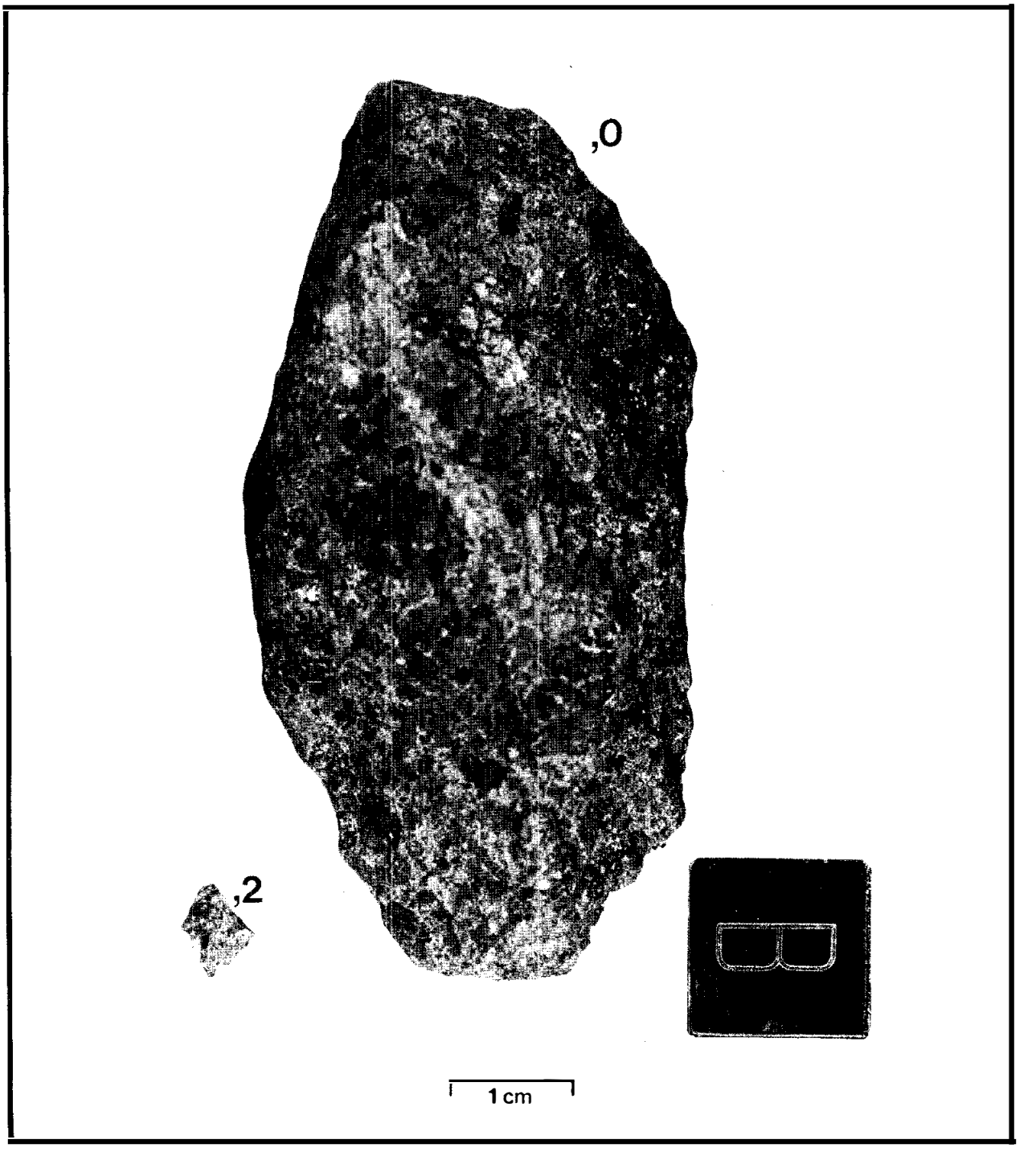
The comprehensive sample from Apollo 14 has been described, classified and discussed by Phinney et al. (1975) in their publication devoted to that topic. The information collected and discussed by them is included herein for purposes of completeness only, and very little attempt has been made to redescribe these samples except that new thin section descriptions are included whenever possible.

The purpose of the comprehensive sample was to acquire a statistically significant set of small rock samples to petrographically characterize the distribution of rock types in the lunar regolith. The sample location was selected 100 to 125 m west of the LM. A two to three meter diameter circle was marked and all of the walnut sized rocks on the surface within the circle were collected with tongs. Then, a soil sample was collected from within the circle. Two weigh bags were to be used to contain the samples: weigh bag 1039 was to contain rock fragments and weigh bag 1007 was to contain the soil sample. Unfortunately, as discussed in the Apollo 14 Preliminary Science Report (1971), there was some confusion about the origin of the contents of weigh bag 1027. It contained 20 small rock fragments (14169-14188) and a large undocumented rock, 14303. On the basis of their association with two documented rocks (14304 and 14305) returned in the same weigh bag and collected near the comprehensive sample site, the 20 fragments and 14303 were tentatively considered to be parts of the comprehensive sample. Later, 14303 was found to have been part of 14304, collected at the end of the first EVA. The astronauts were unable to get all of the weigh bags containing the comprehensive sample in the SRC so they put the "small samples of small rocks" from the comprehensive sample in the weigh bag (1027) with the football-size rocks collected later (14303/14304 and 14305). It seems probable, therefore, that some portion of the samples 14169-14188 could be parts of the larger samples 14303/14304 and 14305 that were in the same bag but not part of the contingency sample. It was believed by Phinney et al. (1975) that all of the small samples 14169-14188 were fragments of 14303 because they are all identical in their lithologies and are lithologically identical to 14303 and because they show freshly fractured surfaces with no patination or zap pits and one end of 14303 is a fracture surface (later shown to fit 14304).

The following table summarizes the contents of the three weigh bags:

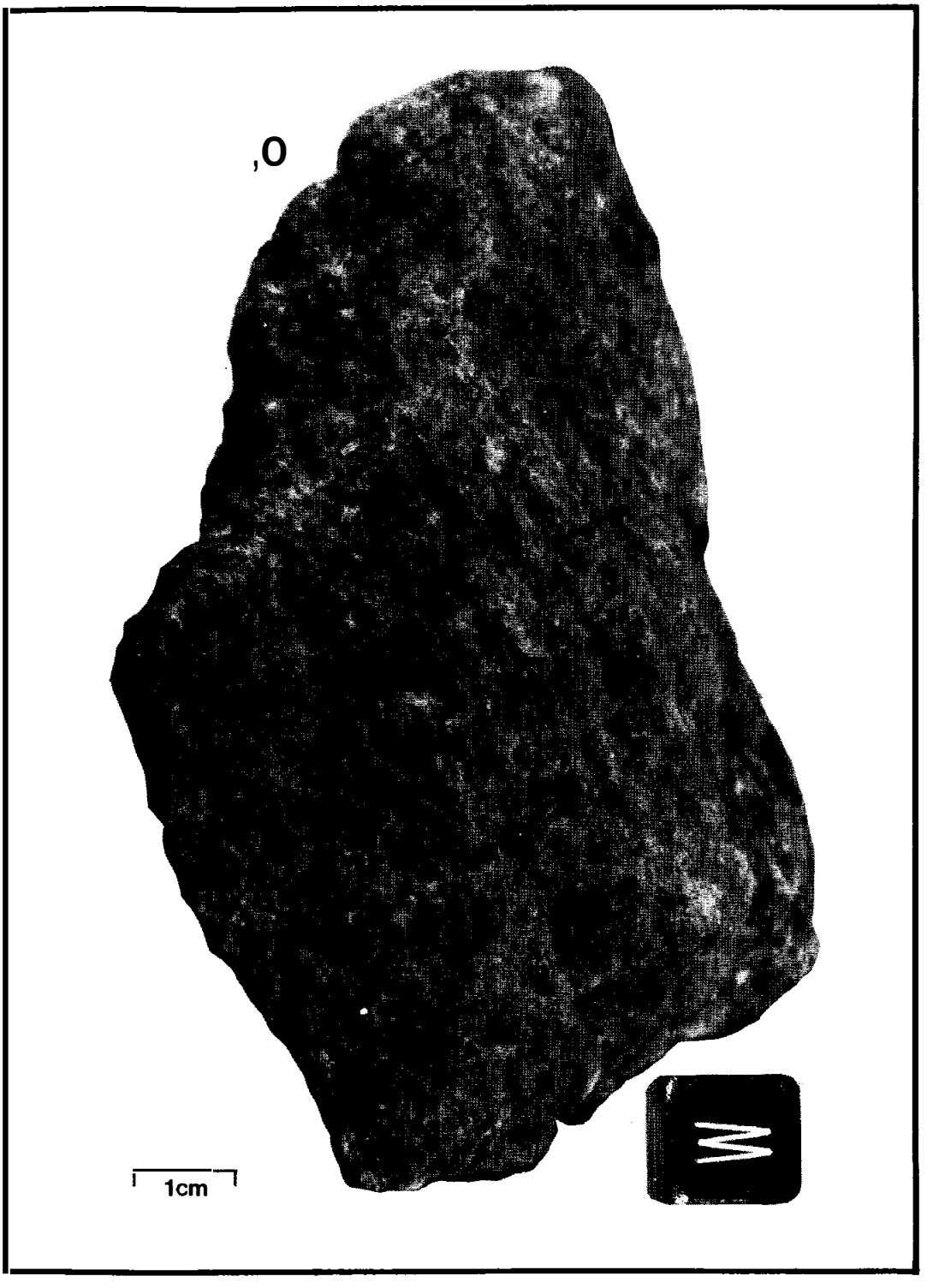
Weigh Bag Number	Rock Samples	Soil Samples
1007	14250-14255	14256-14259
	(Rocks separated from soil)	14298-14299
1039	14264-14288	14260-14263 (Soil collected with rocks)
1027	14169-14188	14165-14168
	14303/14304 and 14305	(Residue)

14169



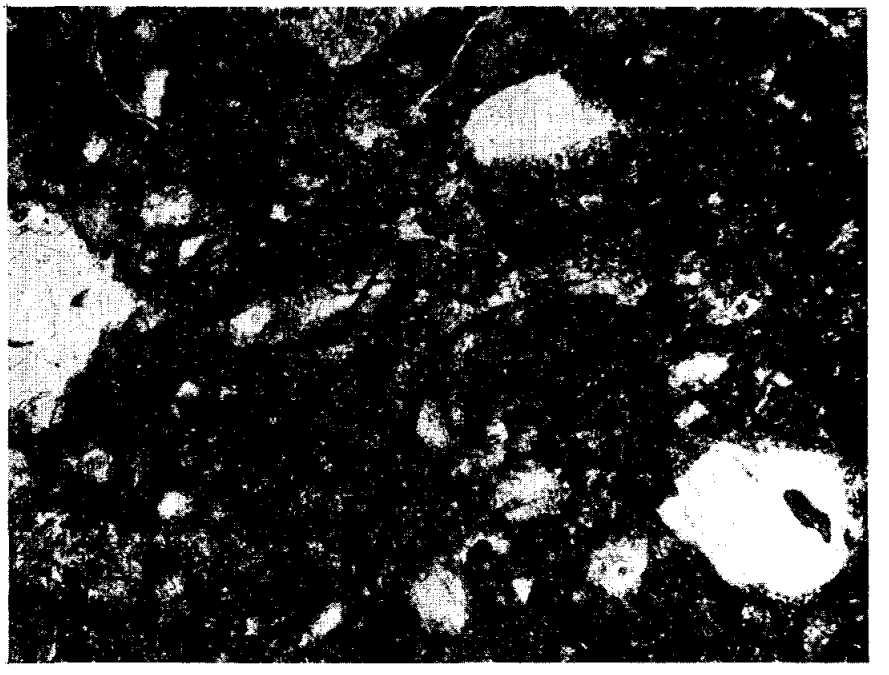
S-75-24302

14170



S-76-23611

14169, 8



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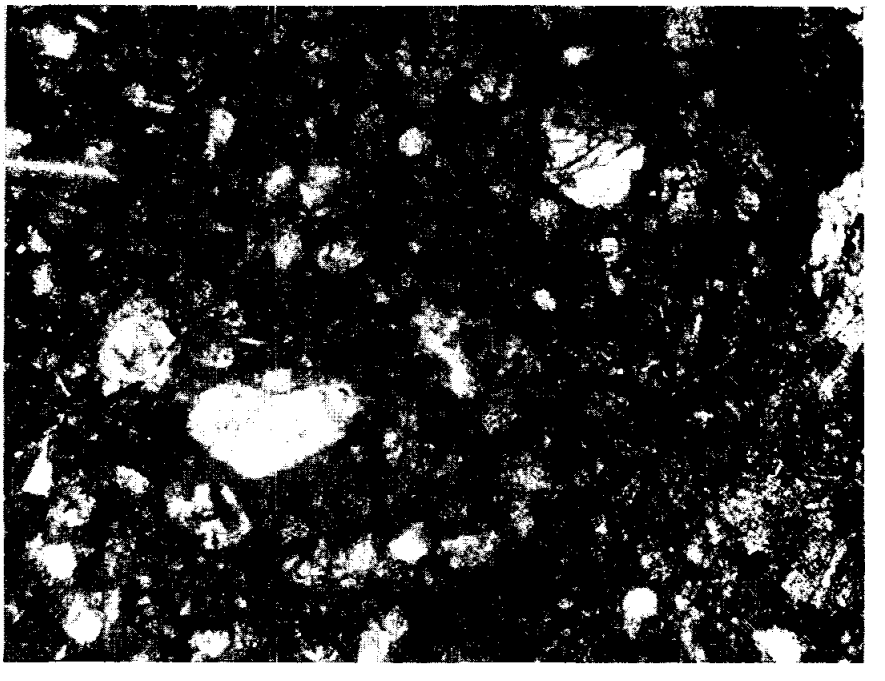
14170, 4



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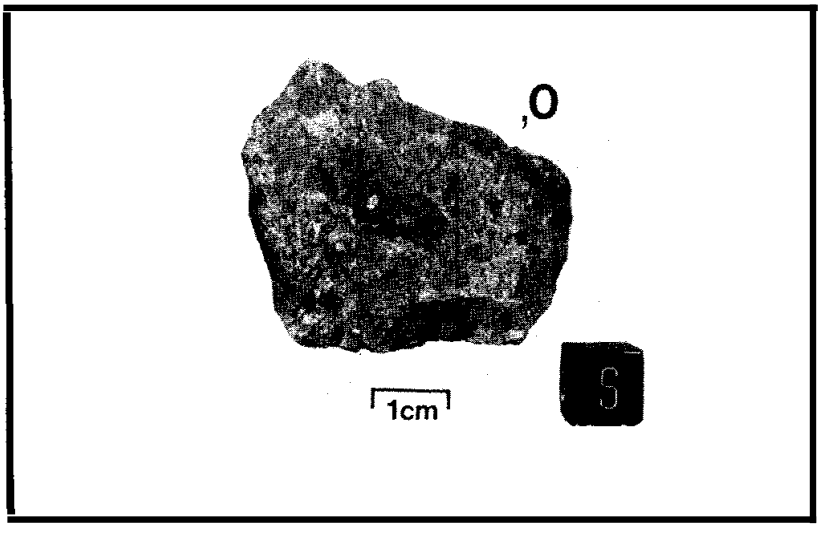
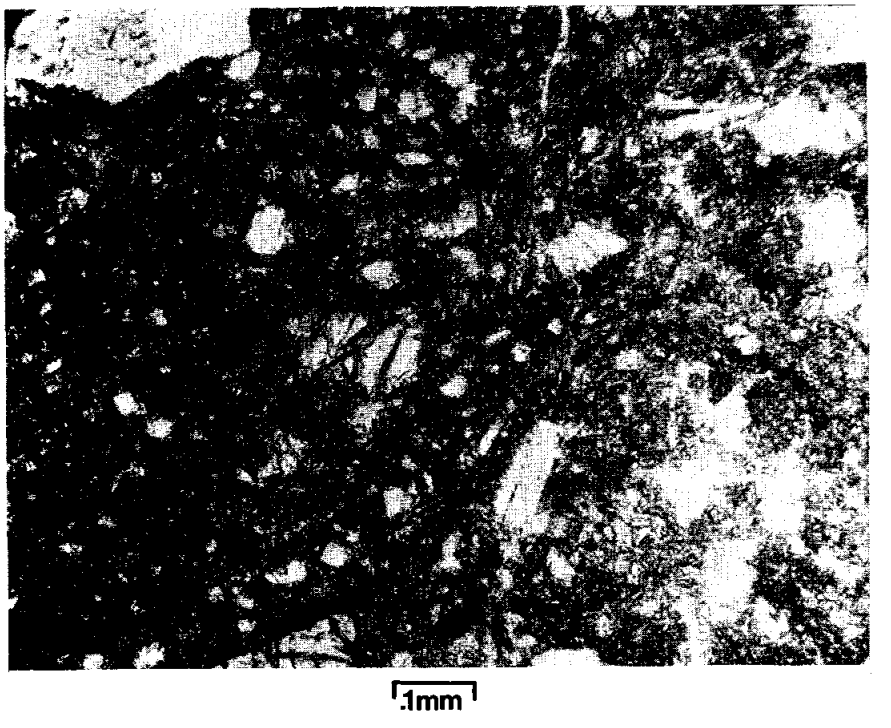
14171

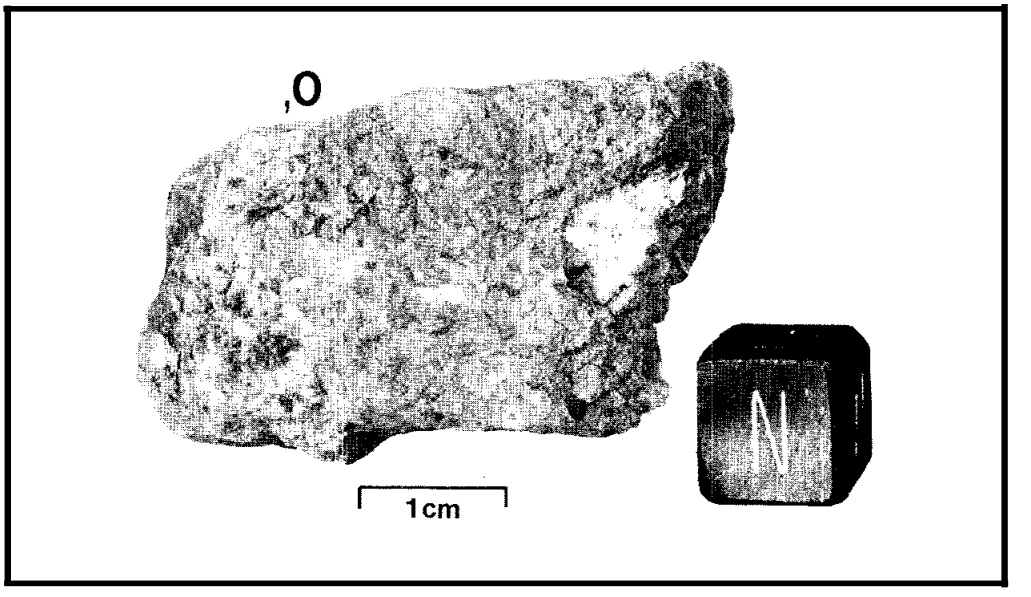


S-71-30349

14171,11

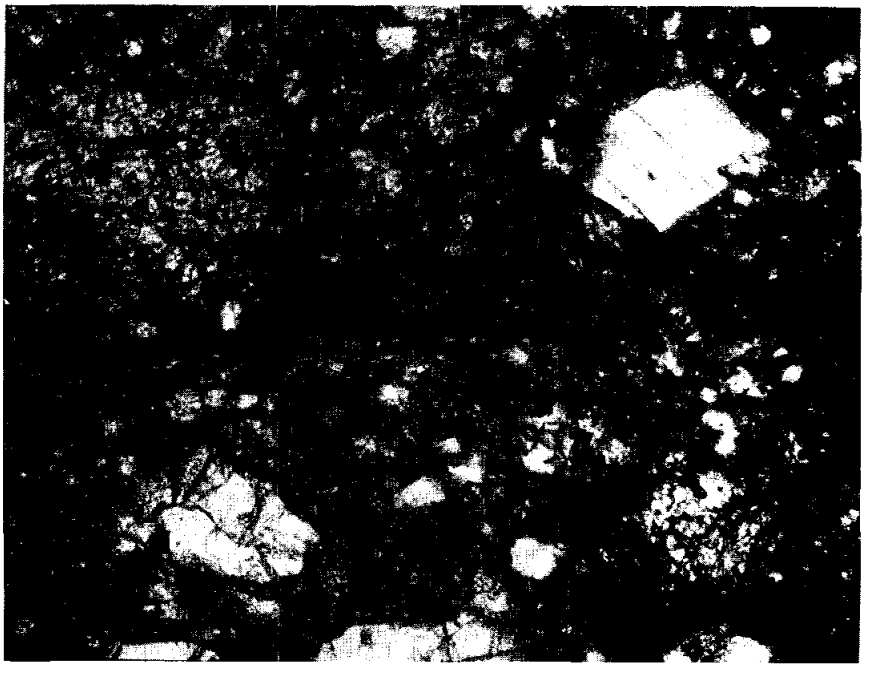


14172

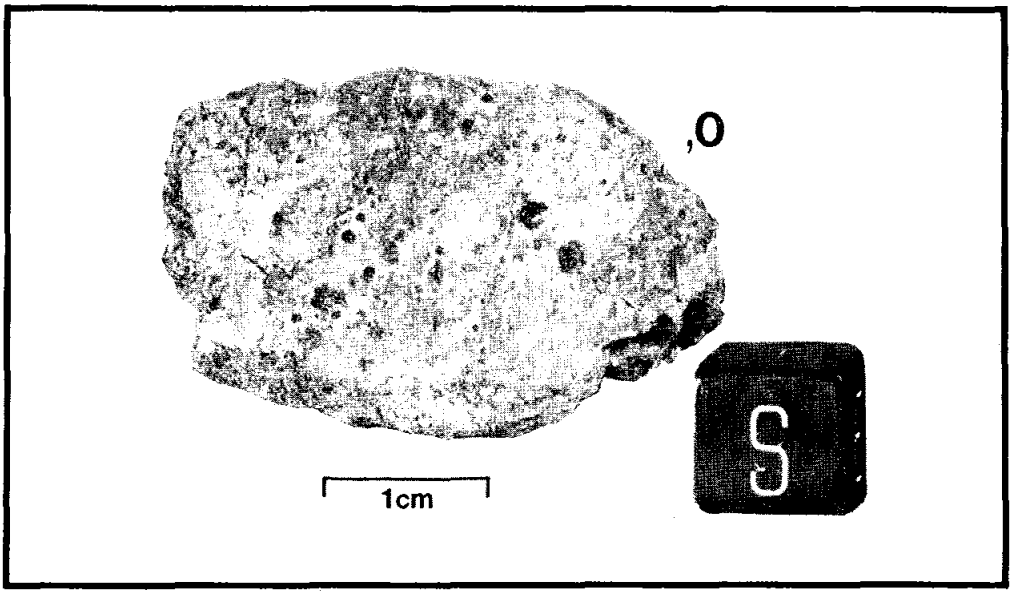


S-71-25279

14172,17



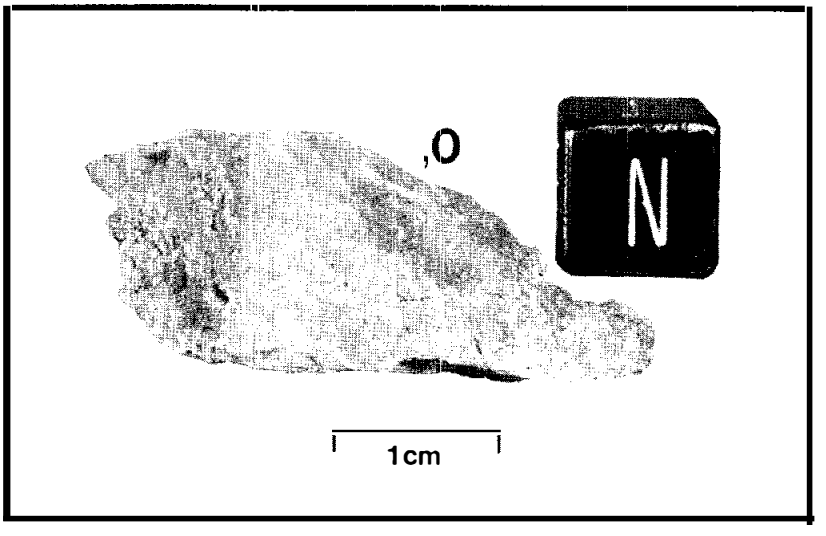
14173



S-71-25288

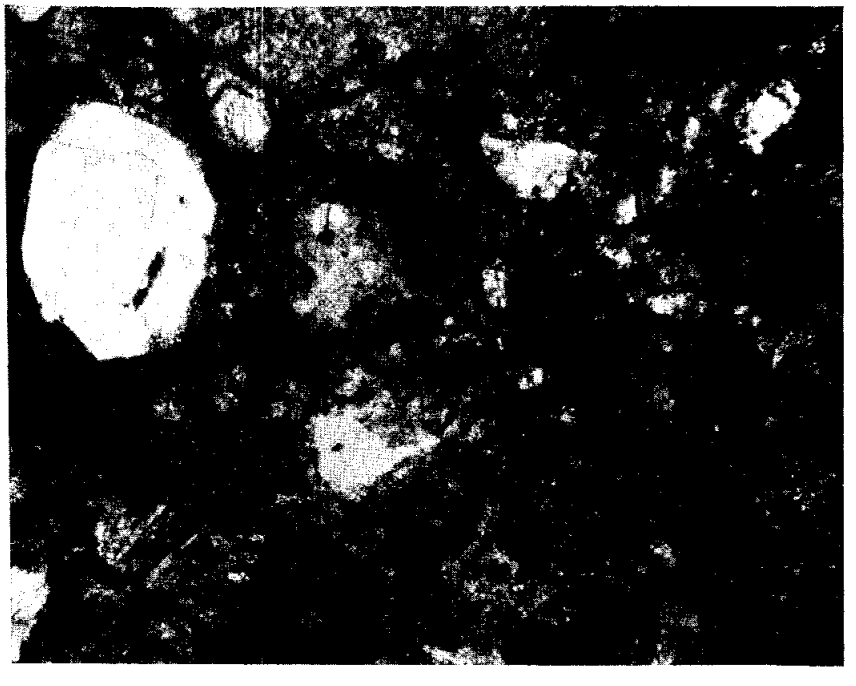
14173,17

14174

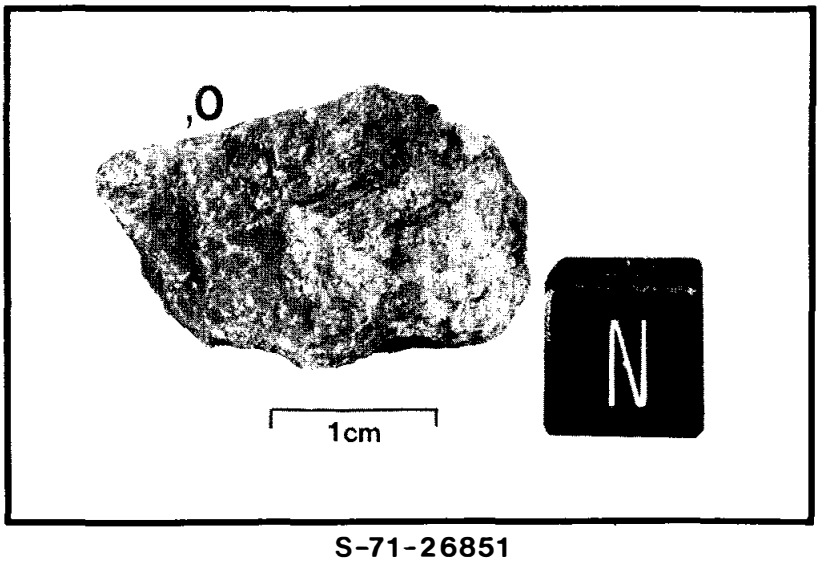


S-71-25292

14174,5

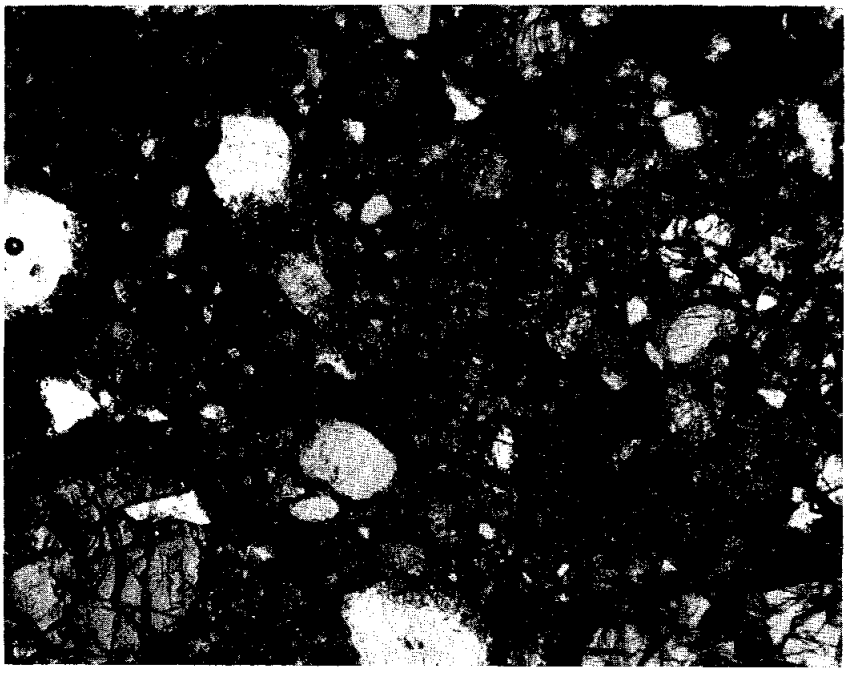


14175

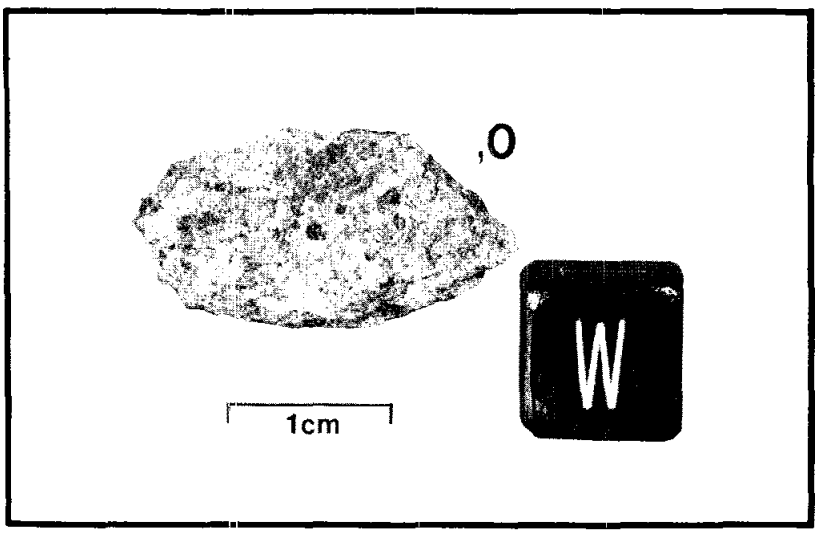


S-71-26851

14175,3

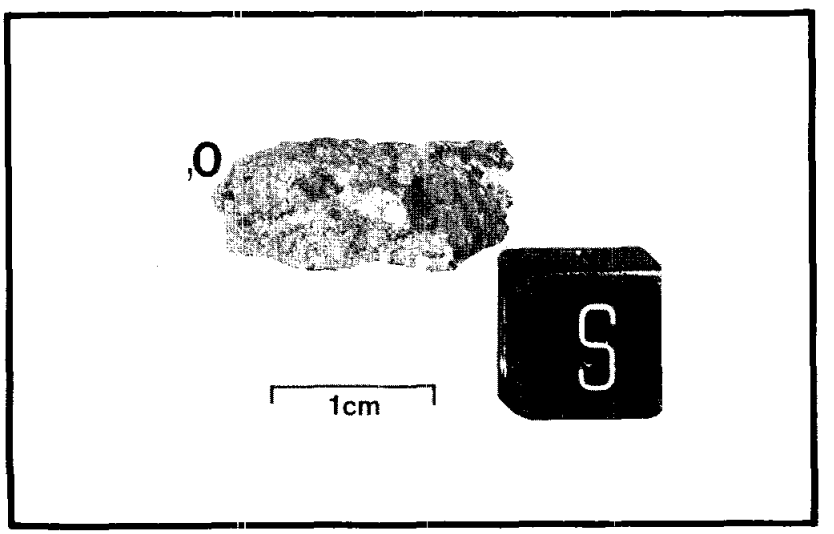


14176



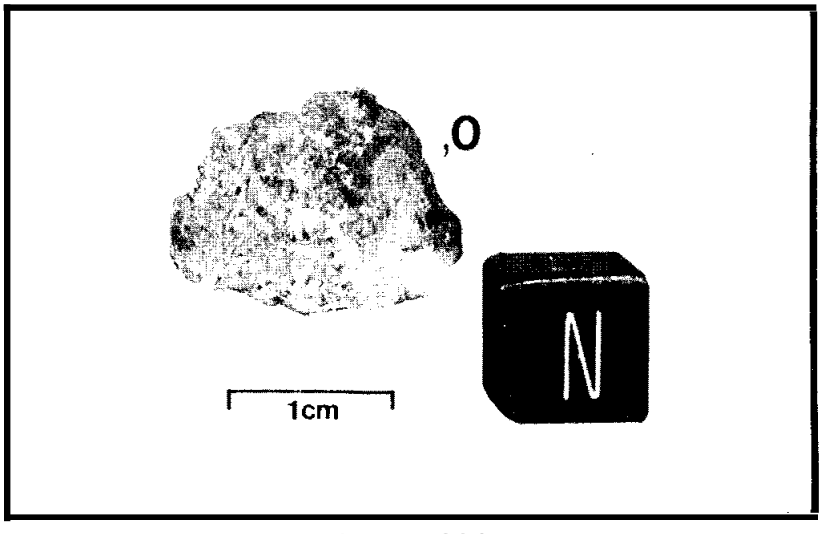
S-71-26858

14177



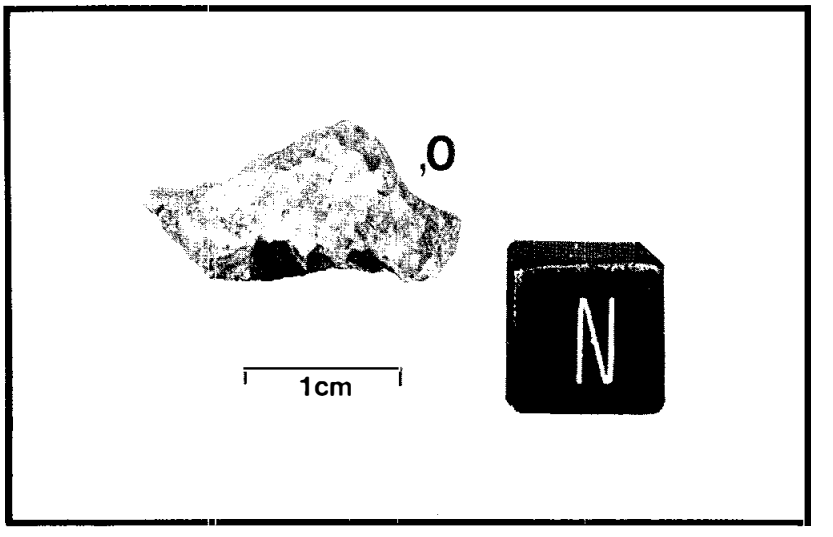
S-71-26904

14178



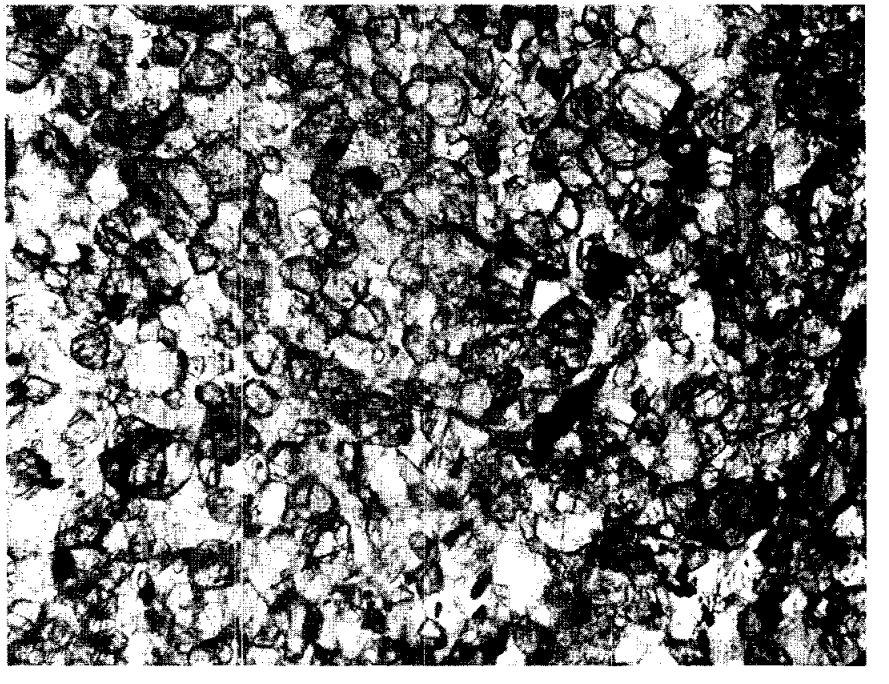
S-71-26907

14179

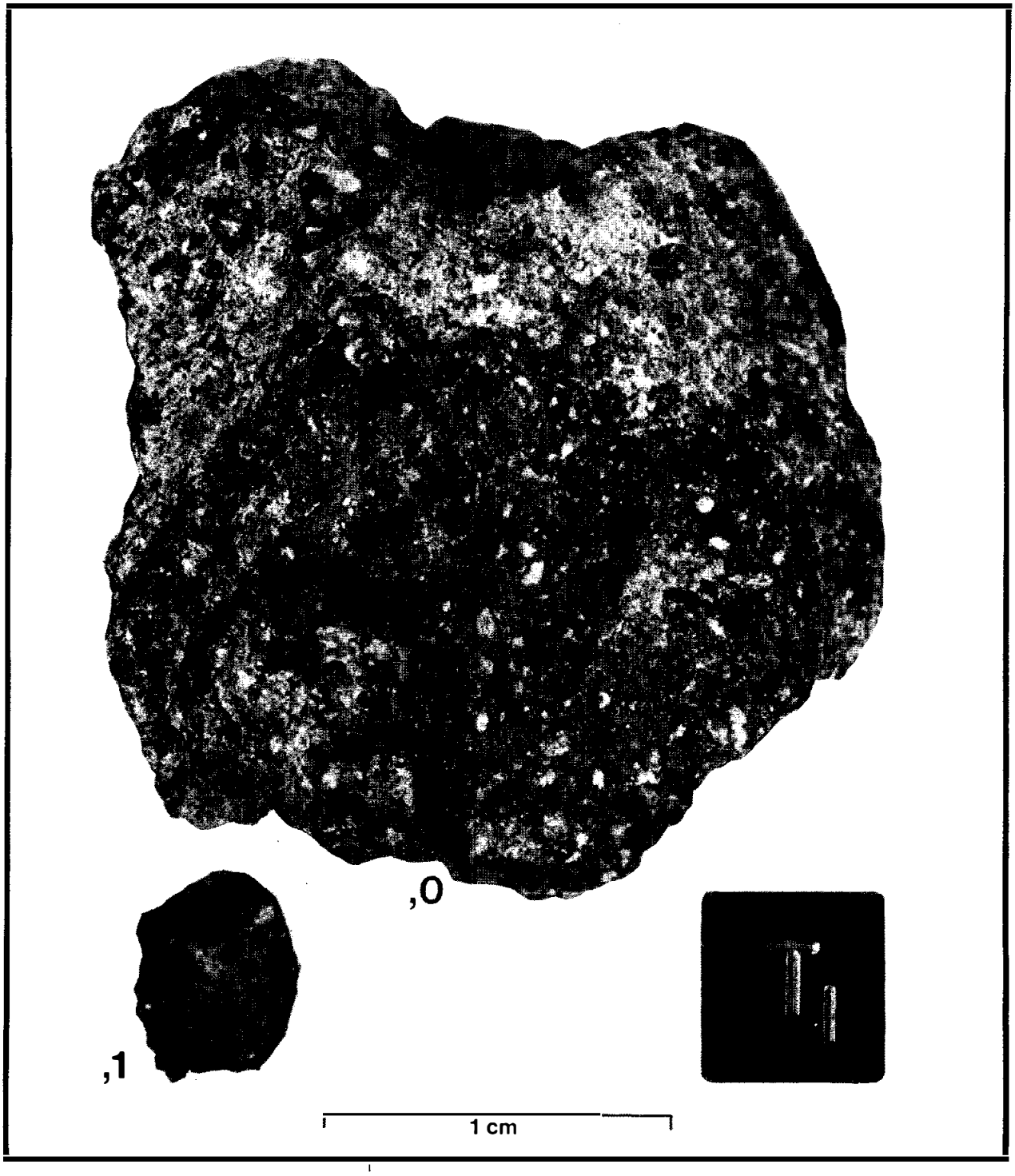


S-71-26887

14179,4

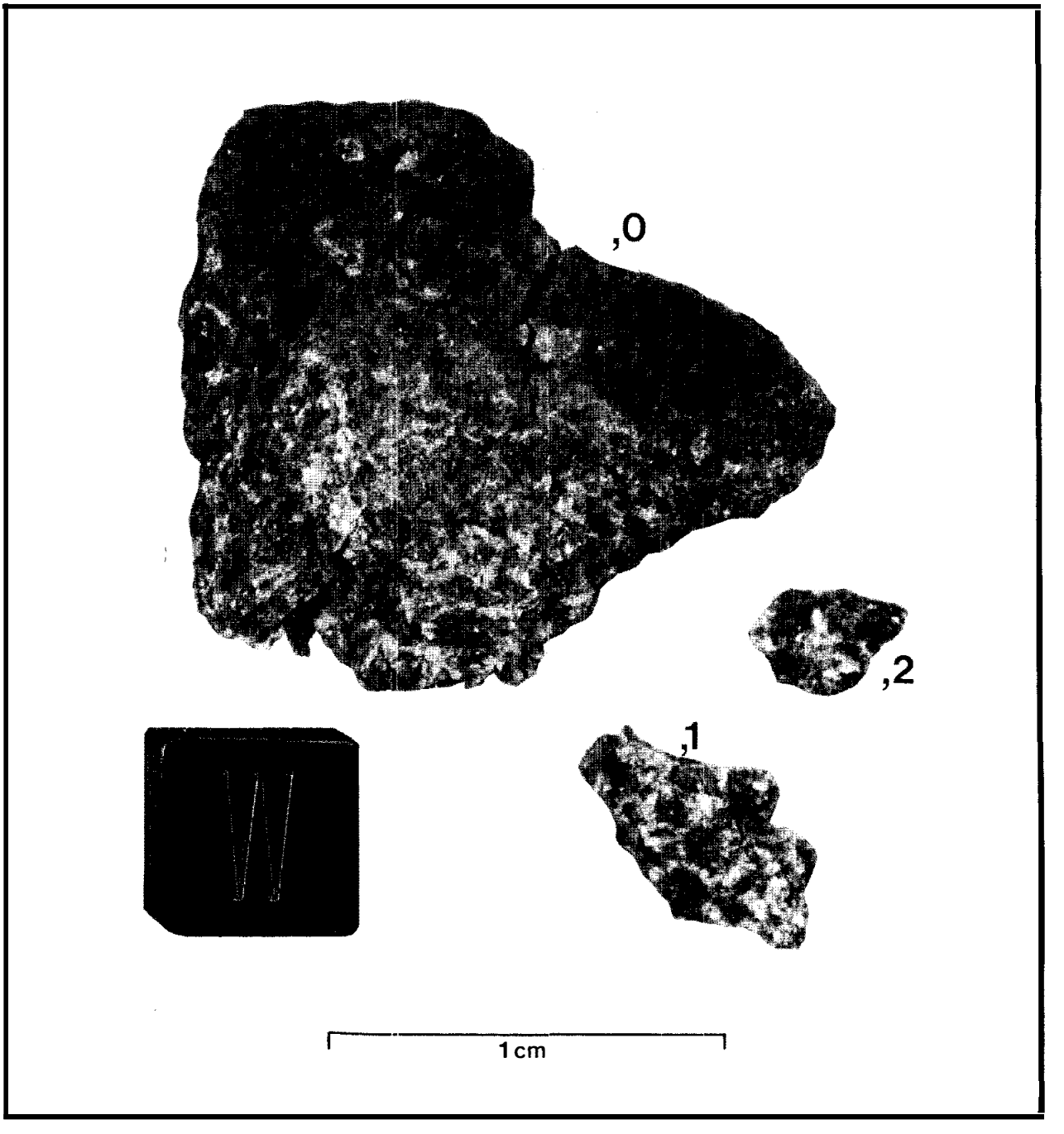


14180



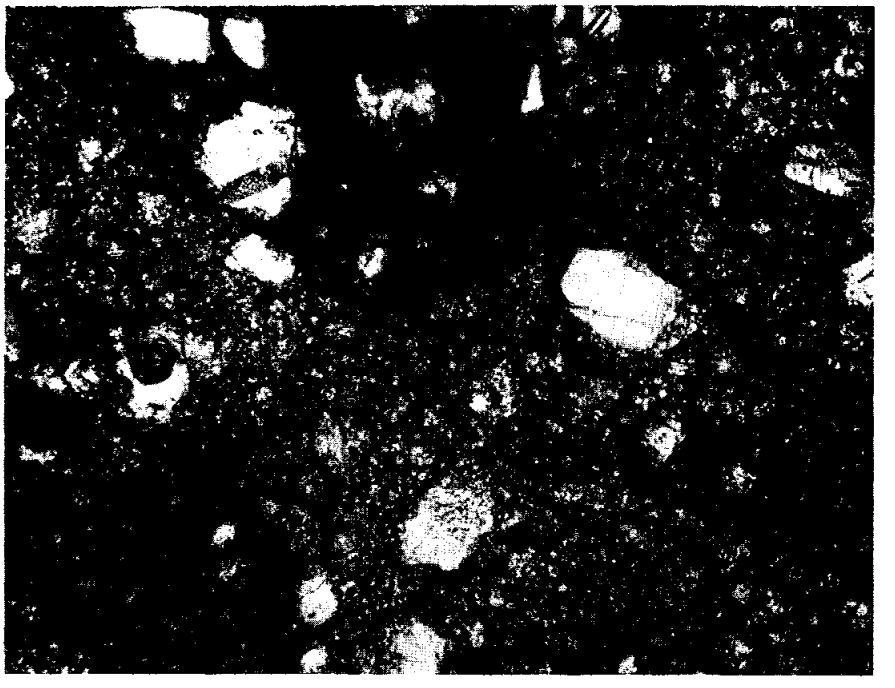
S-75-24299

14181



S-75-24300

14180, 3

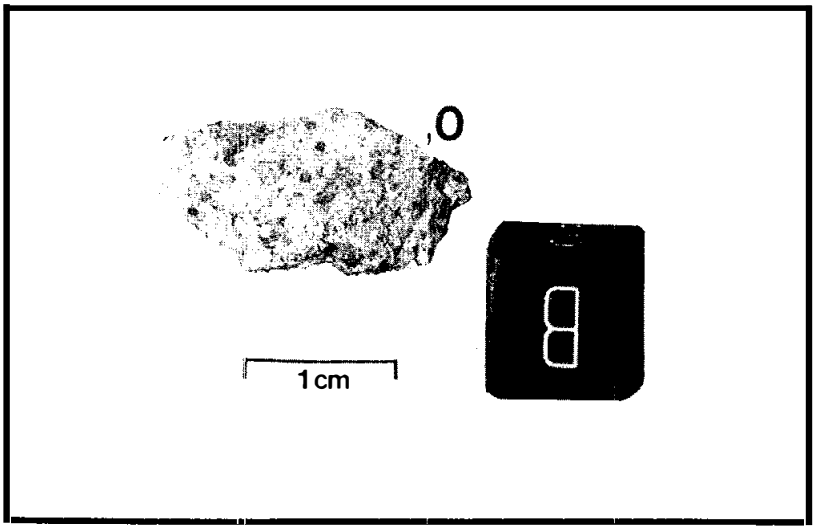


.1mm

14181, 5

.1mm

14182



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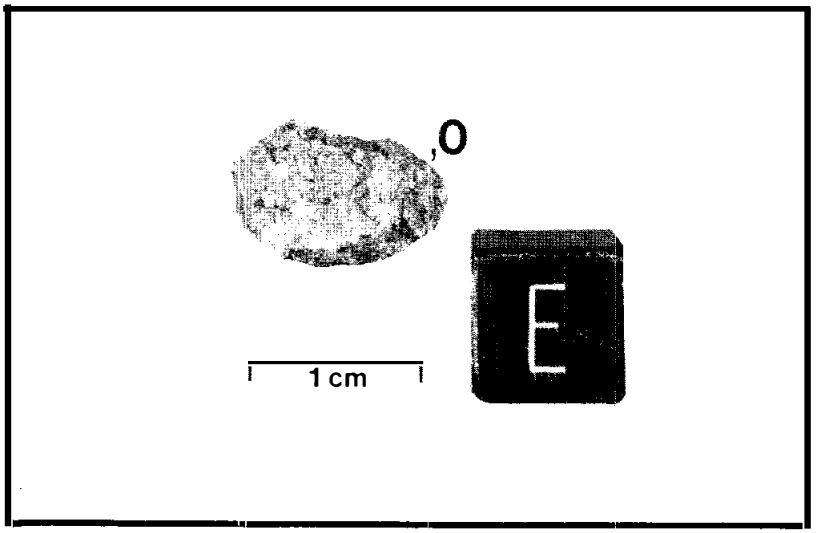
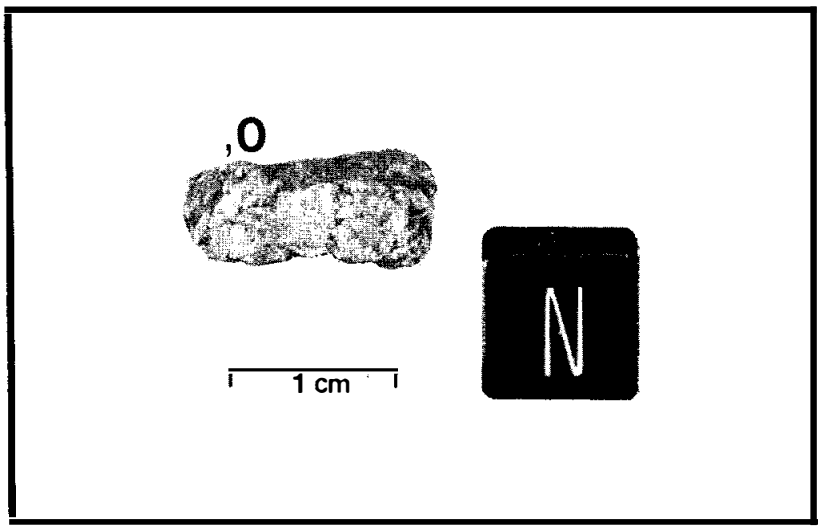
14183



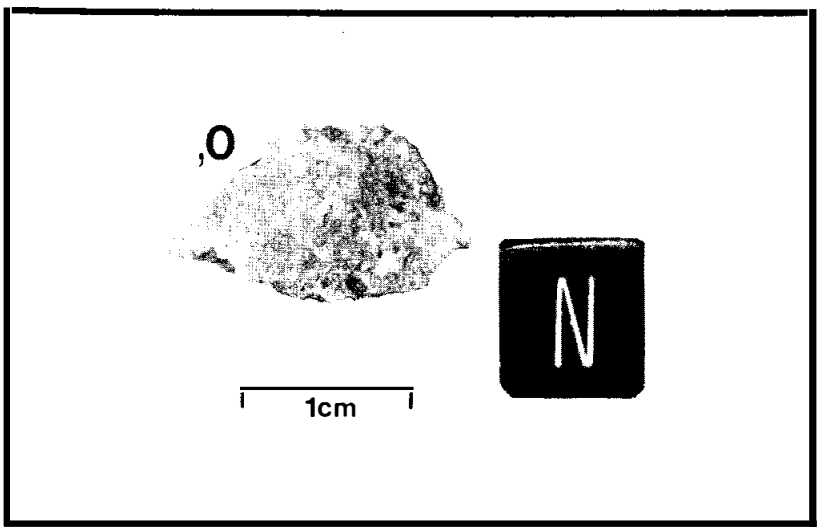
S-71-26973

14184



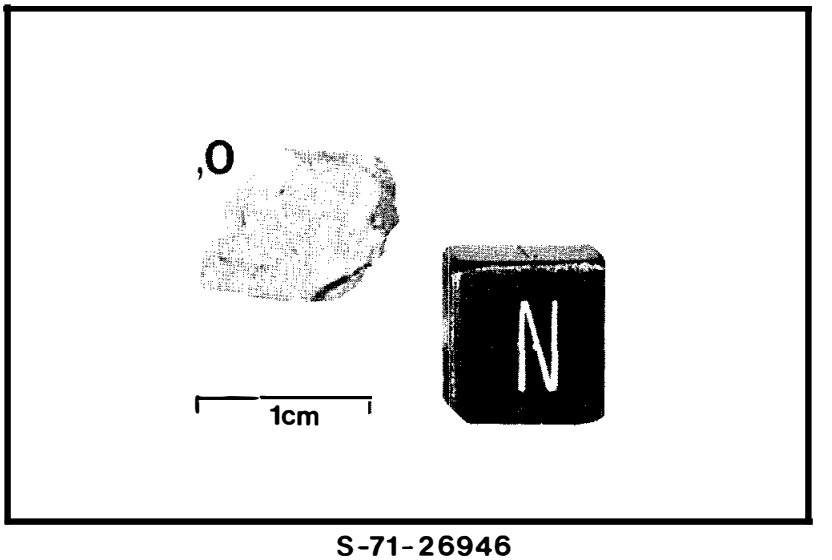
S-71-26976

14185



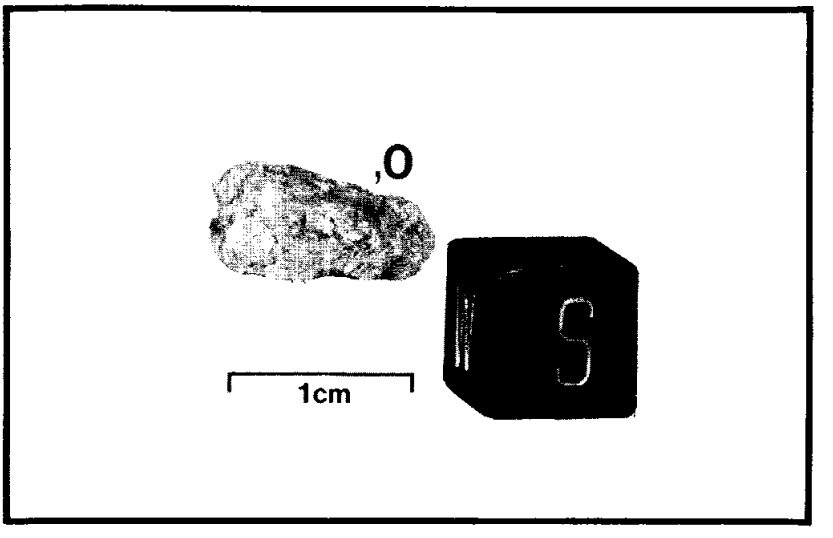
S-71-26942

14186



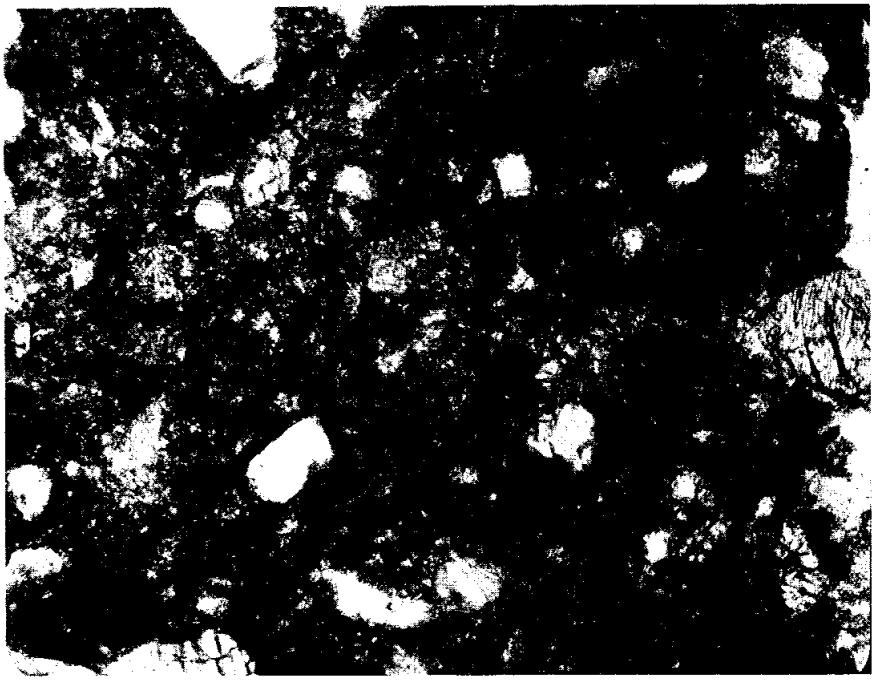
S-71-26946

14187

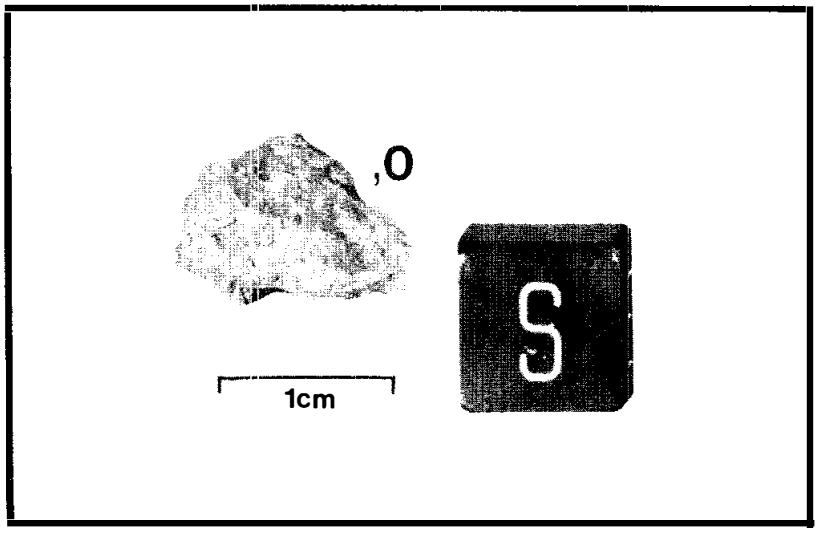


S-71-26957

14187, 3



14188



S-71-26962

This entire set of samples was returned in weigh bag 1027, along with 14303/14304 and 14305. They were determined to be fragments of 14303 by Phinney et al. (1975) and described as such in their booklet on the comprehensive sample (see especially samples 14250-14288).

PHYSICAL CHARACTERISTICS

	Mass	Dimensions
14169	78.66 g	7.1 x 3.2 x 2.7 cm
14170	26.34 g	4.2 x 3.3 x 1.3 cm
14171	37.79 g	3.9 x 4.3 x 1.5 cm
14172	32.10 g	4.0 x 1.8 x 2.3 cm
14173	19.59 g	3.7 x 2.2 x 1.8 cm
14174	11.62 g	3.5 x 2.3 x 1.8 cm
14175	7.48 g	2.8 x 2.0 x 1.6 cm
14176	4.12 g	2.3 x 1.8 x 1.0 cm
14177	2.32 g	0.5 x 1.0 x 1.8 cm
14178	2.88 g	1.8 x 1.4 x 1.1 cm
14179	3.03 g	0.7 x 2.0 x 2.0 cm
14180	4.75 g	0.6 x 1.2 x 1.6 cm
14181	2.48 g	0.6 x 1.1 x 1.4 cm
14182	2.29 g	0.6 x 1.7 x 1.9 cm
14183	1.40 g	1.2 x 1.0 x 1.0 cm
14184	1.48 g	1.6 x 1.1 x 0.6 cm
14185	1.52 g	2.0 x 1.2 x 1.0 cm
14186	1.26 g	1.0 x 0.8 x 0.5 cm
14187	1.90 g	1.2 x 1.2 x 0.4 cm
14188	1.60 g	1.5 x 1.0 x 1.0 cm

These samples contain a seriate distribution of clasts as large as two centimeters across. The samples are all polymict breccias with fragmental matrices.

SURFACE FEATURES

Glass lined zap pits are present on samples 14169, 14171, 14172, 14173, 14176, 14182, 14185, and samples 14170 and 14187 contain only unlined pits. Sample 14169 has pits ranging from 0.1 to 2.0 mm in size with a density of 10 to 12 pits per square centimeter. One hackly surface is sparsely pitted, perhaps indicative of the sample's bottom. The rest are less densely pitted. None of the samples contains surface glass.

The only cavities present are clast molds on all samples except for 14181 and 14186. Sample 14181 contains irregularly shaped vugs 0.5 to 1.5 mm in size with a homogeneous distribution in the matrix only. These are 10 mm apart and account for less than 1% of the sample's volume. Sample 14186 also contains irregularly shaped vugs with an average size of 0.8 mm. These occur in clusters on one side of the rock. A few others are widely spaced.

Several are lenticular. No projecting minerals have been observed.

Fractures are present in all samples except 14175 and 14188. The only shock features noted occur on sample 14172. The substrate below the zap pits has milky feldspar characteristic of surface shock material.

PETROGRAPHIC DESCRIPTION

Samples range in coherence from tough (14180, 14186) to friable (14171, 14185, 14187). All samples appear to be fragmental polymict rocks in hand specimen. Most clasts are medium gray, aphanitic fragments which contain some white spots and may be partially devitrified. The bulk of the other clasts are white to light gray lithic fragments which are composed mostly of plagioclase grains with 10-20% mafic minerals, and 1% opaques. In order to better characterize the clast population, all of the clasts larger than 5 mm across were described by Phinney *et al.* (1975) and are included in Table 7.

TABLE 7

Clast Descriptions (Phinney *et al.*, 1975)

	Color	Shape	Size (mm)	Comments
14169	Medium Gray	Subround	20.	Similar to main matrix of 14303 but somewhat darker and more annealed. Sharp contact with matrix. Contains many white clasts and a large olivine clast.
14169	Medium Gray	Subround	20.	Identical to previous clast.
14169	Light Gray	Round	6.0	Dark gray rind around 1.0 mm size mixture of white plagioclase, resinous brown material and gray vitreous patches.
14169	Dark Gray		10.	Aphanitic, crystalline with white feldspar specks.
14170	Dark Gray	Angular	5.0	Aphanitic, crystalline, contains 10% white feldspar clasts.
14170	Med.Dark Gray	Angular	5.0	Aphanitic, crystalline with a few white specks <0.1 mm.

(Clast Description Table cont'd)

	Color	Shape	Size (mm)	Comments
14171	Pinkish brown to Dk. Gray	Round	10.	Band of pinkish brown, fine-grained material across center. On one side is black, aphanitic, crystalline material with a few white feldspar clasts. On other side is a mixture of medium gray and white material.
14171	Dark Gray	Subround	10.	Aphanitic, crystalline with a few white feldspar clasts.
14171	Lt.Med.Gray	Round	5.0	Mare basalt? 5-10% opaques as stringers 2-3 mm long and 0.1 mm wide through a mixture of plagioclase and pinkish brown mafic minerals.
14172	Gray & White	Subround	15 x 7	Core of white plagioclase as 0.5 mm grains mantled by dark gray aphanitic material.
14172	Medium Gray	Angular	5.0	Very similar to main matrix of 14303 but sharp contacts definitely indicate a clast.
14173	Greenish Gray	Diffuse Boundaries	7.0	Primarily vitreous gray plagioclase with 30% green mafic silicate as 1.0 mm crystals and <1% black opaques.
14173	Med.Dk. Gray	? Makes up end of rock	20.	Aphanitic, crystalline with many white specks.
14174	Medium Gray	Angular	10.	Aphanitic, crystalline with many white specks of feldspar.
14179	Gray & Lt.Green	Angular	5.0	3.0 mm patch of fractured green mafic silicate and 5.0 mm patch of gray, vitreous feldspar probably from a coarse-grained gabbroic rock.
14180	Med.Dk. Gray	Angular	15.	Clastic to somewhat annealed breccia with many subround white feldspar clasts and one subround crystalline clast with mottled appearance of poikilitic melt rocks.

(Clast Description Table cont'd)

	Color	Shape	Size (mm)	Comments
14181	Entire Sample is 2 Clasts		7.0	1) Medium gray aphanitic crystalline rock with many white feldspar specks.
			10.	2) Troctolitic anorthosite with 0.5-1.0 mm plagioclase as crushed white or vitreous gray material, 10% 0.5-1.0 mm green mafic silicate (olivine) and a few <0.5 mm dark red grains (spinel).
14182	Medium Gray	Subround	5.0	Very similar to main matrix of 14303 but somewhat darker and a bit more annealed.
14186	Medium Gray		10 x 6	Very similar to main matrix of 14303 but somewhat darker and a bit more annealed.

Several thin sections from generics in this group are available and were examined for this booklet. The following descriptions are included for purposes of completeness:

14169,8

There is a small amount of dark brown "glass" (5-10%) present in the matrix of sample 14169,8. Only one clast larger than 1 mm is present in the section. It is a fine-grained breccia with crystallites scattered throughout. Many of these crystallites appear to be pyroxene. The clast has fractured and the matrix has been injected between the two pieces. A seriate mixture of shocked mineral fragments (including reddish spinel) and three dark clast-like areas are present in the matrix. These "ghost clasts" are areas of fine-grained, turbid material with abundant small crystallites present. These areas merge into the matrix.

14170,4 & 14170,5

Some "glass" is present in the matrix of breccia 14170. The samples consist of a partly crystalline-partly "glassy" matrix with abundant mineral and lithic clasts. Several large clasts of pyroxene and basaltic igneous rock fragments are scattered throughout the sections. There are fewer clasts in 14170,4 than there are in 14170,5. Sample 14170,4 contains several devitrified clasts and larger "glassy" breccia clasts. Few, widely scattered, pyroxene/basaltic clasts are present in section 14170,4 but are common in 14170,5. Pyroxene crystals are nearly free of inclusions. Basaltic lithic clasts have a subophitic texture with anhedral masses of brownish pyroxene

and acicular plagioclase. Only small, scattered clasts of plagioclase are present in either section.

14171,11

Section 14171,11 is nearly holocrystalline and contains numerous lithic clasts. Lithic clasts include a variety of dark matrix microbreccias, a clast of devitrified glass containing abundant dendritic crystals, and a small, crystalline rock fragment. Opaque minerals are scattered throughout the section. The matrix is a seriate mixture of mineral fragments and small lithic fragments. Mineral fragments are pyroxene and plagioclase in approximately equal proportions.

14172,7

Section 14172,7 is a breccia with a "glassy" matrix (30%) in one area, which grades into a much more crystalline area in other areas (5-10% "glass"). Very few lithic fragments are present, and only one clast is larger than 1 mm. This clast consists of a shocked plagioclase crystal with minor pyroxene adhering to one edge. The crystal is highly fractured and shows poorly defined twin planes. Of the identifiable mineral fragments in the matrix, 80% are pyroxene and 20% are plagioclase. Lithic fragments are a fine-grained breccia with corroded pyroxene crystals. These crystals contain some inclusions.

14173,6 & 14173,7

Section 14173,6 grades from vitric to more crystalline as does 14172,7. Sample 14173,7, cut from the same rock chip is almost entirely crystalline with a few small masses of a more "glassy" breccia. Most clasts consist of pyroxene and plagioclase grains and almost all grains are fractured. Twinning is present in some of the pyroxene. A crystalline cumulate is present near the edge of the section. A few small, glassy breccia clasts are present in 14173,7. Crystals in 14173,7 appear fresher with less evidence of shock and fewer inclusions than those in 14173,6.

14174,5

A very minor amount of "glassy" material is present in the matrix. Several large lithic clasts are present and consist of fine-grained microbreccias with remnant pyroxene shards, small igneous fragments, and several masses of devitrified glass. One microbreccia fragment has a small mass of olivine cumulate present.

14175,3

Section 14175,3 resembles section 14174,5 but contains more plagioclase and more "glassy" material. One edge has what appears to be a totally devitrified glass coating which has bent and radiating crystals. Some areas have larger crystal grains than others and may be "ghost" clasts, however the contact is gradational.

Lithic microclasts are scarce and most are small clusters of plagioclase and pyroxene surrounded by a mass of crystallites. Pyroxene (80%) and plagioclase (20%) make up the mineral grains, and all are shocked. Chondrule-like bodies occur as remnant features, and patches of opaque minerals are also present.

14179,4

Sample 14179,4 is an olivine-rich granulitic rock with 2-3% pyroxene cemented together by anhedral plagioclase. The olivine crystals are highly rounded and somewhat elongate. Pyroxene crystals are more equant and square in outline. Only a trace of brownish "glassy" material is scattered throughout the section.

14180,3

Sample 14180,3 contains a fine-grained, nearly holocrystalline microbreccia clast surrounded by a small border of a dark opaque-rich breccia. In this clast, smaller fragments of darker, fine-grained, opaque-rich breccias are present. Opaques form subhedral to anhedral crystals, and are widely dispersed throughout the section. Euhedral crystals occur in the matrix surrounding the clast.

14181,5

This sample is a section of a troctolitic anorthosite with large, anhedral olivine grains and long, bladed plagioclase crystals. A second generation of anhedral crystals of plagioclase has filled the interstices between other phases. Large crystals of iron metal and other opaques are also present. One, well rounded, reddish spinel is enclosed in an olivine crystal.

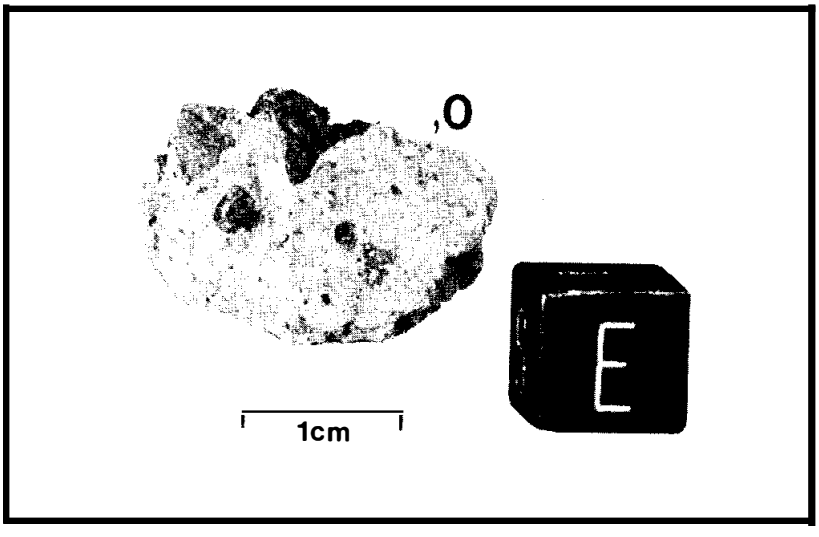
14187,3

This section is essentially a holocrystalline breccia with abundant, dark gray matrix material which is unresolvable. Abundant, small, opaque crystals are present in the matrix. The section area is small, so an accurate evaluation of the clast population is not possible. Large fragments present include a few shards of pyroxene, plagioclase, and partly devitrified glass. The thin section has a very turbid appearance.

DISCUSSION

The only samples that have received detailed study in this group are 14169 and 14180. Eldridge *et al.* (1972) determined potassium, thornum, uranium, ^{26}Al, and ^{22}Na concentration in these samples using gamma-ray spectrometry. They found a remarkable uniformity in the primordial radio element content in all samples. They estimate a KREEP content of 60-85% in Apollo 14 soils and breccias on the basis of a two-component mixing model.

14194



S-71-26965

Weigh bag 1031 was used on the traverse during the second EVA. Samples 14194 -14201 are small rock fragments that were left in weigh bag 1031 after samples 14306 - 14311 were removed. Their lunar location and orientation are unknown and there are no lunar surface photographs of these samples. Some of these are probably pieces broken off the larger rocks during transit.

14194

PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.28 g	3.5 x 2.5 x 2.5 cm

This sample is a light gray, moderately friable, polymict breccia which appears to be bounded by freshly broken surfaces.

SURFACE FEATURES

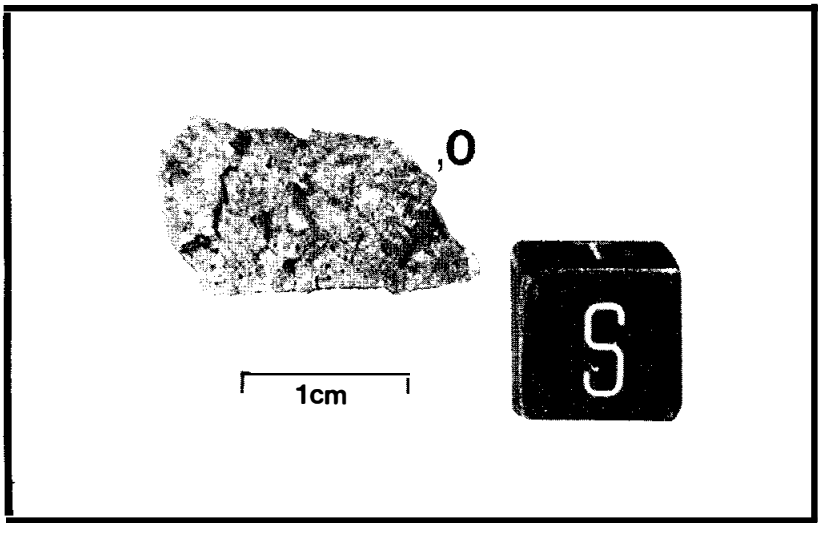
No pits were seen on this sample and it appears to be bounded by fresh fracture surfaces. No surface glass is present. Angular clast molds with sizes ranging from less than 0.1 mm to 1.0 mm are distributed evenly over the surface indicating poor cementing of clasts to the host rock.

PETROGRAPHIC DESCRIPTION

Sample 14194 is a moderately friable, light gray polymict breccia with 5 - 10% fragments larger than 1 mm and 90 - 95% matrix grains smaller than 1 mm. Of the clasts larger than 1 mm, 10 - 20% are mineral fragments, 70 - 80% are lithic fragments and 20% are glass fragments. Mineral fragments consist of polycrystalline shattered aggregates of medium to light brown pyroxene and a greenish brown mineral, and single crystals of shattered feldspar. Lithic fragments are medium to dark gray cryptocrystalline fragments (possibly devitrified glass) and leucocratic fragments consisting of subequal amounts of feldspar and a dark gray mineral. Glass fragments are as large as 5 x 5 mm. These are angular, dull dark gray, and a few have vesicles.

The average grain size of the matrix is 0.1 mm and the matrix is composed of dark gray glass, brown pyroxene, one basaltic fragment (like 14053), a few fragments of the type of sample 14082, and feldspar fragments.

14195



S-71-26970

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.77 g	2.5 x 1.5 x 1.5 cm

Sample 14195 is a coherent, medium to dark gray, fragmental rock.

SURFACE FEATURES

One surface appears weathered and the other sides are irregular fracture surfaces. Vugs with varied shapes range in size from less than 1.0 mm to less than 100 μm. They are homogeneously distributed and comprise 20% of the rock volume. Some small zones of interconnecting vugs resemble strings of beads. Most of the vugs are drusy in appearance, with relatively smooth walls, but some have projecting feldspar (?) crystals. The drusy coatings resemble reaction rims. In several cases vugs have evacuated space around crystals 200-300 μm in size, as if by solution.

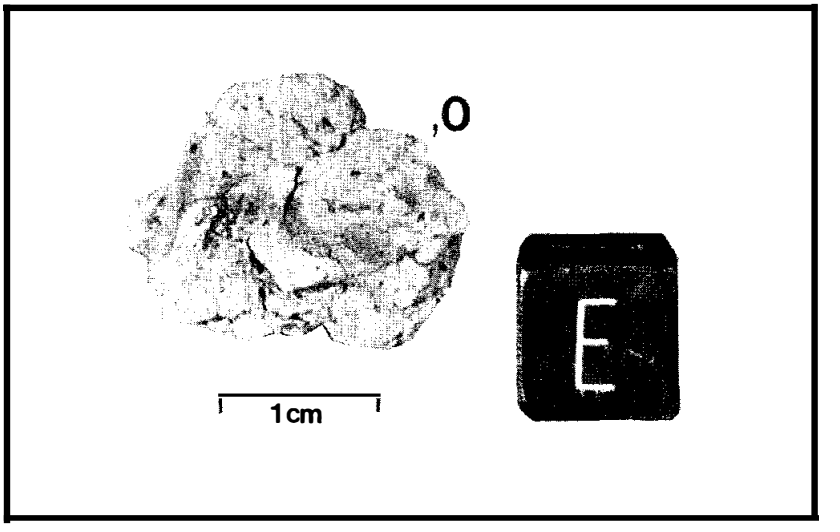
PETROGRAPHIC DESCRIPTION

The sample is coherent and very fine grained, with only two clasts larger than 1 mm visible. These appear to be mineral fragments. The average grain

size is less than 100 μm.

The matrix is medium to dark gray with 40 - 50% clear feldspar. Approximately 5% of the matrix is opaque minerals, and the rest are not identifiable.

14196



S-71-27000

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.93 g	2.5 x 1.5 x 1.5 cm

Sample 14196 is a friable, polymict breccia similar to 14051 or 14066.

SURFACE FEATURES

No zap pits or vugs are present, but sparsely distributed clast molds up to 1 mm in size are present.

One set of non-planar fractures with one member is present. The fractured surface shows no differences in rock texture from elsewhere on the sample.

PETROGRAPHIC DESCRIPTION

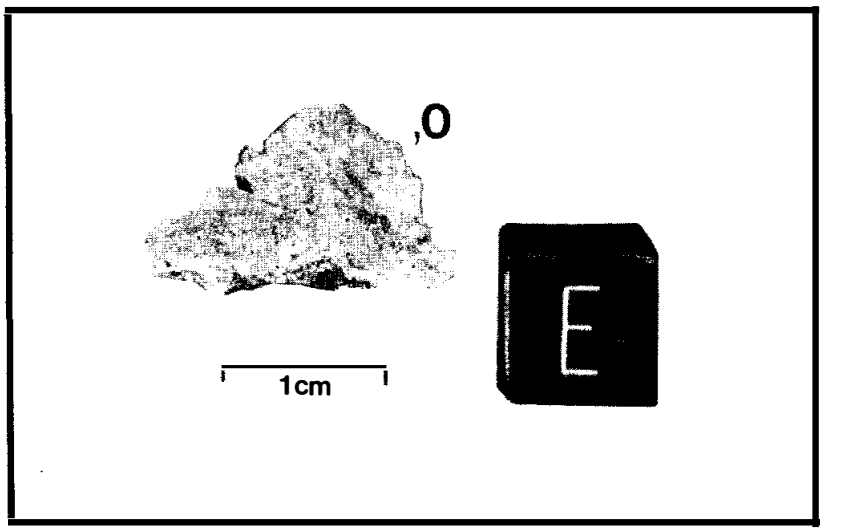
Sample 14196 is a fine grained, polymict breccia with an average grain size of approximately 0.1 mm. It is composed of 5% clasts larger than 1 mm and 95% matrix less than 1 mm. Of the clasts, 20% are mineral fragments and 80% are lithic fragments. Mineral fragments are bottle-green, yellow-brown,

and many angular dark gray glassy-looking fragments.

Lithic fragments include angular, dark brown to black vesicular glass fragments; friable leucocratic rock fragments composed of 70% plagioclase and 30% olivine and pyroxene, and medium-to-dark-gray glassy clasts.

The matrix is fine grained and light-to-medium-gray. It consists of plagioclase, mafic minerals, and black, angular glass 0.2 to 0.5 mm in size, as well as fine grained fragments similar to the clasts.

14197



S-71-27004

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.63 g	2.0 x 1.5 x 0.5 cm

This sample is very fine grained and appears to be completely recrystallized.

SURFACE FEATURES

There are no pits visible. Irregular-to-spherical-shaped vugs and vesicles up to 3 mm in size are homogeneously distributed throughout the surface. They are 1 - 2 mm apart and occupy 20% of the surface area. Minerals lining these cavities are too small for positive identification but some acicular colorless crystals with pinacoid terminations are visible and are probably plagioclase. Some of the cavities may be interconnected forming drusy, irregular and branching caverns up to 3 mm in length. The rock is bounded by fracture surfaces but none penetrate the rock.

PETROGRAPHIC DESCRIPTION

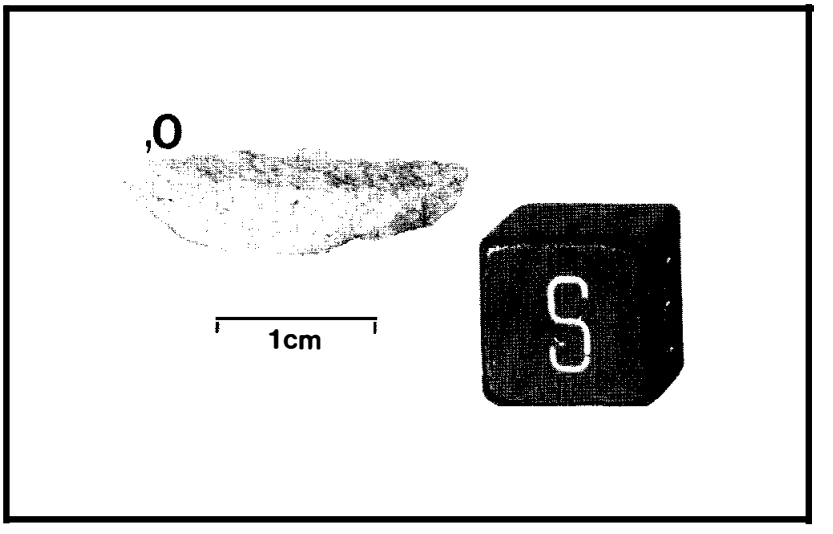
The sample is fine grained with an average grain size of less than 0.1 mm and is both texturally and mineralogically homogeneous. It appears to be a completely recrystallized fragmental rock. Grain size is too fine for positive mineralogic determination, but color suggests that it is 50% plagioclase, 48% pyroxene, and 2% opaques. The possible clasts resemble true phenocrysts, and are clear and unshattered. There are three types:

1) Clear equant masses 3 mm in size which have two apparent cleavages.

2) Yellow-green, prismatic masses without cleavages 2 x 1 mm in size.

3) Equant masses of plagioclase and brown pyroxene 1 mm in size.

14198



S-71-26989

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.63 g	2.2 x 1.5 x 0.5 cm

Sample 14198 is a crystalline rock.

SURFACE FEATURES

One glass-lined zap pit measuring 100 μm in diameter was observed on the narrow side of the rock. All other sides are fresh fracture surfaces.

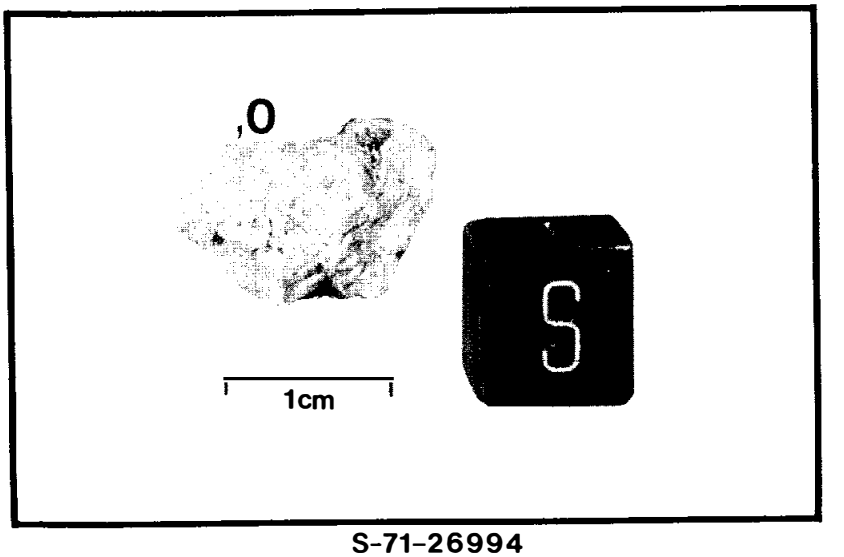
Irregular shaped vugs (1 mm) are sparsely distributed over the surface. They contain projecting minerals of plagioclase and probably tridymite. Pyroxene was the only tangential mineral noted. Vugs make up less than 1% of the volume.

PETROGRAPHIC DESCRIPTION

The sample contains 30% light yellow pyroxene, 40% clear anhedral and euhedral feldspar, 20% gray-brown pyroxene and 3 or 4% opaque minerals.

The texture is diabasic. It appears similar to 14310 and is finer grained than 14053.

14199



S-71-26994

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.88 g	1.3 x 1.0 x 0.8 cm

This sample is a freshly fractured, polymict breccia.

SURFACE FEATURES

No pits are visible, and all surfaces appear to be freshly fractured. A trace of dark brown glass and a small patch of brown stain which may be remnants of a glass splash covering or remnants of deep glass lined pits with a large radius of curvature. One fracture which has a smooth surface is present in the rock. Some clast molds are visible.

PETROGRAPHIC DESCRIPTION

Sample 14199 is a coherent, fine grained, polymict breccia with an average grain size of less than 0.1 mm. It is texturally homogeneous and appears to be mineralogically homogeneous, as well. It is composed of 20 - 25% clasts larger than 1 mm and 75 - 80% matrix grains.

Mineral fragments make up 8 - 10% of the whole rock and include:

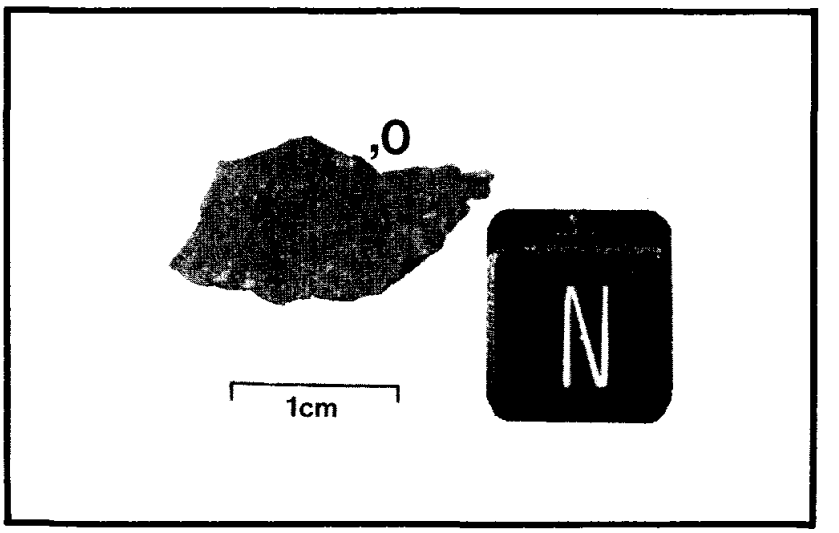
1. green vitreous olivine 0.1 - 0.8 mm in size comprising 3 - 4% of the rock,
2. honey-brown pyroxene 0.2 - 0.8 mm in size comprising less than 1% of the rock,
3. light gray plagioclase displaying cleavages and commonly shattered comprising more than 5% of the rock,
4. a black or dark brown mineral grains which appear reddish brown on the surface and are 0.2 mm in size. It occurs in trace amounts.

Lithic fragments are 10 - 15% of the rock composition. They range in size from less than 0.5 mm to more than 2 mm and are mostly dark gray aphanitic clasts with a vitreous luster. One large clast 8 x 8 x 3 mm is mottled dark and very light gray. It contains abundant brown pyroxene, light mineral, plagioclase, and a black metallic mineral. Some glass lined pits are present in the clast. A third clast type, 0.5 mm in size, is light to medium gray and very fine grained. A fourth type is a 3 x 1 mm medium gray lithic fragment with an olivine inclusion and some suggestion of internal lamination.

One dark gray or brownish gray glass sphere is present 0.1 - 0.2 mm in diameter.

The light brownhish gray matrix has a distinct modal compositional break at a grain size of approximately 0.1 mm. It appears porous under a binocular microscope.

14200



S-71-26324

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.24 g	2.0 x 1.2 x 0.9 cm

Sample 14200 is a fragment of very fine grained basaltic crystalline rock.

SURFACE FEATURES

One 0.8 mm size glass-lined pit was noted. The sample has an irregular surface and appears to be a fragment of a larger rock.

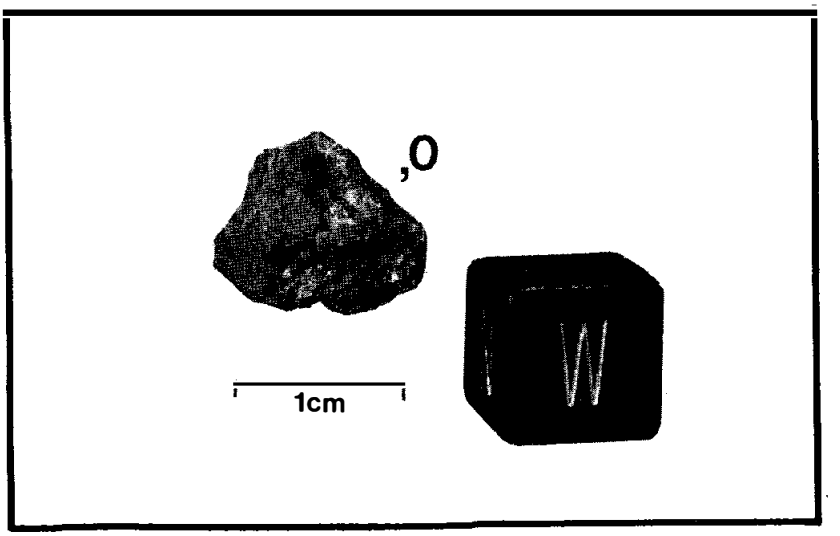
Clusters of elliptical vesicles with sizes ranging from less than 0.1 mm to 2.0 mm occur on the rock. These occupy 10% of the rock volume and are 1 - 3 mm apart. Colorless minerals (probably feldspar) with a sub-botryoidal surface line these vesicles.

PETROGRAPHIC DESCRIPTION

Sample 14200 is fine grained with an average grain size of less than 0.1 mm. There are less than 1% possible phenocrysts. It is a texturally and miner-

alogically homogeneous, holocrystalline, basaltic fragment. As can best be determined, the rock is composed of three minerals: clear, subhedral, yellow-green olivine (in groundmass and as phenocrysts < 0.5 mm in size), clear, subhedral pyroxene (occurring only in the groundmass in grains < 0.5 mm), and clear, subhedral feldspar (occurring in cavities, in the groundmass, and as 1 mm size phenocrysts). Glassy feldspar accounts for at least 40% of the rock.

14201



S-71-26328

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.56 g	1.2 x 1.2 x 1.0 cm

This sample is a fine grained polymict breccia similar to 14042.

SURFACE FEATURES

There are no pits and no surface glass. Angular clast molds larger than 1 mm to 4 mm in size have a homogeneous distribution on the surface. One clast mold 4 x 2 in size is well preserved and represents an angular pre-existing slabby clast.

PETROGRAPHIC DESCRIPTION

Sample 14201 is a moderately friable polymict breccia composed of 15% fragments larger than 1 mm and 85% matrix grains smaller than 1 mm. One 2 mm-size, rounded, greenish white mineral fragment appears to be polycrystalline. Of the clasts, 2/3 are leucocratic lithic fragments and 1/3 are fragments of glassy rocks. All of the lithic clast types consist of 60% feldspar, 35%

pyroxene, and 2 - 3% olivine and opaques. The glassy fragments are dark gray.

The matrix contains 40 - 50% feldspar, many dark gray glass clasts which are both angular and rounded, and angular and rounded plagioclase-pyroxene fragments. The matrix does not appear to be recrystallized.

Comprehensive Sample (14169-14188, 14250-14299)

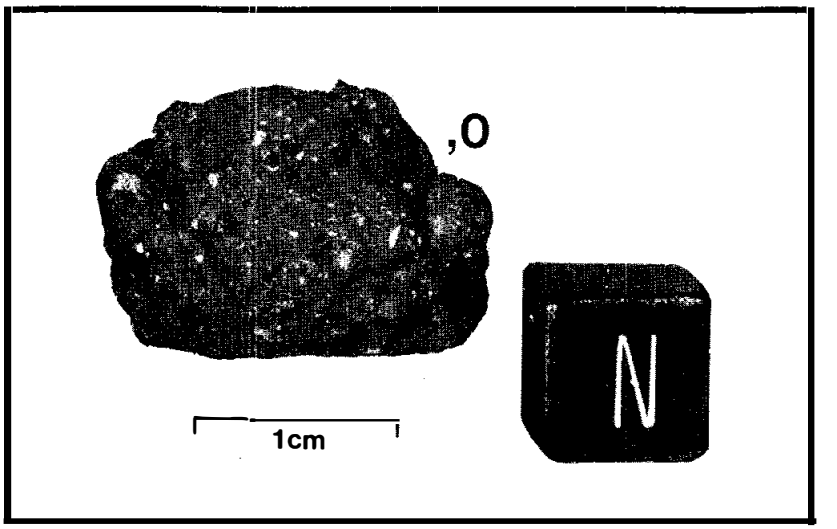
The comprehensive sample from Apollo 14 has been described, classified and discussed by Phinney et al. (1975) in their publication devoted to that topic. The information collected and discussed by them is included herein for purposes of completeness only, and very little attempt has been made to redescribe these samples except that new thin section descriptions are included whenever possible.

The purpose of the comprehensive sample was to acquire a statistically significant set of small rock samples to petrographically characterize the distribution of rock types in the lunar regolith. The sample location was selected 100 to 125 m west of the LM. A two to three meter diameter circle was marked and all of the walnut sized rocks on the surface within the circle were collected with tongs. Then, a soil sample was collected from within the circle. Two weigh bags were to be used to contain the samples: weigh bag 1039 was to contain rock fragments and weigh bag 1007 was to contain the soil sample. Unfortunately, as discussed in the Apollo 14 Preliminary Science Report (1971), there was some confusion about the origin of the contents of weigh bag 1027. It contained 20 small rock fragments (14169-14188) and a large undocumented rock, 14303. On the basis of their association with two documented rocks (14304 and 14305) returned in the same weigh bag and collected near the comprehensive sample site, the 20 fragments and 14303 were tentatively considered to be parts of the comprehensive sample. Later, 14303 was found to have been part of 14304, collected at the end of the first EVA. The astronauts were unable to get all of the weigh bags containing the comprehensive sample in the SRC so they put the "small samples of small rocks" from the comprehensive sample in the weigh bag (1027) with the football-size rocks collected later (14303/14304 and 14305). It seems probable, therefore, that some portion of the samples 14169-14188 could be parts of the larger samples 14303/14304 and 14305 that were in the same bag but not part of the contingency sample. It was believed by Phinney et al. (1975) that all of the small samples 14169-14188 were fragments of 14303 because they are all identical in their lithologies and are lithologically identical to 14303 and because they show freshly fractured surfaces with no patination or zap pits and one end of 14303 is a fracture surface (later shown to fit 14304).

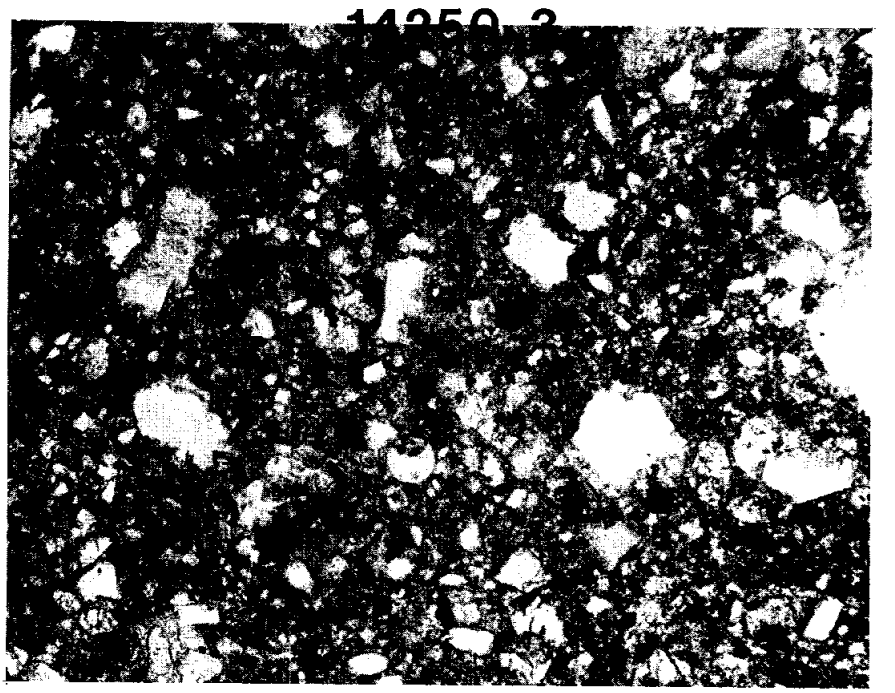
The following table summarizes the contents of the three weigh bags:

Weigh Bag Number	Rock Samples	Soil Samples
1007	14250-14255	14256-14259
	(Rocks separated from soil)	14298-14299
1039	14264-14288	14260-14263 (Soil collected with rocks)
1027	14169-14188	14165-14168
	14303/14304 and 14305	(Residue)

14250



S-71-26317



PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.06 g	2.1 x 1.5 x 1.5 cm

Sample 14250 is a medium gray, blocky, subangular, moderately friable, seriate fragmental rock.

SURFACE FEATURES

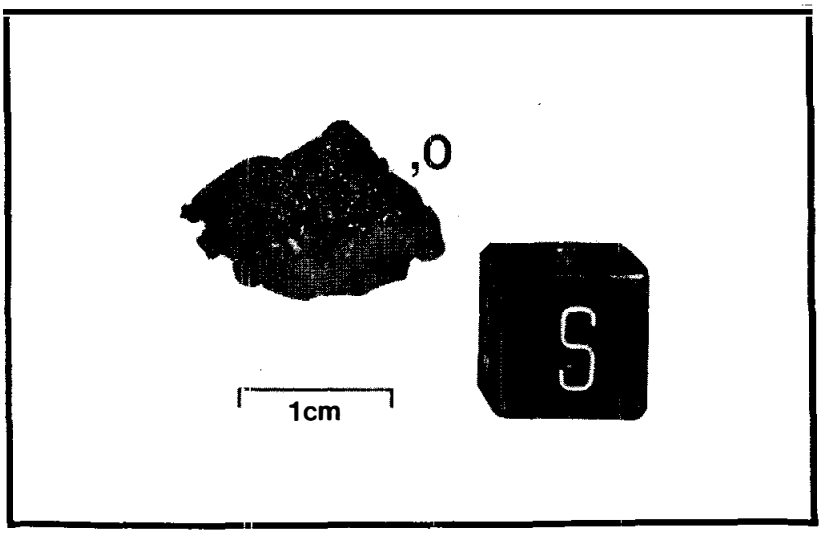
There are pits lined with dark brown glass on all surfaces. The surface is irregular, with few, non-penetrative fractures.

PETROGRAPHIC DESCRIPTION

Sample 14250 is described as a microbreccia or soil breccia (Phinney *et al.*, 1975) which is homogeneous but seriate in texture. Gray and white lithic fragments make up less than 5% of the sample. They are rounded to subrounded in shape and up to 1.0 mm in size. They are composed largely of milky white feldspar with irregular gray areas. There are two kinds of mineral fragments that can be identified. Type I is white and 0.5-1.0 mm in size. It is subangular to subrounded in shape and makes up 10-15% of the sample. Most grains appear to be crushed plagioclase. Type II is light green in color and is rarer, making up less than 5% of the sample. It ranges up to 1.0 mm in size and is angular to subrounded in shape. These are probably olivine grains.

Thin section 14250,3 shows the rock to be a glass-rich breccia with 50% of the matrix being yellow brown glass, much of which has swirls and bubbles. There are numerous shards and spheres of glass scattered throughout. One partial clast of a fine-grained microbreccia with a few pyroxene and glass shards is the only large fragment in the sample. There is a broken fragment of devitrified glass with remanent plagioclase crystals and numerous new plagioclase plus partly devitrified glass are present in the matrix. Approximately 15% of the sample is larger than 0.5 mm in grain size.

14251



S-71-25203

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.51 g	1.5 x 1.0 x 0.8 cm

Sample 14251 is a medium gray, blocky friable fragmental rock.

SURFACE FEATURES

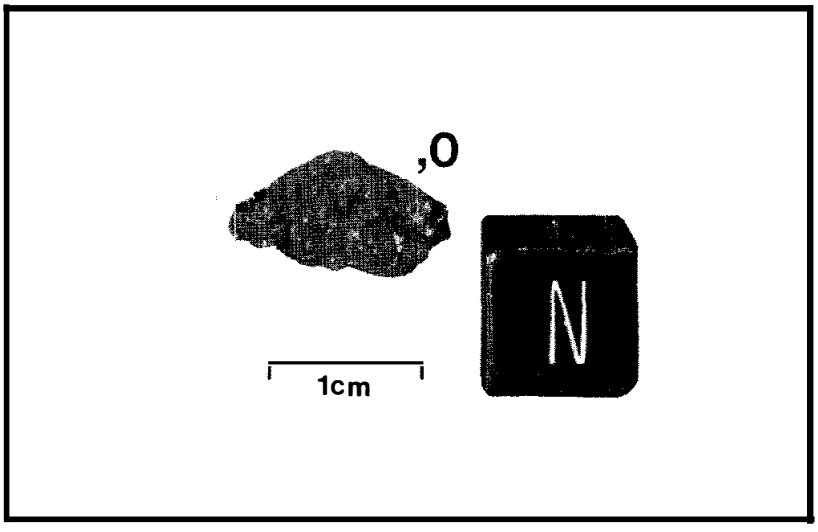
Remnant zap pits are present as glass linings. The surface is irregular with a glass coating over one surface. Forty percent of this glass coating contains 0.2 to 0.6 mm diameter vesicles. No vesicles are present in the rock itself. Some surfaces show slickensides or striations which converge towards a point as though from a shatter cone.

PETROGRAPHIC DESCRIPTION

Sample 14251 is described by Phinney et al. (1975) as being a fragmental, friable, microbreccia or soil breccia. None of the grains is larger than 1.0 mm, with 85% less than 0.5 mm. The sample has a seriate texture, with lithic fragments 0.5 - 1.0 mm in size comprising less than 5% of the sample. These are largely milky white feldspar with irregular gray areas. Grains

are gray and white in color and are rounded to subrounded in shape. There are two types of mineral fragments up to 1.0 mm in size. Type I is white and appears to be crushed plagioclase. Fragments are subangular to subrounded in shape and make up 10 - 15% of the sample. Type II is light green olivine occurring as subangular to subrounded grains up to 1.0 mm in size. These are less than 5% of the sample.

14252



S-71-25211

PHYSICAL CHARACTERISTICS

Mass	Dimensions
0.86 g	1.3 x 0.8 x 0.8 cm

Sample 14252 is a medium gray, friable, fragmental rock. It is subround to angular, appearing to be 1/4 of a sphere.

SURFACE FEATURES

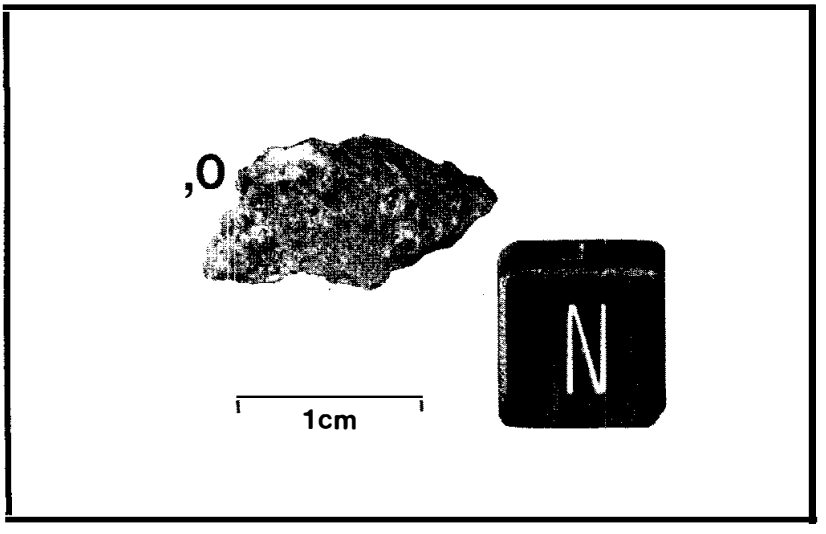
Several zap pits with dark brown glass linings are present on the rounded surface, but none are present on angular faces. The surface is irregular to smooth, with some non-penetrative fractures.

PETROGRAPHIC DESCRIPTION

Sample 14252 is described as a moderately friable seriate microbreccia or soil breccia. All grains are smaller than 1.0 mm. It is homogeneous with 85% of the fragments smaller than 0.5 mm. Lithic fragments averaging 0.5 mm are gray and white and are largely milky white feldspar with irregular gray areas. These fragments are rounded to subrounded in shape and make up less than 5% of the sample. There are two types of mineral fragments

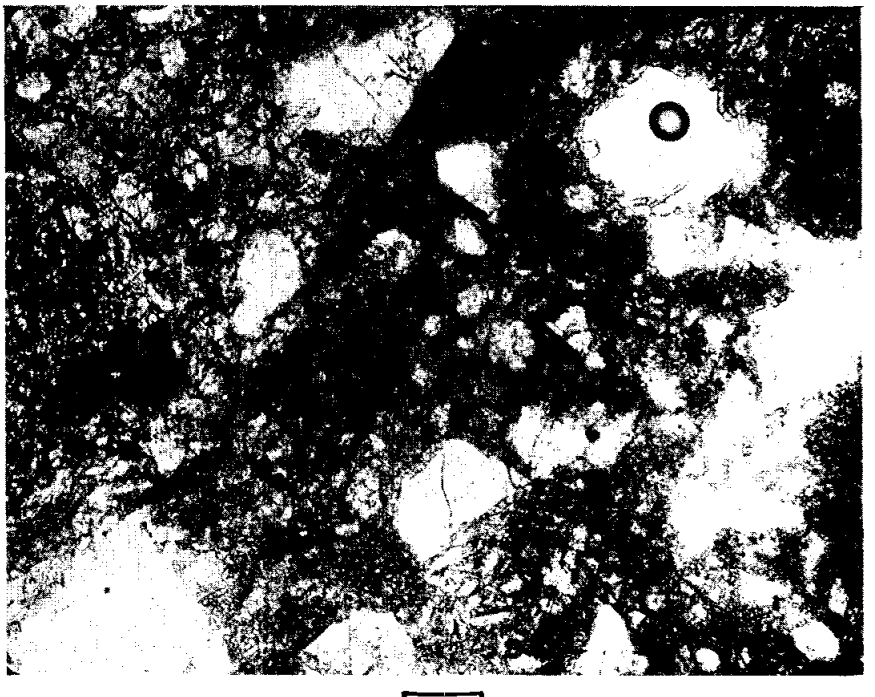
present. Type I makes up 10 - 15% of the sample and is white, probably crushed plagioclase. Type II is light green olivine, occurring as subangular to subrounded grains occupying less than 5% of the sample. These range up to 1.0 mm in size.

14253



S-71-26320

14253,3



PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.23 g	1.6 x 1.0 x 0.4 cm

Sample 14253 is a gray angular, blocky, homogeneous, crystalline breccia.

SURFACE FEATURES

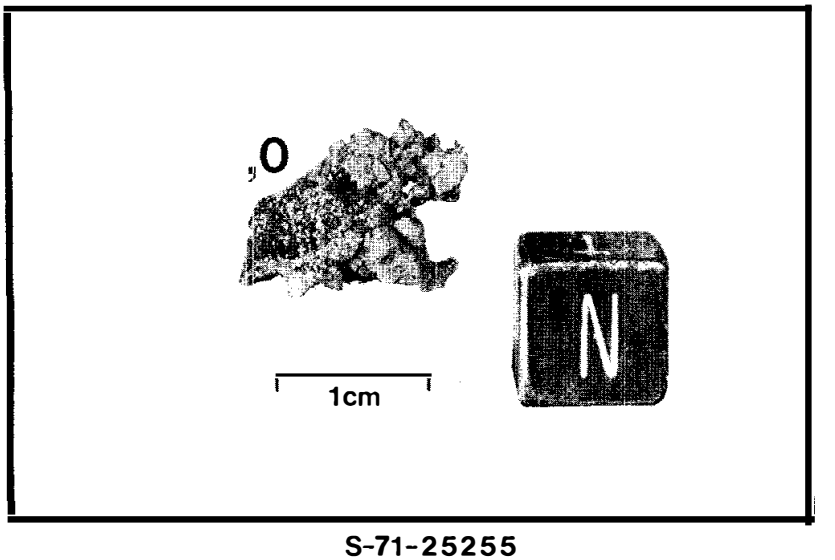
Glass lined pits, 0.5-2.0 mm in diameter, are present on two eroded surfaces. None are present on the hackly surfaces. Vugs 0.2-1.0 mm in diameter, are concentrated at one end, making up less than 5% of the sample. One large vug (3 mm) is lined with white crystalline material. Some penetrative and and some non-penetrative fractures are present.

PETROGRAPHIC DESCRIPTION

Sample 14253 is described as a tough, homogeneous, crystalline breccia. All grains are smaller than 1.0 mm. Ninety-five percent of the grains are between 0.1 and 0.2 mm, appearing to be annealed. Two types of mineral clasts are present. Type I is very light gray and appears to be plagioclase, some showing gradational white to gray contacts with the matrix. Grains are round in shape and occupy 5% of the sample. Type 2 is light greenish yellow, probably pyroxene and/or olivine, and round. It is only approximately 1% of the sample.

Thin section 14253,3 shows the rock to be nearly all crystalline with 10-15% of gray matrix. There are only two clasts present. The first is a highly deformed granulated crystal of plagioclase which now shows multiple domains in the crystal. The second type is a fine-grained microbreccia, with scattered pyroxene and olivine fragments. The remainder of the matrix is composed of a seriate mixture of pyroxene, plagioclase and minor olivine fragments. Most of the fragments are pyroxene.

14254



S-71-25255

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.01 g	1.6 x 1.1 x 0.8 cm

Sample 14254 is gray soil, adhering to frothy black glass and is highly irregular in shape.

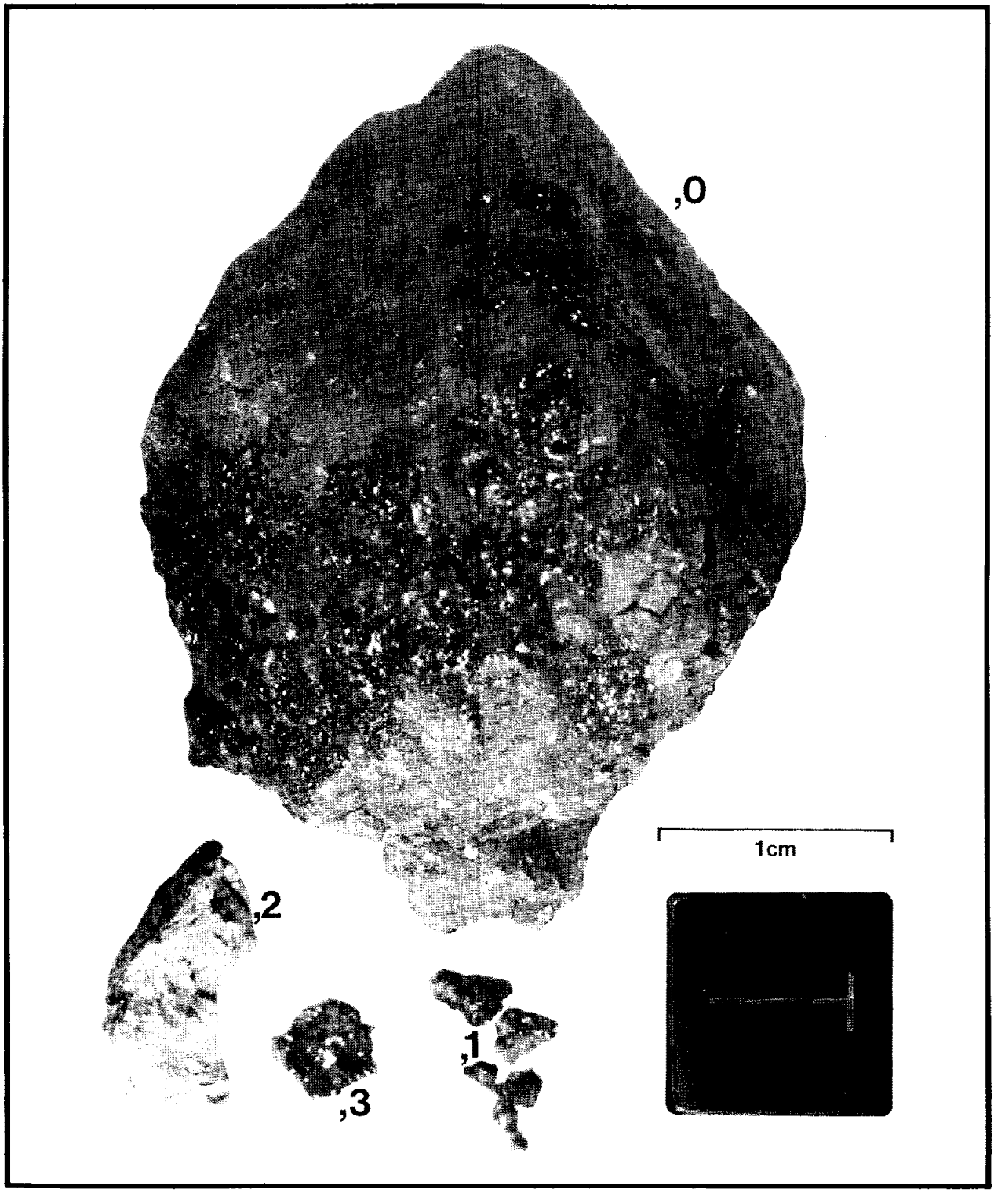
SURFACE FEATURES

There are no zap pits. Vesicles, 0.1 to 1.0 mm in size, make up 30% of the volume of the glass. The surface is rough.

PETROGRAPHIC DESCRIPTION

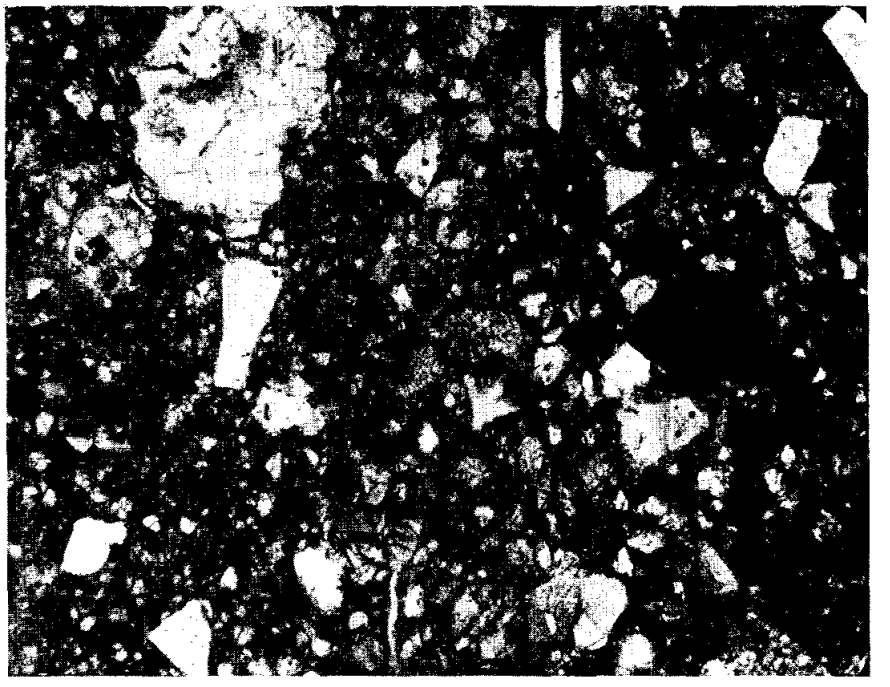
Eighty percent of the sample is black glass and 20% is brownish-gray soil less than 0.1 mm in size.

14255



S-75-24427

14255,5



.1mm

PHYSICAL CHARACTERISTICS

Mass	Dimensions
22.15 g	1.2 x 2.2 x 2.5 cm

Sample 14255 is a medium gray, subangular, blocky, friable fragmental rock.

SURFACE FEATURES

Pits were present on all surfaces at one time, as is evidenced by remaining glass linings up to 1.0 mm in diameter, however, they have been abraded during transport and/or handling. Glass splash present on some surfaces is very vesicular. Slickensides or grooves converge towards a point on some surfaces as though from a shatter cone. The surface is rough with 0.1-1.0 mm thick glass spatter on three surfaces.

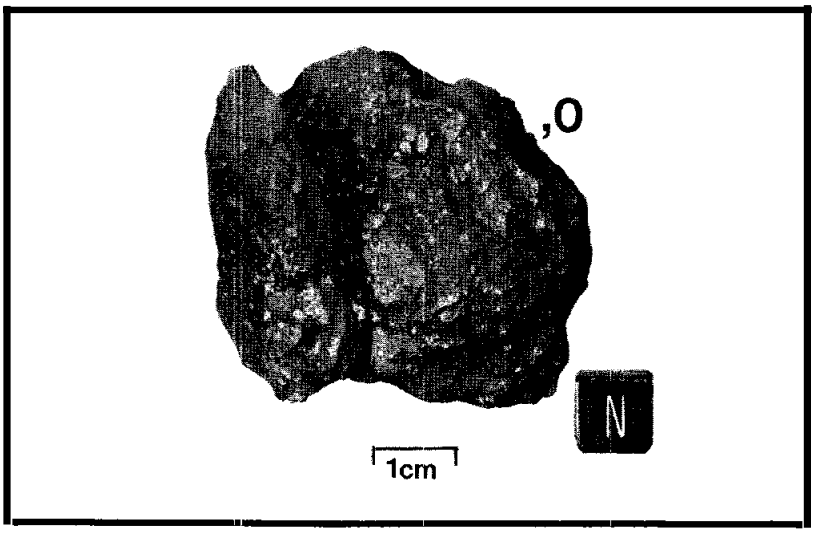
PETROGRAPHIC DESCRIPTION

The sample is a fragmental moderately friable microbreccia or soil breccia (Phinney et al., 1975). No grains are larger than 1.0 mm in diameter. Grains averaging less than 0.1 mm make up 85% of the sample. Gray and white lithic

fragments make up less than 5% of the sample. They appear to be largely milky white feldspar with irregular gray areas and are round to subrounded in shape. There are two types of mineral fragments present. Type I is white and is 10-15% of the sample. Most appear subangular to subround and are probably crushed plagioclase. Type II is light green olivine occurring as subangular to subrounded grains up to 1.0 mm in size.

Thin section 14255,5 shows the rock to be a glass-rich breccia with 20% of the matrix composed of yellow brown glass. The most numerous large fragments in the matrix are undevitrified glass shards. A few masses of devitrified glass are also present. There are no clasts in the section. Numerous shards of plagioclase and pyroxene with minor olivine and opaques make up the rest of the matrix. There is a glass coating on one edge.

14264



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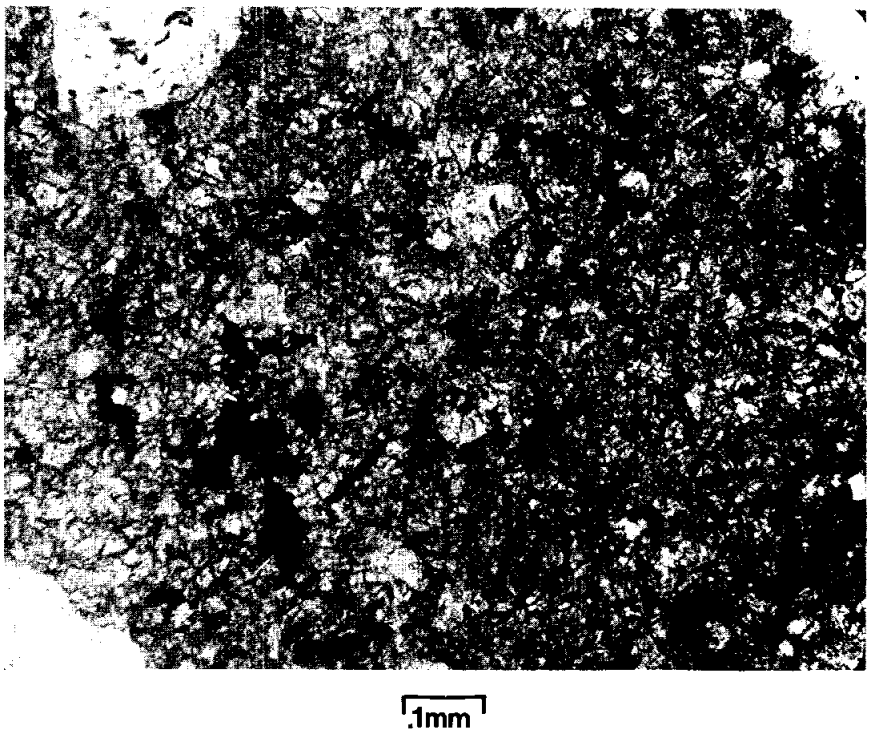
14264,5



PHYSICAL CHARACTERISTICS

Mass	Dimensions
117.8 g	5.0 x 4.5 x 4.0 cm

Sample 14264 is a dark gray, blocky, tough fragmental rock, described by Phinney *et al*. (1975) as a vitric (matrix) breccia.

SURFACE FEATURES

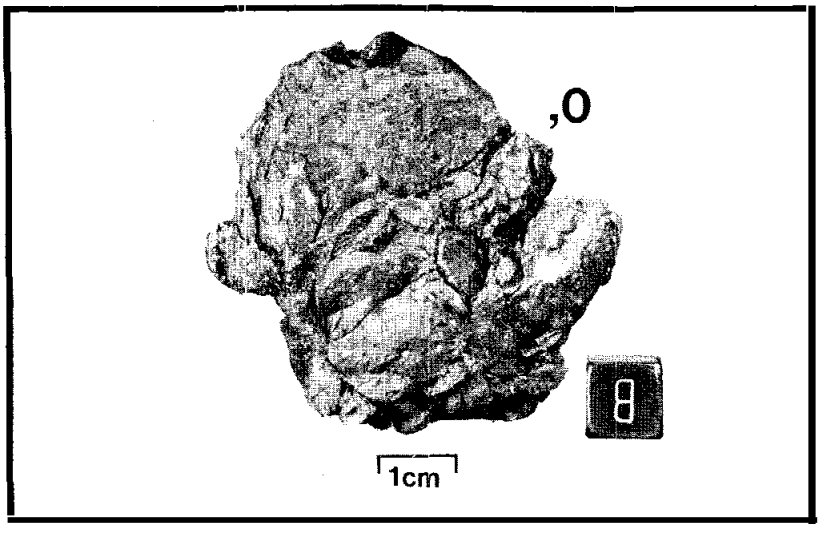
One surface is fresh and rough, but the older surfaces are smooth and contain zap pits. There are a few clusters of rounded cavities less than 1.0 mm in size making up less than 1% of the rock. The fresh surface has a few slit-like cavities. There are a few non-penetrative fractures.

PETROGRAPHIC DESCRIPTION

Dark gray aphanitic glassy material makes up 65-70% of the sample. Fragments present are of two types. Type I averages less than 5 mm and ranges up to 14 mm. These are lithic clasts which are very light gray and round and comprise 15% of the sample. Clasts contain equal portions of crushed white material (plagioclase) and crushed yellow-brown material in areas 0.5-1 mm across. There is also some scattered black opaque material 0.1-0.3 mm across present in these clasts. Type II are also lithic clasts. They are medium gray and subangular to subrounded in shape. These account for 15% of the sample and range from less than 1 mm up to 5 mm in size. Most are mottled light and dark gray. The dark gray areas seem somewhat vitreous.

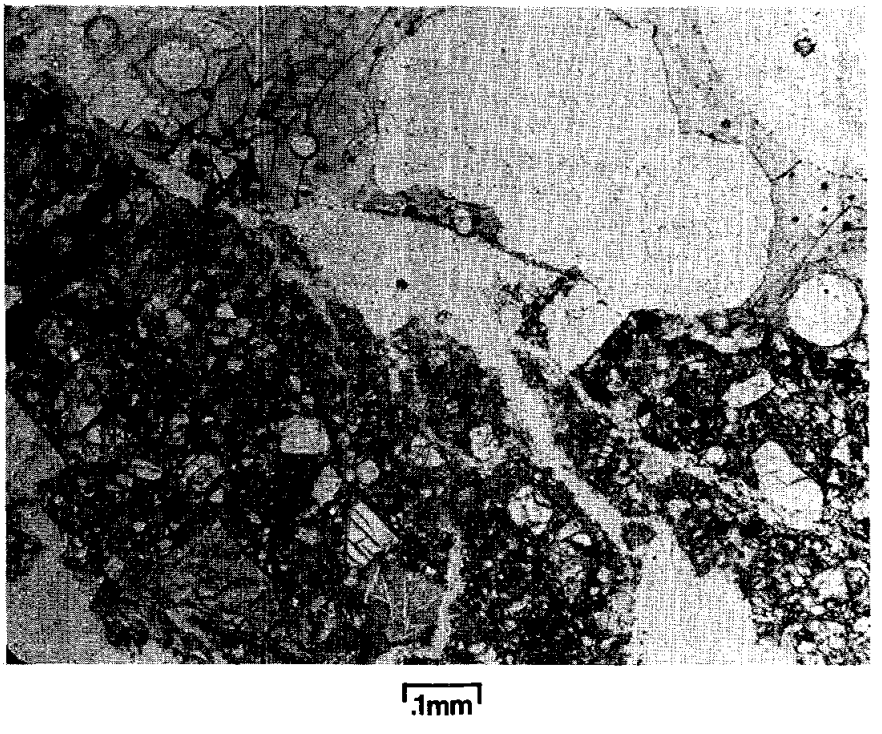
Thin section 14264,5 is composed of a holocrystalline mixture of pyroxene, abundant opaque grains and minor plagioclase. This section, therefore, must represent a crystalline clast from the described hand specimen. Some of the larger pyroxene crystals are polygranular. There is a suggestion of segregation in the section which may represent previous clasts and thus this rock may be a recrystallized glass or melt rock.

14265



S-71-29151

14265, 7



PHYSICAL CHARACTERISTICS

Mass	Dimensions
65.79 g	5.5 x 5.5 x 4.5 cm

The sample is angular, with half the surface coated with dark greenish gray to black glass. The rock is a medium dark gray, coherent fragmental rock.

SURFACE FEATURES

The surface of the rock is irregular and 50% glass-coated. Traces of what may have been glass linings of zap pits on the breccia suggest that some surfaces may have been pitted, but abrasion has removed most of the evidence of pitting. There are no pits on the glass. The glass is finely vesicular. Many penetrative fractures are present in the samples, some of which are filled with glass.

PETROGRAPHIC DESCRIPTION

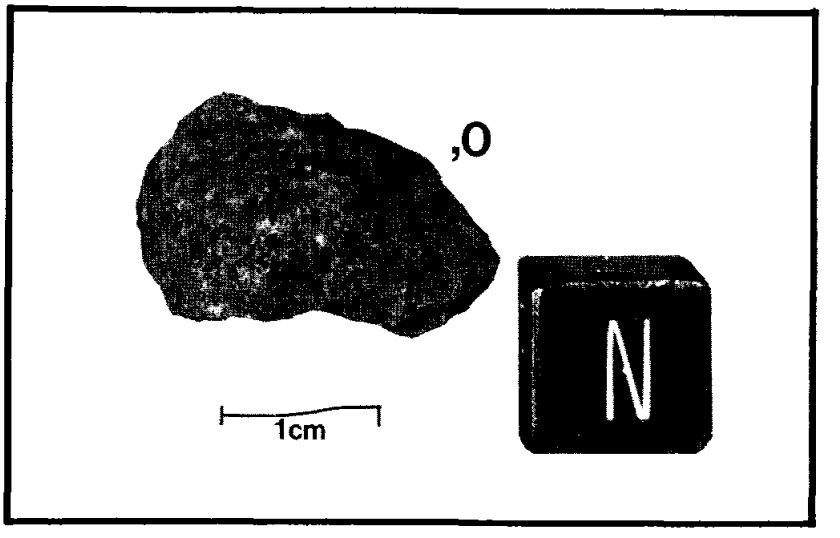
Eighty-five to ninety percent of the sample is a medium dark gray material less than 0.1 mm in size. It does not have the resinous luster of glass and may be aphanitic crystalline texture The remaining 10-15% of the sample is composed of two types of lithic fragments and two types of mineral fragments. Type I are very light gray lithic fragments and account for all but a couple percent of the remaining material. They are subangular to subrounded and are dominantly less than 0.1 mm in size, but range up to 3 mm in size. These lithic fragments contain various proportion of crushed white and gray material looks vitreous. The second type of lithic clast is medium light gray and is less than 1% of the sample. Grains are subrounded to subangular in shape and are less than 1.0 mm in size. These appear to be finely recrystallized material. The first type of mineral fragment is light yellow-green olivine occurring as subrounded grains making up less than 2% of the sample. The second type of mineral fragment is reddish brown, probably pyroxene and is subrounded in shape. It is less than 1% of the sample. Both types of mineral fragments are less than 1.0 mm in size.

Thin section 14265,7 is to a large extent composed of vesicular glass bonding small fragments of a polymict breccia. The glass shows only minor devitrification and is highly fractured. The vesicles are 0.1-0.2 mm in diameter. The glass is more or less continuous. The breccia part of the section has abundant glass in the matrix both as free fragments and as bonding material. The glass accounts for approximately 30% of the matrix. There are no clasts present and the largest fragments are glass. The remaining fragments are pyroxene, plagioclase, devitrified glass, and small pieces of microbreccia.

DISCUSSION

Sample 14265 is one of those investigated by Eldridge *et al*. (1972). Concentrations of K, Th, U, ^{26}Al, and ^{22}Na were determined by gamma-ray spectrometry.

14266



S-71-26356

PHYSICAL CHARACTERISTICS

Mass	Dimensions
6.95 g	2.0 x 2.0 x 1.0 cm

Sample 14266 is a light medium gray, rounded, slabby, tough, fragmental matrix, polymict breccia.

SURFACE FEATURES

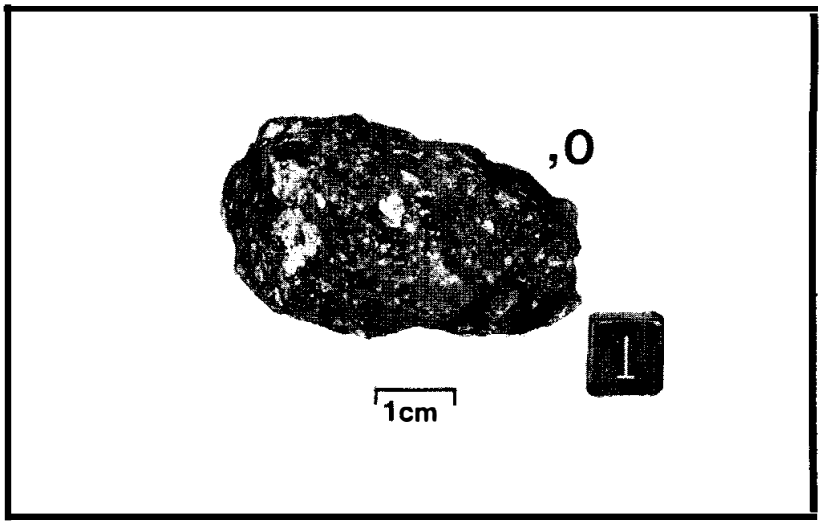
Glass lined zap pits up to 1 mm in diameter are present on all but one surface. The sample is smooth except on one side, which is hackly. There are very few non-penetrative fractures.

PETROGRAPHIC DESCRIPTION

The sample is homogeneous with a seriate texture. It is made up of 50 - 55% light gray material which has a sugary texture and appears to be a mixture of white and gray grains in the 0.1 - 0.2 mm size range. Gray lithic clasts from 1 - 3 mm in size make up 40% of the sample. These lithic clasts are subangular to subrounded and appear to be breccias with a gray aphanitic

matrix and a few small white fragments. There are three kinds of mineral fragments. The most abundant (5% of the sample) is white plagioclase grains in various degrees of crushing. One grain has a cleavage face approximately 1 mm across. The plagioclase grains are subangular to subrounded and range from less than 1.0 to 3.0 mm. Light green olivine grains are also present (< 1% of sample) and are subrounded in shape. Light brown pyroxene grains are subrounded and occur in less than 1% of the sample.

14267



S-71-29249

PHYSICAL CHARACTERISTICS

Mass	Dimensions
54.77 g	5.0 x 3.0 x 2.0 cm

Sample 14267 is a blocky, angular, dark gray, tough, vitric [matrix] breccia.

SURFACE FEATURES

Glass-lined zap pits up to 1.2 mm are present on all surfaces. The surface is irregular except for a discontinuous glass coating over 40% of the surface. The only cavities are in the glass coating. There are few non-penetrative fractures.

PETROGRAPHIC DESCRIPTION

The sample is homogeneous except for the frothy glass coating present on one surface. Fifty percent of the breccia appears to be dark gray aphanitic glassy material. Three types of lithic and 3 types of mineral fragments can be identified. White lithic fragments up to 10 mm in size compose 20% of the sample. They average 0.5 mm in size and are mostly angular, but some are

subrounded. These have a sugary texture with grain sizes from 0.1 - 0.2 mm; usually more than one mineral is present. A second type of lithic fragment is gray, with grain sizes up to 30 mm (dominately 0.5 mm). The third type of lithic clast is also gray, but is a 50:50 mixture of plagioclase and a pinkish brown mineral (spinel?). This clast is represented by only one subangular grain 2.0 mm in size.

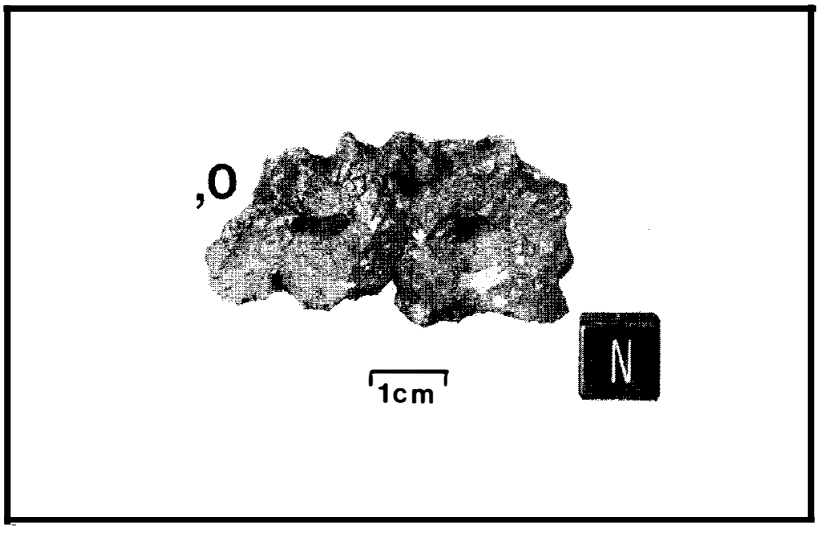
Mineral fragments make up less than 5% of the sample, the most abundant of which is white plagioclase in various degrees of crushing. Some contain small zones of vitreous gray material. Grains are subangular to subrounded and range from 0.1 to 0.3 mm in diameter. A second type of mineral fragment is light green olivine (?) up to 0.5 mm in size. These are subangular in shape. A light brown mineral fragment, also as large as 0.5 mm in size, occurs as subrounded fragments and is probably pyroxene.

DISCUSSION

Sample 14267 was classified as a coherent rock with light clasts (F_2) by Wilshire and Jackson (1972).

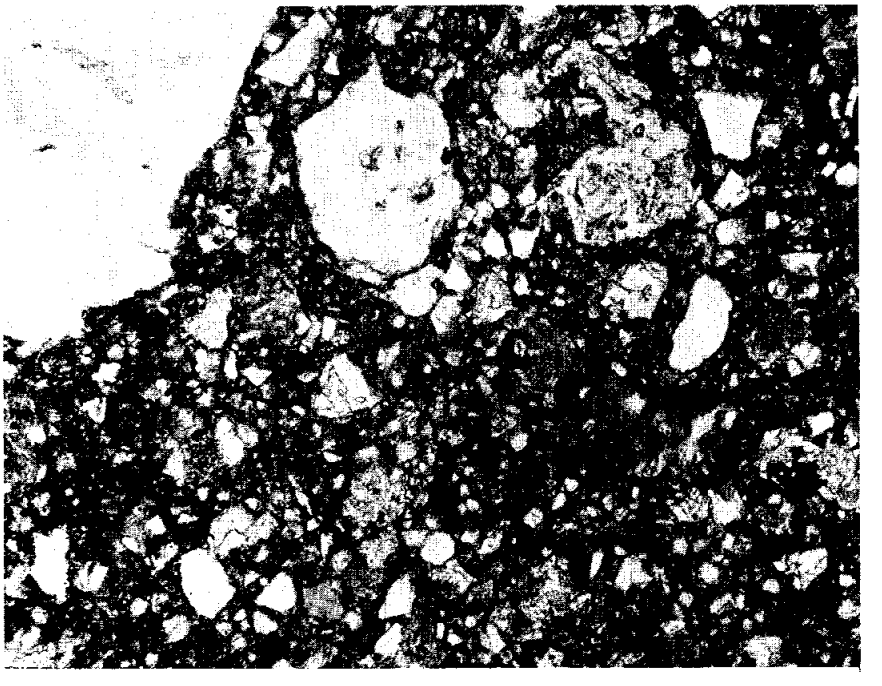
The European Consortium investigated this sample and determined its history on the basis of their studies on the bulk chemistry, mineralogy, petrology, cosmic ray tracks, noble gases, carbon chemistry, and optical polarization (Eglinton et al. 1974). They determined the age of formation to be 3.9 b.y. ago. It was produced by shock-induced lithification of soil grains. They found the temperature reached during compaction to be not in excess of 800°C. The metamorphic grade of the rock is described as Warner's grade 2. After formation, they determined that the rock was buried at a depth of at least two meters until it was ejected, probably by the Cone Crater event, approximately 30 m.y. ago.

14268



S-71-29172

14268, 3



PHYSICAL CHARACTERISTICS

Mass	Dimensions
23.12 g	4.5 x 1.5 x 3.0 cm

Sample 14268 is described by Phinney et al. (1975) as a blocky, medium dark gray, vitric [matrix] breccia.

SURFACE FEATURES

There is a vesicular glass coating over 30% of the sample surface. Few zap pits are present, occurring up to 0.2 mm in size on the glass coating. Approximately 50% of the glass coating is made up of rounded vesicles less than 1 mm across. Many penetrative fractures are present, with glass intruded into some of them.

PETROGRAPHIC DESCRIPTION

The rock is seriate in texture. The sample contains approximately 70% medium gray aphanitic material with a dark resinous luster (glass?). Twenty per cent of the sample is composed of very light gray, subangular to subrounded, lithic fragments which range from less than 0.2 to 7.0 mm in size. Plagioclase is 60 - 90% of these lithic fragments and the rest is unidentifiable light gray material. There are two other types of lithic fragments visible in the sample, both of which are round and composed of aphanitic material. One is medium gray and ranges up to 0.5 mm in size and the other is medium dark gray and ranges up to 0.8 mm in size. Each makes up 5% of the sample. Two types of mineral fragments can be seen, one white, subrounded fragment composed of plagioclase, and the other light yellow brown, subrounded pyroxene (?). Both are less than 1 mm in size and make up less than 1% of the sample.

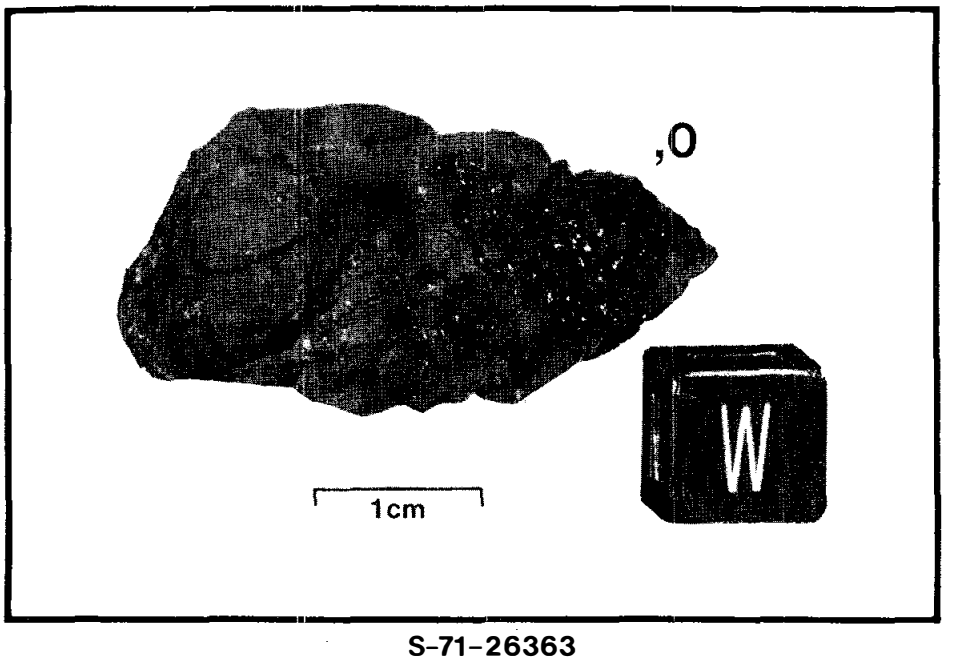
Thin section 14268,3 contains brownish "glass" in the matrix (< 1 mm). The "glass" is fairly evenly distributed and forms approximately 50% of the total matrix. There are numerous masses of clear glass which are hemispherical to ovoid in shape. A fracture which occurs in the section is glass-lined and the glass extends to the outer surface.

There are only three clasts present in the section. Two of the clasts (> 1 mm) consist of a devitrified glass in which the crystallites are so small their exact identification could not be made. A few residual eroded crystals of plagioclase are included in the masses. One of the clasts contains crystallites that are much more dendritic in habit than in the other clast.

The third clast consists of a large, shocked pyroxene in a matrix of pyroxene, plagioclase and glass. The crystal is highly deformed and shows some reaction with the matrix.

The matrix (< 1 mm) has a seriate mixture of mineral and lithic fragments. Most of the lithic fragments are composed of devitrified glass, many showing dendritic crystals. There are a few small basalt-like masses which have maskelynite pseudomorphic after plagioclase. This gives the grain a nearly "barred" appearance under cross-nichols. The mineral fragments are approximately 2/3 pyroxene and 1/3 plagioclase.

14269



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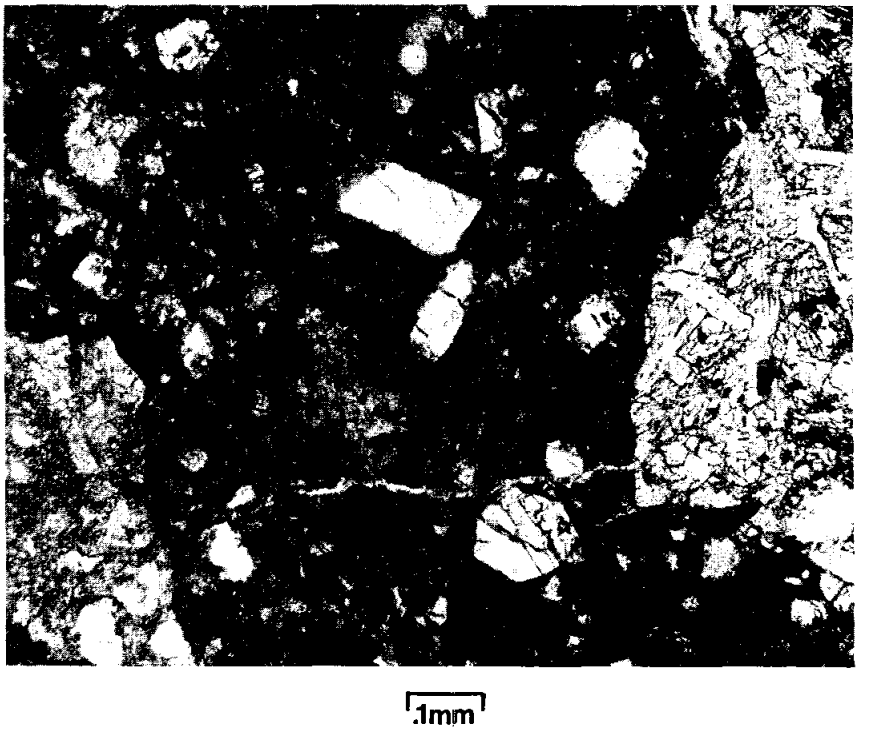
14269, 4



PHYSICAL CHARACTERISTICS

Mass	Dimensions
17.19 g	4.0 x 2.5 x 3.0 cm

Sample 14269 is a dark medium gray, fragmental microbreccia with one rounded side.

SURFACE FEATURES

Glass coating covers 20% of the surface. Glass lined zap pits up to 0.3 mm in diameter occur on the rounded side of the breccia and are present but sparsely distributed on the glass coating. Numerous penetrative fractures are present with glass veins occurring along several fractures.

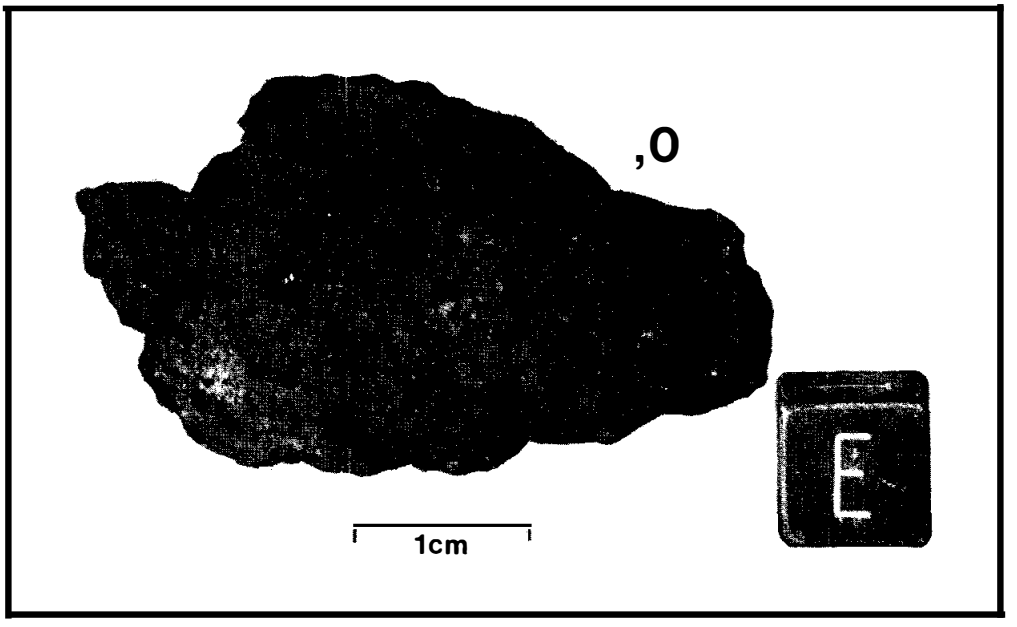
PETROGRAPHIC DESCRIPTION

The sample has a seriate texture with no fragments as large as 1.0 mm. Seventy-five percent of the sample is dark medium gray, aphanitic material. Twenty percent is composed of very light gray, lithic fragments that are subround to subangular in shape. These have a fine, crushed appearance with about 60% feldspar and 40% mafic minerals. Another type of lithic clast is medium light gray and is a 50:50 mixture of gray and white material giving a salt and pepper appearance to these grains. These are 4 - 5% of the sample. One grain of what looks like feldspar coated with rust is present. It is pale orange in color, irregular in shape, and 0.5 mm in size.

This sample appears to be intermediate in color and coherence between vitric and fragmental, friable microbreccias (soil breccias) Phinney et al. (1975).

Thin section 14269,4 shows the rock to be a glass-rich breccia with 10 - 20% "glass" in the groundmass. One clast is present in the section. The clast is a crystalline rock which appears to be most like a melt rock. The plagioclase and pyroxene are not well formed and it lacks a typical igneous texture. Numerous glass shards, many containing mineral fragments and some partly devitrified, are scattered throughout the section. Fragments of microbreccia, shocked plagioclase, pyroxene and devitrified glass comprise the remainder of the fragments in the matrix.

14270



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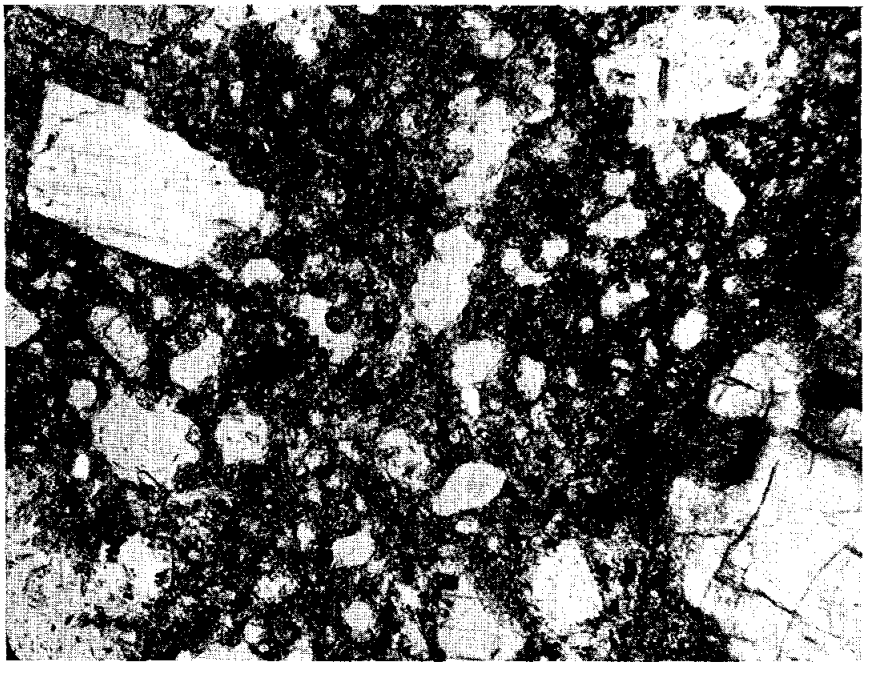
14270,8



PHYSICAL CHARACTERISTICS

Mass	Dimensions
25.59 g	4.0 x 2.8 x 2.0 cm

Sample 14270 is a blocky, medium greenish gray fine-grained crystalline breccia.

SURFACE FEATURES

Some glass-lined zap pits averaging 0.5 mm in diameter are present over most of the rock surface. Smooth, spherical to irregular vugs as large as 2.0 mm in diameter make up 5-10% of the rock. There are also a few slit-like cavities 0.1 x 3.0 mm in size present on the surface. Few, non-penetrative fractures are present.

PETROGRAPHIC DESCRIPTION

The rock is 95% medium greenish gray material less than 0.1 mm in size which has a sugary texture with light and dark patches. Light gray fragments 0.1 to 1.5 mm in size make up the other 5% of the sample. These are subrounded and slightly less than half of these have a vitreous luster and could be shocked plagioclase. The rest is aphanitic. Clasts generally have reaction rims.

Thin Section 14270,8 is composed of a seriate mixture of lithic and mineral fragments with widely scattered fine-grained, dark, microbreccia clasts. A couple of crystalline microbreccia clasts are also present. There is a patch of partly devitrified glass with wormy crystallites. The remainder of the matrix appears to be glass free. Lithic fragments include microbreccia, crystalline rocks composed of plagioclase and pyroxene, plagioclase rich microbreccias, and devitrified glass. The mineral fragments include isolated opaque grains, large and small plagioclase and pyroxene grains, and occasional spinel grains. Lithics account for approximately 20% of the fragments.

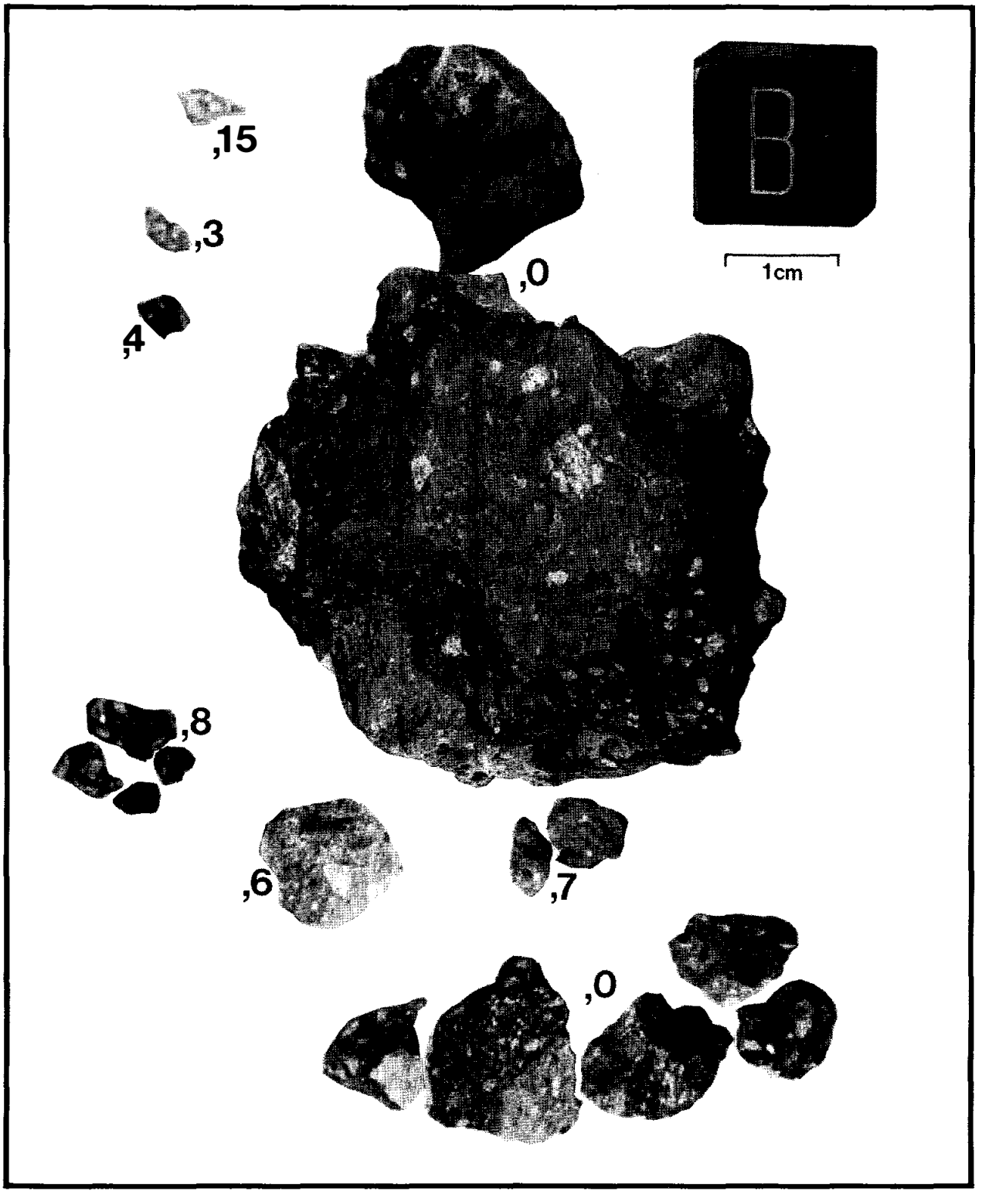
DISCUSSION

Lindstrom *et al*. (1972) investigated the compositional characteristics of various Apollo 14 clastic materials, including sample 14270. They describe it as lacking distinguishable clasts and noted that 14270,1 matches the composition of average microbreccia - 3 clasts from 14321,184, and is different from 14270,2,3,4, and ,5 in composition.

Warner (1972) found sample 14270 to be strongly annealed and grouped it in his high grade metamorphic (7) category. Wilshire and Jackson (1972) classify it as being coherent, with dark clasts (F_4). Chao et al, (1972) list it as being strongly annealed, but unshocked (2c), and Simonds et al. (1977) describe it as being a crystalline matrix breccia (CMB).

It was found to have an ^{40}Ar-^{39}Ar gas retention age of 3.89 ± 0.05 b. y. by Alexander and Kahl (1974).

14271



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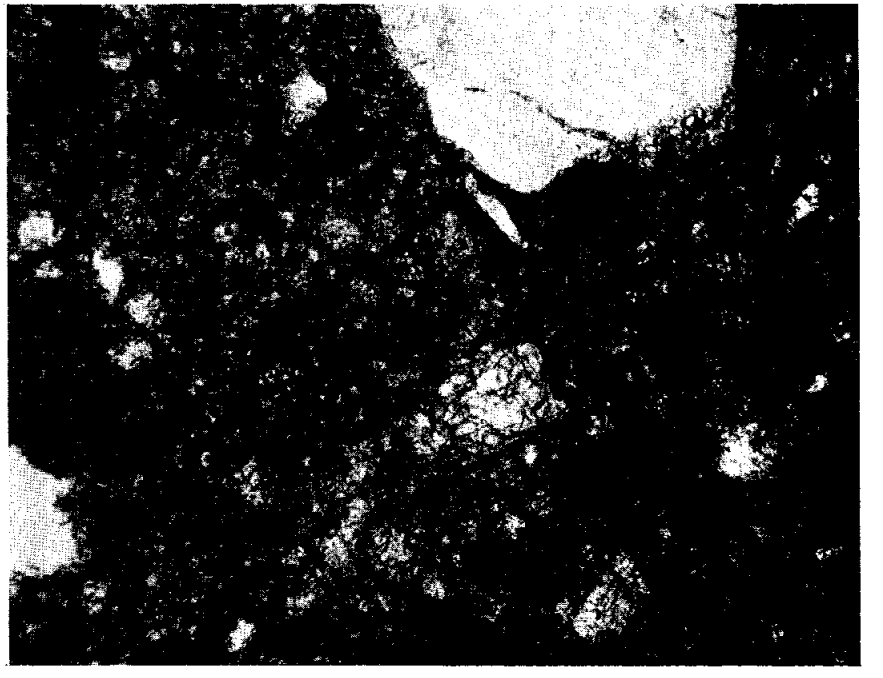
14271, 10



.1mm

PHYSICAL CHARACTERISTICS

Mass	Dimensions
97.41 g	5.0 x 4.7 x 3.0 cm

Sample 14271 is a blocky, dark medium vitric [matrix] breccia with light gray clasts.

SURFACE FEATURES

Sample 14271 has one rounded side with many pits as large as 2 mm in diameter, with very few pits on the angular surfaces. Some penetrative and some non-penetrative fractures are present.

PETROGRAPHIC DESCRIPTION

Sample 14271 has a coarse texture and is coherent. It is composed of 40% dark medium gray vitreous or glassy-appearing matrix and 60% clasts. Thirty-five percent of the lithic fragments 47 x 40 mm and 30 x 25 mm respectively, in size. These two clasts appear to be the same petrologically. Both are breccias with 90% light gray matrix with sugary texture that is a mixture

of 0.1 mm white and gray grains. Fifteen percent of the sample is represented by light gray lithic clasts as large as 5 mm. These are angular to rounded in shape and consist of a finely brecciated mixture of white and brownish gray material. A third type of lithic clast is subrounded and light gray. These are large as 30 x 10 mm in size and consist of crushed zones of plagioclase and mafic minerals. Zones are approximately 1.0 mm across and have a sugary texture. A fourth type of lithic clast is represented by 1 subrounded clast 2 mm in size composed of reddish brown spinels and plagioclase in a 50:50 mixture. Veins of matrix partially penetrate the large clasts.

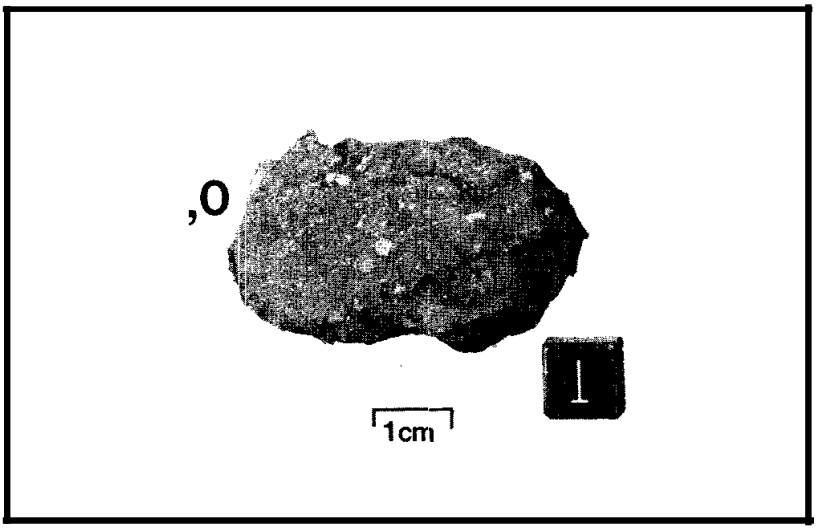
Thin section 14271,10 must be a section of one of the clast types described as the matrix appears to be holocrystalline and there are no clasts present in the section. Very few large fragments are found in the matrix. Those present are shocked pyroxene crystals and what appears to be devitrified plagioclase-rich glass. The later fragments are poorly formed but contain abundant plagioclase crystallites.

DISCUSSION

Sample 14271 was described as being coherent with light clasts by Wilshire and Jackson (1972) and placed in their F_2 category. More recently, Simonds *et al*. (1977) list it as a vitric matrix breccia (VMB).

This was one of the samples analyzed by Eldridge *et al*. (1972) for K, Th, U, ^{26}Al, and ^{22}Na.

14272



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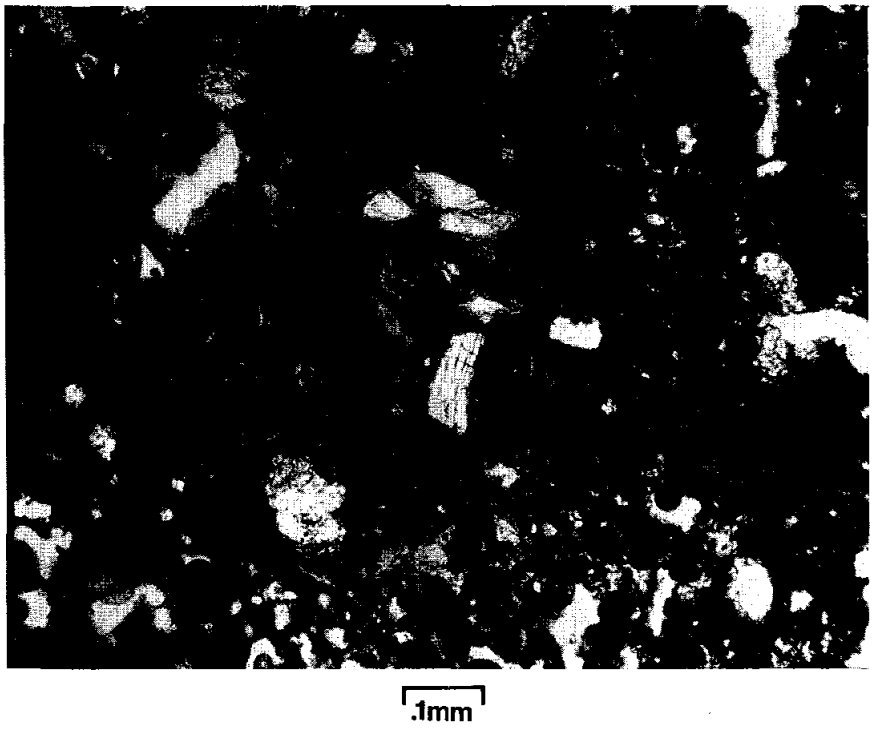
14272, 6



PHYSICAL CHARACTERISTICS

Mass	Dimensions
46.63 g	4.5 x 3.5 x 2.5 cm

Sample 14272 is a blocky medium dark gray coherent vitric (matrix) breccia.

SURFACE FEATURES

More than 30% of the surface is covered with a dark gray glass coating. Glass lined zap pits up to 0.5 mm occur on one side. None is present on the glass or elsewhere. The glass is composed of 30% vesicles 0.5 mm in diameter.

PETROGRAPHIC DESCRIPTION

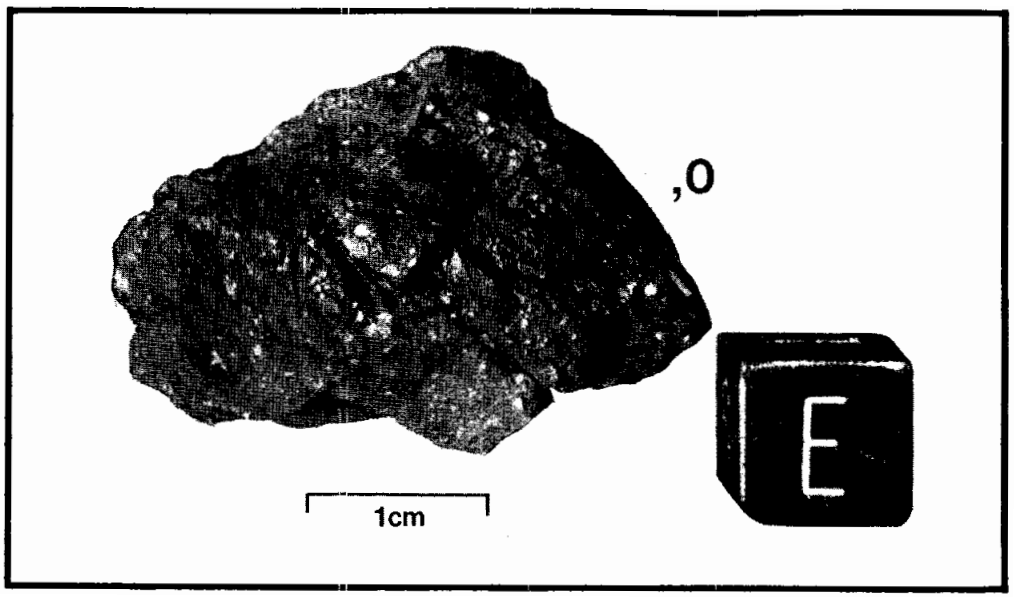
Seventy percent of the sample is composed of medium dark gray aphanitic vitreous or glassy material. Twenty-five to thirty percent is composed of lithic fragments which are dominately less than 1 mm but are as large as 20 mm in size. They are angular to subrounded very light gray fragments. They consist of fine-grained mixtures of 60-70% white plagioclase and two light colored mafic minerals. A second type of lithic clast is light gray in color and subrounded ranging up to 1.0 mm in size. It makes up less than 1% of the sample and is composed of equigranular 0.1 mm material. Light green olivine is present in subangular to subrounded grains less than 1.0 mm in size. These make up less than 1% of the sample.

Thin section 14272,6 is composed of a glass-rich matrix with a thick vesicular glass coating on all sides. The coating is full of holes and discontinuous in thin section. The inner matrix has approximately 50% turbid brownish "glassy" material cementing the few clasts (> 1 mm) and the matrix fragments. The only clast present in the thin section was a fine-grained microbreccia with some large pyroxene crystals which are highly shocked. Almost all the mineral fragments seen in the thin section are pyroxene shards with minor olivine and plagioclase.

DISCUSSION

Sample 14272 was examined by Wilshire and Jackson (1972) and classified as being coherent with light clasts (F_2). It was analyzed for K, Th, U, ^{26}Al, and ^{22}Na by Eldridge *et al*. (1972).

14273



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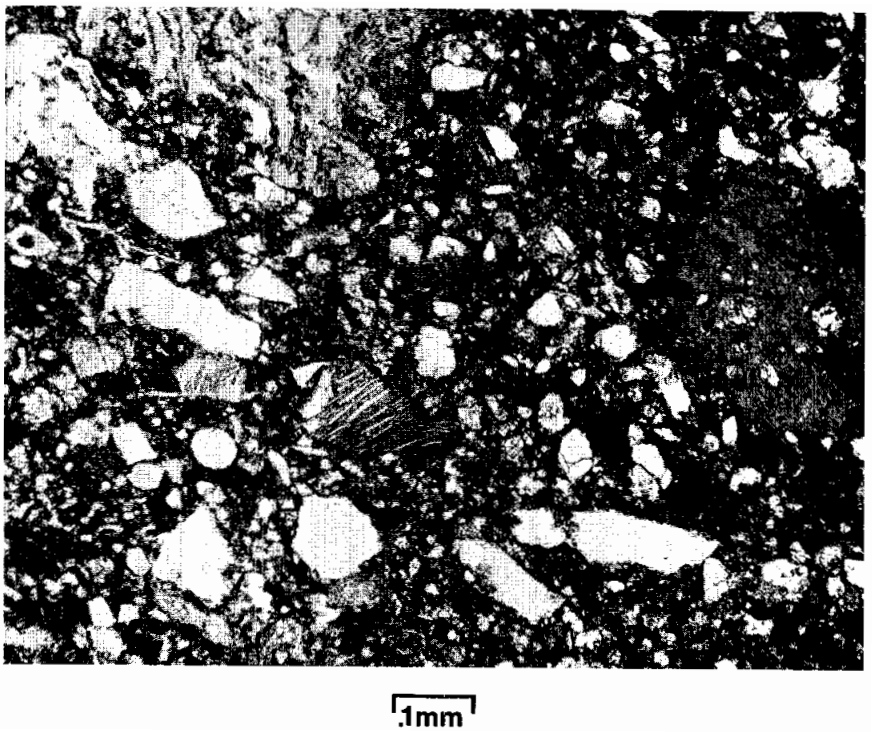
14273,4



PHYSICAL CHARACTERISTICS

Mass	Dimensions
22.4 g	3.5 x 3.0 x 2.0 cm

Sample 14273 is a medium dark gray, vitric (matrix) breccia.

SURFACE FEATURES

The irregular surface is 20% covered with dark gray vesicular glass. No distinct pits are visible but there may be a few small ones. Vesicles in the glass coating are less than 1 mm and occupy 30% of the glass. There are some non-penetrative fractures present.

PETROGRAPHIC DESCRIPTION

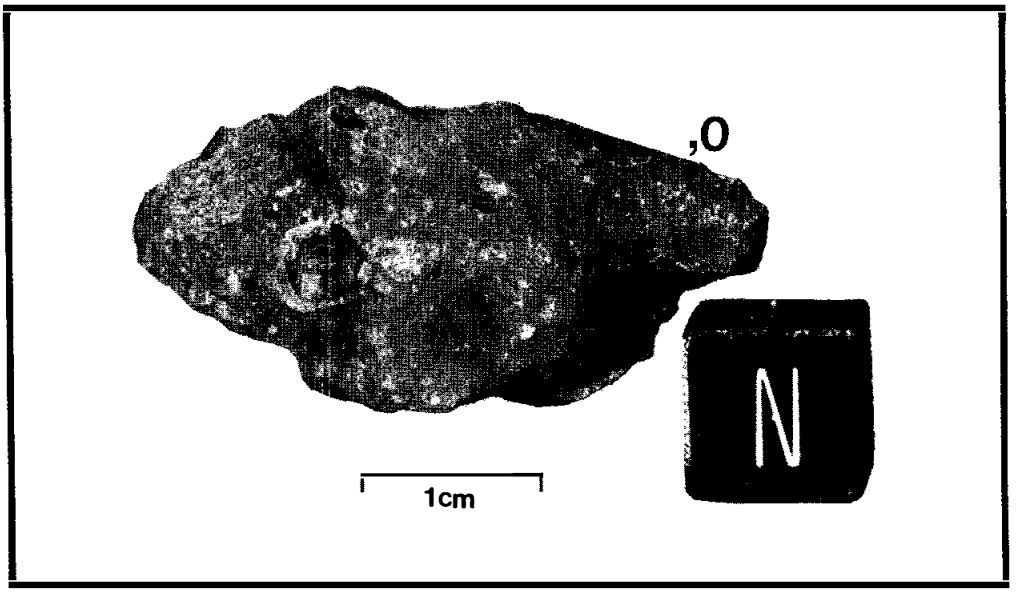
Sample 14273 has a seriate texture and is coherent. Seventy percent of the sample is medium dark gray, aphanitic, vitreous material. Twenty-five to thirty percent of the sample consists of very light gray, angular to subrounded, lithic clasts up to 10 mm in size. These fragments are, however, mostly less than 1 mm in size. They are composed of a fine-grained mixture of 60-70% white plagioclase and two light colored mafic minerals. Some light gray subrounded lithic fragments are present ranging up to 1 mm in size. These are equigranular with 0.1 mm grains. Light green olivine mineral fragments smaller than 1.0 mm are present and are subangular to subrounded in shape.

Thin section 14273,4 shows that this rock is similar to 14277 except for having a much larger lithic clast content. The matrix is glass-rich and there are abundant spheres and masses of glass throughout the section. The matrix mineral fragments are approximately 1/3 plagioclase and 2/3 pyroxene fragments, all of which are shocked and fractured. The thin section shows that most of the lithic clasts are devitrified glass and highly shocked and granulated plagioclase-rich rocks with some pyroxene.

DISCUSSION

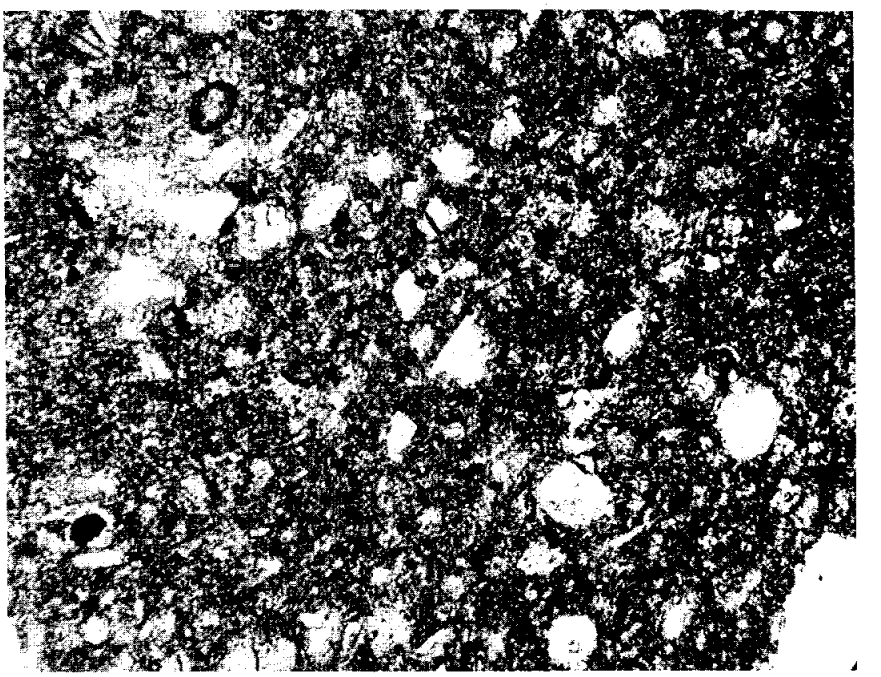
Sample 14273 is one of those studied by Wilshire and Jackson (1972), who classified it as belonging to their F_2 category (friable with light clasts). It was also studied by Eldridge et al. (1972), who analyzed it for K, Th, U, ^{26}Al, and ^{22}Na.

14274



S-71-26622

14274,4



PHYSICAL CHARACTERISTICS

Mass	Dimensions
15.18 g	3.0 x 2.5 x 1.5 cm

Sample 14274 is a light medium gray, blocky, tough, crystalline, polymict breccia.

SURFACE FEATURES

The surface is 50% smooth and 50% rough, with many glass-lined pits as large as 1 mm on rounded surfaces and very few on others. There are a few rounded vesicles 1 - 2 mm across and a few 0.1 to 0.2 mm irregularly shaped vugs making up less than 1% of the rock. The sample has numerous non-penetrative fractures.

PETROGRAPHIC DESCRIPTION

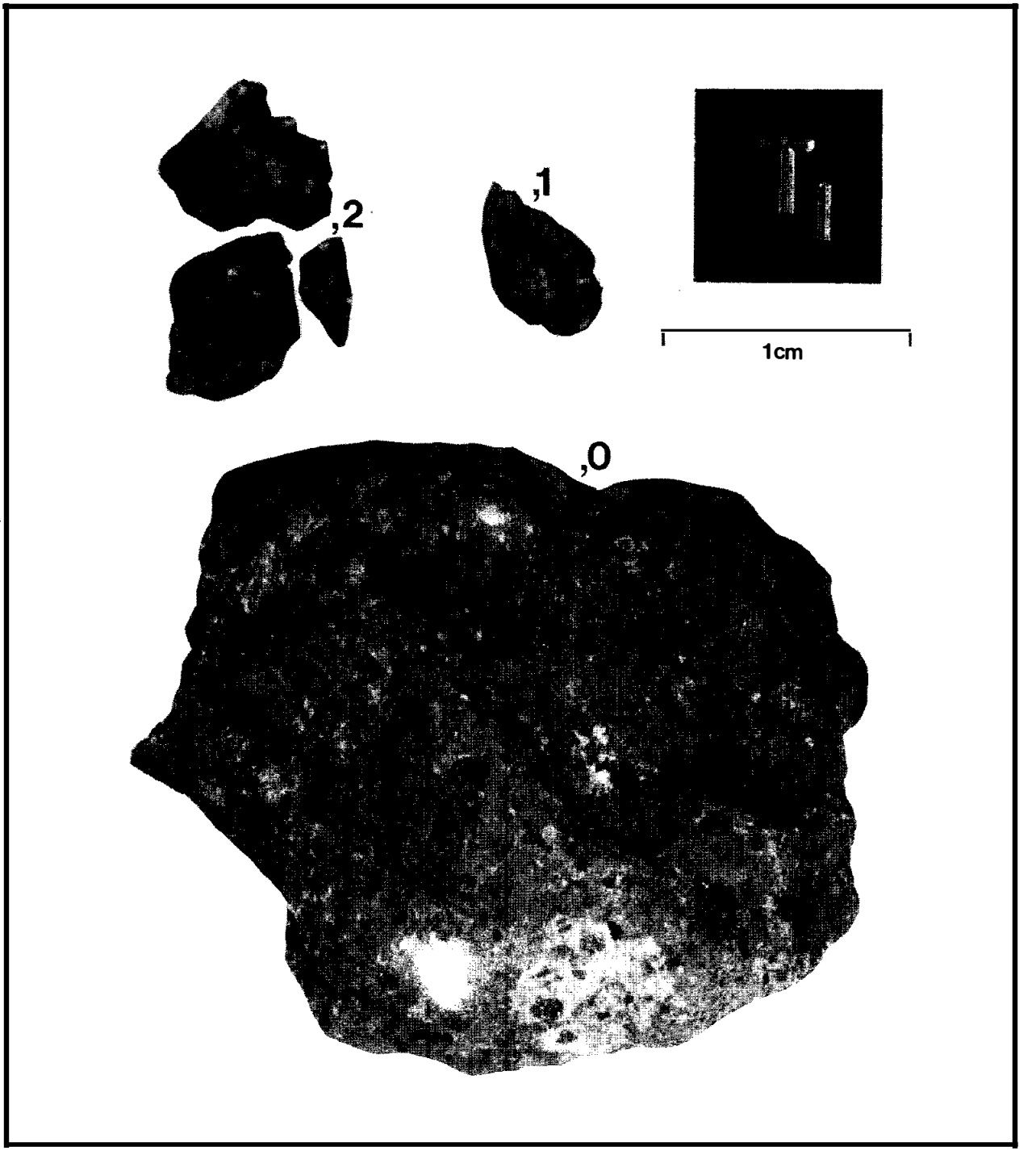
Sample 14274 is coherent and seriate in texture. It is composed of 85% light medium gray material with a sugary texture less than 0.1 mm in size; < 5% very light gray, subrounded, lithic clasts up to 2 mm in size; 10% white, subrounded, plagioclase fragment in various degrees of crushing up to 1 mm in size; less than 5% somewhat crushed, light green, subrounded material up to 1 mm in size; and 1 grain of a light brown, mineral fragment 0.9 mm in size which is subrounded and composed of crushed 0.1 mm grain. The lithic clasts are composed of a 50:50 mixture of fine-grained plagioclase and a light green material.

Thin section 14274,4 contains a seriate mixture of mineral fragments with no visible glass in the matrix. The only clast present is a large single crystal of plagioclase. There are numerous small, opaque grains in the matrix. There are scarce lithic fragments in the matrix. The only type represented is a granulitic mass of pyroxene and plagioclase. Minor devitrified glass is also present. The remainder of the large fragments are mostly pyroxene. There are minor spinel crystals also in the matrix.

DISCUSSION

Sample 14274 is listed as a crystalline rock by Wilshire and Jackson (1972) and as a crystalline matrix breccia (CMB) by Simonds *et al*. (1977).

14275



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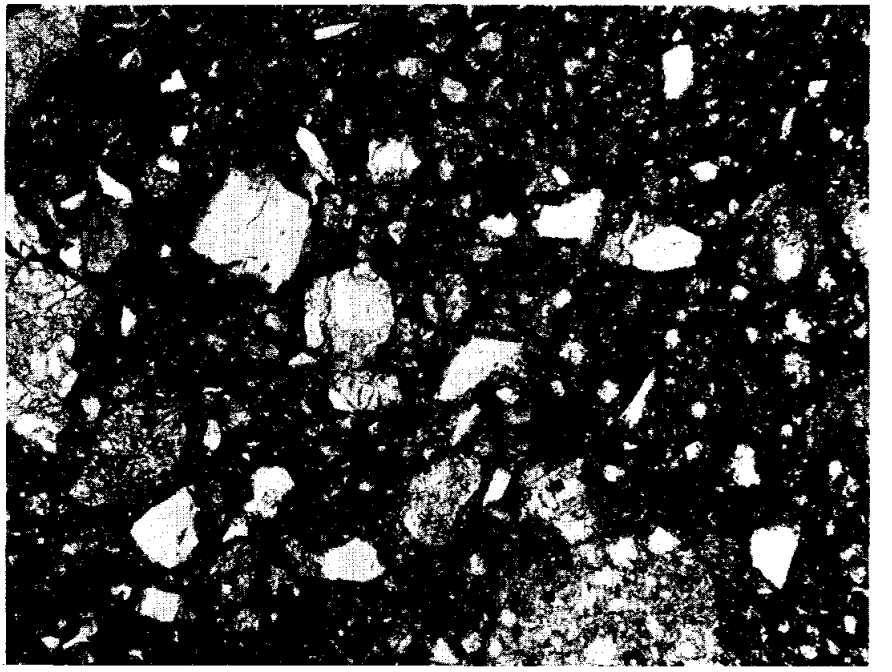
14275,4



1mm

PHYSICAL CHARACTERISTICS

Mass	Dimensions
12.46 g	1.2 x 1.2 x 3.1 cm

Sample 14275 is a medium light gray, blocky, polymict breccia.

SURFACE FEATURES

Glass-lined pits up to 2.0 mm in diameter occur over most of the rock surface. There are a few non-penetrative fractures.

PETROGRAPHIC DESCRIPTION

Sample 14275 is a medium light gray, blocky, coherent, low-grade, polymict breccia with a homogeneous texture. Sixty-five to seventy percent of the sample is medium light gray fragmental material which is partially recrystallized. It appears to be a mixture of mostly plagioclase and at least two mafic minerals. This material is smaller than 0.2 mm. Twenty percent of the sample consists of very light gray, subangular to subrounded, lithic clasts up to 6 mm in size composed of crushed mixtures of plagioclase and mafic material. Some are mostly crushed plagioclase. A second type of

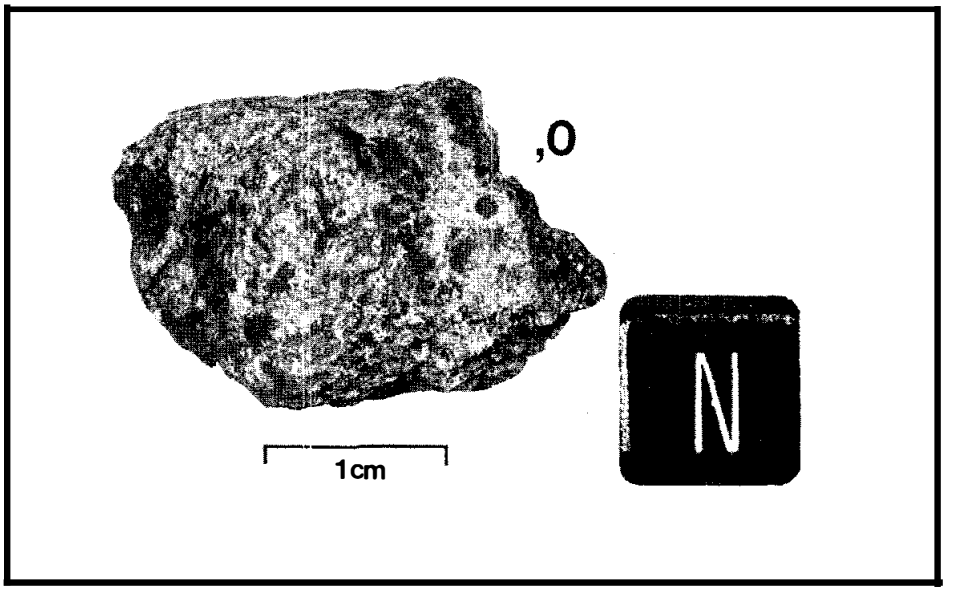
lithic clast making up less than 5% of the sample is subangular to subround in shape, dark gray in color, and up to 2.0 mm in size. These are composed of very fine grained material, some with white specks. The third type of lithic clast is medium gray, subrounded, and as large as 4.0 mm in size. These are mixtures of gray and white material. The gray is partly vitreous. It could contain mixtures of crushed and melted plagioclase. White mineral fragments are subangular to subrounded plagioclase grains in various stages of crushing. Black mineral fragments are subangular, probably pyroxene. Some show cleavage faces.

Thin section 14275,4 shows a glassy breccia with approximately 10% glass in the ground mass. The matrix also contains numerous orange to reddish orange spheres of glass as well as colorless shards of glass. There are no clasts present in the section. The fragments in the matrix consist of fine-grained microbreccia with pyroxene and olivine fragments, fine-grained opaque material, plagioclase and pyroxene crystal fragments and devitrified glass masses. One unusual feature is a sphere of a microbreccia with a small glass rim. There appears to be no glass in the sphere as the matrix is very crystalline. It does not appear to be a devitrified product.

DISCUSSION

Sample 14275 was studied by Wilshire and Jackson (1972) and classified by them as an F_2. Simonds *et al*. (1977) list it as a vitric matrix breccia (VMB).

14276



S-71-26626

14276,14

PHYSICAL CHARACTERISTICS

Mass	Dimensions
12.75 g	3.0 x 2.2 x 2.0 cm

Sample 14276 is a brownish-gray, blocky, coherent, medium-grained, crystalline rock.

SURFACE FEATURES

Few zap pits are present. Irregularly shaped vugs from 0.2 to 1 mm make up 10% of the rock. Some penetrative fractures are present.

PETROGRAPHIC DESCRIPTION

Sample 14276 is a blocky, subrounded, coherent, crystalline rock. It is medium-grained and homogeneous in texture. White to clear plagioclase is 60 - 65% of the sample. It occurs as laths up to 0.5 mm in sizes and in ellipsoidal areas up to 2.0 mm in size which contain crushed equigranular grains smaller than 0.1 mm in size. Fifteen percent of the sample is a light yellow-brown mafic mineral which occurs as subhedral equant grains 0.2 - 0.4 mm in size and in ellipsoidal areas up to 3.0 mm in size. The mineral is probably pyroxene in two distinct morphologies. The ellipsoidal areas contain crushed equigranular grains. A light yellow-green euhedral mineral up to 0.3 mm in size, probably olivine, is less than 1% of the sample. A brown mafic mineral, probably euhedral pyroxene, is 5 - 10% of the sample. An anhedral, slightly gray, mafic mineral is 10% of the sample, and 1 - 2% is black opaque, probably ilmenite.

Thin section 14276,14 shows a plagioclase-rich crystalline rock with small anhedral masses of pyroxene between the blades of plagioclase in a diabasic-like texture. There are at least two and perhaps three generations of plagioclase present. The rock is approximately 70% plagioclase and 30% pyroxene. Small to large patches of opaque crystals are scattered throughout the section.

DISCUSSION

Sample 14276 is listed as a basalt by Wilshire and Jackson (1972) and as a melt rock by Simonds *et al*. (1977).

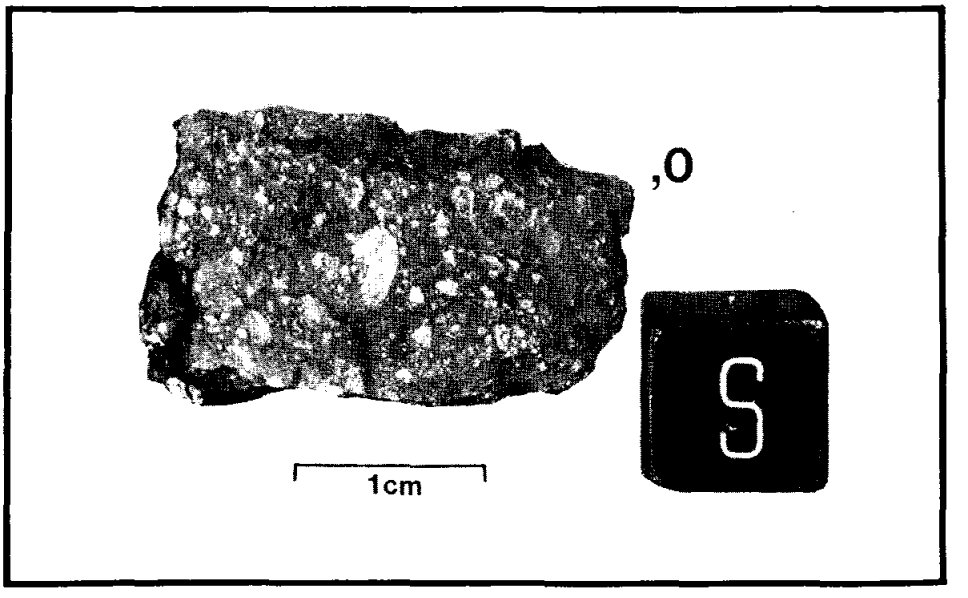
Wasserburg and Papanastassiou (1971) described sample 14276 as closely resembling sample 14310 in thin section. The age they determined for this sample is in exact agreement with ages obtained on samples 14310, 14073, and 14001,7, which are described as having similarly high Rb/Sr. This age was determined to be 3.88 ± 0.04 billion years before the present, and is distinct from the 3.95 ± 0.03 b.y.b.p. obtained for basalt 14053 and a basaltic clast from sample 14321 (Papanastassiou and Wasserburg, 1971). These data were interpreted by Wasserburg and Papanastassiou (1971) as indicating that Mare Imbrium was excavated between 3.88 and 3.71 billion years ago, if the

Fra Mauro Formation represents an ejecta blanket from this excavation. If the Apollo 14 samples are, instead, breccias produced in localized lava pools overlying the Fra Mauro Formation, then Mare Imbrium must have been formed before 3.95 billion years ago.

Gancarz et al. (1972) described sample 14276 in order to compare it and sample 14310 with sample 68415, which is texturally similar to 14276 and 14310. They studied section 14276,13, which consists of a subophitic, intergranular to interstitial basalt composed of 65% plagioclase, 33% pyroxene, 2% opaque minerals (mostly ilmenite), and 4% mesostasis containing glass and other minor phases. The texture is unlike that of Apollo 11 and 12 basalts and also unlike that of sample 14053. Gancarz et al. (1972) further describe the sample as consisting of 0.5 mm long, euhedral, plagioclase laths which form an interlocking framework with anhedral pyroxene grains and mesostasis in the interstices. Phenocrysts exhibit an optical discontinuity and a reversal in composition. Phenocryst rims are zoned to more Ab-rich compositions (i.e., An_{74} vs. An_{87}). Individual pyroxene grains are described as consisting of a low birefringent orthopyroxene core surrounded by higher birefringent clinopyroxene which displays a weak mosaic structure.

Gancarz et al. (1972) conclude, on the basis of the observed differences between these so called feldspathic basalts, and mare basalts, that there are two generations of plagioclase, the earlier of which was cumulate in origin and suggested that this type of basalt may form by impact melting of regolith. Simonds et al. (1977) adhere to this theory and call these basalts "melt rocks" and "clast-free impact melts."

14277



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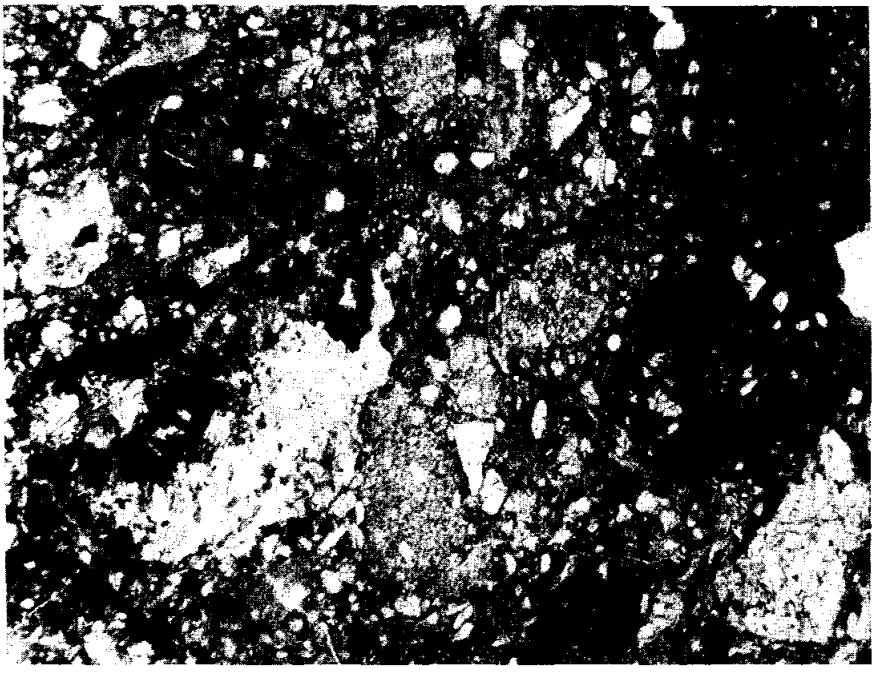
14277, 5



PHYSICAL CHARACTERISTICS

Mass	Dimensions
7.59 g	1.2 x 1.7 x 2.5 cm

Sample 14277 is a dark gray, blocky, coherent vitric [matrix] breccia.

SURFACE FEATURES

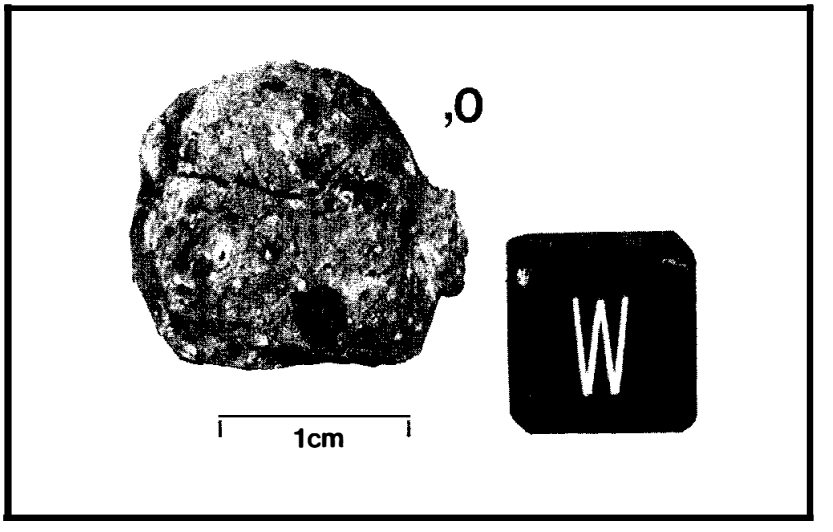
Few pits are present. They occur only on one side and two ends. There are few non-penetrative fractures. A few veins of black vesicular glass is present in some fractures.

PETROGRAPHIC DESCRIPTION

Sample 14277 is a dark gray, coherent, seriate textured breccia. The matrix is dark gray, aphanitic, vitreous material and is 65 - 70% of the rock. Twenty-five to thirty percent is composed of very light gray, subangular to subrounded, lithic clasts that are dominantly 1.0 mm in size, but are as large as 4 mm in diameter. These consist of a crushed mixture of plagioclase and gray material. There are scattered specks of a black, opaque mineral present in these clasts. A second type of lithic clast is medium gray, subangular to subrounded and range up to 2 mm in size. These fragments are dominately smaller than 1.0 mm in size and, in all, comprise 5 - 10% of the sample. Thin section analysis shows the lithic fragments to be primarily devitrified glass and fine-grained microbreccias. Approximately 10% of the matrix is lithic and 90% mineral fragments and glass. There are abundant glass droplets scattered throughout the matrix. They are composed of very fine grained material which is probably annealed.

Thin section 14277,5 shows the rock to be a glass-rich breccia with approximately 40% yellow-brown glass in the matrix (< 1 mm). There are a few chondrule-like bodies present but clasts (> 1 mm) are rare. The one present in this section is a breccia with minor glass in the matrix and composed of deformed crystals of pyroxene with minor plagioclase. There are scattered vugs which are elongate and vary from 0.4 to 0.2 mm in length and 0.1 mm in width.

14278



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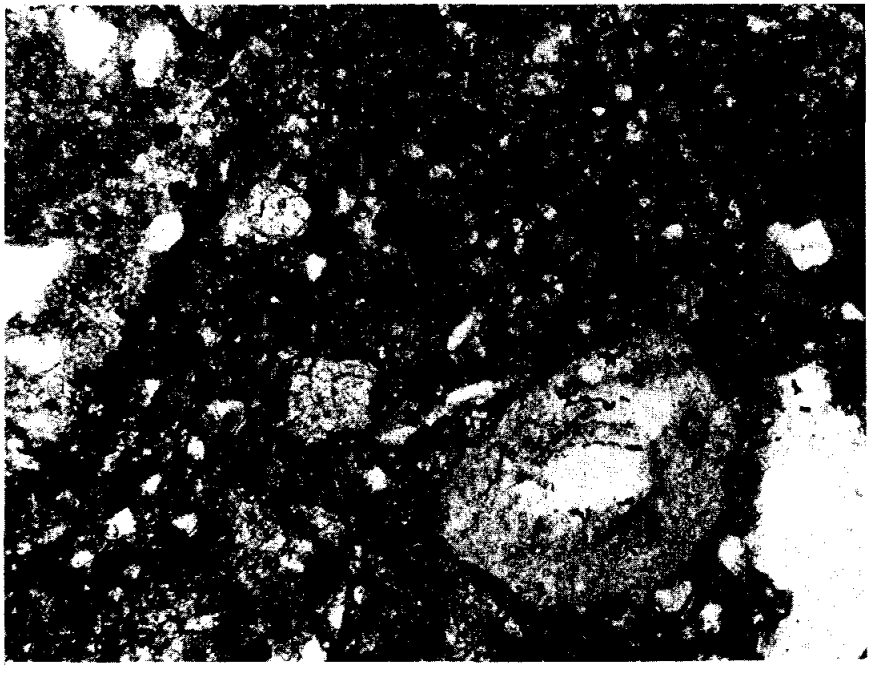
14278,4



PHYSICAL CHARACTERISTICS

Mass	Dimensions
7.60 g	1.5 x 3.0 x 1.5 cm

Sample 14278 is a medium light gray, subrounded, coherent, low-grade, polymict breccia.

SURFACE FEATURES

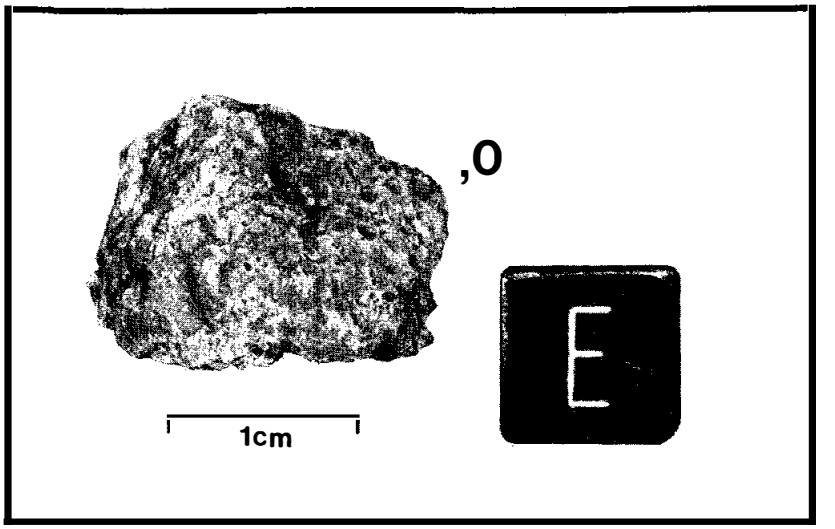
Glass-lined zap pits, 0.5 to 2.0 mm in diameter, occur on most surfaces. There is one irregular, fresh surface which contains no zap pits. Few non-penetrative fractures are present.

PETROGRAPHIC DESCRIPTION

Seventy-five percent of the sample is medium light gray, fragmented material which is a mixture of mostly plagioclase and at least two mafic minerals. These are partially recrystallized, and are less than 0.2 mm in size. The most abundant fragments are light gray, lithic fragments, which comprise 15% of the sample. They range up to 1.0 mm in size and are subangular to subrounded in shape. They are composed of plagioclase with scattered mafic minerals, giving a salt-and-pepper appearance. The second type of lithic fragment is dark gray, subangular to subrounded, and range up to 1.0 mm in size. These comprise 10% of the sample and have an aphanitic texture. Mineral clasts are light greenish, irregular in shape, and range up to 2 mm in size. These appear to be crushed pyroxene and/or olivine.

Thin section 14278,4 shows the rock to be a breccia with approximately 5% "glass" in the groundmass. The only clast present is a fine-grained microbreccia with few large mineral fragments. Numerous microbreccia fragments are scattered throughout the matrix. Some masses of devitrified glass is also present in the matrix. A few partly devitrified glass shards are also present. The majority of the mineral fragments are pyroxene with a few olivine grains, some of which are in the microbreccia.

14279



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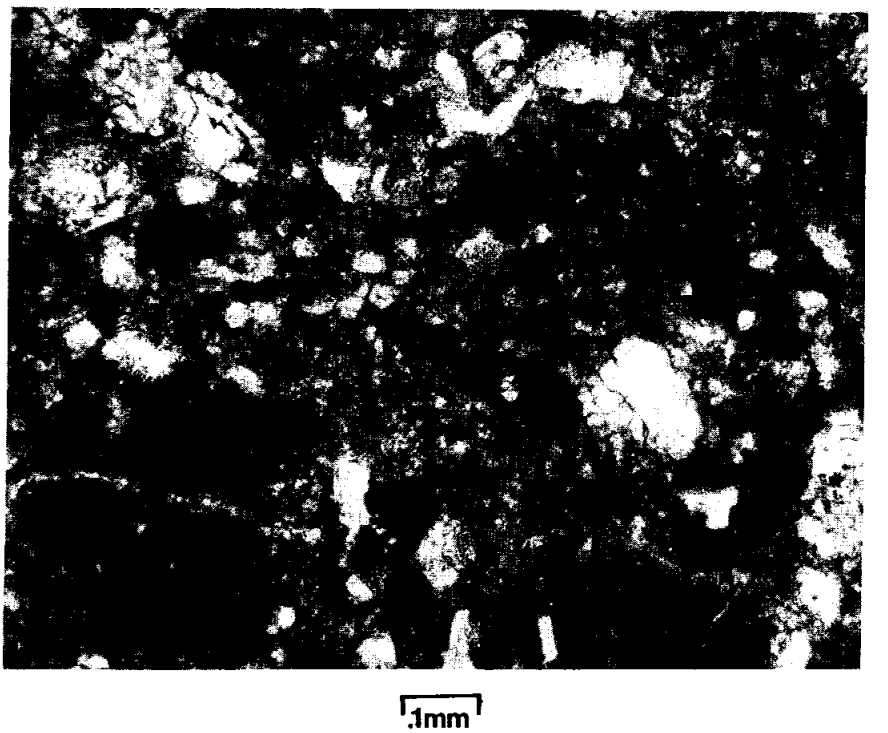
14279, 4



PHYSICAL CHARACTERISTICS

Mass	Dimensions
5.67 g	2.0 x 1.8 x 1.5 cm

Sample 14279 is medium light gray in color, blocky, rounded to subrounded in shape, and is a coherent, polymict breccia with a fragmented matrix.

SURFACE FEATURES

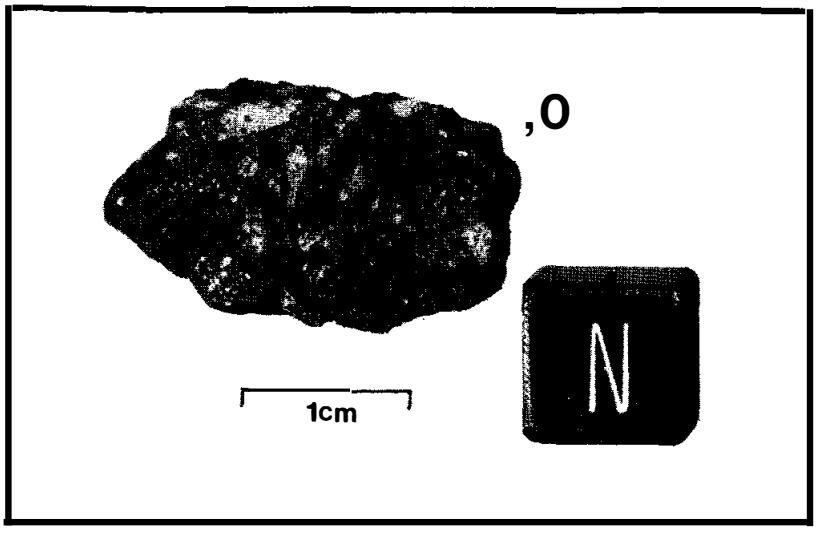
The slightly irregular surface has glass-lined zap pits over all surfaces but one.

PETROGRAPHIC DESCRIPTION

This coherent, light gray breccia is composed of medium light gray, fragmental material about 0.1 mm in size. It is a mixture of white and gray fragments and is 85 - 90% of the sample. There are some very fine-grained medium gray, lithic fragments making up less than 5% of the sample. White mineral fragments, probably plagioclase in various degrees of crushing, are angular and range up to 1.0 mm. They are predominantly 0.3 - 0.4 mm in size and are 10% of the sample. Light yellowish green, subangular, mineral fragments range up to 0.5 mm in size. These make up less than 5% of the sample and are probably olivine and/or pyroxene.

Thin section 14279,4 is composed of several small fragments of the sample which does not allow for a detailed discussion of the fabric of the rock. No clasts are present in any of the fragments. The groundmass appears to be holocrystalline with abundant small opaque crystals. The only lithic fragments present in the matrix is a crystalline rock composed of pyroxene and plagioclase and some fine-grained microbreccias. The rest of the fragments in decreasing order of abundance are pyroxene, olivine, and plagioclase.

14280



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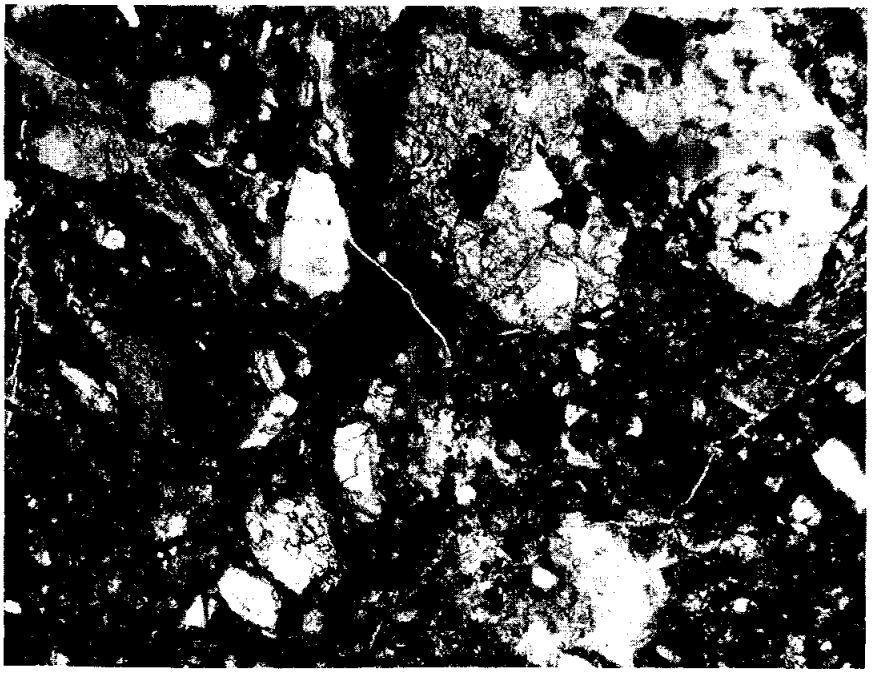
14280,5



PHYSICAL CHARACTERISTICS

Mass	Dimensions
6.20 g	1.0 x 1.3 x 3.6 cm

Sample 14280 is a medium dark gray, angular block of vitric [matrix] breccia.

SURFACE FEATURES

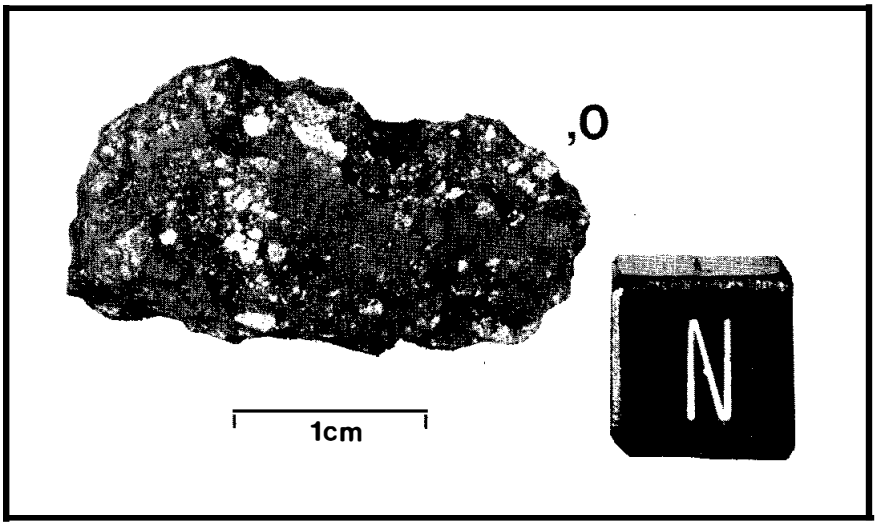
Glass coats 20% of the surface and contains cavities. Zap pits occur on all surfaces and are numerous. There are several penetrative fractures on the sample.

PETROGRAPHIC DESCRIPTION

The sample is coherent and is seriate in texture. Fifty-five percent of the sample is medium dark gray, aphanitic, vitreous material. The more abundant lithic fragments, making up 30% of the sample, range up to 3.0 mm in size, but are predominantly 0.3 - 0.5 mm in size. These are very light gray, subrounded fragments composed of crushed or sugary-textured plagioclase with accessory pale brown mafic minerals and specks of black, opaque minerals. The other type of lithic clasts is medium gray, subrounded, and very fine-grained with a few white spots. In thin section they are represented as devitrified glass and fine-grained microbreccias. These are predominately 0.3 - 0.4 mm and range up to 2 mm in size. They make up 15% of the sample.

Thin section 14280,5 shows the rock to be a glass-rich breccia with a heavy glass coating on one side. The glass coating is full of small crystals and crystallites. The coating also shows evidence of flowage and has numerous bubbles. Scattered throughout the section are masses of dark brown glass. The rock is highly fractured. Approximately 40% of the matrix (< 1 mm) is glass or "glassy". All the mineral grains are highly shocked and most are pyroxene crystals.

14281



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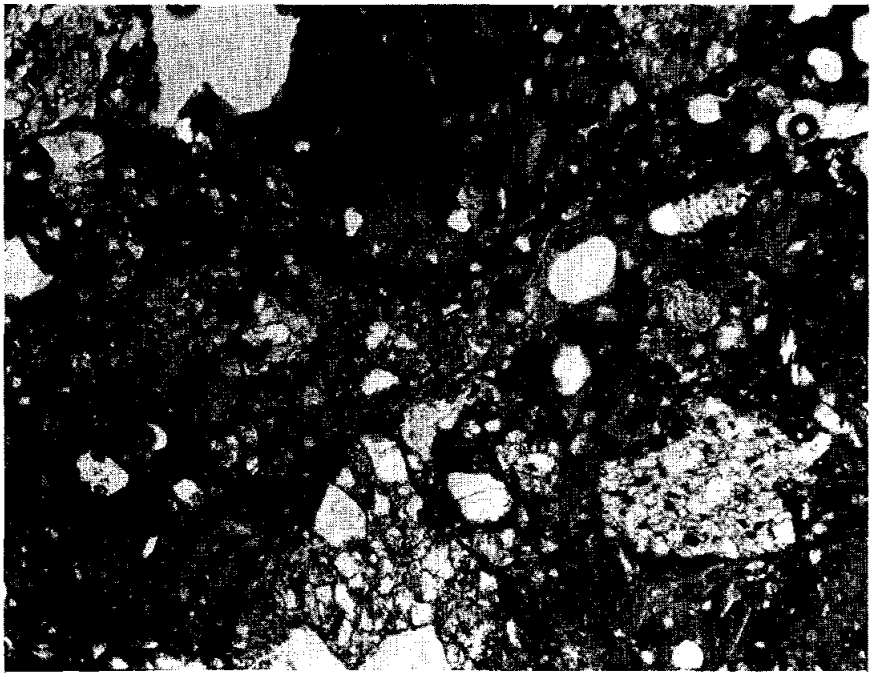
14281, 3



PHYSICAL CHARACTERISTICS

Mass	Dimensions
12.03 g	2.7 x 2.0 x 1.5 cm

Sample 14281 is a medium dark gray, subrounded to angular block of coherent, vitric [matrix] breccia.

SURFACE FEATURES

There are a few glass lined zap pits, 0.2 to 0.5 mm in diameter, on one surface, only. Very few penetrative fractures are present on the sample.

PETROGRAPHIC DESCRIPTION

Sample 14281 is medium dark gray and coherent, with a seriate texture. Seventy to seventy-five percent of the sample is aphanitic, medium dark gray, vitreous material. Light gray, lithic clasts ranging up to 10 mm in size make up 15% of the sample. They are predominately 0.5 mm in size and are composed of sugary to crushed, white plagioclase mixed with light gray material and scattered opaques with a salt-and-pepper appearance. A second type of lithic fragment, making up to 10% of the sample, is medium gray, subrounded, and up to 1.0 mm in size. They are very fine grained and are mostly smaller than 0.5 mm in size. A third type is similar to these, but has white clasts. It is 10 mm in size, subrounded, and is represented by 1 clast.

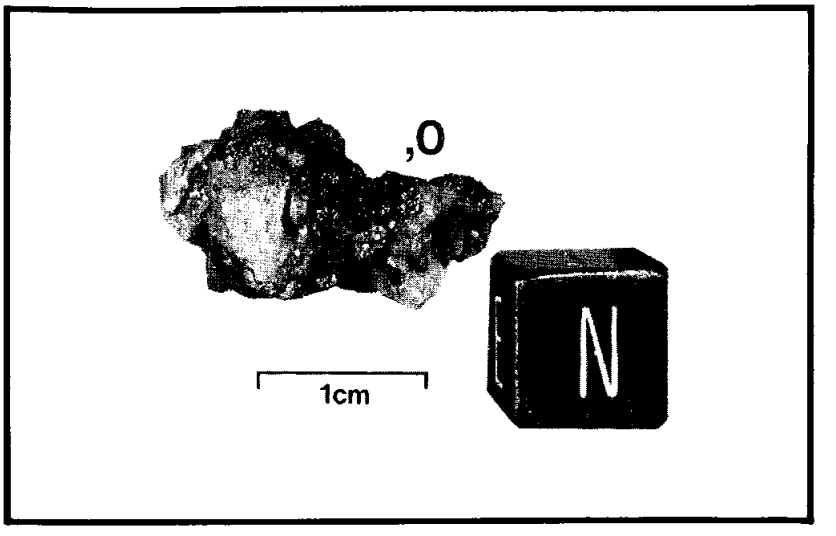
Section 14281,3 has abundant yellow/brown glass which contains numerous bubbles and swirls and shows some flowage lines. There are a few reddish-brown glass masses scattered throughout the section.

Only two clasts (> 1 mm) are present in the section. They are both an anorthositic breccia with minor pyroxene. One of the clasts consists of a granulated mass of plagioclase crystals with a few phenocrysts of shocked and fractured larger plagioclase. The other consists of a more bladed mass of plagioclase crystals which show a somewhat radiating structure. The later type grades to the first type near one edge of the clast.

The matrix consists of approximately 50% glass and a mixture of lithic (25%) and mineral (75%) fragments. All of the lithic fragments also consist of anorthosite type breccia. Most of the mineral fragments are plagioclase shards which are fractured and show shock effects. There are also a few pyroxene crystals present. A few of the pyroxene crystals are bent and show dislocations. A few devitrified glass spheres are also present. The glass in the matrix is very turbid.

A few small vesicles (0.1 - 0.3 mm) which are irregular to rounded are scattered about the section. Most of the vesicles are in the glassy portion of the matrix and none show crystals in the cavities.

14282



S-71-26646

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.89 g	2.1 x 1.4 x 1.1 cm

The sample is a medium gray, friable, fragmental rock (soil breccia).

SURFACE FEATURES

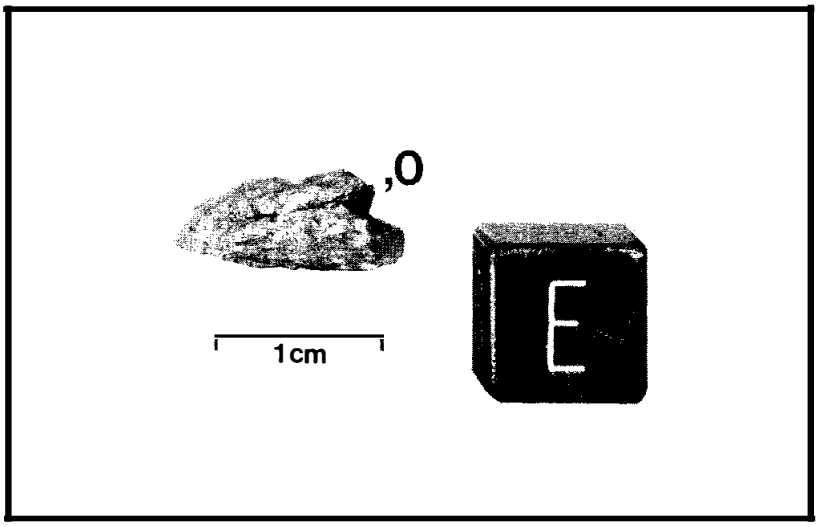
Forty-five percent of the surface is coated with black vesicular glass. The cavities are more than 20% of the glass. This coating is up to 2 mm thick. Several non-penetrative fractures are present. No zap pits are visible.

PETROGRAPHIC DESCRIPTION

The breccia is homogeneous and contains no grains larger than 0.5 mm. Eighty-five percent of the sample is medium gray fragmental material smaller than 0.1 mm. Two types of mineral fragments are visible. The first is very light gray, subangular to subrounded, and smaller than 0.5 mm in size. They occupy 10 - 15% of the sample and are composed primarily of crushed plagioclase, some with a bit of gray material. The second mineral fragment type is represented by one round grain 0.5 mm in size. It is light green, probably olivine or pyroxene.

Thin section 14282,5 is that of a breccia with 5 - 10% "glass" in the matrix. There is one very fine-grained microbreccia clast present which is nearly opaque. Small pyroxene shards are isolated in the clast. The rest of the matrix has fragments of microbreccia, basaltic rocks, pyroxene grains, and rare plagioclase fragments.

14283



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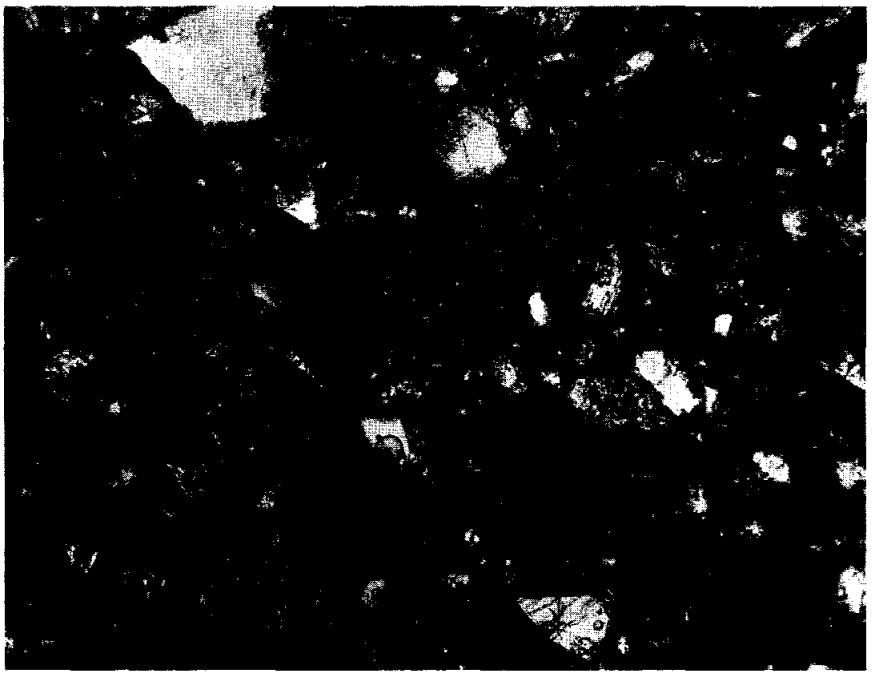
14283,5



.1mm

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.25 g	1.5 x 1.2 x 0.6 cm

Sample 14283 is a light gray, slabby, angular, coherent, crystalline, polymict breccia.

SURFACE FEATURES

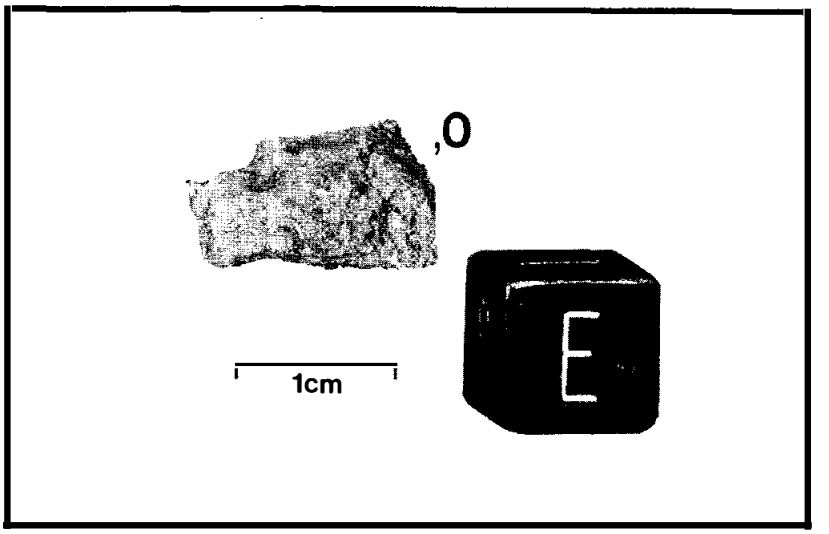
Zap pits are present on one face, only, and are few in number. There are few, penetrative fractures present.

PETROGRAPHIC DESCRIPTION

The sample is light gray, coherent, and has a seriate texture with some lineation of clasts. Sixty-five to seventy percent of the sample is medium light gray, fine-grained, granular, crystalline material smaller than 0.1 mm in size. Fifteen percent are very light gray, lithic clasts that are subrounded and are mostly 0.5 mm in size, ranging up to 4.0 mm. These are mostly white plagioclase, with 10 - 20% mafic material. A second type of lithic clast is light gray, subrounded, and generally is 0.5 mm in size, but is as large as 2.0 mm. These are composed of a 50:50 mixture of white, sugary grains and gray, vitreous material. A third type of lithic clast is 1 mm in size, light gray, and composed of equigranular 0.2 mm grains of 80% plagioclase and 20% mafic silicates with a trace of opaques. Pyroxene and/or olivine, light brown to light green in color is present as mineral clasts.

Thin section 14283,5 shows the rock to be nearly holocrystalline with only scattered small amounts (< 1%) glass in the matrix. The only clasts present are microbreccias with residual pyroxene shards. One microbreccia has a dark, nearly opaque matrix hosting the mineral shards. There are several small, orange glass droplets scattered throughout the matrix. There is also a trace of spinel in the matrix. There are numerous irregular, blocky masses of undevitrified glass in the matrix. Most of the glass is colorless to yellow. The remainder of the matrix is composed of pyroxene mineral fragments, devitrified glass, microbreccia fragments, small amount of opaques, rare crystalline rock fragments, and abundant fine-grained material.

14284



S-71-26656

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.47 g	1.5 x 1.2 x 0.8 cm

Sample 14284 is a subrounded, medium gray, coherent, fragmental rock.

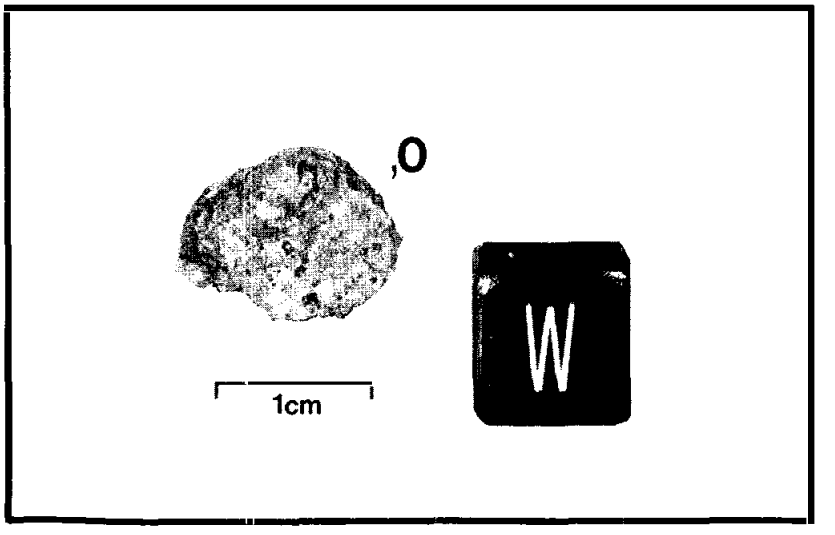
SURFACE FEATURES

Glass lined zap pits, up to 2 mm in diameter, are present on all surfaces. Few, non-penetrative fractures are present.

PETROGRAPHIC DESCRIPTION

Sample 14284 is a seriate, homogeneous microbreccia, with no grains larger than 1.0 mm. Seventy to eighty percent of the sample is medium gray material less than 0.2 mm in size. Two types of lithic fragments are present. The more abundant is very light gray, subangular to subrounded, and most are 0.5 mm in size. They range up to 1 mm in size and comprise 10 - 15% of the sample. Some may be individual plagioclase grains, but most are polycrystalline, probably crushed material. Five to ten percent of the sample is very fine grained, dark gray, angular lithic fragments 0.2 - 0.4 mm in size.

14285



S-71-26661

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.23 g	1.5 x 1.1 x 0.9 cm

Sample 14285 is a light medium gray, coherent, polymict breccia.

SURFACE FEATURES

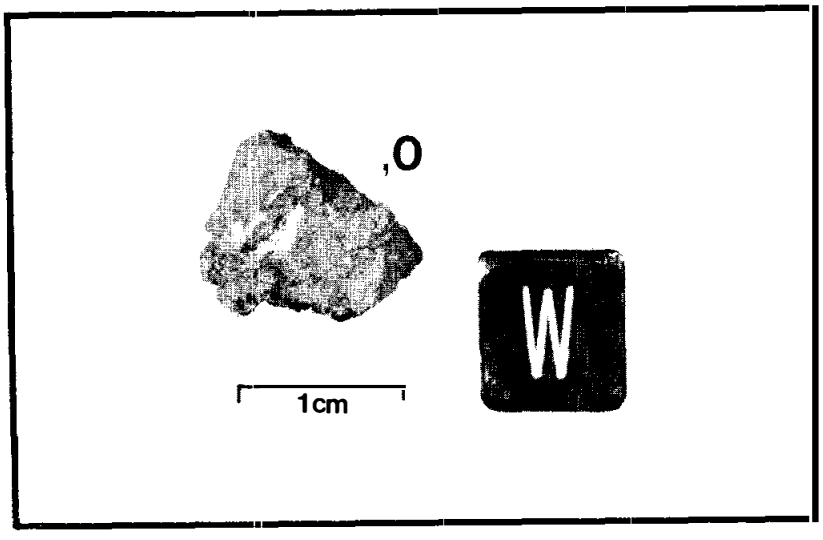
Glass-lined zap pits up to 1 mm in diameter are present on all surfaces. There is one, non-penetrative fracture.

PETROGRAPHIC DESCRIPTION

Sample 14285 is a blocky, rounded, light medium gray, polymict microbreccia. It is homogeneous, with a seriate texture. None of the grains is larger than 1 mm. Sixty to seventy percent of the sample is medium light gray fragmental material less than 0.2 mm in size. It is a mixture of mostly plagioclase and at least two mafic minerals. It appears to be partially recrystallized. Two types of lithic fragments are present. Thirty percent of the sample is very light gray, subangular to angular, lithic fragments 0.4 - 0.5 mm in size. Some appear to be breccias with fine grained matrices and dark

gray clasts, others may be finely crushed, medium grained igneous rocks. Five percent is dark gray, subangular to subrounded, fine grained to vitreous, lithic or mineral fragments 0.2 - 0.4 mm in size.

14286



S-71-26983

PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.42 g	1.4 x 1.1 x 0.5 cm

Sample 14286 is a medium brownish-gray fragmental rock.

SURFACE FEATURES

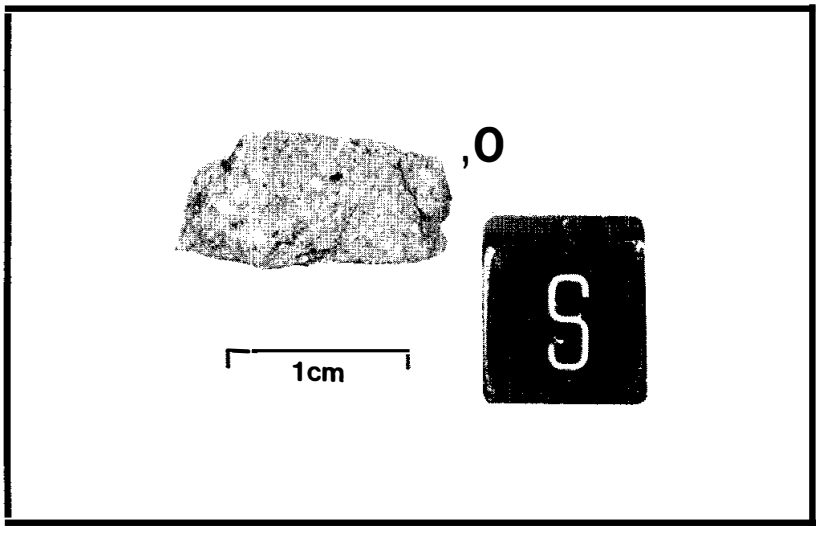
The irregular surface has an unusual metal coating up to 1 mm thick over half of it, with one small area of glass splash. Glass lined zap pits up to 2 mm in diameter, are present in the breccia. Pits in the metal coating have upturned, flange-like rims. The metal coating appears to have been deposited in one continuous mass, but erosion by micrometeorites has made the coating discontinuous.

PETROGRAPHIC DESCRIPTION

The sample has a fragmental seriate texture, and is coherent. Seventy to eighty percent of the sample is medium gray and seems to be a mixture of brown, white, and gray fragments less than 0.2 mm in size. Fifteen percent is very light gray lithic fragments subangular to subrounded in shape and

commonly 0.5 mm in size. These are as large as 5 mm and are composed of a 50:50 mixture of crushed white plagioclase and a light green mineral in 1 mm sized areas. A second type of lithic clast, represented by one 5 mm fragment is subangular and light gray in color. It has a fine-grained sugary texture and represents less than 5% of the sample. The metal is silver in color and is 5% of the sample. It has differing shades of tarnish from gray to black.

14287



S-71-26663

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.07 g	1.5 x 0.8 x 0.5 cm

Sample 14287 is a medium brownish gray, coherent, fragmental rock that is blocky and angular in shape.

SURFACE FEATURES

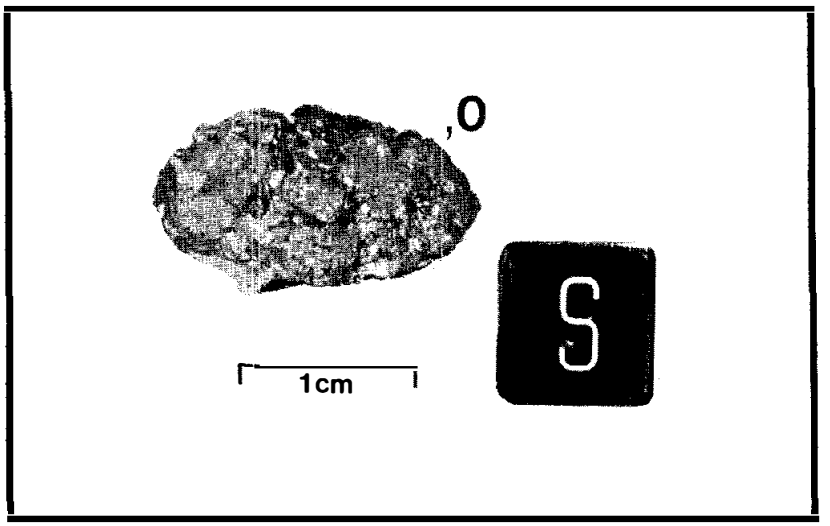
Few zap pits are present on all surfaces. Less than 1% of the surface has cavities smaller than 1 mm in diameter. There are few, penetrative fractures.

PETROGRAPHIC DESCRIPTION

The sample is a gray, coherent, fragmental microbreccia. It is seriate in texture and homogeneous. Eighty percent is medium gray fragmental material smaller than 0.1 mm. Two types of lithic clasts are present, each accounting for 10% of the sample. One is very light gray, subangular to subrounded, and is predominately 0.5 mm in size. These clasts range up to 2.0 mm in

size and are composed mostly of crushed plagioclase with some light colored mafic minerals. The other type of lithic clast is composed of aphanitic material. The clasts are subangular to subrounded, commonly 0.4 mm in size, and range up to 1.0 mm.

14288



S-71-26669

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.44 g	0.7 x 1.3 x 1.7 cm

Sample 14288 is a medium dark gray, vitric [matrix] breccia. It is blocky and angular in shape and is coherent.

SURFACE FEATURES

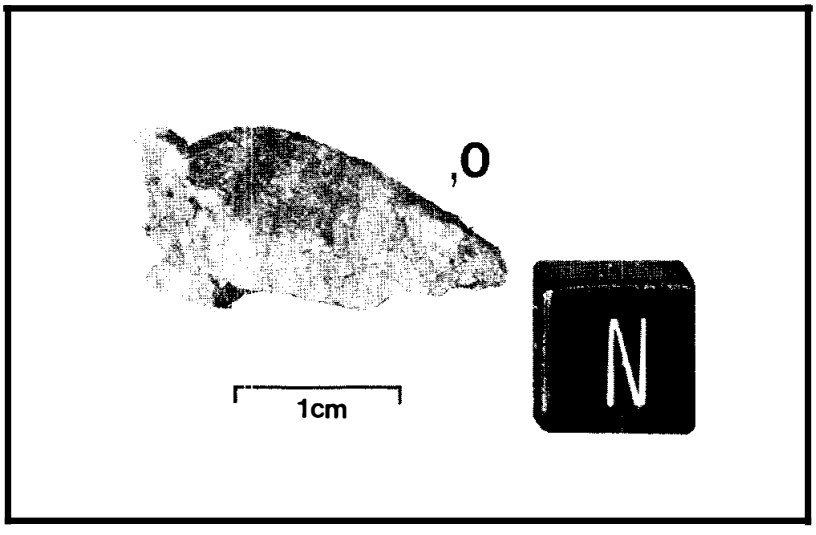
Glass lined zap pits, up to 1.0 mm in diameter, are present on all sides. There are many, penetrative fractures on the sample.

PETROGRAPHIC DESCRIPTION

The sample is medium dark gray and is composed mostly (60%) of aphanitic, medium dark gray, vitreous material. Two types of lithic clasts are present, each making up 20% of the sample. The subangular, light gray clasts are predominantly 0.5 mm in size, but range up to 5.0 mm. They are plagioclase-rich, but contain 20 - 40% mafic minerals and scattered black opaque grains smaller than 0.1 mm in size. Dark gray lithic clasts are smaller, generally 0.4 mm,

but range up to 1.0 mm in size. These are subrounded, and are composed of very fine grained, almost vitreous-appearing material.

14294



S-71-26670

Weigh bag 1038 was used to hold rocks and fragments from station H, EVA-2. The largest samples are numbered 14312 - 14320 and the residue is 14290 - 14297. Samples 14294 - 14297 are the largest fragments of the residue.

14294

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.43 g	2.5 x 1.5 x 1.5 cm

Sample 14294 is a breccia with one rounded side and one angular side. It is grayish brown on the rounded surface and light to medium gray on the fresh surface.

SURFACE FEATURES

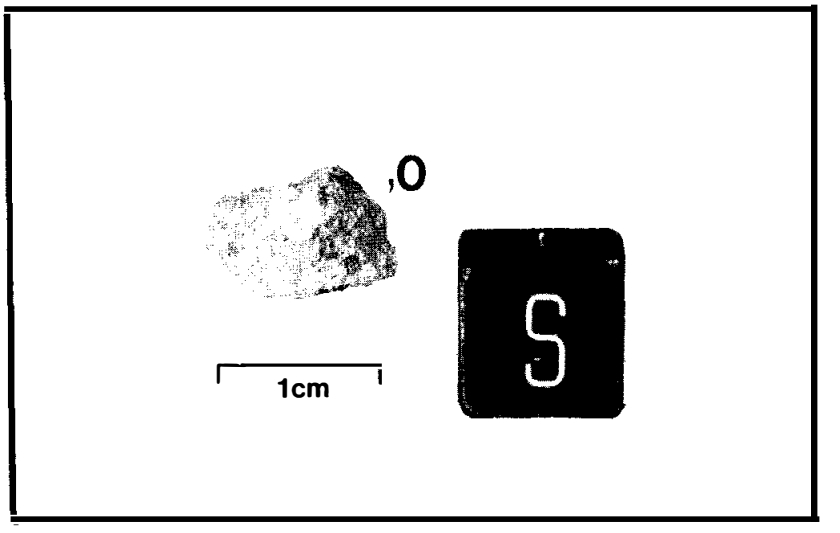
Pits ranging from 0.1 to 1.0 mm in size are glass lined. There are eight pits per square centimeter on the rounded surface. The angular side is a fresh fracture surface. Several spalls are parallel to this surface. A thin patina of dust appears to be welded to the rounded surface by a very thin layer of glass.

PETROGRAPHIC DESCRIPTION

Sample 14294 is medium grained, with an average grain size of 0.5 mm. It is texturally and mineralogically homogeneous. Ten percent of the rock is clasts larger than 1 mm and the rest is matrix grains. Clasts are leucocratic lithic fragments consisting of 80% white to colorless mineral. The clasts are equigranular. The matrix consists of 40% black unresolvable material in grains less than 0.1 mm in size, 50% feldspar in grains 0.2 to 1 mm, and leucocratic lithic fragments. Traces of pyroxene occur in the matrix.

A thin vein of black glass which is 0.2 mm wide and 6 mm long forms a dendritic pattern.

14295



S-71-26676

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.24 g	1.2 x 1.2 x 1.0 cm

Sample 14295 is a fine grained, polymict breccia with 5% clasts larger than 1 mm and 95% matrix grains smaller than 1 mm in size.

SURFACE FEATURES

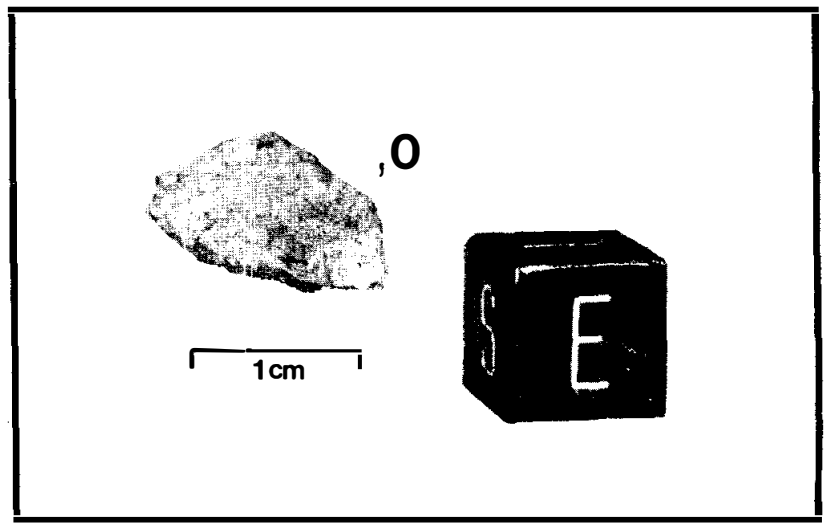
Pits ranging from 0.1 to 0.8 mm in size are lined with black glass. They occur over 20% of the rock surface. There are no fractures, but 80% of the rock are fresh fracture surfaces.

PETROGRAPHIC DESCRIPTION

Sample 14295 is a coherent, fine grained, polymict breccia with an average grain size of less than 0.1 mm. It is composed of 5% fragments larger than 1 mm and 95% matrix grains. One percent of the clasts are feldspar fragments. The rest are lithic clasts of two main types. Both are mesocratic. The first type consists of dark gray glassy or lithic fragments which are set in

a light colored clast matrix primarily composed of plagioclase with some pyroxene. The second lithic clast type are blocky, angular light-colored feldspathic fragments with traces of pyroxene and a crystalline texture. The rock matrix is fine grained with many lithic fragments of the second type and many areas of feldspar and pyroxene concentration. A vein of matrix material occurs in a type two lithic clast. The sample appears to be similar to 14321.

14296



S-71-26678

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.26 g	3 x 1.2 x 0.5 cm

Sample 14296 is a light gray, angular, flat, polymict breccia chip.

SURFACE FEATURES

Pits ranging from 0.1 - 1.0 mm are lined with dark brown glass. The depth to width ratios of the larger pits are 1:2. These deep pits resemble hemispheres. There are no fractures.

PETROGRAPHIC DESCRIPTION

Sample 14296 is a moderately coherent, medium grained, polymict breccia. It is texturally but not mineralogically homogeneous. It is composed of 10 - 20% clasts larger than 1 mm and 80 - 90% matrix grains. Clasts are all leucocratic rock fragments of three types:

1) Feldspar-rich sub-rounded rock fragment of a finely crystalline equigranular rock. It contains a trace of light brown pyroxene and some

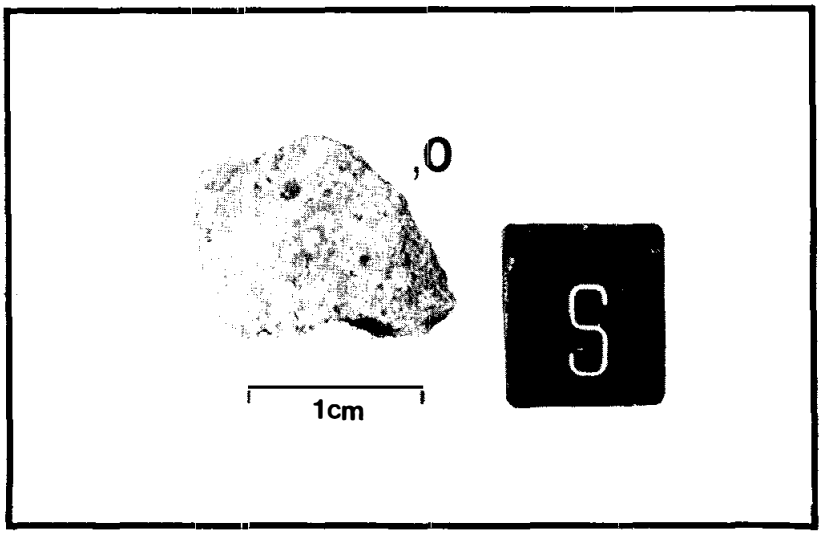
small (< 0.1 mm) opaques.

2) Very finely crystalline, mafic clasts which are subangular, dark gray, and measure up to 3 mm long. They may be rich in feldspar.

3) Coarser crystalline varieties of the second type with crystals up to 0.4 mm in length.

The matrix contains 60 - 65% feldspar, 30% pyroxene, and 1% opaques in sizes less than 0.05 mm.

14297



S-71-26684

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.73 g	2.0 x 2.5 x 1.0 cm

Sample 14297 is a polymict breccia with an unusual clast mineralogy.

SURFACE FEATURES

No zap pits are present and all surfaces appear to be fresh fracture surfaces. One planar fracture is present. There are neither vugs nor vesicles, but one or two clast molds occur on the surface.

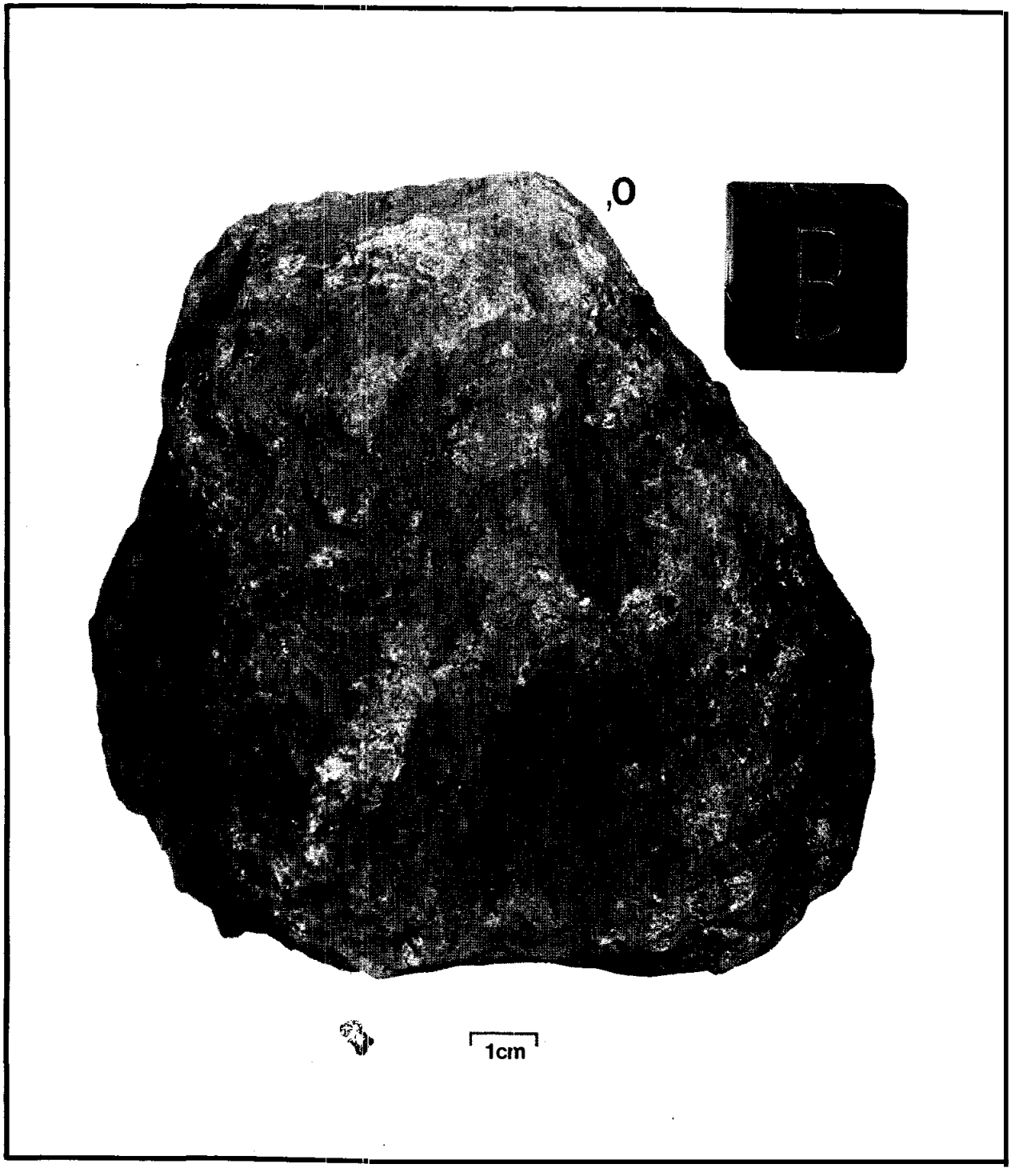
PETROGRAPHIC DESCRIPTION

Sample 14297 is a polymict breccia composed of 15% clasts larger than 1 mm and 85% matrix. The clasts are mostly melanocratic and leucocratic rock fragments and some glassy rock fragments. One type of lithic clast is a mixture of white and yellow minerals in equal proportions and one garnet-like pyroxene crystal. A second type is medium gray and cryptocrystalline. A third type is a mixture of feldspar and a gray mineral phase. Clasts of

angular, medium to dark gray glass have a large variance in size and degree of devitrification. These glass clasts are 1 - 2% of the sample.

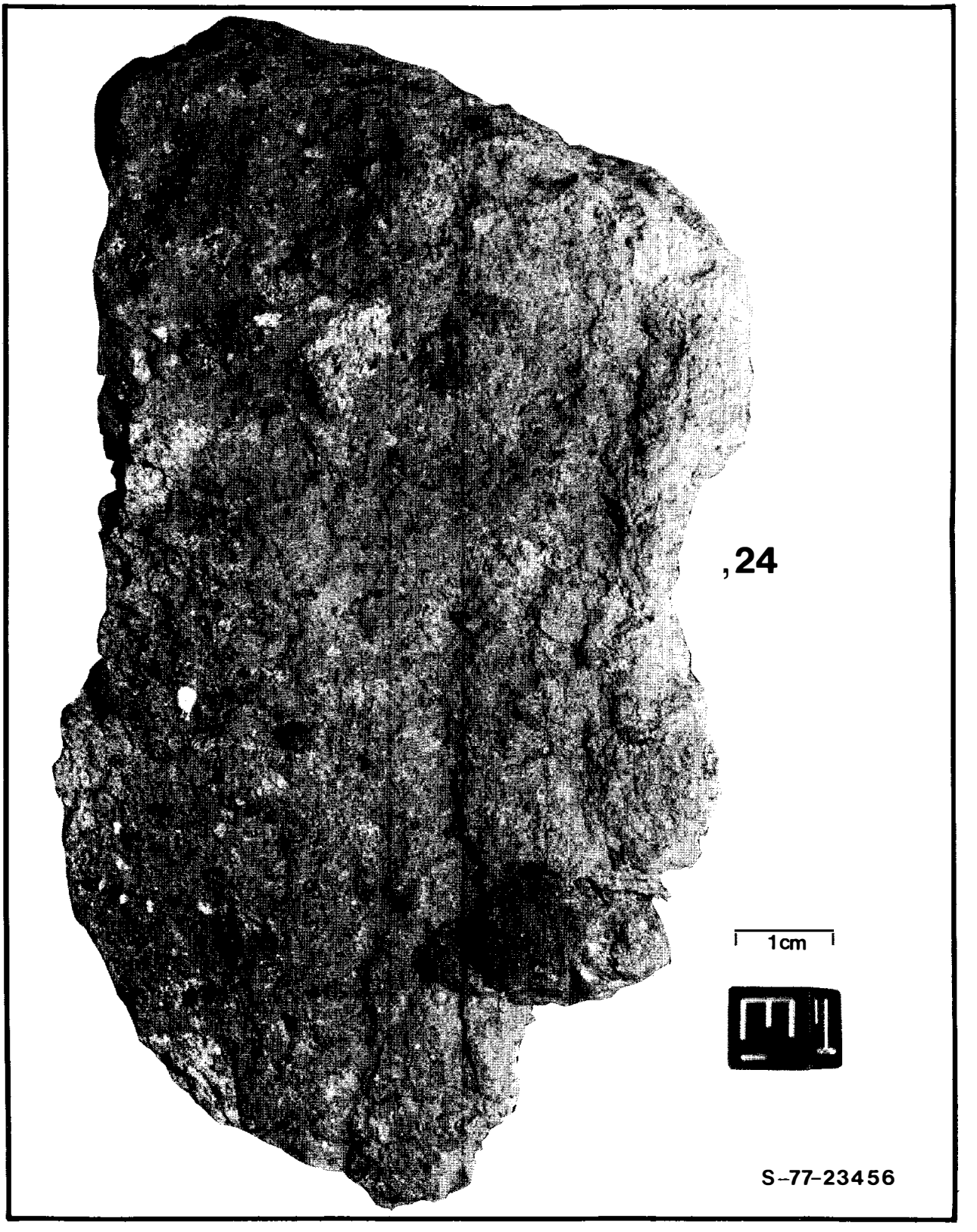
Matrix grains appear to be feldspathic but not highly recrystallized. It is light gray, very fine grained (average < 100 μm), and contains specks of gray to black glass.

14301

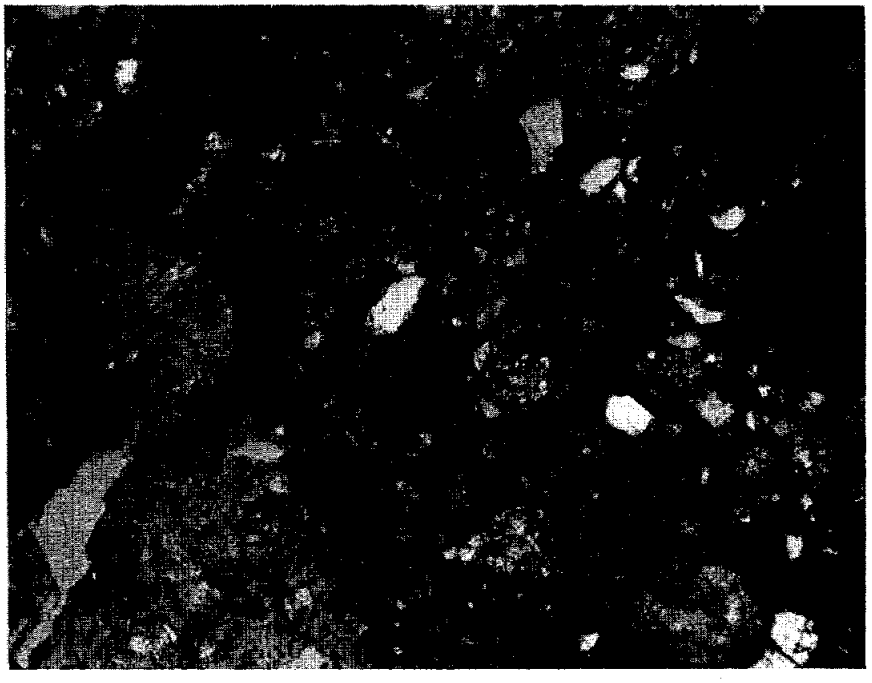


S-71-32476

14301



14301,81



1mm

Sample 14301 is one of two samples (14301 and 14313) collected at station G1, 150 m east of the LM on the north rim crest of North Triplet Crater during the second EVA. According to the astronauts, the rock appeared to be similar to the other rocks in the area; these appear to be ejecta from North Triplet Crater. Except for samples dug from trenches, 14301 was the most deeply buried rock returned during the Apollo 14 mission (Swann et al., 1977). This sample was larger than anticipated, and was placed directly in weigh bag 1031 (?) by the astronauts.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1361. g	12.5 x 12.0 x 8.0 cm

Sample 14301 is a moderately coherent, light medium gray, polymict breccia. It consists of at least 20% clasts larger than 1 mm.

SURFACE FEATURES

Hörz et al. (1972) report that one set of surfaces is marked by micro-meteoroid impact pits, whereas another is not. The face in NASA photograph S-71-32476 displays slickensides, and this face has abundant microcraters,

although the slickensided area has a low crater density. Morrison et al. (1972) found the distribution indicative of a single exposure interval because the exposed surface is subangular to subrounded and cratered, while the buried surfaces are angular and uncratered. There is no color change boundary between cratered and uncratered surfaces. Cavities appear as clast molds. Several sets of penetrative fractures are present.

PETROGRAPHIC DESCRIPTION

Sample 14301 is a polymict breccia with 20% clasts larger than 1 mm, most of which are leucocratic. White, angular clasts occasionally are associated with small olivine clusters. Larger, subangular clasts with a whitish gray color, irregular glass clasts with a dark brown color (spatter?), chalky white clasts with black specks, and angular or subhedral, equant, pyroxene clasts which are honey brown in color are also present.

Thin sections 14301,76 and 14301,17 appear to fit the criteria for being classified as VMB's using the classification of Simonds et al. (1977). These sections also appear to have some LMB characteristics. Most clasts are breccia fragments with an abundance of plagioclase. Matrix glass occupies approximately 10% of the sample. Some of this glass is very turbid, brown in color, and is partly devitrified. Approximately 40% of the fragments are mineral fragments and 60% are lithic. Clasts range up to 4 mm in size. Most are mildly shocked, and some have 5 - 10% glass with large crystals of plagioclase and pyroxene. A few crystals have inclusions. Most fragments are very irregular and jagged.
A second type of clast is composed of blocky, plagioclase crystals with minor pyroxene and mesostasis between grains. Mineral fragments include pyroxene grains which show large reaction rims, and plagioclase which appears mildly shocked without zoning.

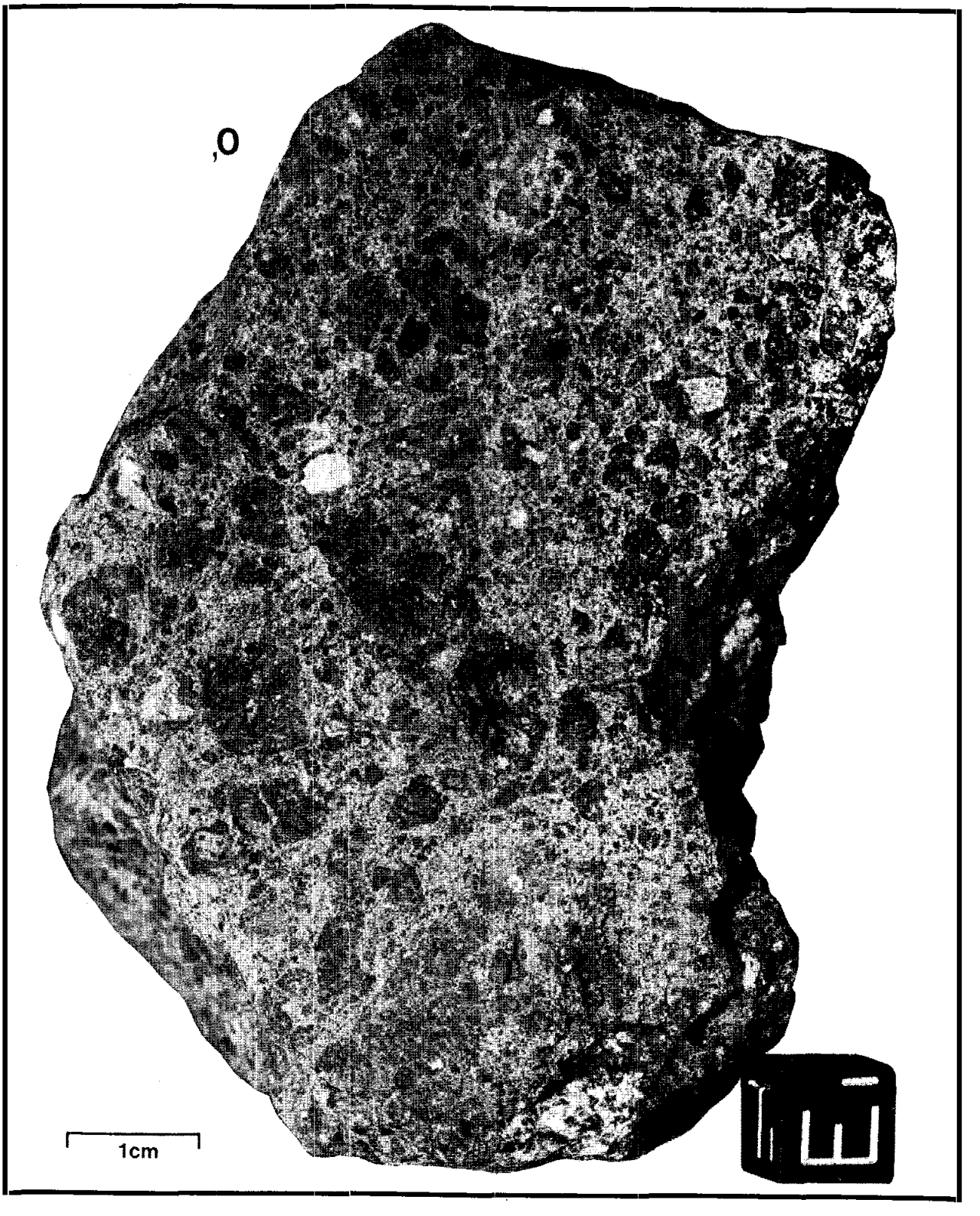
DISCUSSION

Morrison et al. (1972) found the lowest average ratio (3) of spall diameter to central pit diameter on the glassy surface of 14301. The exposure age using the particle track method (Hart et al., 1972) is 3.4 x 10^5 years. This correlates with the small cumulative number of craters with spall diameter larger than 0.1 (Morrison et al., 1972). The microcrater distribution and exposure age for rock 14301 indicate a production of 10 craters per million years of 0.1 cm spall diameter or larger.

Sample 14301 was studied by Warner (1972), who classified it as his metamorphic grade 2 (low grade). Wilshire and Jackson (1972) list it as an F_2, and Chao et al. (1972) classify it as an unshocked, porous, regolith microbreccia. Simonds et al. (1977) list it as a vitric matrix breccia (VMB). King et al. (1972) list 14301 as one of the samples with abundant chondrules and chondrule-like bodies present.

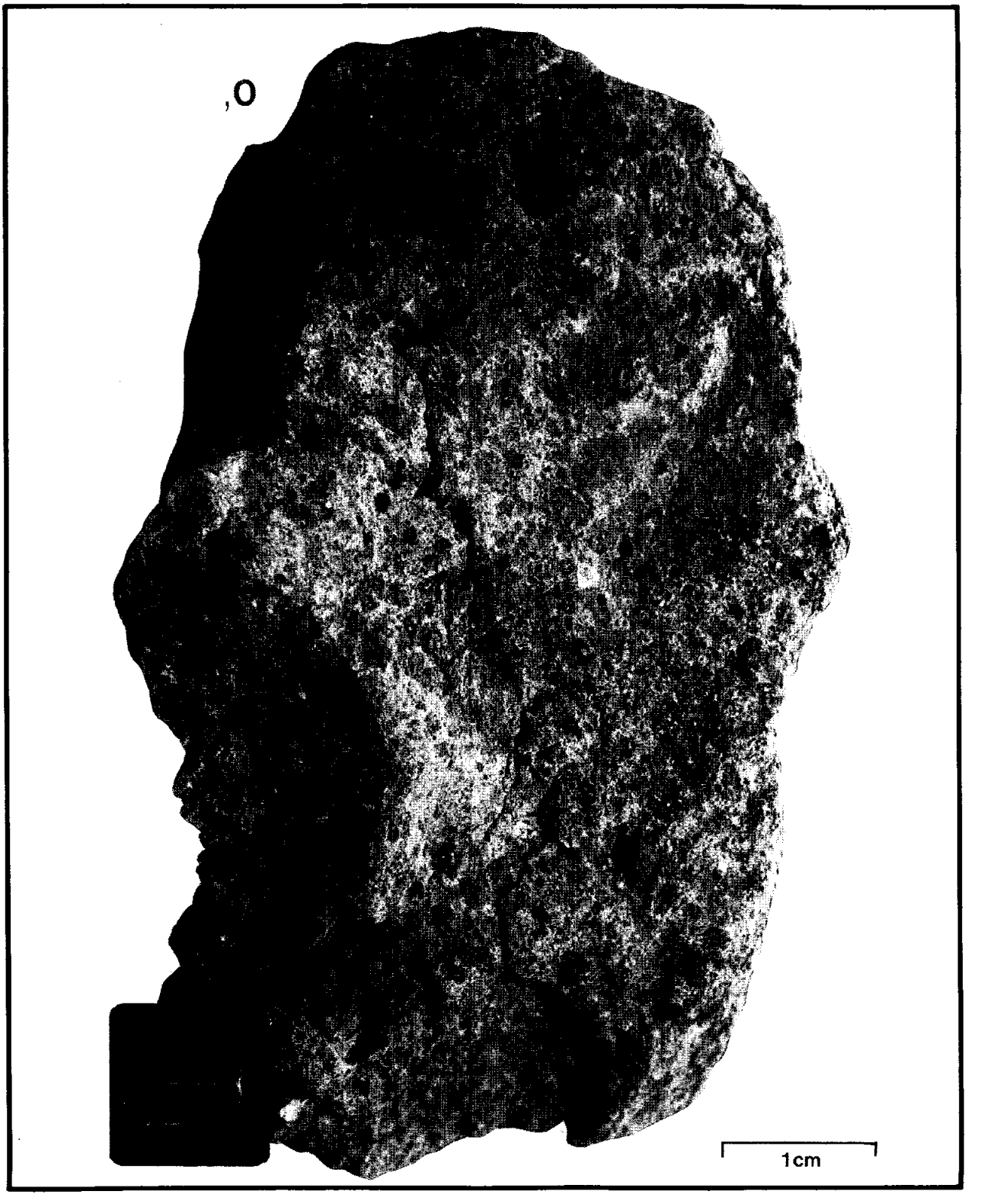
Sample 14301 is one of those mapped by Twedell et al. (1978). Its geneology is available on page 351 of this booklet.

14303



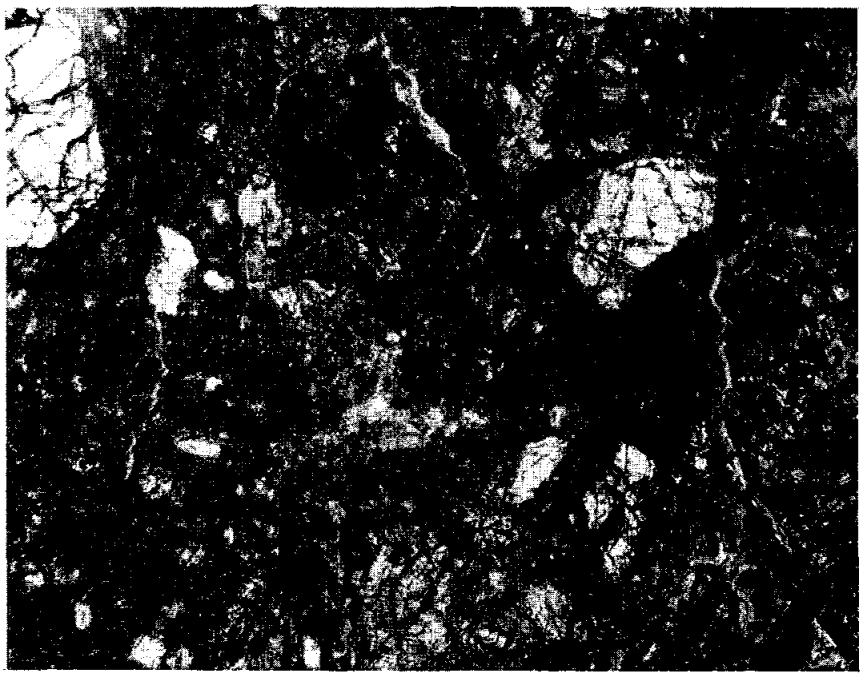
S-77-23372

14304



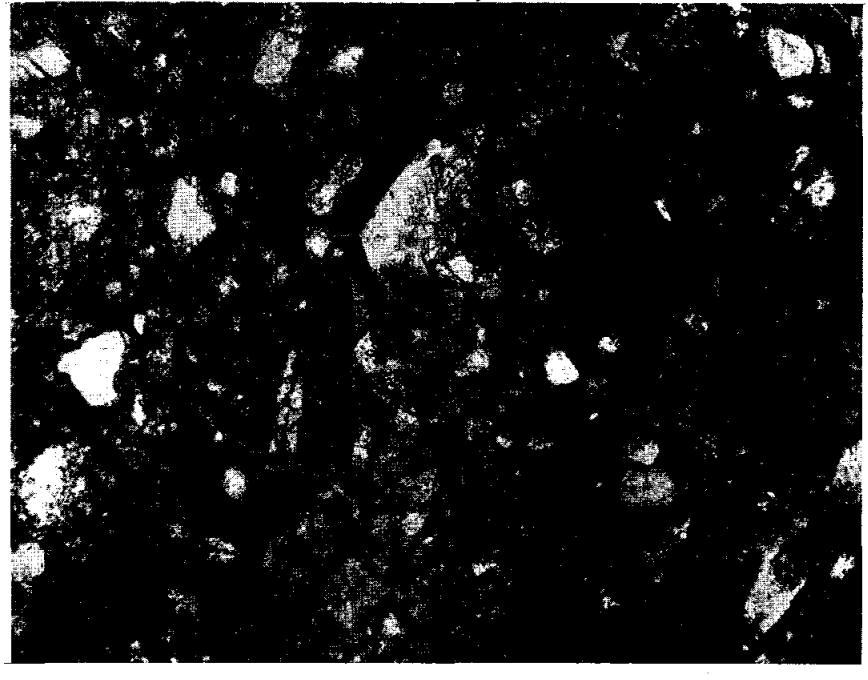
S-77-23099

14303, 52



.1mm

14304, 13



.1mm

These samples are pieces of a football-size rock collected from a location 80 m NNW of the LM during EVA 1. This rock was almost completely buried in the regolith and its orientation is unknown. Both of these samples have freshly broken surfaces. They were first identified as pieces of the same rock in March, 1977, when the models of the rock were found to fit together along their freshly broken surfaces. They share a common lithology which is especially evident along the broken surfaces. These samples were returned together in weigh bag 1027 which also contained sample 14305/302 and various smaller chips (see Phinney et al., 1975). These samples were examined in the CRA and NNPL by the PET, and 14303 was extensively distributed for scientific experimentation. Sample 14304 has been designated a posterity sample.

PHYSICAL CHARACTERISTICS

	Mass	Dimensions
14303	898. g	16 x 9 x 7 cm
14304	2499. g	20 x 11 x 10 cm

This rock is a coherent, gray, blocky to subrounded breccia.

SURFACE FEATURES

The sample is saturated with zap pits and is considerably fractured in some places. The zap pits range in size from less than 0.1 - 7 mm on 14303 to 0.1 - 3 cm for 14303. The pits are lined with a dark brown botryoidal to bubbly glass. This glass is 0.2 mm thick in the larger zap pits.

There are at least two sets of fractures on these samples, so that although the rock is tough with clasts firmly imbedded in the matrix, the rock would break apart if handled roughly.

PETROGRAPHIC DESCRIPTION

14303: This rock is a polymict breccia with a holocrystalline matrix. The average grain size is approximately 0.2 mm with 95% of the grains less than 1 mm. Approximately 40% of the rock is white, turbid plagioclase averaging 0.1 mm in size. Olivine fragments are rare as are pyroxene fragments. Thin coatings of black glassy material on part of the lithic fragments give them the appearance of black glass fragments.

14304: This sample is also a polymict breccia with a holocrystalline matrix and it appears to have the same grain size distribution as 14303 (Simonds et al., 1977, their figure 1).

Approximately 35% of the fragments are larger than 1 mm. These are rounded to subangular. The large fragments are darker than those in 14303, consisting of dark gray, microbreccia fragments from an earlier generation. The clast mineralogy is subhedral, white, feldspar and brownish green olivine. Pyroxene

is also present but is difficult to resolve except in thin section.

Mapping of 14303,7 and 14304,0 shows the distribution of pits, clasts, and fractures on various faces (Twedell et al., 1978).

In an attempt to characterize the nature of this generic, 3 thin sections with different parents were chosen for modal analysis of the ≥ 1 mm clasts. The samples examined with the proper parent designated were:

Sample	Parent	Dominant Clast ≥ 1 mm
14303,49	,17	Plagioclase shards, dark metaclastic rocks, light metaclastic rocks and coarse-grained plutonic rocks
14303,51	,23	Coarse-grained plutonic rocks, dark metaclastic rocks, light metaclastic rocks and plagioclase shards
14303,52	,19	Dark metaclastic rocks, light metaclastic rocks, coarse to fine-grained plutonic rocks and coarse-grained cumulates to crystalline breccias

In summing the results of this summary, the predominant type of rock clast in this generic is the dark metaclastic variety. This is in agreement with Wilshire and Jackson (1972). As can be seen from the results, local variations increase other types of clasts, but the general trend is the same.

Weigand and Hollister (1972) studied adjacent polished thin sections 14303,47 and 14303,53. They found that the sample consists of mineral, lithic, and fragmental clasts. Mineral clasts range up to 2 mm in size and are predominantly plagioclase with pyroxene, olivine, and small disseminated opaque minerals also present. Three distinct fragmental clasts are described: plagioclase and pyroxene in a light matrix (the largest of which is at least 2.5 x 3.5 mm in size), with accessory opaque minerals; one with a gray matrix with a few opaque grains and many disseminated ones, and the main constituent mineral clasts are plagioclase and pyroxene. The plagioclase grains have a fine mosaic texture, probably a shock effect, and the pyroxene grains are described as being unusually large. Basaltic lithic fragments are also present.

DISCUSSION

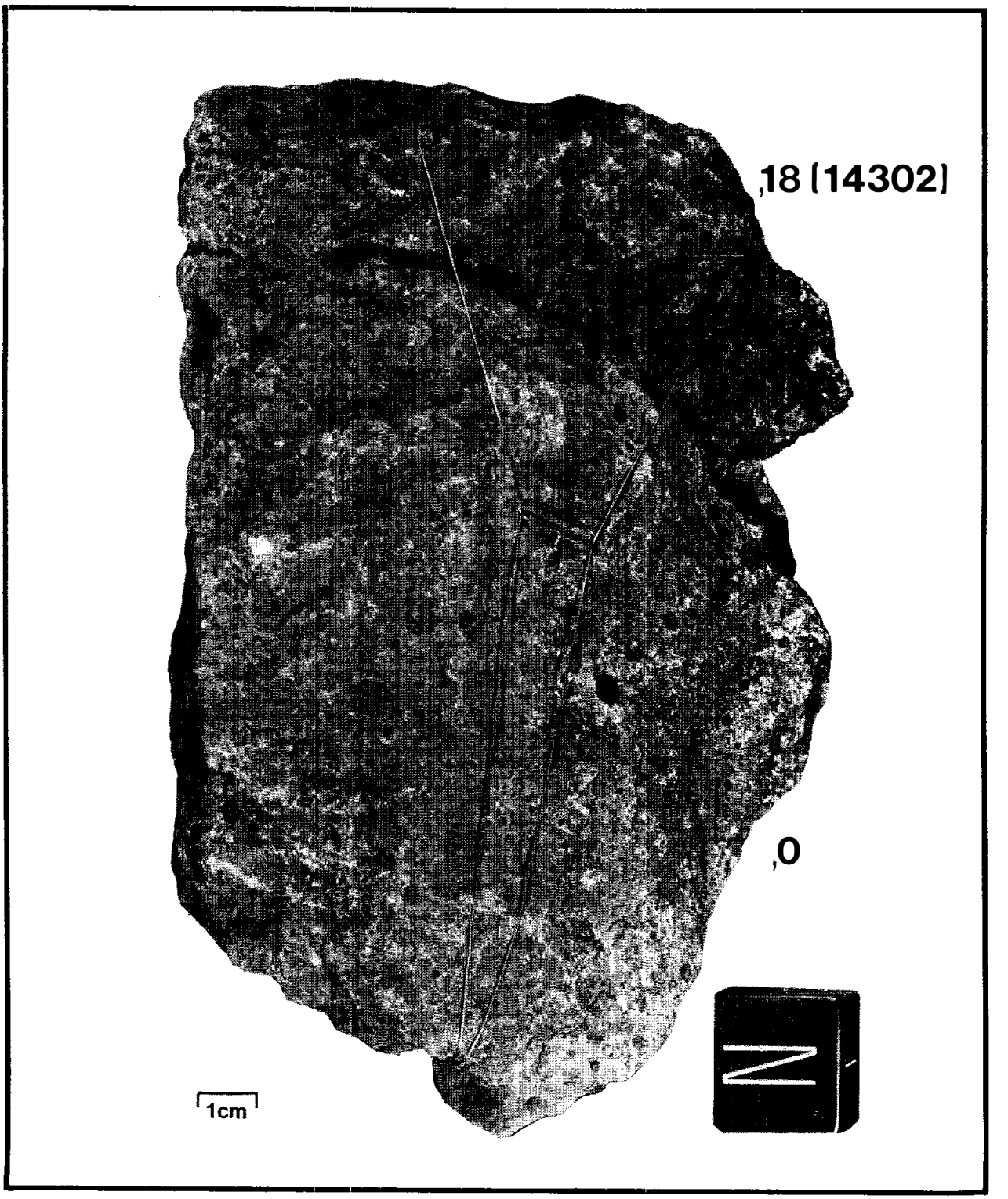
Wilshire and Jackson (1972) found this sample to be coherent with dark clasts, placing it in their F4 category. Chao et al. (1972) described 14303 and 14304 as shocked, strongly annealed Fra Mauro breccias (2c) and Warner (1972) placed them in his group 6. Quaide and Wrigley (1972) placed them in their annealed breccia group and Simonds et al. (1977) list them as crystalline matrix breccias (CMB).

Weigand and Hollister (1972) interpret their study of polished thin sections as indicating that the pyroxenes originally crystallized in a plutonic-metamorphic environment beneath the pre-Imbrian crust. Groundmass pyroxenes are mainly pigeonites and augites, and are interpreted as being fragments of quickly cooled surface basalts.

Roedder and Weiblen (1972) studied melt inclusions in 14303 and found much evidence of a complex thermal history. They note that the groundmass of sample 14303 must have excess (normative) SiO_2 in it, because all olivine grains in contact with it (other than fayalite) have reacted to form thin, almost monomineralic, rims of pyroxene. They find, as did Weigand and Hollister (1972) that at least some of the original rocks have undergone slow cooling. They note that some plagioclase single crystal clasts are almost spherical, presumably by abrasion in transport.

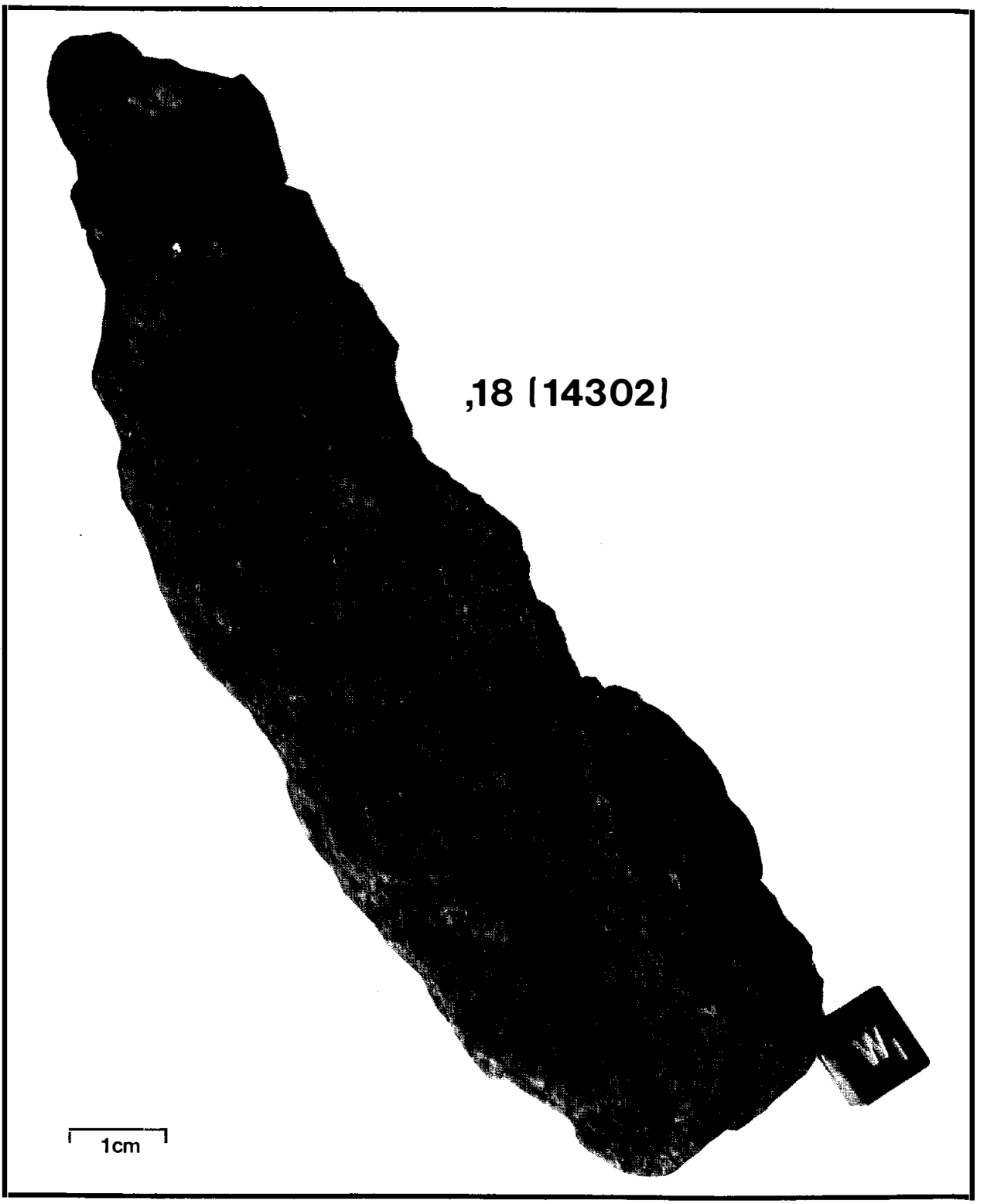
The sample's geneology and a photograph of a model of the sample is available beginning on page 352 of this booklet.

14305/14302



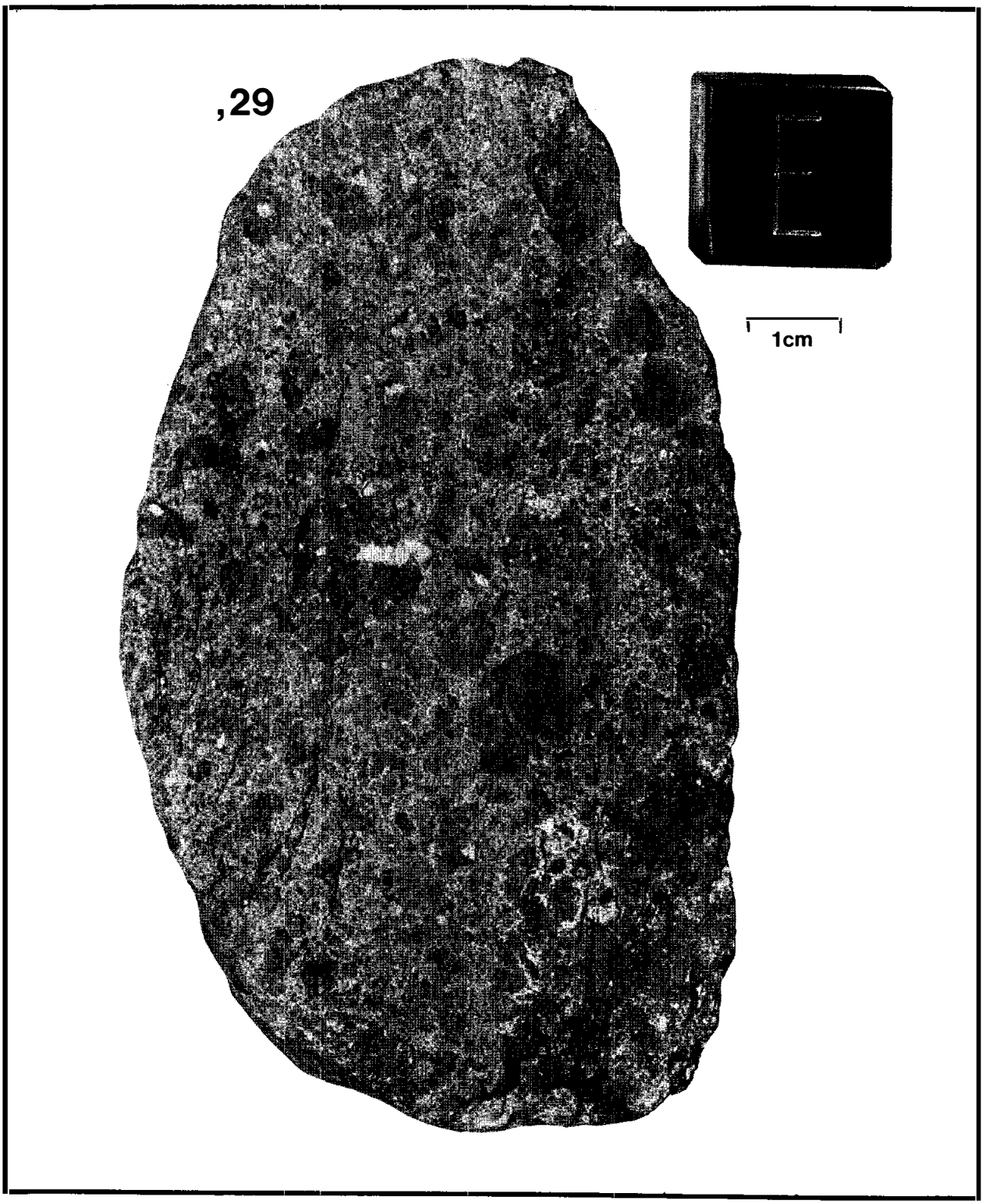
S-71-31391

14305



S-77-21474

14305



S-75-33045

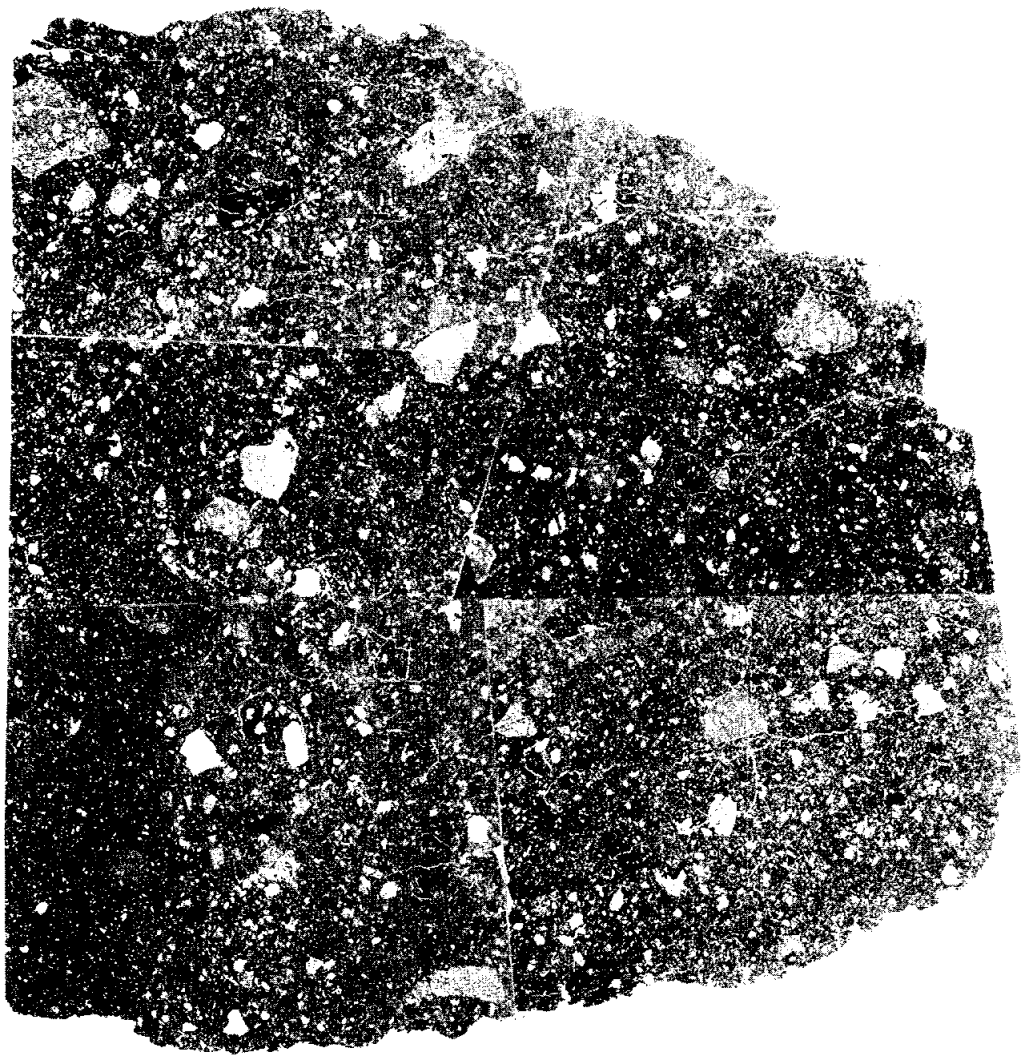
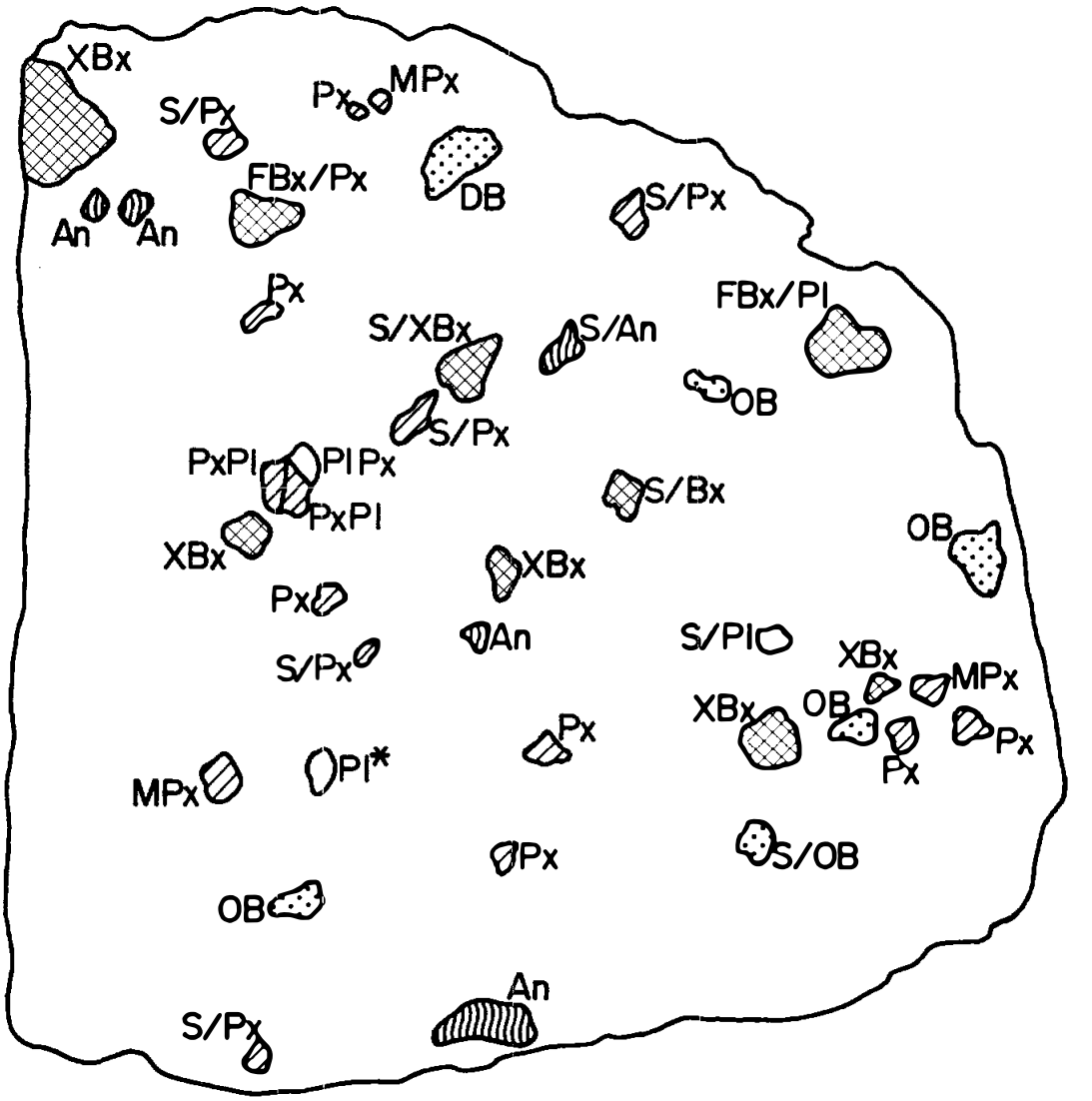


Figure 4a. Reconstructed slab of sample 14305.

Figure 4b. Map of clasts in reconstructed slab of sample 14305.



Pl	Plagioclase (* - multitwinned)
PlPx	Coarse plagioclase crystals with pyroxene
Px	Pyroxene
MPx	Myrmekitic-like textured pyroxene
PxPl	Coarse pyroxene crystals with plagioclase
An	Anorthosite with/without pyroxene and olivinite inclusions
XBx	Crystalline breccia - larger pyroxene, smaller plagioclase
FBx/Px	Fine-grained breccia with large pyroxene crystals
FBx/Pl	Fine-grained breccia with large plagioclase crystals
DB	Diabasic basalt
OB	Ophitic basalt
S/	Shocked

Two football-sized rocks (FSR) were collected about 80 meters NNW of the LM during the first EVA. Both were broken apart during transit to the LRL. The pieces were numbered 14305/14302, and 14303/14304. Sample 14305/302 was returned in weigh bag 1027 along with 14303/304 and fragments 14165-14189. All of these samples have similar lithologies, numerous fractures, and freshly broken surfaces, so the fragments 14165-14189 could be from either of the two. It is believed that these football-size rocks may have been transferred into weigh bag 1027 inside the LM, but this transfer was not documented. They were taken out of 1027 in the CRA before entering NNPL for examination. Sample 14302 was later renumbered 14305,18.

PHYSICAL CHARACTERISTICS

	Mass	Dimensions
14305	2117 g	14 x 15 x 10 cm
14302 (14305,18)	380 g	14 x 3.5 x 6 cm
Combined	2497 g	14 x 20 x 10 cm

The sample is a medium gray, holocrystalline, clast rich breccia which has been well-sintered together.

SURFACE FEATURES

The N_1 face is subrounded and heavily zap-pitted. It contains one large glass-lined pit 8 mm in diameter. This is the surface facing up in lunar photographs. The T_1, W_1, B_1, and part of S_1 (facing E) is made up of a flat planar fracture, surface containing no zap pits. The combined rock was found on the regolith surface about two-thirds exposed. The orientation is well-documented by photography, however, the distribution of zap pits on the buried surface indicates a different orientation at an earlier time. The planar fracture and zap-pit distribution indicate that 14305/302 was exposed as part of yet another rock and was subsequently broken off and projected to its documented orientation [more detailed discussion can be found in Swann et al. (1971) and Hörz et al. (1972)].

Except for three fractures parallel to the S_1 planar surface on the S_1-B_1 edge, the rock is relatively tough. It is easy to shape with a saw, and the clasts are well sealed in matrix.

The turbid and shattered feldspars are the only shock features visible on the surface.

PETROGRAPHIC DESCRIPTION

14305 is a clast-rich, holocrystalline breccia that has been well-sintered together. It is composed of a light gray fragmental matrix ($\sim$ 70%) with an average grain size less than 0.1 mm (Simonds et al., 1977). The mineralogy of the matrix is indeterminate in binocular observation, but appears to be plagioclase rich. Only a few percent of mafic silicates are recognizable.

The rock has a seriate texture with clasts ranging in size from 10 cm down to the crystallites comprising the matrix. Approximately 30% of the rock is composed of clasts larger than 1 mm. Most of these clasts (80%) are themselves microbreccias of an older generation. A dominant clast lithology is a dark gray aphanitic microbreccia. Only a small percentage of the clasts are of a non-fragmental nature. These include white plagioclase-rich clasts (15%) and brown mare basalt clasts (5%). All of the clasts are well-cemented to the matrix and cannot be broken free. One dark clast has a black glassy matrix contuining 15% phenocrysts and microphenocrysts of subhedral white feldspar and pale green olivine. These phenocrysts are approximately 0.2 mm long set in the crypto-crystalline matrix. Maps of 14305,27; 14305,30; and 14305,18 (Twedell et al., 1978) show the three major clast types (plagioclase, dark gray microbreccia, and mare basalt) as well as several other clasts that are interesting.

In an attempt to characterize the nature of the sample, a reconstruction of slab 14305,46 was undertaken. 14305,46 was subdivided into five portions and each of these were made into probe mounts (14305,104-14305,108). Micro-photography at approximately 3.75x was undertaken and a photo mosaic reconstruction of the slab was made. A detailed mapping of those clasts $\geq$ 1 mm was made and the phases characterized (see figure 4).

As can be seen, the major clasts present include a variety of crystalline breccias and/or cumulates and scattered basaltic fragments. Most of the single mineral clasts lie below the size limitation set and only occasional small clasts of pyroxene and plagioclase are present. A few clasts of anorthositic breccia are also present. Only part of the clasts (as designated) show extensive shock effects. A total of six other sections with various parents were examined to give a more complete characterization of the rock.

The samples examined with the proper parent designated were:

Sample	Parent	Dominant Clasts > 1 mm
14305,4	- ,1	Subdiabasic basalt, anorthositic breccia and fine-grained breccia.
14305,17	- ,11	Large, shocked single crystal pyroxenes, coarse-grained anorthositic breccia and fine-grained breccia.
14305,87	- ,44	Pyroxene/plagioclase cumulates, olivine bearing basalt, fine-grained breccia and single crystal shocked pyroxene.
14305,89	- ,55	Medium-grained breccia and a fine-grained breccia.
14305,95	- ,46	Single crystal pyroxene, subophitic basalt, fine-grained basalt, anorthositic breccia and pyroxene-plagioclase cumulates.

14305,99	- ,37	Myrmekitic-like pyroxene crystal, ophitic basalt, fine-grained glass-rich breccia, spherulitically recrystallized plagioclase, and fine grained anorthositic breccia.

In summing the results of this survey, the predominant type of clasts in these examples is a coarse-grained basalt to pyroxene-plagioclase cumulate. The next most abundant type is the fine-grained breccia. Wilshire and Jackson (1972) list the order of abundance of clasts larger than 1 mm in 14305:

1. Dark metaclastic, most abundant.
2. Intersertal to variolitic basalt.
3. Opaque minerals.
4. Intergranular basalt/plagioclase-pyroxene cumulate-recrystallized pyroxenes.
5. Orthopyroxene/aphanitic basalt/graphic quartz-alkali feldspar/recrystallized plagioclase, least abundant.

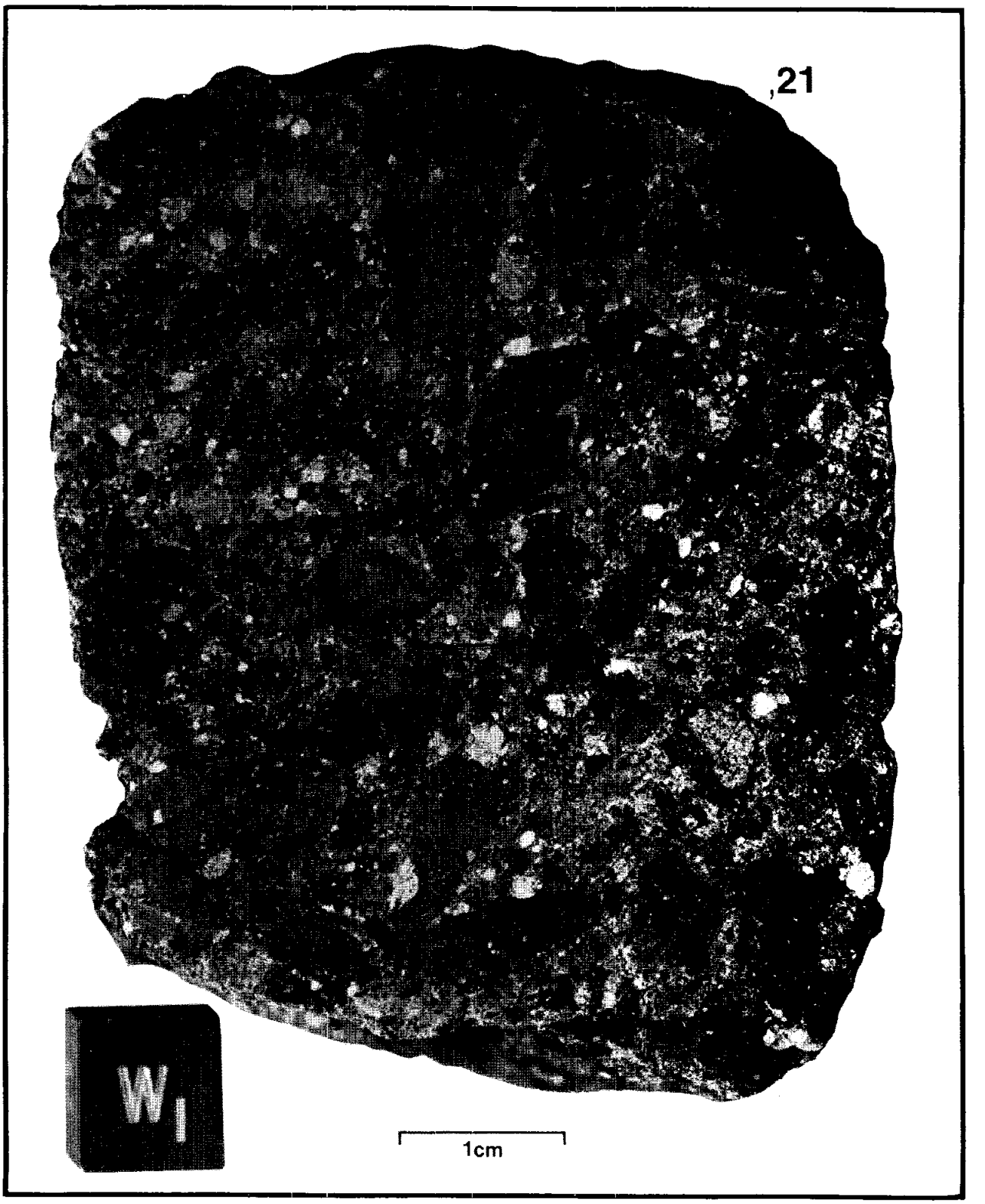
DISCUSSION

Sample 14305 is listed as an F_4 by Wilshire and Jackson (1972), and as a shocked, strongly annealed, Fra Mauro breccia by Chao et al. (1972). It is listed as a grade 6 (high-grade metamorphic) by Warner (1972) and as a crystalline matrix breccia of the Fra Mauro type by Simonds et al. In their studies of the mineral and chemical variations in these samples, Brown et al. (1972) found fragments and lenses of rhyolite, which they believed to have been derived from melting of crystalline granophyre fragments. Several granophyre fragments were observed. K-feldspar in one granophyre (14305,111) contains 4.1% BaO. Dence and Plant (1972) note that in section 14305,5 annealed glass, predominantly of Fra Mauro basalt composition, encloses small amounts of potassic granite.

In their discussion of the effects of micro cratering on the lunar surface, Gault et al. (1972) pointed out the deep fracture cutting across the spalled region surrounding a large glass-lined pit. This impact apparently almost ruptured the rock, and is a good example of the violent and catastrophic disruption that is caused by particles which are capable of forming a crater with a diameter that is a significant fraction of the rock's dimensions discussed in the study by Gault et al. (1972). Sample 14305 is described by Morrison et al. (1972) as being heavily cratered on all major surfaces indicating a complex exposure history. A discussion of the surface orientation is presented in an article by Hörz et al. (1972).

A photograph of a model of sample 14305/302 is available on page 355 of this booklet, along with its geheology on page 354.

14306



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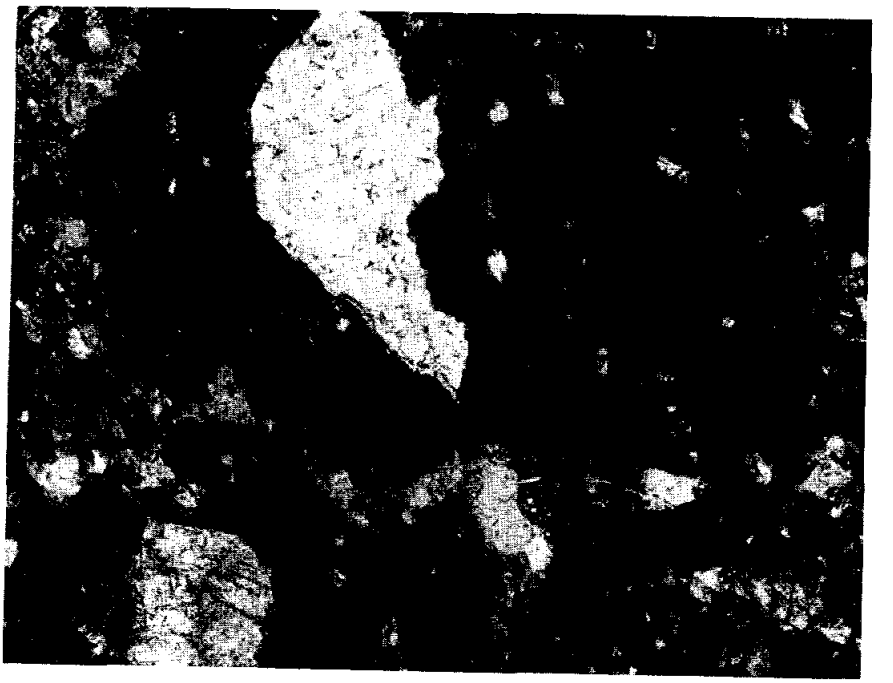
14306, 65



1mm

Sample 14306 is a fragmental rock collected at station G, 230 meters ESE of the lunar module (LM), and 50 meters E of the rim crest of North Triplet Crater. It is said to be somewhat more tabular and less irregular than 60 cm boulder but similar to it in color and albedo. The lunar location and orientation are well documented.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
582.8 g	15.0 x 7.5 x 6.0 cm

This sample is gray with ∿ 25% white clasts and is blocky in shape. The rock is a coherent breccia.

SURFACE FEATURES

The most prominent feature is a 2 mm wide planar fracture lined by vesicular glass, which is oriented at about 20° to the long axis of the sample. This fracture cuts matrix and clasts alike. The rock split along this fracture thereby exposing part of the fracture plane and its glassy coating.

The one flat face of 14306 is lightly covered by glass-lined microcraters (zap pits), and the exposed rounded faces are more densely covered with these zap pits. This rock is one of those used by Morrison et al. (1972) to present and interpret crater population data in terms of the flux and mass distributions of meteoroids in near lunar space. The results of their microcrater studies were then applied to reconstruct the history of the rocks during their residence time on the lunar surface.

PETROGRAPHIC DESCRIPTION

The rock is a coherent, rounded, fragmental rock with some norite clasts and few mare basalt clasts as is evident in the mapped surfaces of 14306,103 (Twedell et al., 1978).

This generic is unlike most of the other Apollo 14 rocks in that there is an extremely high clast content with only minor "matrix" material. The sizes of the clasts vary considerably, but few (in the sections examined) exceeded 1 mm in size. The variety of compositions in these clasts is also less diverse than in the other generics.

A total of two thin sections each with a different parent were examined.

Sample	Parent	Dominant Clast > 1 mm
14306,65	29	Glassy dark metaclastic rock, light metaclastic rock and anorthositic rock.
14306,68	41	Fine-grained dark metaclastic rock, light-colored metaclastic rock and anorthositic rock.

This analysis is in very good agreement with the work of Wilshire and Jackson (1972). Their work concluded that the dark metaclastic rock was represented in the largest clasts in the greatest abundance.

DISCUSSION

The sample is classified as a crystalline matrix breccia by Simonds et al. (1977), and like the other CMB's it falls into the F_4 category of Wilshire and Jackson (1972), grade 4 of Warner (1972), and 2c Fra Mauro (shocked) of Chao et al. (1972). The thermal and mechanical history of sample 14306 has been investigated by Anderson et al. (1972), who describe it as a multi-generation metamorphosed breccia. They found the oldest fragments to be basaltic (noritic) microbreccias that are coarsely crystalline and partly glassy. The second generation fragments are dark-gray micro-to-cryptocrystalline polymict metabreccias. The third generation is the host matrix, and is similar in composition to the second generation.

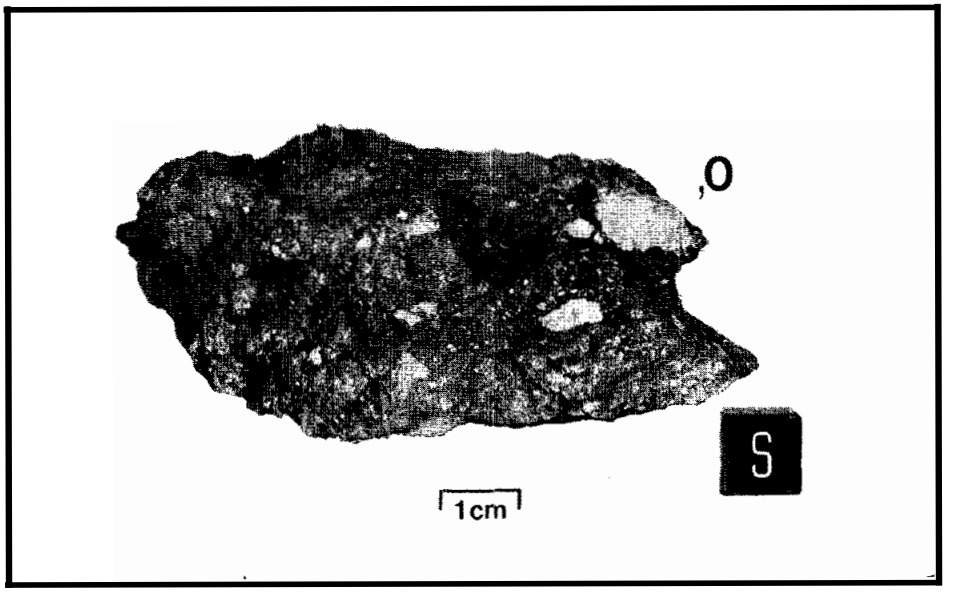
Anderson et al. (1972) interpret the first generation as possibly pre-impact in age. It was fragmented and combined with igneous material to produce the second generation, and the third generation was produced when an impact embedded the second generation material in a crystal rich matrix and was thrown three crater-diameters from Cone Crater. An interesting feature of this rock is that the glass filling the fracture (SURFACE FEATURES) contains three cylindrical metal particles 1-2 mm long and a 200 μm diameter metal spherule observed by Morrison et al. (1972). They noticed that one of the metal particles intersects a glass-walled vesicle and that section of the particle is concave conforming to the vesicle wall. The two other fragments appear to have pulled apart. Although they are now separated by several millimeters, the ends clearly could fit together (Morrison et al., 1972). The particles appear to have been injected with the glass into the fracture at a high temperature.

Crozaz et al. (1972) found the cosmic ray exposure age to be 24 m.y. and feel the rock was ejected during the Cone Crater event, the object that caused the event is interpreted as being metallic.

Wosinski et al. (1972) have identified metal spherules in the same glass on 14306. They are said to range in size from 30 Å to 100 μm in diameter.

A photograph of a model of sample 14306 and a diagram of its geneology is available beginning on page 356 of this booklet.

14307



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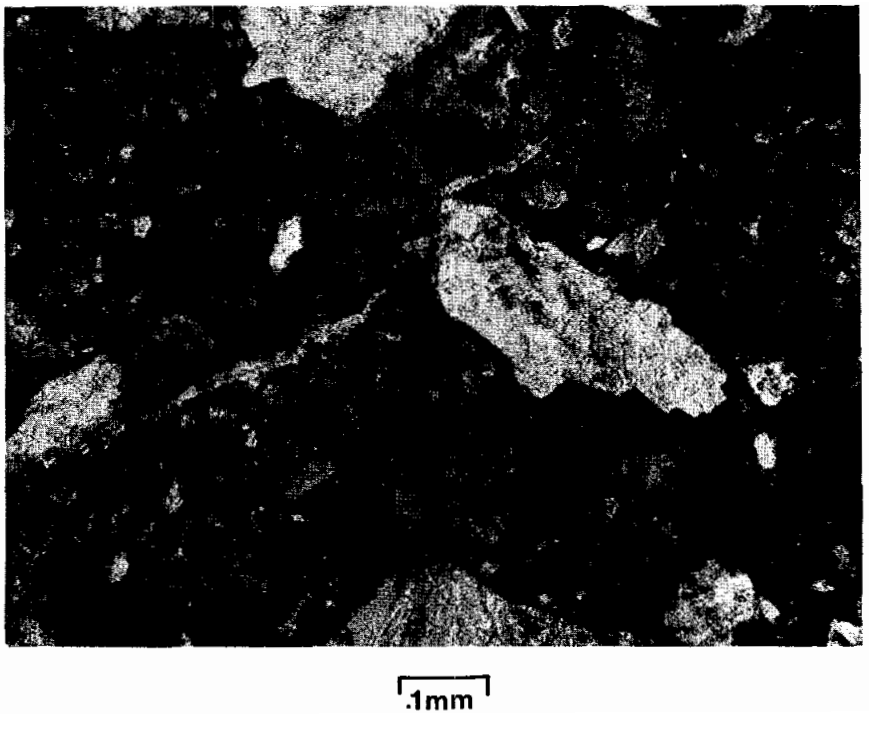
14307, 31



Breccia sample 14307 was collected during the second EVA at station G. This sample was not well-documented because its position had already been changed by the time it was collected. There are no lunar surface photographs of 14307, and its lunar orientation is only known through surface pitting. The rock was placed in documented bag 25N and returned in weigh bag 1031.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
155.0 g	5.0 x 2.5 x 8.0 cm

This is a blocky, subrounded rock with an irregular surface. The color varies from white to dark gray. The rock is friable, but sufficiently strong to prevent clasts from falling out.

SURFACE FEATURES

There are few zap pits (only 15% of surface), but irregular-shaped vugs which range from 0.1 - 0.5 mm in size have been observed. There are many (5-10) irregular superficial cracks 5 - 10 mm in length. One fracture cuts a large white clast and is filled with glass.

PETROGRAPHIC DESCRIPTION

This sample is a polymict breccia with a seriate texture. Twenty to thirty percent of the fragments are larger than 1 mm. Fragments 0.05 - 0.10 mm in size are predominately leucocratic, with angular to subrounded shapes. There are two large (> 5 mm) clasts. One clast (5 x 7 mm) is mesocratic. It is composed of 30-35% lath-shaped feldspar (< 2 mm long) associated with two grains of yellow to pale brown olivine. One grain (0.5 x 0.25 mm) is bright green chrome diopside. The other big blocky clast is coarsely crystalline feldspar, with 5% ilmenite laths, and 5% grayish to transparent anhedral material. Sample 14307 is about 5-10% glass, occurring mostly as black to dark gray botryoidal clasts and as vesicular splash.

Thin section 14307,4 was examined by Ridley during PET and described as being a fine-grained clastic rock. The color, under low power in transmitted light, is a mottled dark brown, with abundant white clasts. The largest lithic clast observed is 1.3 x 1.6 mm in size, and angular to subangular in shape, with the average size being 0.2 - 0.3 mm. The average mineral fragment size is 0.05 - 0.15 mm. Clasts are evenly distributed throughout, with no evidence of any concentrations by clast type. Mineral fragments consist of broken fragments of feldspar, clinopyroxene, and orthopyroxene. There are abundant glass fragments which are colorless, pale brown, and dark brown in color, as well as three glass spheres. The groundmass is very difficult to resolve, being almost entirely unrecrystallized, but is

dark brown in color, with a mottled texture. This finely comminuted material makes up 61% of the sample.

Lithic clasts are, themselves, breccias and contain lithic microclasts, mineral, and glass clasts. Lithic microclasts are observed to include microclasts of breccia and basalt, but most are breccias. Commonly, glass is pale yellow and flow banded. Some honey-brown glass is present. One large clast has a basaltic texture. It is coarsely poikilitic, and composed of feldspar and clinopyroxene, with accessory anhedral ilmenite. One fragment is very olivine-rich. Some clasts could be noritic.

Opaques present in the groundmass include ilmenite, troilite, and metallic iron, with spheres of iron common. Within the clasts, ilmenite, spinel, ulvospinel, troilite and metallic iron are seen.

DISCUSSION

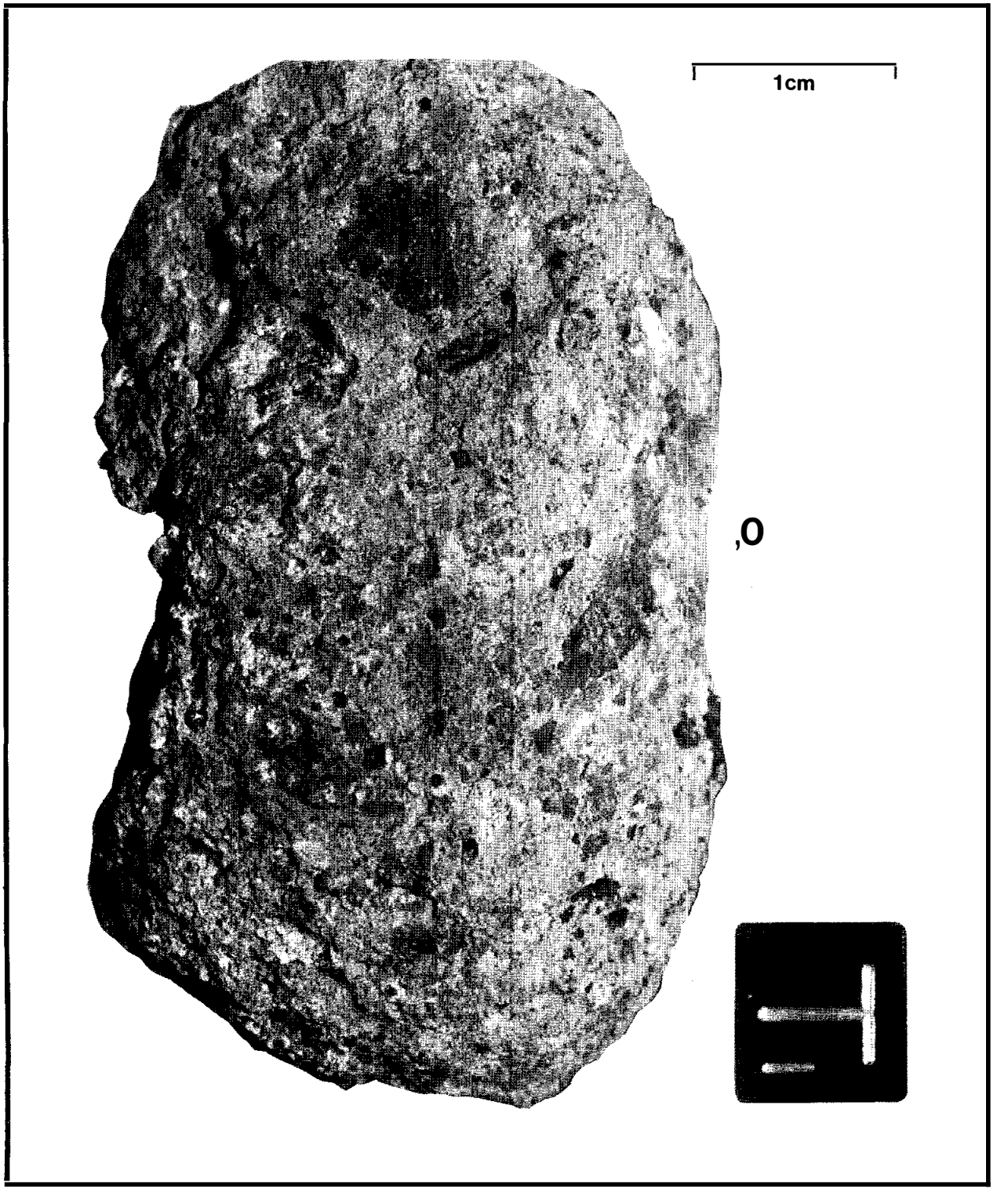
Sample 14307 is classified as a shocked regolith microbreccia (1 c) by Chao et al., (1972), and placed in Warner's group 1. Wilshire and Jackson list it as F2, and von Engelhardt et al., (1972), call it a glass-rich regolith breccia. Simonds et al., (1977), likewise, place it in their vitric-matrix breccia category.

Hörz et al., (1972) studied 14307 to determine the surface orientation of it. They found that part of the glass splatter has been removed by micrometeroid bombardment. The preservation of uncratered, highly vesicular glass splashes, which are very delicate, is said to be an indication that the rock did not tumble after the glass was deposited.

Berdot et al., (1972) found, during their irradiation studies of 14307, that it is KREEP-rich, with a mean model age (T_{GABI}) for the KREEP material of about 4.4 b.y. (Nyquist, et al., 1972). If the compaction of 14307 resulted from the Imbrian event, dated at 3.8 b.y. (Wasserburg and Papanastassiou, 1971), then the time to produce the observed track density is too short with the present solar flare activity.

Berdot et al., (1972), also note that the dark matrix of 14307 contains the "largest absolute amount of 'excess' ^{40}Ar ever measured in a lunar sample, with a $^{40}Ar_{exc}/^{36}Ar$ ratio of 4.8.

14309



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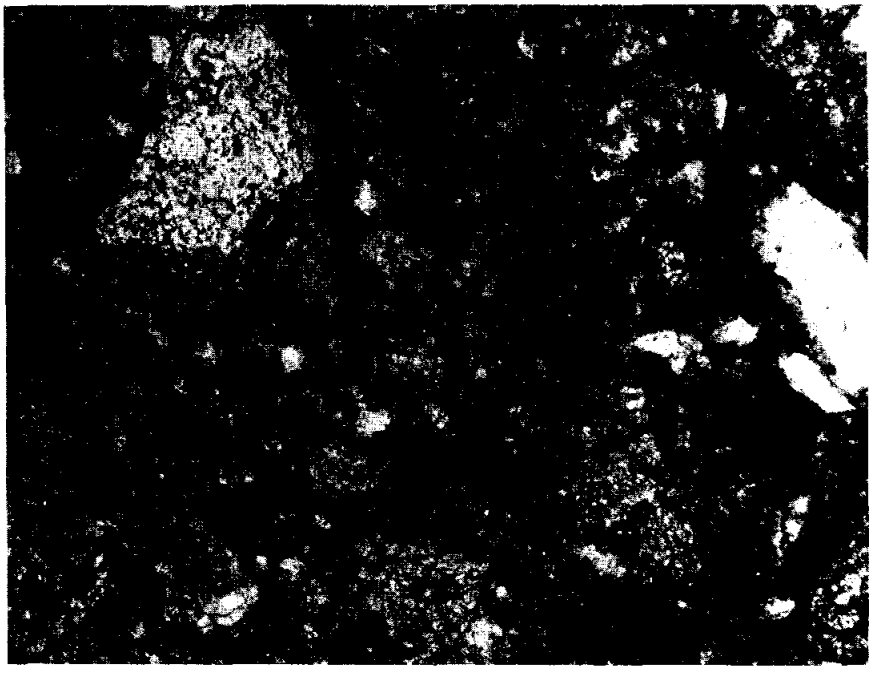
14309, 4



1mm

Sample 14309 was collected sometime during the second EVA. No lunar-surface photographs were made, nor are the location and orientation known. The sample was returned in weigh bag 1031 with other grab samples from EVA 2.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
42.4 g	4.30 x 5.10 x 3.05 cm

Sample 14309 is a moderately friable, vitric matrix breccia.

SURFACE FEATURES

Some small patches of glassy spatter are present, but tend to spall off the surface. The T_1 surface is moderately covered with zap pits (10) as large as 1 mm in size. Spall zones are lacking around zap pits.

One corner is cut by a penetrative fracture; there are very few non-penetrative fractures on the surface.

The N_1 surface is subrounded, and contains a black glassy splash. The B_1

surface is broken and contains no zap pits (Twedell et al., 1978).

PETROGRAPHIC DESCRIPTION

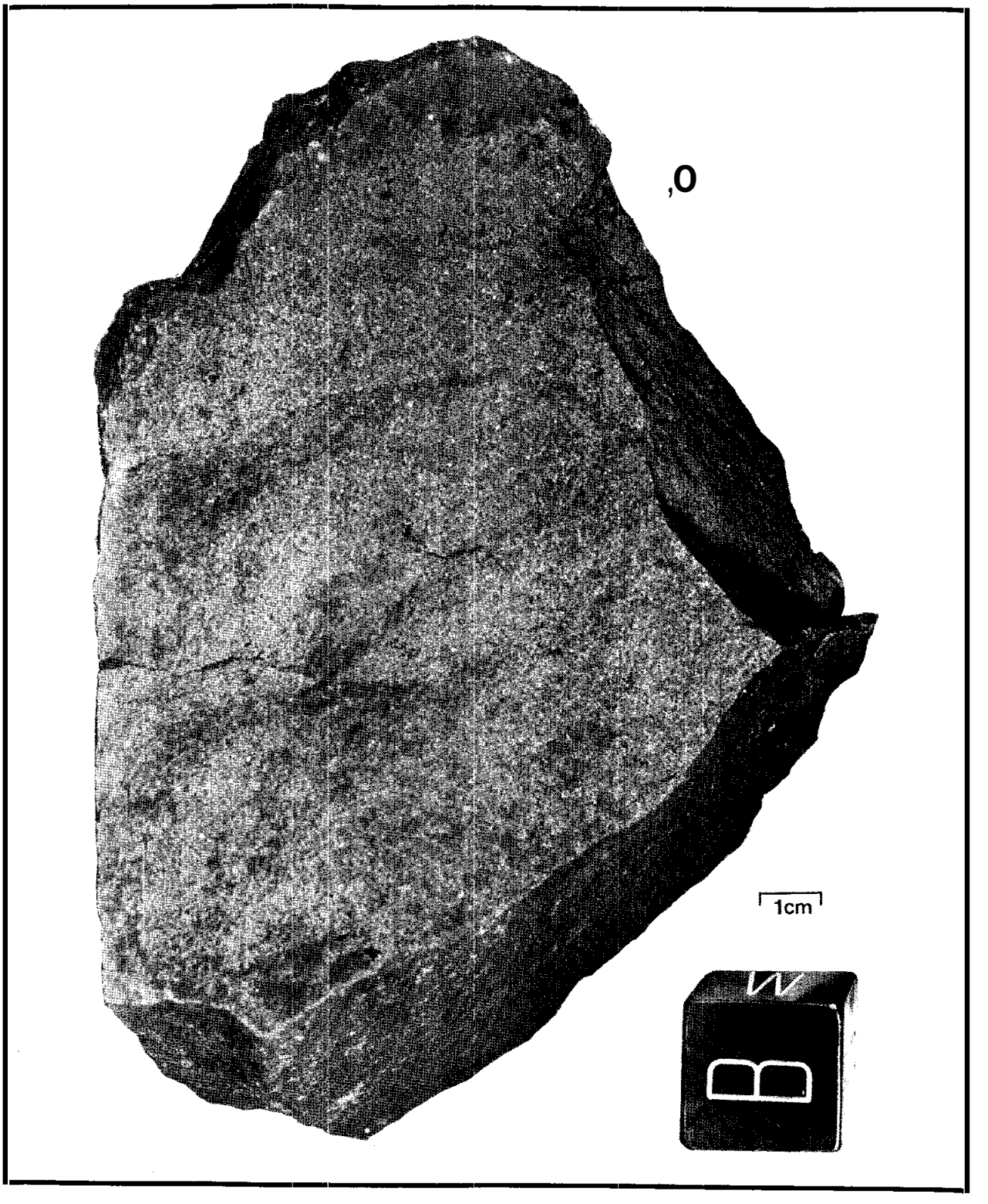
The matrix is 50% off-white and 50% light gray in hand specimen. The white portions are surrounded by the gray, in general. Numerous small irregularly shaped vugs are in the white areas. No clasts of mare basalt are visible in hand specimen. Clast outlines are vague. Clasts include four 1 x 2 mm vitreous black grains, one 1 x 1 mm light yellow-green olivine, and one 3 x 3 mm cloudy white plagioclase grain.

Thin section 14309,4 reveals the rock to be a vesicular glassy matrix breccia with approximately 10% "glass" in the matrix. The vesicules range from as large as 1 mm x 0.6 mm to smaller than 0.5 mm. There are no crystals extending into any of the voids. In addition, the matrix contains abundant mineral fragments and several portions of yellowish glassy spheres, many with reaction rims. There are some ill-defined lithic clasts (> 1 mm) of a "glassy" (5 - 10%) matrix breccia containing very fine crystallites. A few large plagioclase shards are also included in these clasts.

The matrix is composed of approximately 30% lithic fragments and 70% mineral fragments. The lithic fragments, like the clasts, are of fine-grained breccia with occasional plagioclase shards. There are a few fragments of a crystalline nature, but distinct crystals could not be resolved. Most of the mineral fragments are pyroxene which are slightly shocked and some have shock-induced twinning. Several of the crystals show some reaction with the surrounding matrix. The plagioclase is fresh and shows little shock effects.

There are scattered masses of yellowish brown glass with bubbles, swirls and flow lines. There is also a small amount of clear glass in the matrix.

14310



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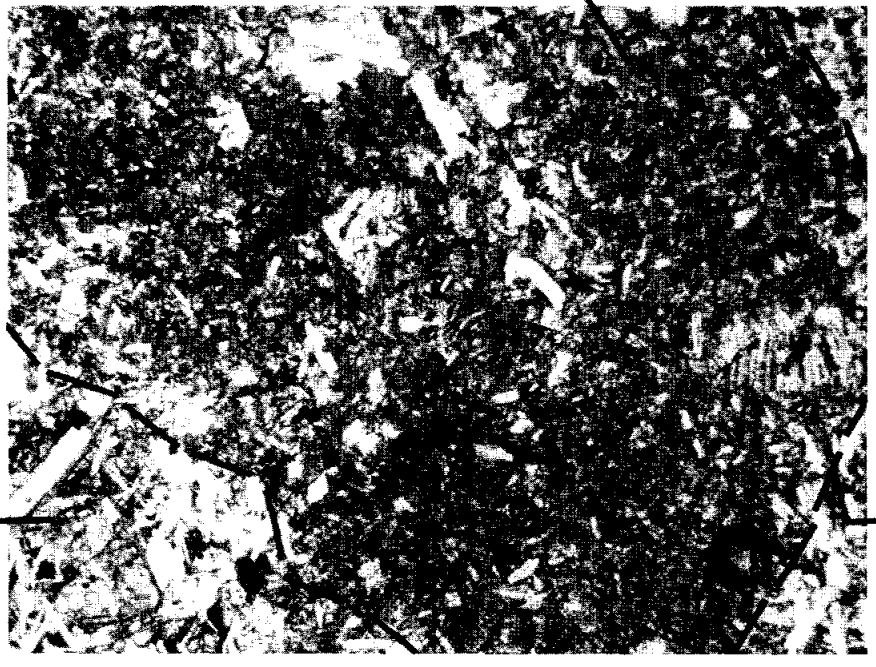
14310, 564

Breccia



1mm

Crystalline sample 14310 was collected during the second EVA at station G. The collection was not well documented -- no lunar-surface photographs were made, and the orientation is known only from surface pitting.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3439.0 g	19 x 14 x 11 cm

This rock is a medium, gray, blocky melt rock, which is subrounded on the pitted sides. It is fine grained and homogeneous in mineralogy.

SURFACE FEATURES

This rock has a smooth surface and is densely pitted on the two subrounded faces. The other three faces are angular and show no evidence of previous microcrater bombardment. The zap pits range in size from 0.1 mm to 4.0 mm, with approximately 90% of them glass-lined. There are estimated to be 20-50 pits per square centimeter on the pitted faces. There are two exfoliation fractures, one of which is parallel to the fresh surface. There are feldspar-lined vugs 0.5 - 2 mm in diameter covering ∿ 1% of the surface of 14310. In large cavities, the feldspar appears to have a honeycomb texture, but in smaller cavities there are clear to gray feldspar crystals projecting into the vugs.

PETROGRAPHIC DESCRIPTION

The rock is composed of feldspar and pyroxene in approximately equal quantities. The feldspar occurs as both clear and turbid euhedral grains of 0.3 mm size. Pyroxene occurs as turbid subhedral grains 0.2 - 0.3 mm in size. Traces of opaques with grains < 0.1 mm are also present. The rock is medium grained and very homogeneous in texture.

In thin section (14310,5), the rock is seen to be composed of 31% pyroxene (mostly pigeonite), 68% plagioclase (∿ An_{90}), 0.5% opaques (ilmenite, chromite, ulvospinel, and troilite), and a trace of metal, with only 0.5% mesostasis. Reid and Melson (LSPET 1971) describe thin sections 14310,4; 14310,5; 14310,6; as having intersertal to subophitic texture. Platy plagioclase forms a framework, with individual crystals as long as 1 mm, and length/width of approximately 30. Pigeonite, possibly rimmed in places by augite, occurs in interstitial to subophitic to sheathlike grains. Discrete areas (as large as 500 μm across) consist of a felted aggregate of plagioclase (and minor alkali feldspar?) laths with a grain size noticeably smaller than the rest of the section. What can be described as a "cognate xenolith" consists of an area 3.3 x 1.5 mm, with the same phases as the remainder of the section, but with a noticeably finer grain size. It is this sort of area that suggests that basalt samples such as 14276 and 14310, for example, were melted during impact, rather than formed by the usual igneous processes. This is especially evident in thin section 14310,564 which contains a breccia clast enclosed by crystalline material.

The mesostasis includes late stage, very diverse materials. Some can be resolved into colorless material (glass?) with opaque to reddish brown spherules, and high relief fibers (apatite?). Minerals include ilmenite, metal (some as spherical droplets), "apatite" (as high relief, low birefringent needles), and an orange-brown mineral (as minute isotropic grains with high reflectivity and relief, platy habit, and pseudo-hexagonal outline, possibly hercynite).

DISCUSSION

Originally believed to be a "type sample" of KREEP basalt, sample 14310 received a great deal of attention (Brown and Peckett, 1971; Gancarz et al., 1971, 1972; Ridley et al., 1972; Longhi et al., 1972; Hollister, 1972; and others). However, it has become apparent that 14310 should not be considered the "type sample" KREEP (Meyer, 1977). The composition of 14310 is like that of soil sample 14163 and it contains a high proportion of siderophile elements as well as included Fe-Ni-P-S melt globules (El Goresy et al., 1972; James, 1973) and therefore appears to have been formed as an impact melt rock. The texture of 14310 ranges from fine-grained subophitic to fine-grained intergranular. Gancarz et al. (1971) present a large color photo-micrograph of the texture. Plagioclase forms an interlocking network of randomly oriented laths (∿ 200 μm). Phenocrysts of plagioclase (2 mm) also form part of this network. Pyroxene occurs as intergranular to subophitic grains in the interstices of this plagioclase network. The cores of the pyroxene are orthopyroxene which zones to pigeonite. Augite sometimes forms epitaxial overgrowths on the pigeonite. Ilmenite occurs in the interstices and is intergrown with the outer margin of pyroxene grains. The mesostasis contains globules of Fe-Ni metal -- schreibersite-troilite, Ba-K feldspar, baddeleyite, tranquillityite, Ca-phosphates and patches of above mentioned silica-rich glass. However, in 14310 this glass is often devitrified.

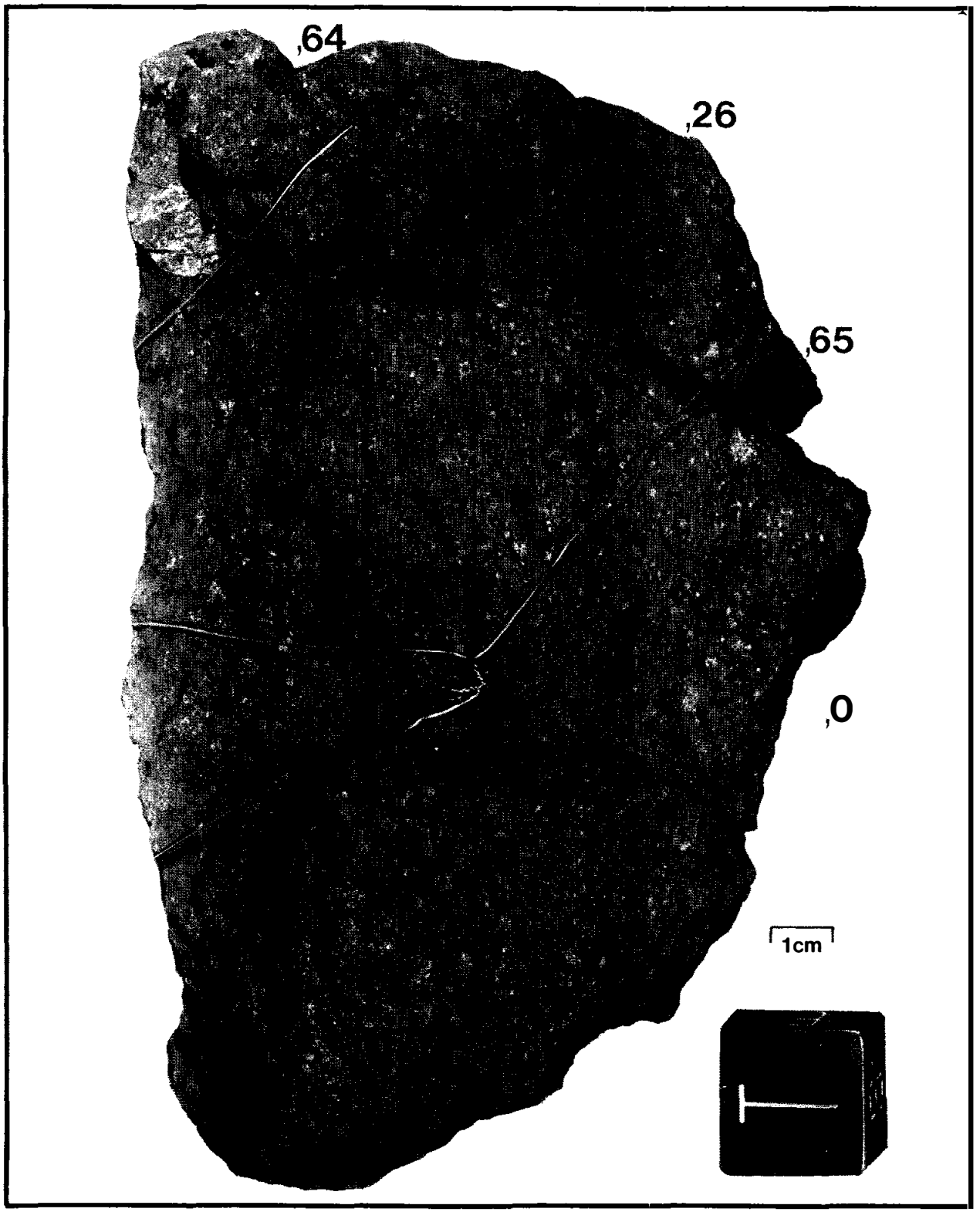
Observation of a large number of thin sections (∿ 30) of 14310 shows that there may be a range in the mineralogical mode (Ridley et al., 1972). Such modal variations as well as a rather wide range in the chemical analyses confirm that 14310 is not a homogeneous rock. In addition, James (1973) and LSPET (1971) report apparently cognate inclusions which are present as small clasts (2 mm across) made up of tightly intergrown plagioclase laths, as well as patches of silicate intergrowths which have significantly coarser grain size than the rest of the rock.

In a thin section study of 14310, Brown and Peckett (1971) found that plagioclase phenocrysts were strongly zones to more sodic and potassic compositions in their outer margins whereas the groundmass plagioclase laths were as calcic as the phenocryst cores. In view of these data they proposed that the basaltic lava lost Na and K by volatilization from the lunar surface during its crystallization. However, Ridley et al.(1972) and Longhi et al. (1972) observe that plagioclase laths often intrude and are included within phenocryst rims and that there is actually a considerable range in the composition of the laths. They conclude, instead, that the alkali content varied locally within the plagioclase network and that

some phenocrysts rims actually grew later than many of the laths. However, the presence of volatiles in the melt and escape of volatiles during crystallization is attested to by the presence of vugs in the rock. The composition of this volatile phase is still unknown.

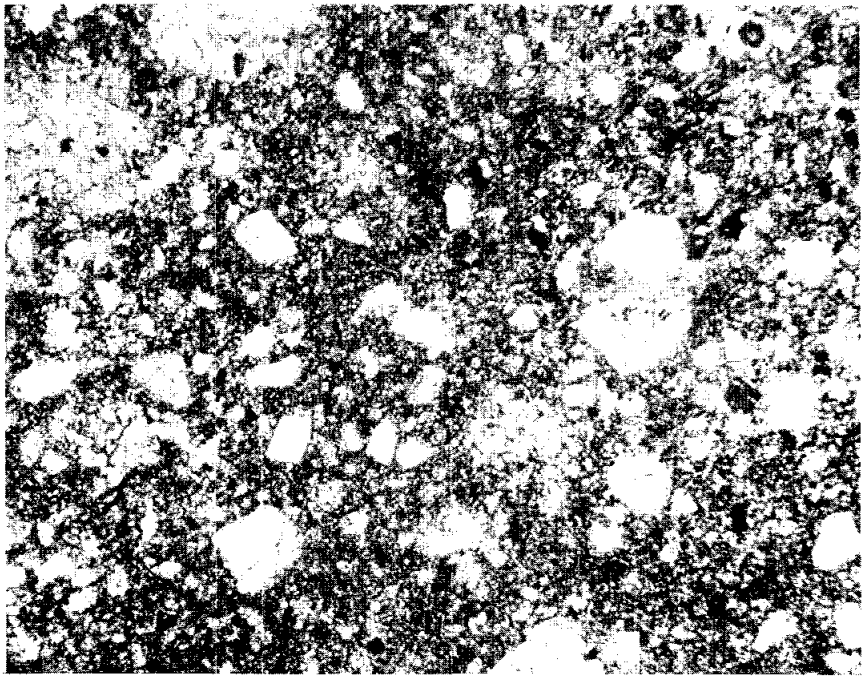
Sample 14310 is listed as a basalt by Wilshire and Jackson (1972) and as a clast-free impact melt rock by Simonds et al. (1977). Wasserburg and Papanastassiou (1971) describe it as closely resembling sample 14276 and different from mare basalts. Ages cluster at 3.88 ± 0.04 billion years ago on these samples, distinct from the age of 3.95 ± 0.03 billion years before present, obtained on 14053 and a clast from 14321 (Papanastassiou and Wasserburg, 1971).

14311/14308



S-71-22900

14311,93



.1mm

Breccia sample 14311 was collected during EVA 2 at station Dg. Lunar surface photographs were not taken and the orientation is estimated from surface pitting. Sample 14308 consisted of 3 pieces which PET found to have been part of 14311 and are included herein. These three pieces were renumbered 14311,26; 14311,64; and 14311,65 (see model, page 359).

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3204.4 g	20.0 x 12.5 x 9.1 cm

This sample is a gray coherent breccia which is broken into pieces along fractures. There are only a few fragments > 1 mm (< 5%) and the rock is mostly (95%) crystalline matrix.

SURFACE FEATURES

Slickensides are present on one face with grooves 3-5 mm apart. Glass lined zap pits range from 0.1 - 1 mm in size with a density of approximately 3 pits per square centimeter. Shock features include fractures and a few shocked lithic fragments. Vugs are present, aligned in a chain like fashion with individual chains spaced 1 cm apart (see also Twedell *et al.*, 1978).

PETROGRAPHIC DESCRIPTION

This fragmental polymict breccia consists of 5% clasts and 95% crystalline matrix. Mineral fragments and lithic clasts are present in subequal amounts. Some mineral fragments are as large as 5 mm and appear fresh. Plagioclase makes up 70% of the mineral fragments. The other 30% is composed of olivine and a black mineral (probably ilmenite). Lithic fragments are 70% crystalline rock fragments and 30% breccia fragments. Some lithic fragments grade into the matrix and it is probably derived from them. Most are leucocratic. There is an intricate relationship between the vugs and the matrix. The rock appears to be igneous in some respects, but the matrix has clast-like fragments. The single crystal clasts are large, fresh, and abundant. This rock is similar in binocular appearance to 14069.

In an attempt to characterize the nature of sample 14311, a selected group of thin sections with different parents were chosen for modal analysis of the $\geq$ 1 mm clasts.

A total of four thin sections were studied and the clast compositions noted. The samples examined with their proper parents designated were:

Sample	Parent	Dominant Clast $\geq$ 1 mm
14311,88 14311,95	42	Anorthositic breccia, basaltic rock, dark metaclastic, light metaclastic.
14311,90	62	Plagioclase shards, dark metaclastic, basaltic rock, light metaclastic, olivine crystals, anorthositic breccia.
14311,91	31	Dark metaclastic, anorthositic breccia, plagioclase shards.

The results of this summary indicate that the predominate rock type in this generic is the dark metaclastic followed by (in order of decreasing abundance) anorthositic breccia, light metaclastic, plagioclase, basalt and olivine crystals.

DISCUSSION

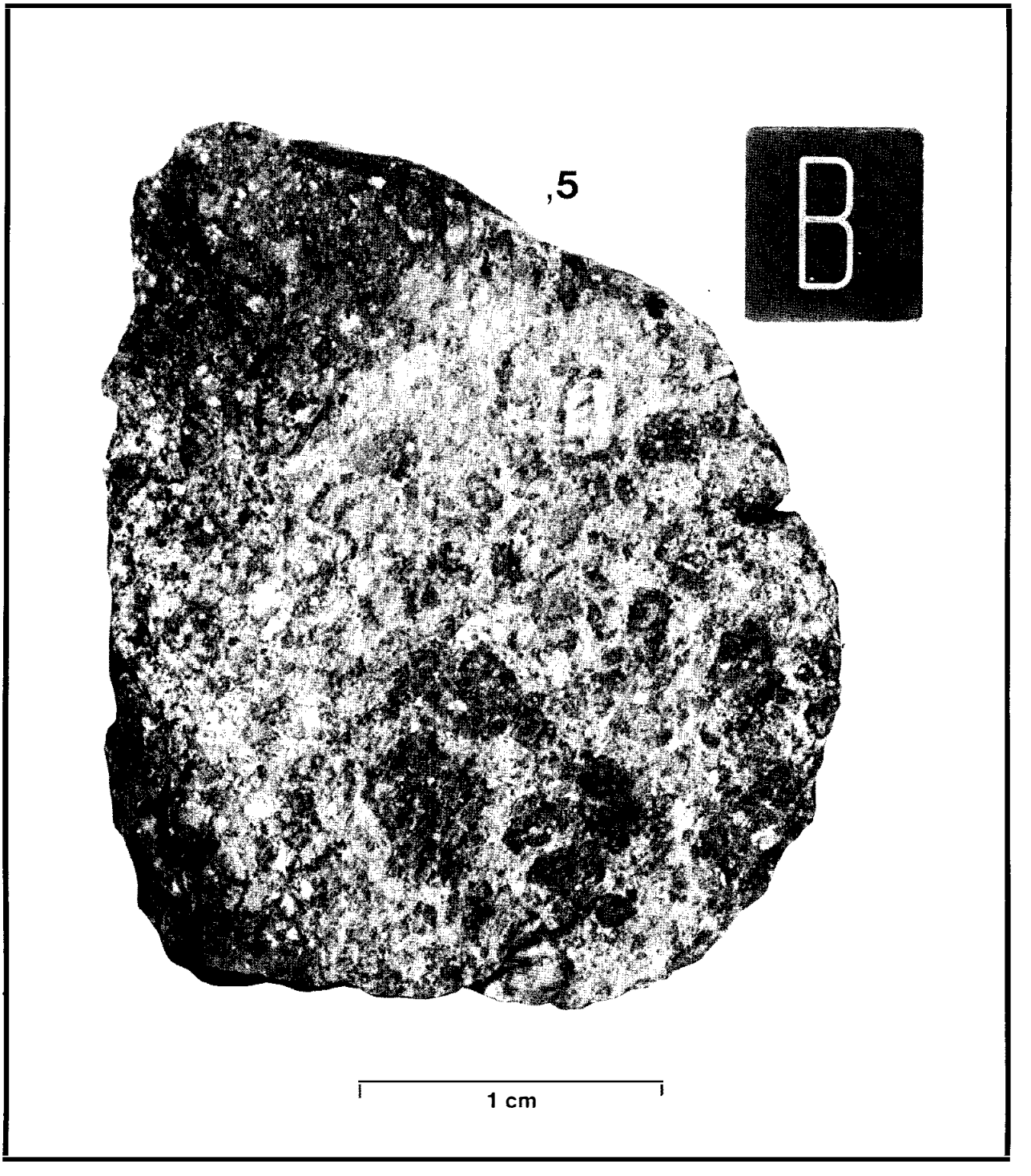
Sample 14311 was investigated by Wilshire and Jackson (1972) and classified as a coherent breccia with dark clasts and placed in their F_4 category. Warner (1972) lists it as a grade 5 metamorphic, and Chao *et al*. (1972) list 14311 as an unshocked, strongly annealed, Fra Mauro breccia, and 14308 as a strongly annealed, Fra Mauro breccia. Quaide and Wrigley (1972) classify it as an annealed breccia. Von Engelhardt *et al*. (1972) and Simonds *et al*. (1977) describe it as being glass poor with a crystalline matrix and a CMB, respectively.

Hart et al. (1972) list the exposure age of 14311 as 3.4 x 10^6 years using particle tracks, Morrison et al. (1972) point out that a portion of 14311 without microcraters was buried at the time of collection, and that the cratered surface represents a single exposure interval. The surface residence time was calculated by them as being 4.5 x 10^5 to 2 x 10^6 years. Sample orientation of breccia 14311/14308 was determined by Horz et al. (1972).

Olivine clasts, with mantles formed by the reaction of the olivine with the breccia matrix, are noted by Cameron and Fisher (1975). They are also present in samples 14304 and 14319. Kesson (1975) attributed these reaction rims to metamorphism during burial in a hot ejecta blanket, using the breccia formation model of Warner (1972). Kesson believed, on the basis of her experimental model, that reaction rims can be formed over a period of years.

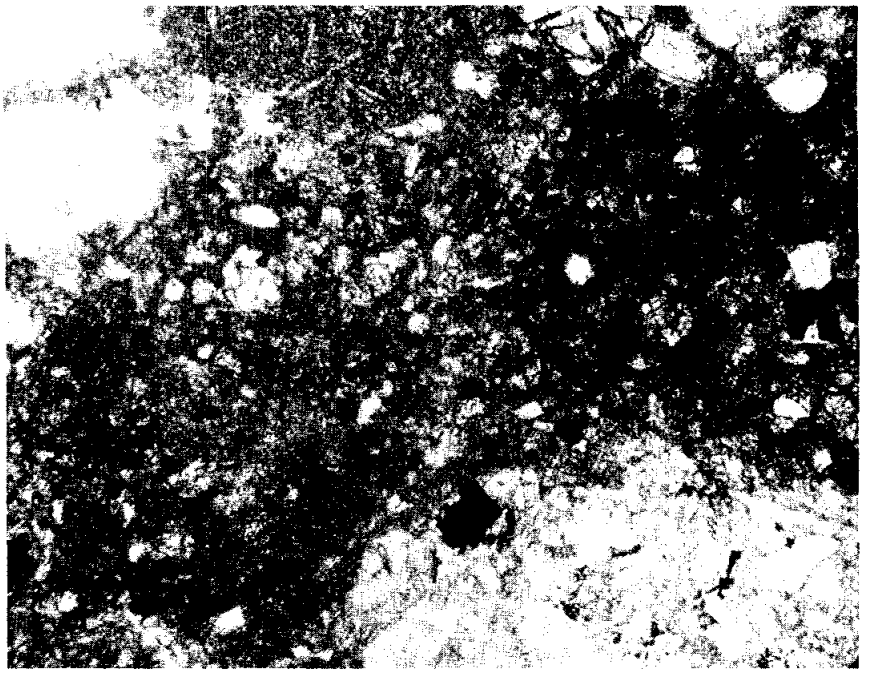
The sample's geneology and a photograph of the model is available on pages 358-359.

14312



S-77-26213

14312, 13



1mm

Sample 14312 is a breccia collected from the top of Turtle Rock during EVA 2 at Station H. Its lunar orientation and location were well documented. Turtle Rock is the largest of several boulders at Station H, and the two rocks on it were nicknamed "turtle eggs", and collected as samples 14312 and 14319.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
299 g	9 x 6 x 4 cm

This rock is a medium gray, coherent breccia which is partly covered with glass.

SURFACE FEATURES

Zap pits are present on all sides of 14312 suggesting that it was turned over after spalling off Turtle Rock or that it fell onto Turtle Rock from elsewhere (Swann et al., 1977). The zap pits are glass-lined and range from 0.1 - 4 mm in diameter. Many of the pits have white halos around them. Pit density is estimated to be 45 pits per square centimeter. The rock has both penetrative and non-penetrative fractures. Three sets of fractures

are filled with veinlets of dark brown, vesicular glass, similar to that on the surfaces of 14312. The glass coating covers half of two faces.

PETROGRAPHIC DESCRIPTION

This rock is a polymict breccia, with at least 80% of the fragments lithic in nature, and less than 15 - 20% mineral fragments. Most lithic fragments are fine-grained and in some cases it is hard to distinguish the clasts from the matrix. Angular lithic fragments are 60% medium gray material and 40% leucocratic material which occasionally contain white feldspar. The matrix is white to light gray with a brownish tinge. Thin section 14312,13 shows that the predominant lithic type is a fine-grained breccia with some included larger mineral fragments. The second most abundant type is a poorly organized mixture of pyroxene and plagioclase. Many of the plagioclase crystals in these fragments are distorted and bent. The section also reveals that the predominate type mineral fragment present is fresh to mildly shocked plagioclase shards. There is also a nearly equal amount of pyroxene fragments, some of which are quite large.

In thin section approximately 30% of the area is composed of a dark, fine-grained material which contains abundant opaque grains. Some large to small areas of devitrified glass are also present.

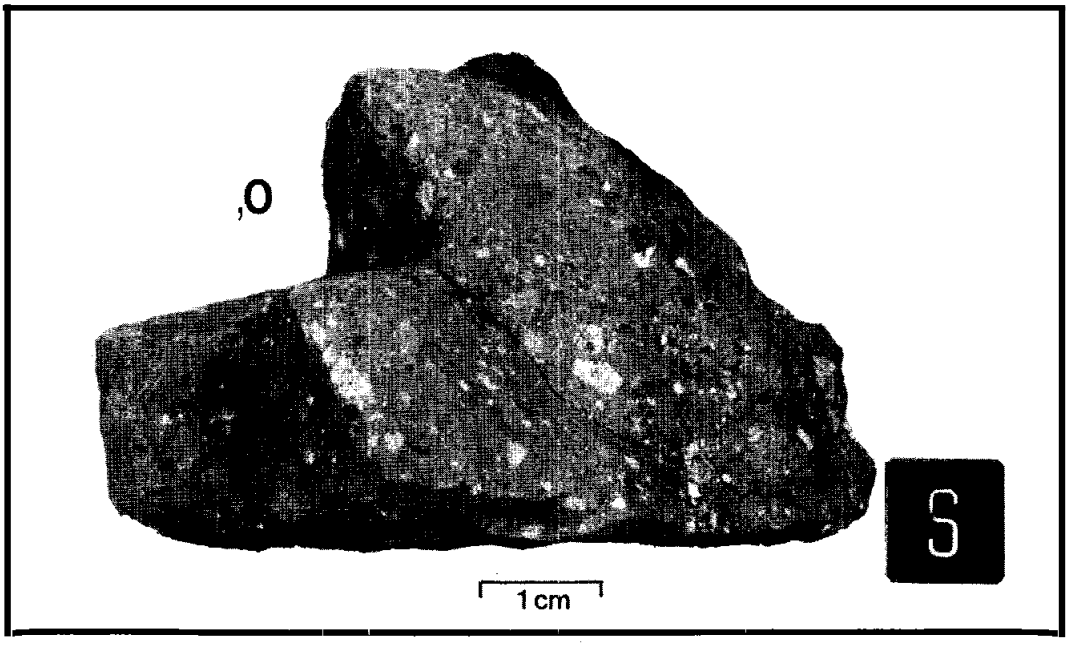
Mineral fragments are mostly plagioclase 0.5 - 2.5 mm in diameter, one large clast of which is shattered. Some light yellow and cinnamon brown material is also present with fragments ranging in size from 0.2 - 1 mm in diameter. A trace of dark gray, angular, glass fragments is present with rounded to equant particles. The rock has been mapped by members of the Imbrium Consortium (1976) and by our recatalog team (Twedell et al., 1978).

DISCUSSION

Sample 14312 was listed as Warner's (1972) grade 7, and as an F_4 by Wilshire and Jackson (1972). Chao et al. (1972) list it as a shocked, strongly annealed, Fra Mauro breccia (2c), and Simonds et al. (1977) describe it as a crystalline matrix breccia (CMB).

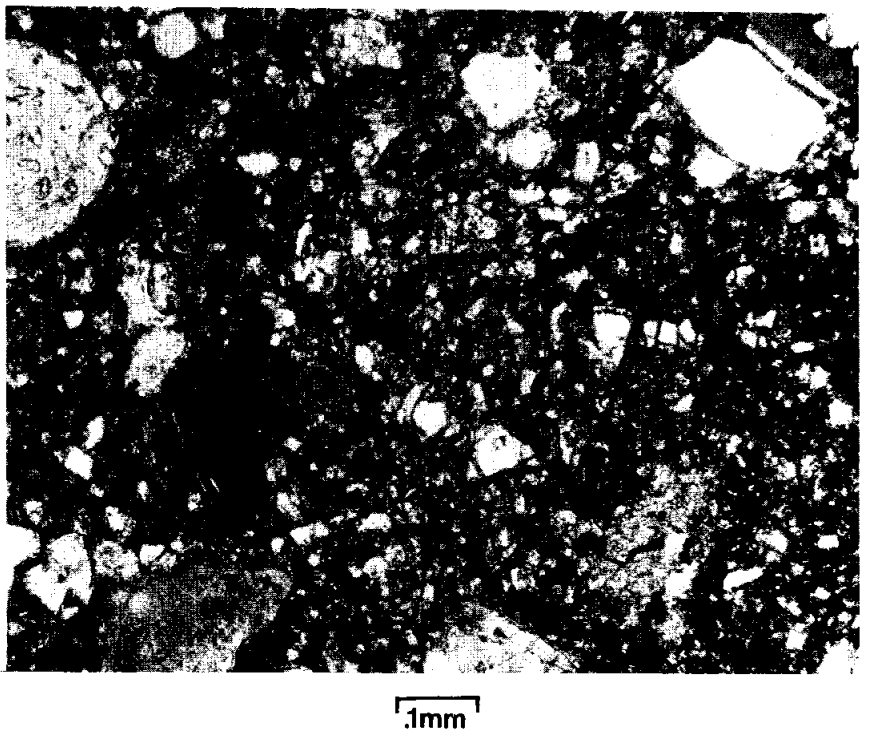
Ryder and Bower (Imbrium Consortium, 1976) investigated the petrology of sample 14312 and mapped thin section 14312,14. They concluded that 14312 was assembled from other polymict breccias at a high temperature. Injected melt phases, maskelynite, and shock mineral phases indicate that the assembly took place in the ejecta blanket produced by a major meteorite impact.

14313



S-71-29134

14313, 41



Breccia sample 14313 was collected during the second EVA at Station G1, 150 m east of the LM, on the north rim crest of North Triplet Crater. It was placed in documented bag 27N. Its lunar location and orientation are well documented.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
144 g	6 x 6 x 4 cm

This is a medium light gray, coherent, fragmental breccia with a distinctive shape due to a prominent notch produced by spalling along two sets of fractures intersecting at an angle of 105°.

SURFACE FEATURES

All surfaces have a light to moderate density of glass-lined zap pits (20 - 30 per square centimeter). The pits range from 0.1 - 1.0 mm in diameter (see Twedell et al., 1978).

Sample 14313 is described by Morrison et al. (1972) as having large crater densities on all major surfaces, Its lunar orientation is well documented by lunar surface photography (Sutton et al., 1971). The tumbling history was investigated and is presented in diagrammatic form in the article by Morrison et al. (1972, p. 2776).

There are two well defined fractures, one of which extends along the length of the rock.

PETROGRAPHIC DESCRIPTION

This sample is a polymict, fragmental breccia with clasts larger than 1 mm comprising 25 - 30% of the rock, and fine-grained matrix the other 70 - 75%.

Thin section 14313,14 contains only about 10% lithic clasts (> 1 mm) with no mineral fragments that large. The clasts are angular to rounded rock fragments which appear to be mostly crystalline with well defined boundaries. The clast composition ranges from 20% feldspar and 80% olivine in mesocratic clasts to 80% feldspar and 20% olivine in leucocratic clasts. Intermediate clasts contain 5 percent pyroxene. The matrix appears to be 70% clear subhedral feldspar grains 0.5 mm in size and 30% pyroxene grains < 0.1 mm in size, with minor amounts of olivine of about 0.1 mm grain size. The matrix is texturally homogeneous but there are inhomogeneities in matrix mineralogy. There is approximately 30% brownish-yellow "glass" in the matrix. There are abundant glass spheres and masses of glass present along with a small amount of spinel.

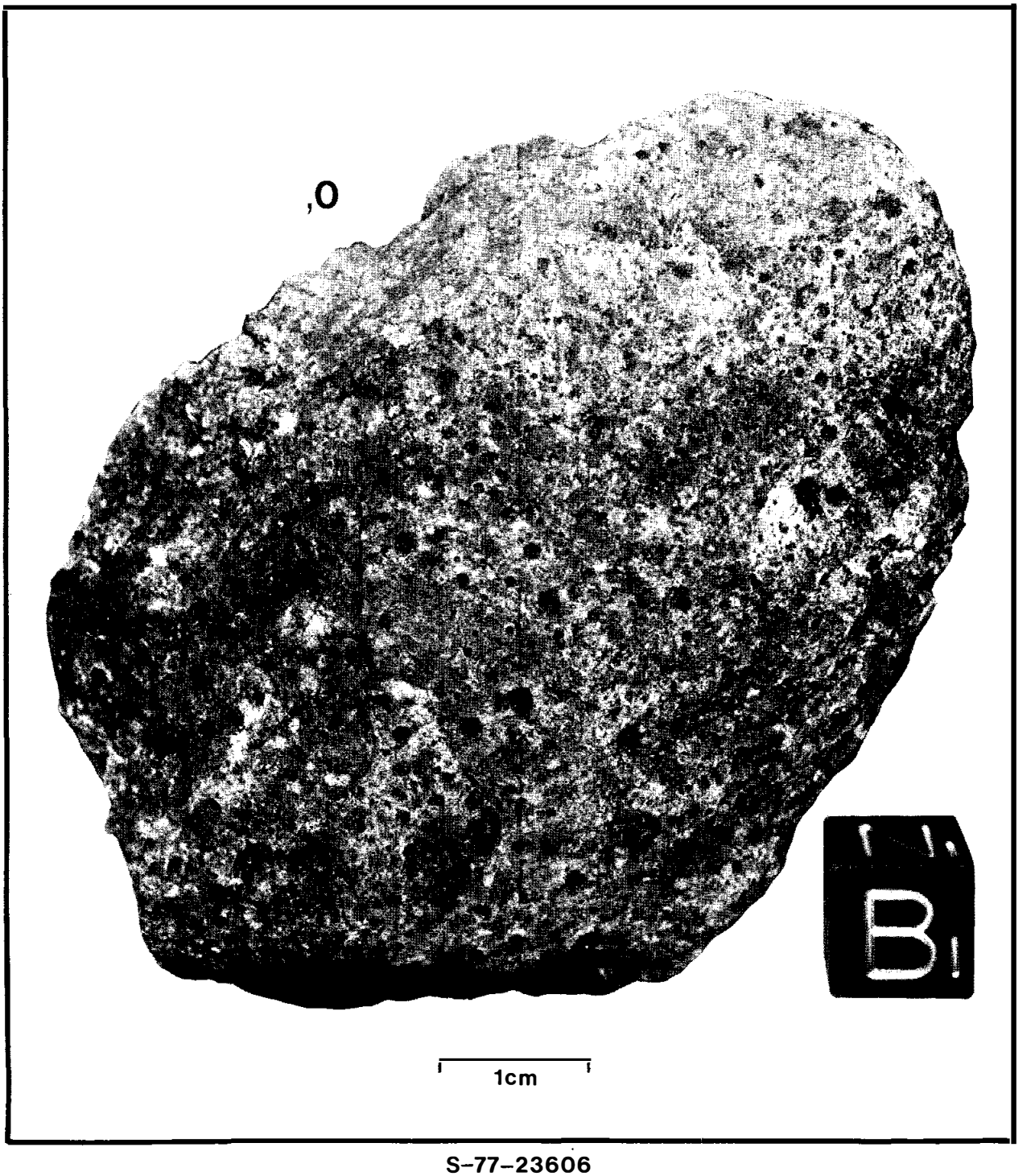
DISCUSSION

Sample 14313 has been studied extensively by a consortium of nine labora-

tories. The mineralogy, petrology, and petrogenesis were investigated by Floran et al. (1972). Sample 14313 was described by them to be a coherent, polymict breccia with a complex history of comminution and reagglomeration. Five thin sections were examined: 14313,7; 14313,39; 14313,40; 14313,41; and 14313,42, but these originated from only two parents: 14313,7 came from 14313,3 and the parent of the others is 14313,35. The dominant clast types were listed as (1) noritic rock fragments, (2) monomineralic fragments, (3) microbreccia clasts, and (4) glassy fragments including glass spherules. These glass spherules are described as chondrules and chondrule-like bodies by King et al. (1972). Mare-type basalt clasts are described as rare by Floran et al. (1972). They found the matrix of the breccia to be composed primarily of fine particles of brownish glass. Varying degrees of shock damage to the clasts were observed, ranging from unshocked through shock-melted fragments. A sequence of four unrecrystallized microbreccias was recognized and recrystallized clasts are also present. The abundance of micronorite clasts in 14313 are interpreted as an indication that noritic rocks were an important pre-Imbrian rock type in the Imbrium Basin area. 14313 was assigned to Group I of Lindsay's classification. He estimated 10% of the sample to be glass, most of which is colorless. Plagioclase and pyroxene are the dominant mineral phases. It was also described as a vitric matrix breccia (VMB) by Simonds et al. (1977), and as a regolith breccia by Quaide and Wrigley (1972). Chao et al. (1972) list it as a compact, nonporous, regolith microbreccia (1b). It is listed as an F_2 by Wilshire and Jackson (1972) and placed in Warner's (1972) lowest metamorphic grade facies (Group 1).

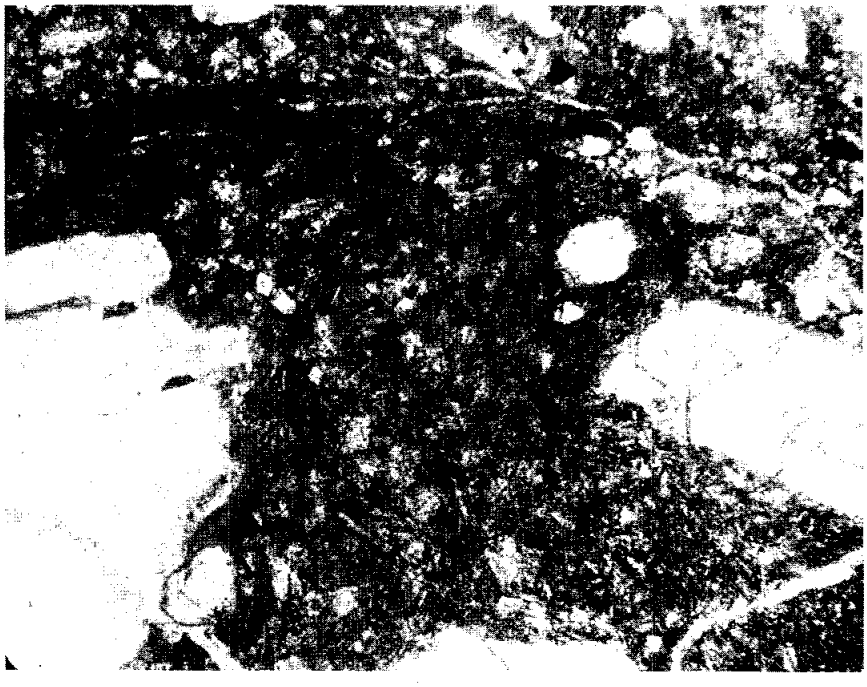
The sample's geneology can be found on page 360 of this document.

14314



S-77-23606

14314, 10



.1mm

Sample 14314 is a breccia sample collected during the second EVA at Station H. It was collected from the fillet below Turtle Rock, 80 meters NW of the LM. The fillet slopes 2 - 3° to the flat regolith and has abundant rocks up to 30 cm in size distributed in it.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
115.7 g	7 x 5 x 3 cm

The rock is a friable breccia, medium to light gray on its fresh surface and dark brownish gray elsewhere. Approximately 40% of the surface is glass covered.

SURFACE FEATURES

Glass-lined pits range in size from smaller than 0.1 mm to 2 mm. There are approximately 60 pits per square centimeter except on the freshly broken surface (see also Twedell *et al.*, 1978).

There are two generations of fractures with the older fractures filled with dark glass and the younger ones slightly opened, very irregular, and closely spaced.

PETROGRAPHIC DESCRIPTION

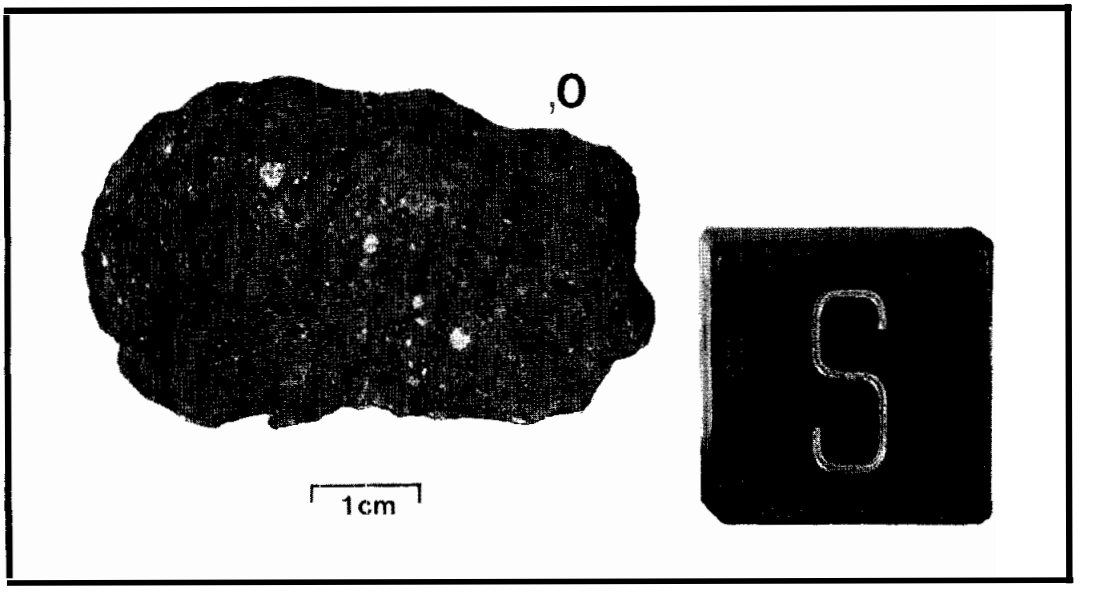
Sample 14314 is a polymict breccia which is composed of 10% leucocratic material and lithic fragments larger than 1 mm and 90% light and dark gray fragments smaller than 1 mm. Five percent of the rock is composed of mineral fragments larger than 0.1 mm. Mineral fragments consist of white to clear plagioclase, pale greenish yellow olivine, and clear cinnamon-brown pyroxene. Nine percent of the rock is composed of angular to rounded lithic fragments, 98% of which are leucocratic. Silicate boundaries are indistinct suggesting shock effects. Angular, dark brown to black glass fragments make up 2% of 14314. The matrix in many cases grades into the clasts. The matrix is a seriate mixture of mineral fragments and small lithic shards with very little dark, fine-grained material.

Thin section 14314,10 shows an abundance of highly shocked, large, pyroxene fragments and clasts interdispersed with a few lithic clasts. The predominant lithic clast type is a plagioclase-rich cumulate and numerous types of fine-grained breccias. There are olivine grains in the cumulates and in many of the pyroxene and plagioclase grains.

DISCUSSION

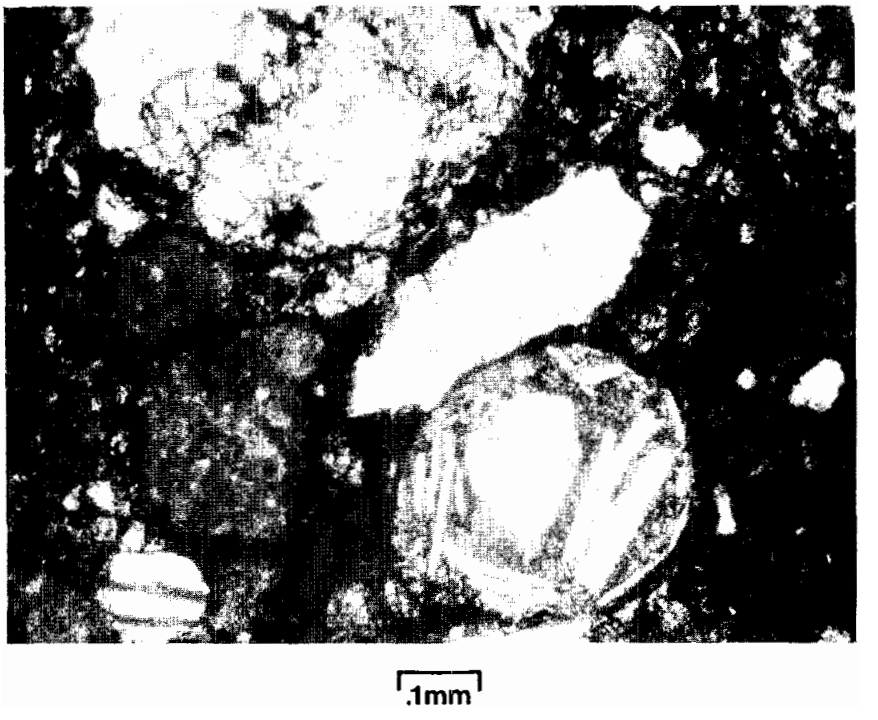
Wilshire and Jackson (1972) list sample 14314 as an F_4 (coherent with dark clasts). Warner (1972) places it in his high grade metamorphic category (7), and Chao *et al*. (1972) describe it as a shocked, strongly annealed, Fra Mauro breccia. Simonds *et al*. (1977) list it in their CMB category. In their analysis of Fra Mauro samples, Dence and Plant (1972) describe sample 14314,13 as containing a wide variety of clasts including mineral fragments, mare basalt, and annealed glass, predominantly of Fra Mauro basaltic composition, enclosing smaller amounts of potassic granite.

14315



S-71-54204

14315, 7



Sample 14315 is a breccia collected from Station H (North Boulder Field) during EVA 2. Its lunar location is documented as being 15 m SE of Turtle Rock and 70 m NW of the LM, but the lunar orientation is tentative. It was returned in weigh bag 1038.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
115. g	3 x 6 x 6 cm

This coherent, gray breccia has a rounded surface and an angular flat underside.

SURFACE FEATURES

Glass-lined zap pits cover the rounded surface more densely than the flat surface, with 30 pits per square centimeter. The pits range in size from less than 0.1 to 2 mm.

There are two fracture sets orthogonal to each other, with three fractures in one set and one in another.

PETROGRAPHIC DESCRIPTION

This sample consists of 20% fragments less than 1 mm and 80% fragments larger than 1 mm. Seventy percent of the rock consists of lithic fragments greater than 0.1 mm which are entirely leucocratic and white. Two fragments of plagioclase rich material about 5 mm in size can be seen on the rounded surface. A prominent set of planar laminae of dark black glass 0.02 mm thick, about 2 mm long, and spaces 2 - 5 mm apart is an unusual feature of this rock. The glass laminae transect some grains but go around others.

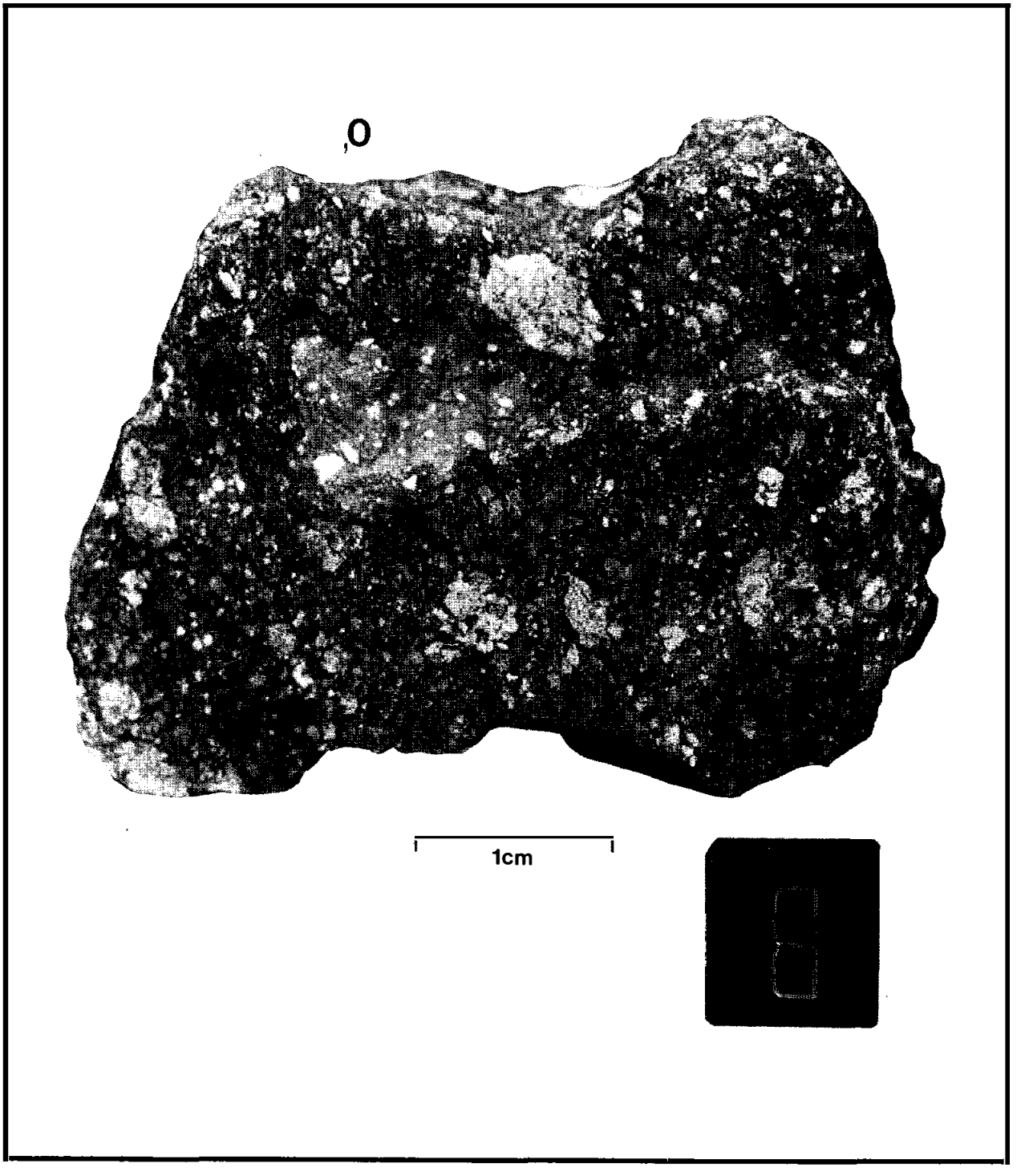
Thin section 14315,7 is very unusual in that the rock displays an interlocking mixture of mostly rounded, partly to nearly totally devitrified glass bodies, abundant chondrule-like bodies and scattered larger, highly shocked mineral and lithic fragments. The main lithic type present is microbreccia with either a very fine-grained matrix to a holocrystalline matrix. Many of the mineral fragments have been shocked to an extent that they are now very "glassy". The material cementing the fragments together is a reddish-brown, fine-grained material which shows a discontinuous pattern. One quarter of the section is a leucocratic clast which is in sharp contact with the other parts of the section.

DISCUSSION

Wilshire and Jackson (1972) describe sample 14315 as a coherent breccia with light clasts (F_2). Warner (1972) places it in his metamorphic grade 3, and Chao et al. (1972) list it as a spherule-rich, transported microbreccia (3). Simonds et al. (1977) classify rock 14315 as a VMB.

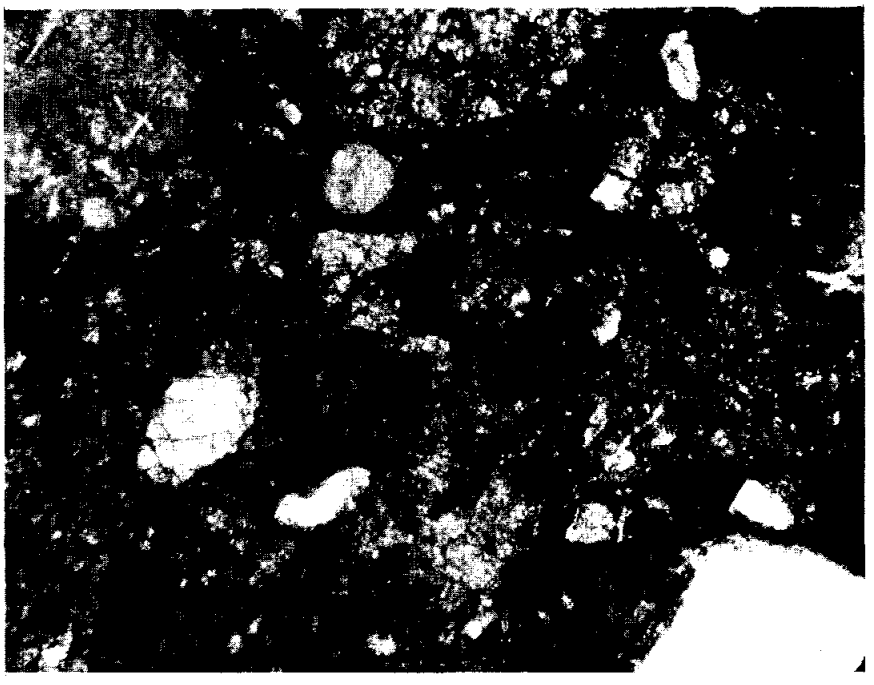
Nelen et al. (1972) describe sample 14315 as dense, plagioclase-rich rock with 5 - 10% chondrules consisting of plagioclase needles in a glassy matrix and glass spherules and fragments, most of which are devitrified. Analyses of the glasses reveal them as having a low (< 10%) iron content. One large fragment (2 x 6 mm) containing several clasts of quartz-K-feldspar intergrowth and a large rounded grain of orthopyroxene were observed. Most of the clasts were described as being olivine or plagioclase, however. Dence and Plant (1972) also observed many chondrule-like bodies and devitrified glasses of feldspathic basalt composition in sample 14315.

14316



S-77-23602

14316, 5



.1mm

Sample 14316 is a breccia collected at station H during EVA 2. It has not been identified in lunar surface photographs, so its exact lunar location and orientation are unknown. It was returned in weigh bag 1038.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
38.2 g	4.5 x 3.0 x 1.5 cm

This rock is a medium gray, inhomogeneous, fragmental breccia with one flat face. There is a predominance of leucocratic clasts.

SURFACE FEATURES

The rock has an irregular surface with less than 2% glass cover. Three surfaces of the rock are pitted, and the rounded surface is covered with glass-lined zap pits with a density of 15-20 pits per square centimeter. The pits range from 0.25 - 1 mm in size. There is glass but no zap pits on the flat surface (see also Twedell et al., 1978).

Two sets of planar fractures cut the rock. The two members of the first set are spaced 6 mm apart. One of these cuts across both matrix and clasts.

Both fracture surfaces are glass splattered. The second fracture set appears fresh and irregular.

PETROGRAPHIC DESCRIPTION

The grain size ranges from 0.1 mm to 0.2 mm, and is inhomogeneous. The rock is polymict with 20% fragments greater than 1 mm and 80% matrix. The clasts are leucocratic, and consist of two types:

1. Fine grained microbreccia with leucocratic clasts and angular feldspar in a fine grained recrystallized matrix.

2. Clasts with pyroxene and plagioclase in varying proportions. These measure up to 1.0 cm in size and have subrounded, very irregular scalloped shapes with sharp outlines. These are the dominant clasts in 14316.

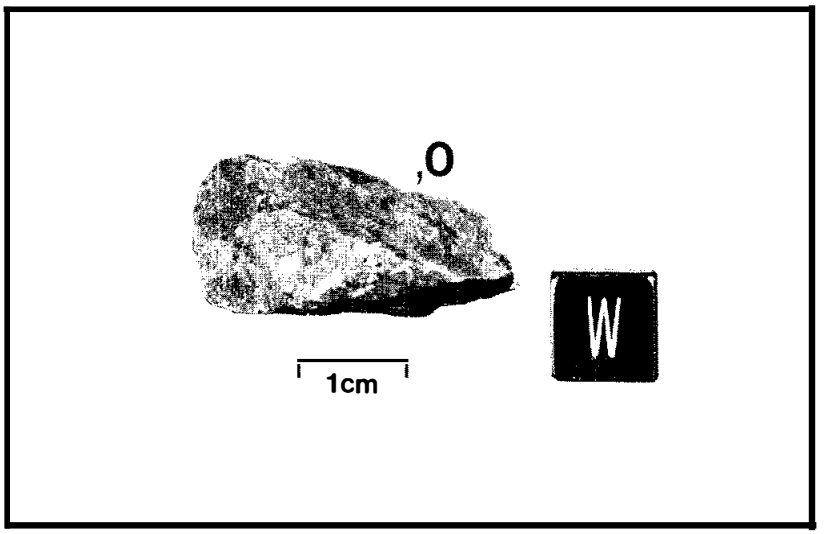
The matrix consists of ∿ 30% very small leucocratic fragments, < 1% brown pyroxene, yellow green olivine (?), and ∿ 70% light gray material. There are numerous small spherical to irregular glass masses, many of which are partly devitrified, scattered through the matrix. Only about 5% of the matrix is the fine-grained dark gray material. The matrix appears to be at least partly recrystallized.

Thin section 14316,5 is somewhat reminiscent of 14315,7 in that the rock consists of an interlocking mixture of mineral and lithic fragments cemented together by a brownish "glassy" material. The fragments are much less resolved than in 14315,7 and there are fewer chondrule-like bodies and devitrified glass masses. There is one large reddish-pink spinel crystal surrounded by opaque grains and a "halo" of finely crystallized material. Smaller masses of spinel are scattered throughout the section.

DISCUSSION

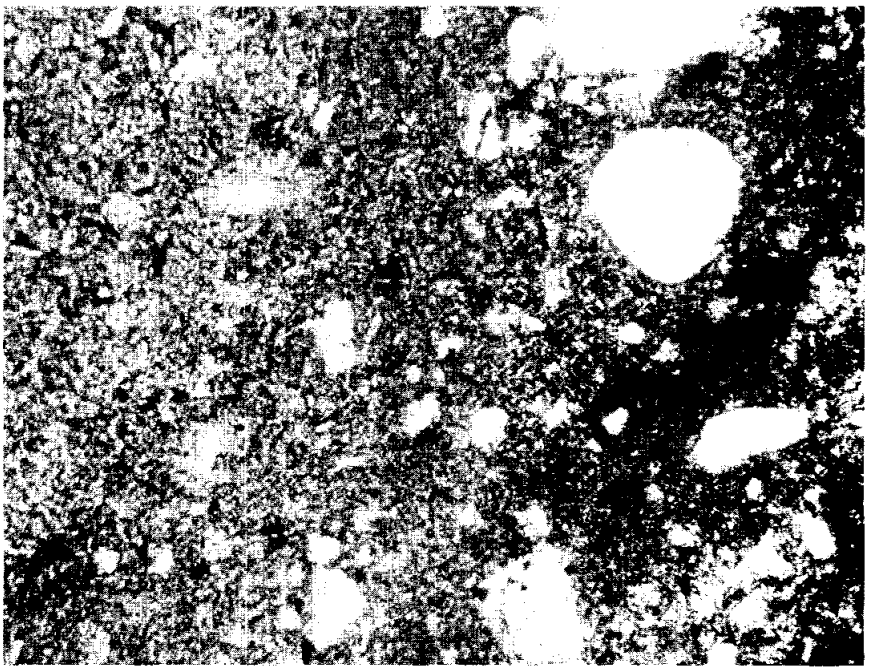
Sample 14316 was placed in their F_2 category by Wilshire and Jackson (1972)

14317



S-71-32588

14317, 4



Breccia sample 14317 was collected at station H during the second EVA but has not been identified in the North Boulder Field photographs, so its lunar location is tentative, and lunar orientation, unknown. It was returned in weigh bag 1038.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
16.1 g	3.0 x 2.5 x 1.5 cm

This rock is a medium gray, coherent breccia.

SURFACE FEATURES

The pitted surface has a density of approximately 20 pits per square centimeter. The pits vary from 0.1 mm to 0.2 mm in size.

PETROGRAPHIC DESCRIPTION

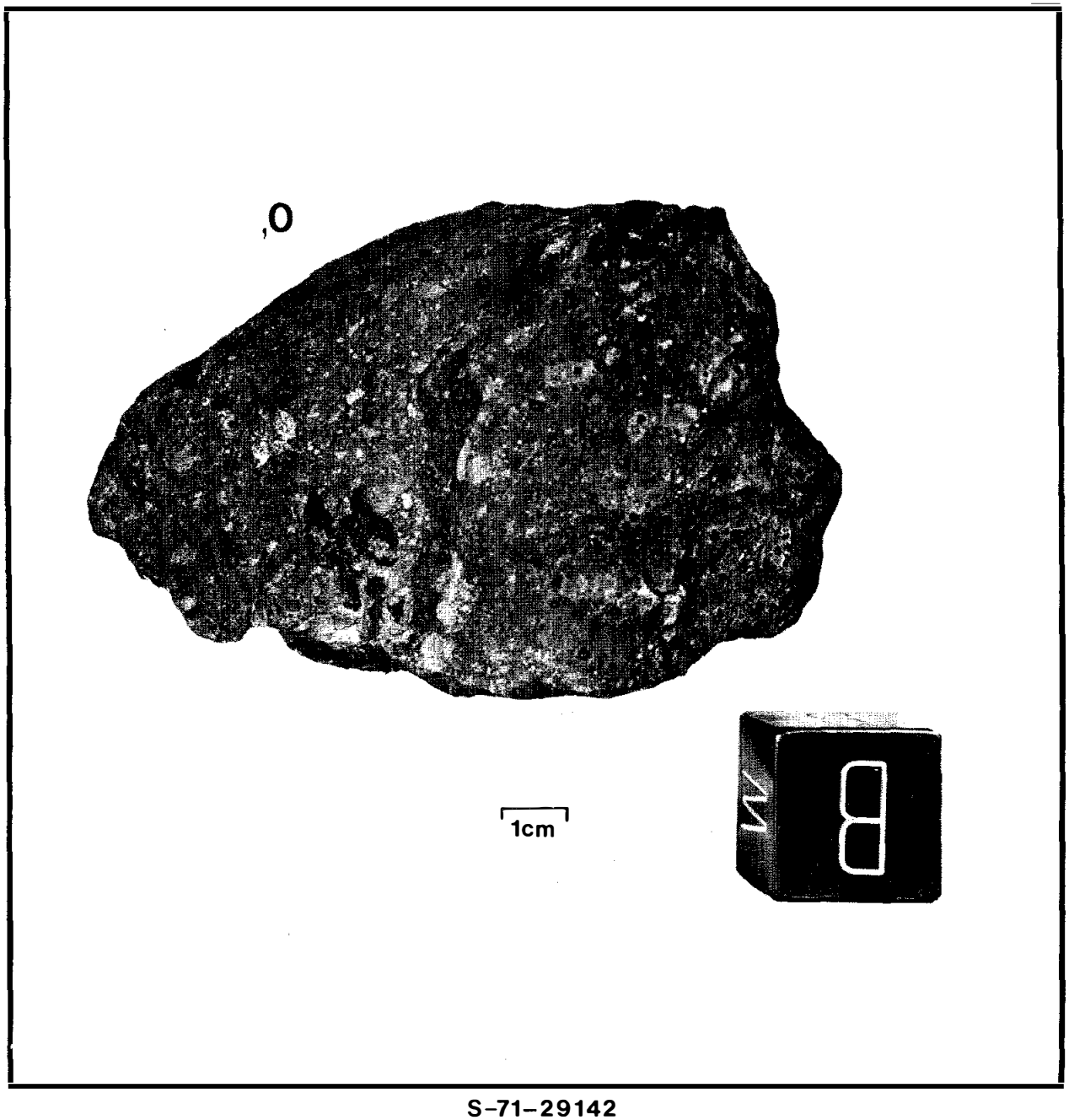
This rock consists of 90% matrix smaller than 1 mm and 10% clasts larger than 1 mm. The matrix is very fine grained and homogeneous. The clasts are very leucocratic and probably are composed of plagioclase.

Examination of section 14317,4 reveals the sample to be breccia with approximately 10% "glassy" material in the matrix (< 1 mm). There are very few lithic fragments present in the section. Lithic fragments are all of a very fine grained microbreccia. There are also several larger masses of an opaque material present. Most of the fragments in the matrix are highly deformed pyroxene crystals, many of which are rounded. There are abundant small crystallites in the matrix. One small fragment of a basalt which has been shocked with highly deformed pyroxene and plagioclase was observed. There are a few small anhedral olivine crystals in some of the pyroxene crystals. A few glass masses are scattered throughout the section and many have dendritic crystals in them.

DISCUSSION

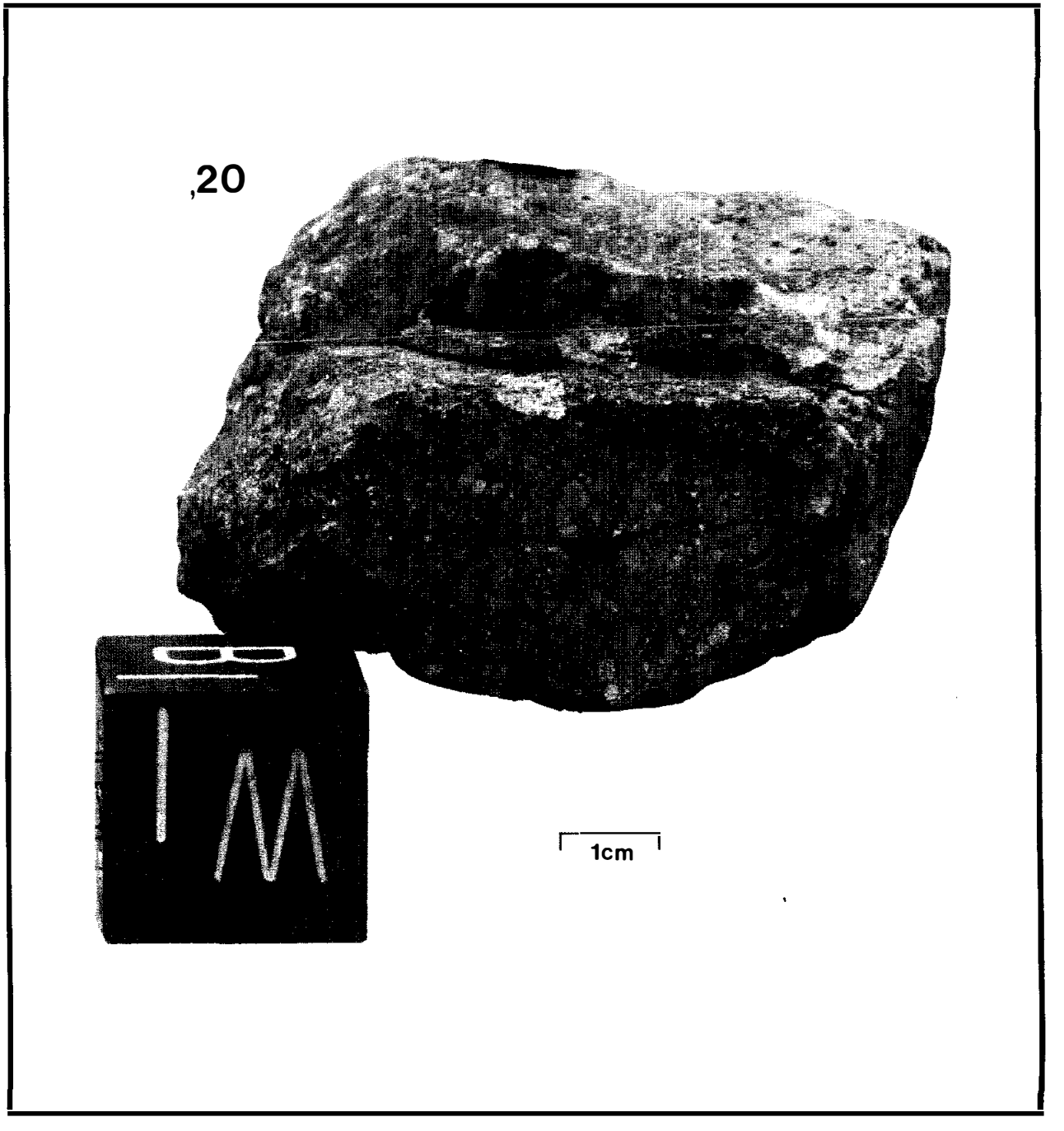
Sample 14317 was placed in the F_2 category of Wilshire and Jackson (1972).

14318



S-71-29142

14318



S-71-38662

14318, 45

.1mm

Breccia sample 14318 was collected from the regolith near the south end of North Boulder Field at station H during the second EVA. It was returned in weigh bag 1038. Sample 14318 is one of the specimens chosen for study by the Imbrium Consortium, who received 14318,0. A complete set of matched thin sections, across the entire specimen was made by the Consortium (1976), and their findings are included in this description.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
600.2 g	11.4 x 7.8 x 5.3 cm

This sample is a very coherent, gray, polymict breccia consisting of light gray clasts in a medium gray matrix.

SURFACE FEATURES

The sample is densely pitted on all surfaces, with pits ranging from < 0.1 to 2 mm in diameter. Pit density is 60 pits per square centimeter. More than 90% of the pits are glass lined.

The rock is cut by three sets of mutually orthogonal planar fractures. Two sets have 0.1 mm thick black vesicular glass filling the fractures, and the surface of the third fracture set is not visible. Many small veins of glass diverge from the fracture plane and extend into the matrix.

PETROGRAPHIC DESCRIPTION

Clasts larger than 1 mm make up at least 20% of the volume. Three clast types are pure white or gray-white plagioclase rich fragments, apple-green olivine-rich spheres (chondrules) (see King et al., 1972; Kurat et al., 1972, 1974), and light yellow-brown "basaltic" fragments. In appearance, the hand specimen, with its range of clast sizes, colors, and shapes, is said to be reminiscent of the Allende meteorite (Imbrium Consortium, 1976). The matrix consists of feldspar, with ∿ 5% olivine and 1% pink pyroxene. This is a highly complex fragmental rock with 50% of the clasts pieces of crystalline rocks and 50% leucocratic microbreccia.

In thin section sample 14318 is described by the Imbrium Consortium (op. cit. 1976) as a very coherent, low porosity polymict breccia which is partly coated with a grayish-green glass containing numerous micron-sized droplets. This is the glass filling some of the fractures in the rock. The grain size ranges continuously from > 1 μm to at least 7 mm. Clasts larger than 1 mm account for 30% (Wilshire and Jackson, 1972) to 50% (Warner, 1972) of individual thin sections. As noted by Warner (1972) and Chao et al. (1972), the large clasts exhibit a faint alignment. The matrix (consisting of crystal, rock, and glass fragments less than an arbitrary 100μ in dimension) is tightly welded together, but not recrystallized to any significant extent. Glass fragments as small as a few microns are not devitrified and some glass and crystal fragments are angular. However, many other grain boundaries are diffuse and there is a small amount of glass that appears to help cement the rock together. Some of this cementing glass is amoeboid in shape (see Kurat et al., 1974, their Fig. 1C), and some is petrographically identical to the brown glass in glass-welded aggregates, or agglutinates. The matrix texture places the rock in Warner's (1972) group 3.

Kurat et al. (1974) attached special importance to the presence of rapidly crystallized spherules, or chondrules, and to the overall textural similarities between 14318 and polymict, brecciated chondritic meteorites. Although they recognized that chondrites and lunar rocks differ markedly in composition, Kurat et al. argued that impact processes played central roles in producing both 14318 and the chondrites. Chao et al. (1972) also considered the presence of spherules of glass, devitrified glass, and chondrules to be significant. They classified 14318 as a "spherule-rich, transported microbreccia".

Kurat et al. (1972, 1974) measured the chemical compositions of lithic fragments, glasses, and chondrules in 14318, but did not ascertain their relative abundances. To obtain abundance data, the Imbrium Consortium (op. cit., 1976) made a modal analysis of one thin section, took a census of all fragments larger than 1 mm in two sections, and compiled another census of particles between 0.2 and 1.0 mm diam., in randomly selected regions of one section. The following discussion is a summary of their results:

Lithic fragments are of the same varieties as found in the Apollo 14 soils (e.g., Taylor et al., 1972) and other breccias (e.g., Chao et al., 1972). Most have KREEP chemistry and are breccias, recrystallized to varying degrees. Some are clearly polymict. Lithic fragments were classified as follows: recrystallized noritic breccias, in which the matrix is fine-grained and unmelted; partially melted noritic breccias, characterized by igneous-textured matrices; granulitic noritic breccias, with coarsely-crystalline, equant matrices. Nonmare basalts, some of which could be total impact melts; mare-like basalts, which are distinguished from nonmare basalts by higher contents of mafic silicates and ilmenite; anorthositic (or ANT) rocks; and others, (ultramafic rocks, graphic intergrowths of quartz and alkali-feldspar, and coarse-grained, unbrecciated noritic fragments). All but the last three categories are chemically equivalent to KREEP.

Glasses are also of the same types as found in soils. They were classified into the following groups: homogeneous glass, almost all of which were pale yellow to bright yellow; ropy, or suevite-like glass that contains crystallites and mineral fragments; brown, swirly, agglutinitic-like glass; and devitrified glass. Chondrules were placed in a separate category, as were mineral fragments.

The modal analysis, incorporating both clasts and matrix, was done on section 14318,48, using a magnification of 80x. An area of about 6 cm^2 was scanned and 4,847 points were counted. Results are as follows:

Lithic fragments	59.6%
Mineral fragments	14.7%
Homogeneous glass	3.0%
Suevite-like glass	5.9%
Brown, swirly glass	10.2%
Devitrified glass	2.5%
Chondrules	4.1%
	100.0%

Compared to Apollo 14 breccias that are obvious soil breccias, such as 14047 and 14055, rock 14318 is much richer in lithic fragments (60% vs. $\sim$ 10%) and poorer in brown, swirly matrix glass (10% vs. 50%). Nevertheless, the same constituents normally found in lunar soils are present. Perhaps 14318 was made from a relatively immature soil.

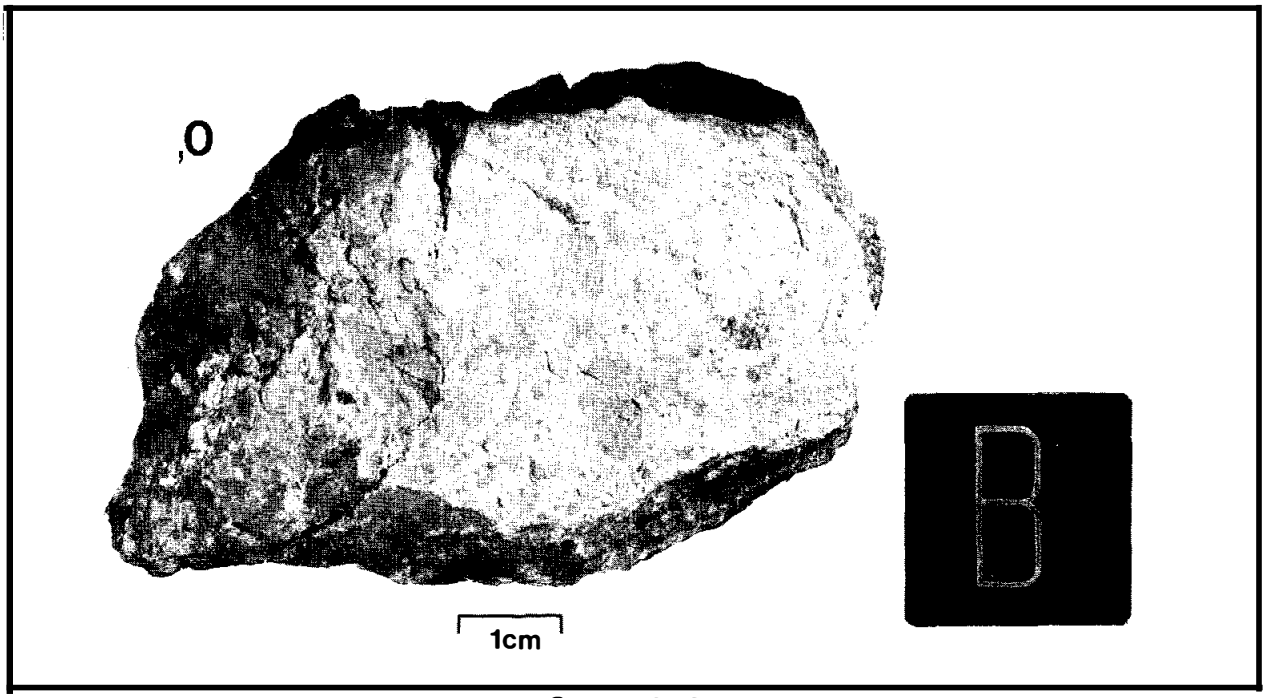
Chondrules are confined to the < 1 mm fraction. These results are consistent with those reported by Wilshire and Jackson (1972). Essentially the same proportions of types are found in each. Curiously, the relative abundances of types of KREEP lithic fragments in 14318 is quite similar to those in the freshest (least mature) soils from Apollo 14: 14142 from Cone Crater and 14151 from the bottom of a 30 cm deep trench (Taylor et al., 1972b). As noted above, it is possible that 14318 was formed from an immature soil. (The previous petrographic discussion of sample 14318 is from Interdisciplinary Studies by the Imbrium Consortium, volume 1, pp. 67-69.)

DISCUSSION

Sample 14318 is classified as an F_2 by Wilshire and Jackson (1972) because of its coherence and abundant leucocratic clasts. Warner (1972) assigned it to his medium metamorphic grade 3, and Chao et al. (1972) placed it in his spherule-rich group (3). Quaide and Wrigley (1972) call it a regolith breccia, and von Engelhardt et al. (1972) place it in their glass-rich regolith breccia category. Simonds et al. (1977) list it as a VMB.

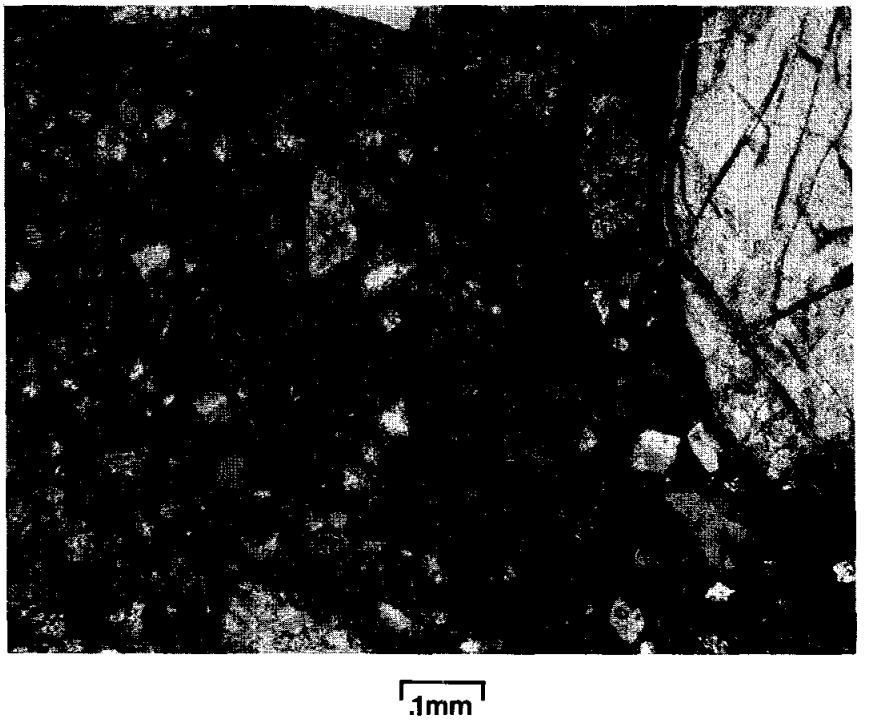
This rock has been studied extensively by Kurat et al. (1972, 1974), mentioned by King et al. (1972), and finally studied by the Imbrium Consortium (1976). It contains fissionogenic xenon derived from extinct 244 Pu (Behrmann et al., 1973; Reynolds et al., 1974). The most interesting feature of 14318, however, is its chondrule content.

14319



S-71-29185

14319, 19



Breccia sample 14319 is the western rock from the top of Turtle Rock ("turtle egg"). This sample as well as 14312 were collected from Turtle Rock at station H during the second EVA and returned in weigh bag 1038. Its lunar orientation and location have been well documented. It appears to be similar to Turtle Rock and the other rocks in the area.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
211.6 g	8 x 5.5 x 3.9 cm

This is a light-medium gray coherent breccia which is flat on one side and rounded on the other sides.

SURFACE FEATURES

The rock is rounded and pitted on all but one side which is flat and partly covered with glass. Pits range from 0.1 to 3 mm in diameter, averaging about 0.5 mm. The glass is dark brown in hand specimen and forms a 0.5 - 1.0 mm thick coating.

There is a set of fractures subparallel to the long axis of the rock which are fragile and ready to break.

PETROGRAPHIC DESCRIPTION

This is a polymict breccia, with 90% of the clasts greater than 1 mm being lithic and 10% rounded feldspar crystals up to 2 mm long. The most common clast type (90%) is medium dark gray, equant to elongate, subangular to rounded, crystalline granular microbreccia. These microbreccia fragments consist of 50% medium gray feldspar, 45% white to colorless feldspar laths, yellow-green olivine, and cinnamon-brown pyroxene. Approximately 10% of the lithic clasts are small (1 - 2 mm) crystalline basalt fragments composed of colorless feldspar, light brown pyroxene, and black opaques. One large feldspar fragment has a rim of opaques completely around the margins. The matrix is made up of feldspar > 1 mm lithic clasts, a yellowish mineral (feldspar?), opaque specks, red brown pyroxene, and lemon yellow olivine (?).

Examination of sections 14319,2 and 14319,13; as well as chips 14319,8; 14319,8A; and 14319,10 by Winzer as part of the PET (1971) indicates that this sample is a gray-green, fragment-laden melt containing basaltic, anorthositic, noritic, and predominately breccia clasts, along with fragments of minerals and glass. Minerals include olivine, pyroxene, opaque minerals, and plagioclase, with plagioclase the major phase present. Olivine is a minor phase, and there are, also, a few reddish-orange spinel fragments observed. Some devitrification of the glass present has occurred, mainly as a growth of very small euhedral feldspar crystals. Large "poikilitic" pyroxenes were not observed.

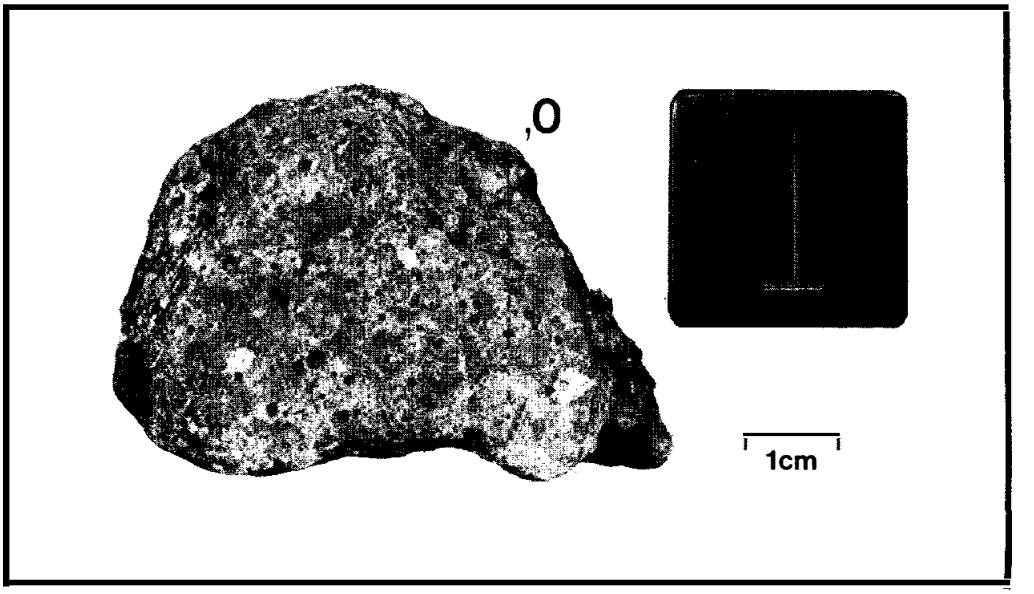
Most clasts are breccias. Those breccia clasts which are not glassy or partly devitrified fragment-laden melts appear to be anorthositic in nature. One relatively large anorthositic clast was observed in 14319,2. The dominant igneous clast is basaltic. These are, normally, either of a "felted" texture, or are microgabbroic. Norite (or gabbro) clasts are secondary. These noritic clasts contain more feldspar than the basaltic clasts, and do not usually contain olivine. Opaque phases occur as small, rounded, metal grains, or as irregular ilmenite. Brett (LSPET, 1971) described the opaques in 14319,5 as similar to 14318,2 except lacking in chrome spinel, ulvospinel, and zircon. Troilite is more abundant, occurring as fine rounded to subrounded blebs to 10 μm, and larger aggregates of grains as large as 80 μm.

DISCUSSION

Sample 14319 was found to be an F_4 breccia (coherent, dark clasts) by Wilshire and Jackson (1972) and a high metamorphic grade (7) by Warner (1972). Chao *et al*. (1972) classify it as a strongly annealed, shocked, Fra Mauro breccia (2c). Simonds *et al*. (1977) list it as a crystalline matrix breccia.

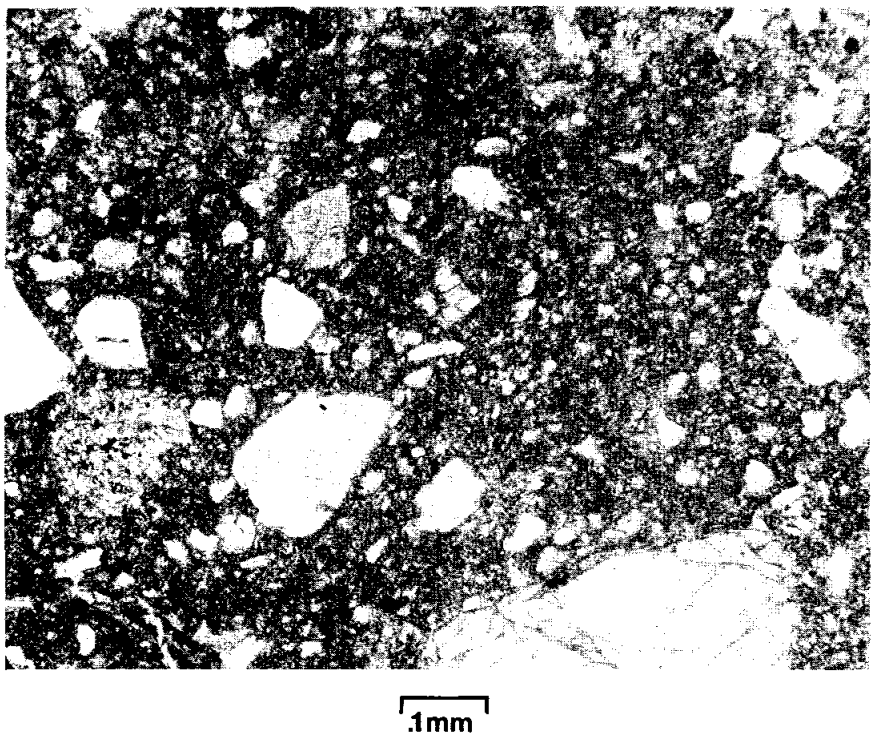
The sample was also investigated by Roedder and Weiblen (1972) in their study of melt inclusions, and they found evidence that the sample had a complex thermal history.

14320



S-71-29196

14320, 7



This breccia was collected from North Boulder Field from station H during EVA 2. The sample has not been identified in lunar surface photographs so the lunar location is only tentative and the lunar orientation is unknown. Sample 14320 was returned in weigh bag 1038.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
64.9 g	5.5 x 5.0 x 2.5 cm

This is a medium gray, coherent, polymict breccia.

SURFACE FEATURES

Glass-lined zap pits are evenly distributed on all sides of the rock with a density of approximately 20 pits per square centimeter. The pits range in size from less than 0.1 mm to 2 mm.

There are two orthogonal sets of planar fractures parallel to the W and the B faces of the sample.

PETROGRAPHIC DESCRIPTION

This polymict breccia has 10% clasts larger than 1 mm and 90% matrix smaller than 1 mm. There are both mesocratic and leucocratic lithic fragments. The bulk of the rock is composed of angular and roughly equant fragments of aphanitic material set in a lighter gray to white groundmass.

A thin, irregular vein of dark brown vesicular glass fills one small crack.

This sample appears similar to 14321 in hand specimen and in thin section.

Thin section 14320,7 has approximately 25% clasts and 75% matrix. The matrix has a salt and pepper appearance with very fine white and dark grains. Approximately 10% of the rock is white feldspar fragments ranging down to less than 0.1 mm in size. Trace amounts of cinnamon brown pyroxene, pale greenish-yellow material, deep red translucent rutile, and a black opaque mineral. The lithic clasts present in 14320,7 are of a dark and light breccia with abundant mineral fragments. Many of the fragments are too small for identification. Those that are large enough are pyroxene, olivine and plagioclase with minor opaques. The matrix contains 10-15% of a fine-grained dark material which includes small opaque fragments.

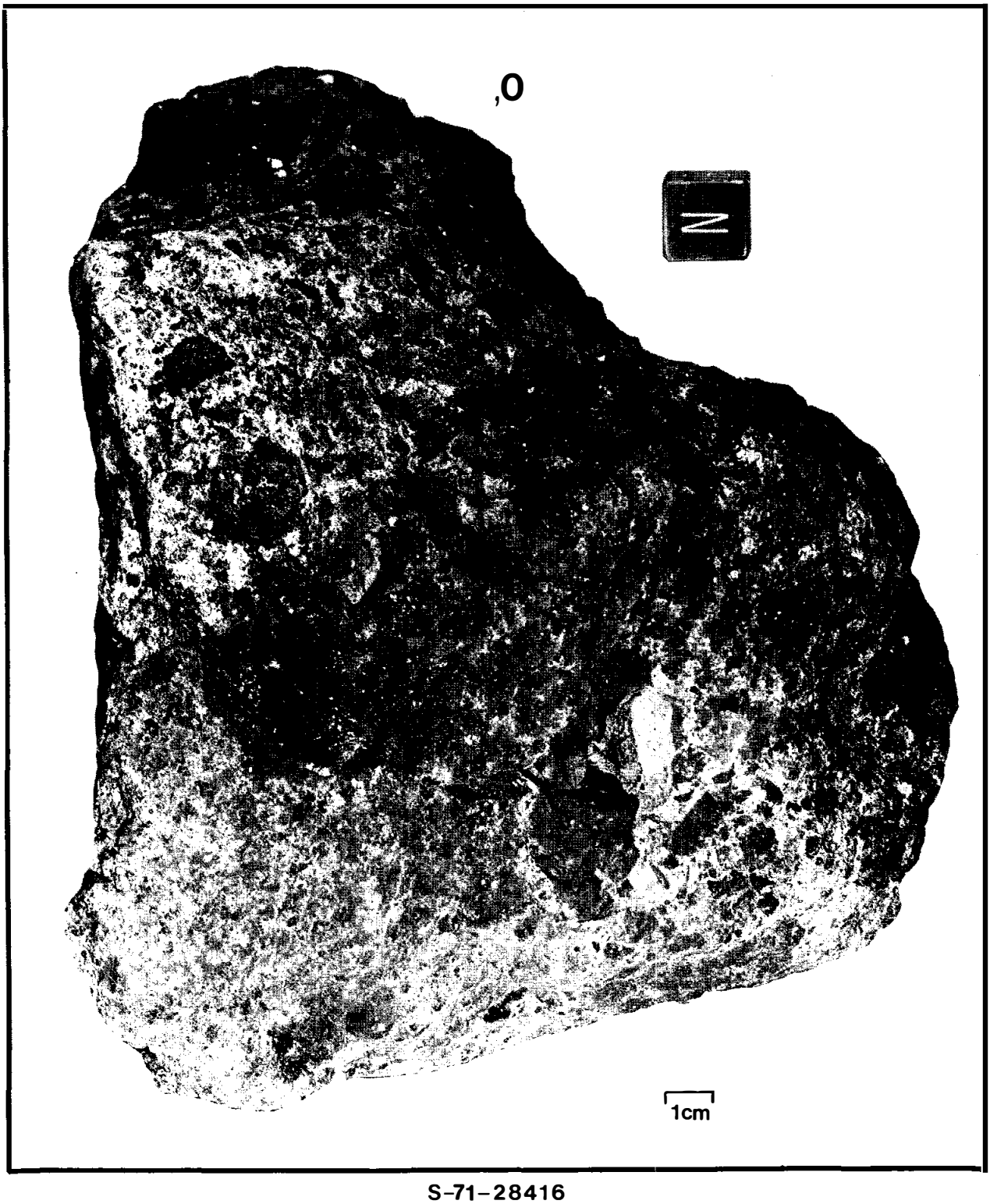
DISCUSSION

Sample 14320 was placed in the F_4 category of Wilshire and Jackson (1972) and is described as coherent with dark clasts. Warner (1972) placed it in

his metamorphic grade 6, and Chao et al. (1972) list it as a shocked, strongly annealed, Fra Mauro breccia (2c). Quaide and Wrigley (1972) list it as an annealed breccia, and von Engelhardt et al. (1972) classify it as glass poor with a crystalline matrix. Simonds et al. (1977) classify it as a crystalline matrix breccia (CMB).

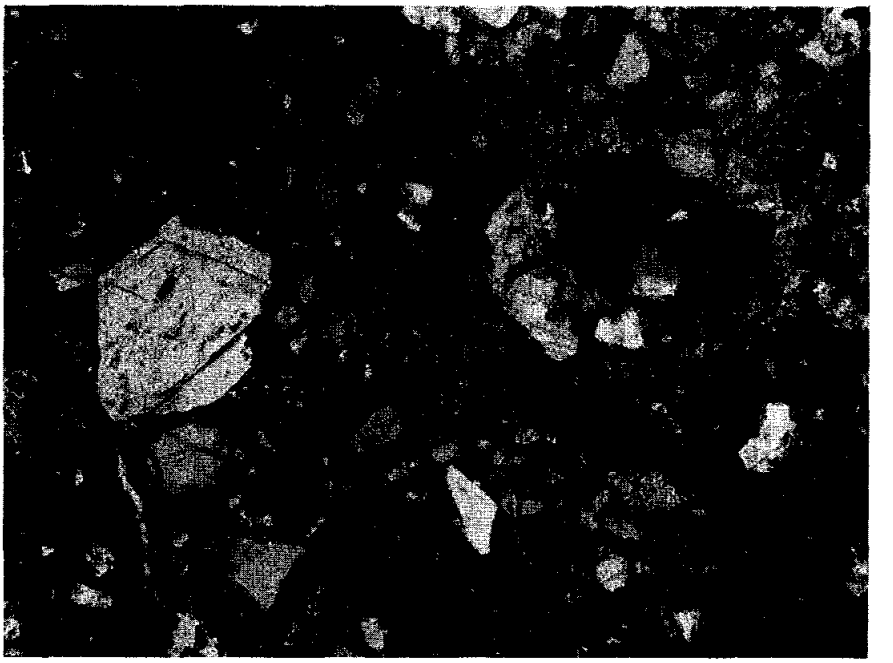
It is described by Roedder and Weiblen (1972) as having had a complex thermal history. Some of the parent rocks were said to have undergone slow cooling. Potassium enriched clasts were observed in this sample, as in 14303, 14319, and 14321.

14321



S-71-28416

14321, 240



.1mm

Lunar sample 14321 (also known as Big Bertha) is the largest sample returned during the Apollo 14 mission. This sample is the third largest sample returned by any Apollo mission. This breccia was collected during the second EVA at station C1, near the rim of Cone Crater. A voice transcript made during the collection, as well as a more detailed discussion of the lunar environment can be found in Geological Survey Professional Paper 880 (Swann et al., 1977). The sample was returned in bag 1038.

This large sample is typical of the apparently dominant rock type in the Cone Crater ejecta blanket. It is a moderately well-indurated breccia, in which predominately dark clasts are set in a lighter matrix. The relative abundance of this rock type suggests that it is probably representative of the Fra Mauro Formation.

PHYSICAL CHARACTERISTICS

Mass	Dimensions
8998 g	23 x 23 x 17 cm

This rock, 14321, is a partly annealed, moderately coherent polymict breccia. The blocky surface is gray with patches of black and white.

SURFACE FEATURES

Pit diameters vary from 0.1 to 5 mm with an average size of 1 mm. Glass lining of the pits consists of dark brown to black vesicular glass. Pits cover approximately 5% of the entire rock surface.

Cube shaped to rounded clast molds which range from 0.5 to 20 mm in length occur on 5% of the surface and occur in clusters along broken surfaces.

There are two sets of fractures present, one of which parallels the rock surface. The second set has a random orientation, including fracturing around clasts which are ready to break out of the matrix.

PETROGRAPHIC DESCRIPTION

Before the rock was cut and distributed, a map was made of its surface by Warner and Heiken (1972).

Warner and Heiken (1972) were able to map four lithologic types:

I. Dark gray breccia with an olive hue. The microbreccia matrix is fine grained and contains feldspathic lithic clasts and powdery, white feldspar fragments up to 2 cm long with an average length of 1-2 mm.

II. Medium gray breccia - very fine grained, friable, fractured.

III. White, feldspar-rich somewhat friable breccia - matrix.

IV. Feldspar-rich basalts.

Petrographic descriptions and an excellent discussion of the lithification processes and genesis of sample 14321 can be found in articles by Duncan et al. (1975) and Grieve et al. (1975).

DISCUSSION

The polymict character of this and many other breccias makes it especially interesting to study, because it is possible to place the various clasts into a relative time sequence. A series of brecciation and lithification events are preserved in the three or four generations of microbreccia contained in this rock.

Duncan et al. (1975) have unraveled the events leading to the lithification of rock 14321. They observe two distinct episodes of thermal metamorphism. The first affected their 1A components producing well developed recrystallization textures lacked by their 1B lithic components, mineral clasts and dark matrix. The latter contain evidence of a less severe thermal event. One or more impact events can also be shown to have occurred leading to the following partial schematic history:

1. Serinitatis impact produces ejecta blanket over Imbrium area.
2. KREEP basalts are extruded, followed by lesser amounts of Apollo 14 type mare basalts.
3. Impacts on south Imbrium region form early (group 1) breccia stages.
4. Imbrium impact forms Fra Mauro ejecta - creates microbreccias 2 and 3.
5. Extrusion of 14321 - type basalt and additional Apollo 14 type mare basalt on the Fra Mauro Formation and adjacent areas.
6. Impact events - final assembly of 14321.
7. Cone Crater impact excavates 14321.

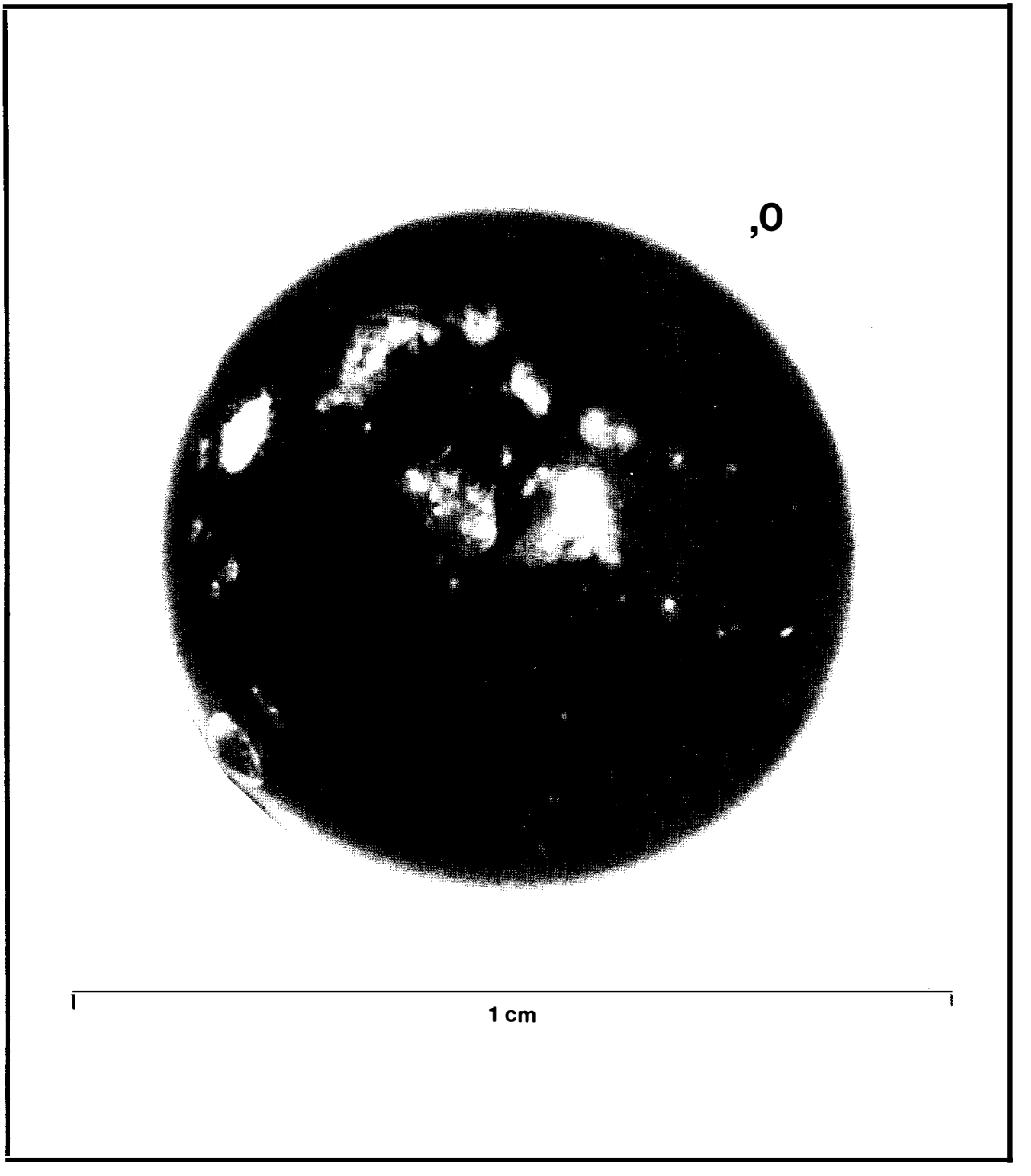
In their petrographic study of 14321, Grieve et al. (1975) found it to be composed of basaltic clasts, a set of fragmental clasts which they designated as microbreccia 3, and a light matrix cementing these two groups. Their microbreccia 3, itself polymict, corresponds to lithology I of Warner and Heiken (1972). Lithology II was not present on the samples sent ot Grieve and his co-workers and was, therefore, not described by them.

Other authors have also discussed the clastic nature of 14321. Swann et al. (1972) delineated a big clast within Big Bertha. Mark et al. (1975) found that while the basalt clasts had equilibrated at 4.0 b.y. ago, two microbreccia clasts indicate lack of complete equilibration at that time. This heterogeneity is used to demonstrate an inconsistency with thermal metamorphism of the sample.

Chao et al. (1972) describe 14321 as having a moderately coherent, white, feldspathic matrix that contains two main fragment types: ophitic mare basalt (like 14053), and fragment-laden extremely fine grained, annealed black glass. The latter probably corresponds to Grieve's microbreccia 3. The complex nature of this breccia is a result of mixing several generations of breccia precursors to form this rock.

A photograph of the model of sample 14321 is on page 361 of this document.

14425



S-72-18775

The bulk sample was collected during the first EVA from the LM area, between the LM and the ALSEP site. The exact lunar location is unknown, but it is thought that the site is visible in photographs taken from the LM window (Swann et al., 1977). From the astronauts' comments, it appears that they removed two shovelfuls of material from the bottom of a small crater in the LM area. The bulk sample includes samples 14160 - 14163 and 14422 - 14453. Samples 14425 - 14453 are those fragments in the bulk sample which did not pass through a 1 cm sieve. The bulk sample was placed in weigh bag 1028 and returned in ALSRC 1007.

14425

PHYSICAL CHARACTERISTICS

Mass	Dimensions
0.794 g	0.8 cm (spherical diameter)

Sample 14425 is a large, black glass sphere.

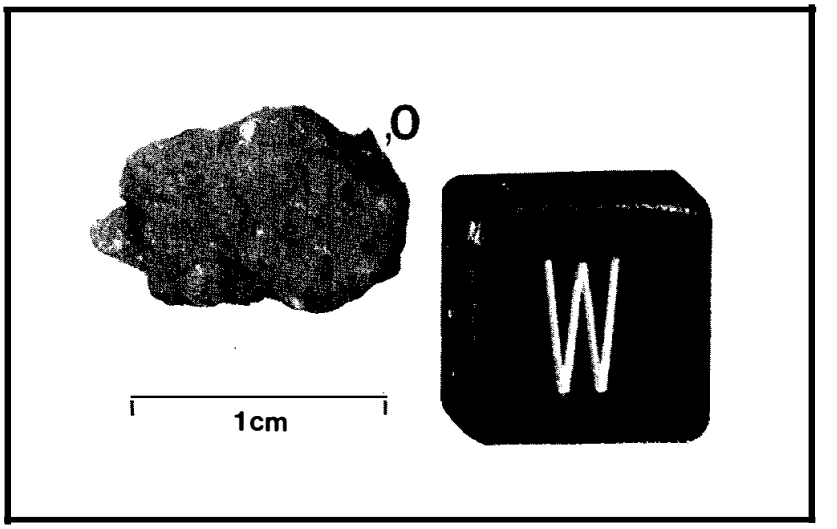
SURFACE FEATURES

The surface is 3 - 5% covered with spherical sections of bright gray metal. Some are hemispherical. These globules vary in size from very small up to 0.5 mm. Both metal and glass surfaces are uniformly covered with very small pits which are likely to be endogenic in origin.

PETROGRAPHIC DESCRIPTION

This large glass sphere appears non-uniform in color in reflected light, with color varying from near black to brownish gray, but is dark brown when light is transmitted through an edge. In some places color contacts appear sharp, but in others, they are gradational.

14426



S-71-26791

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.58 g	0.5 x 1.0 x 1.0 cm 0.5 x 0.5 x 1.0 cm

This sample is a polymict breccia which is broken into two pieces which are similar. The larger of the two is described herein.

SURFACE FEATURES

Unlined pits ranging in size from 0.5 - 2.0 mm are scattered on exposed surfaces with a pit density of two to five pits per square centimeter. The sample is smooth on old surfaces, but irregular on new ones. Two very irregular fractures from two sets occur.

Shock features are visible in feldspar-rich clasts. Some clasts appear vesicular, indicating partial melting, and there is abundant plastic deformation.

ROCK DESCRIPTION

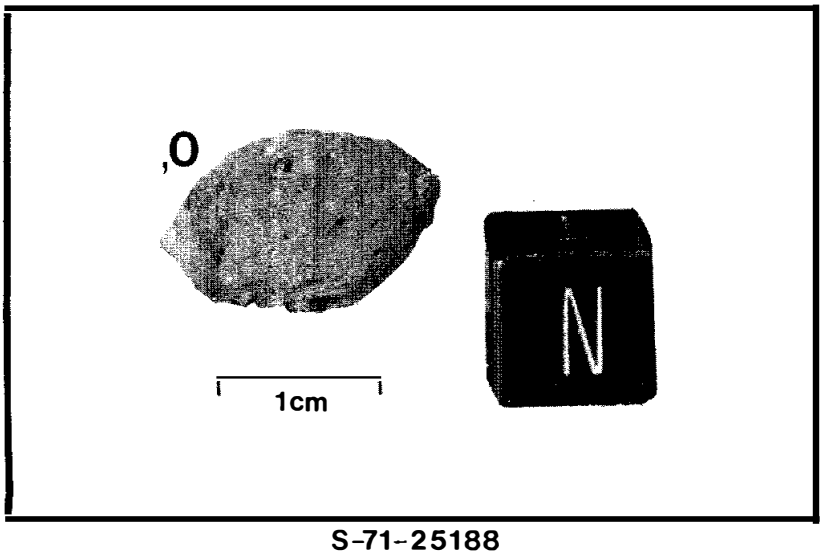
The sample is a friable, fine grained, polymict breccia with textural and

mineralogic homogeniety.

Five percent of the fragments are clasts larger than 1 mm and 95% are matrix grains. Mineral fragments account for 80% of the sample. Dark brown or black glass fragments make up the remaining 20% of the rock.

The main constituents are white clasts (feldspar). Two clasts are definitely lithic for there are associated pyroxene and/or opaque minerals. Black glass fragments are dense and angular. Brown glass fragments are partially vesicular inclusions with smooth surfaces, but irregular and jagged in overall shape. None of the clasts is larger than 2 mm.

14427



S-71-25188

PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.47 g	1.7 x 1.2 x 1.1 cm

This sample is a fine grained clastic rock composed of white feldspar and black glass.

SURFACE FEATURES

Unlined pits are present on the surface. One subplanar set of fractures with five members spaced 1 mm apart are oriented parallel to one flat face of the sample.

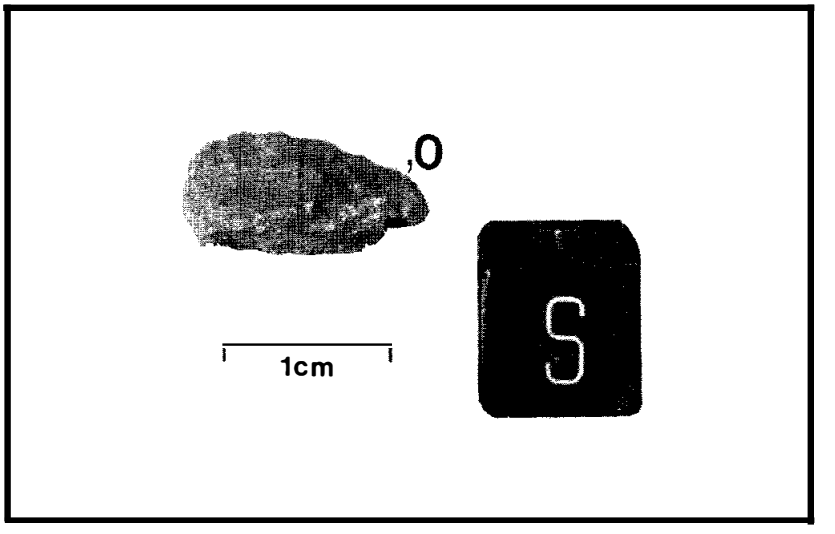
One percent of the rock volume is occupied by irregularly shaped cavities (possibly clast molds) 2 mm in diameter and spaced 1 cm apart.

PETROGRAPHIC DESCRIPTION

Sample 14427 is tough, but can fracture easily along cracks. It is mineralogically and texturally homogeneous. All the particles are smaller than 1

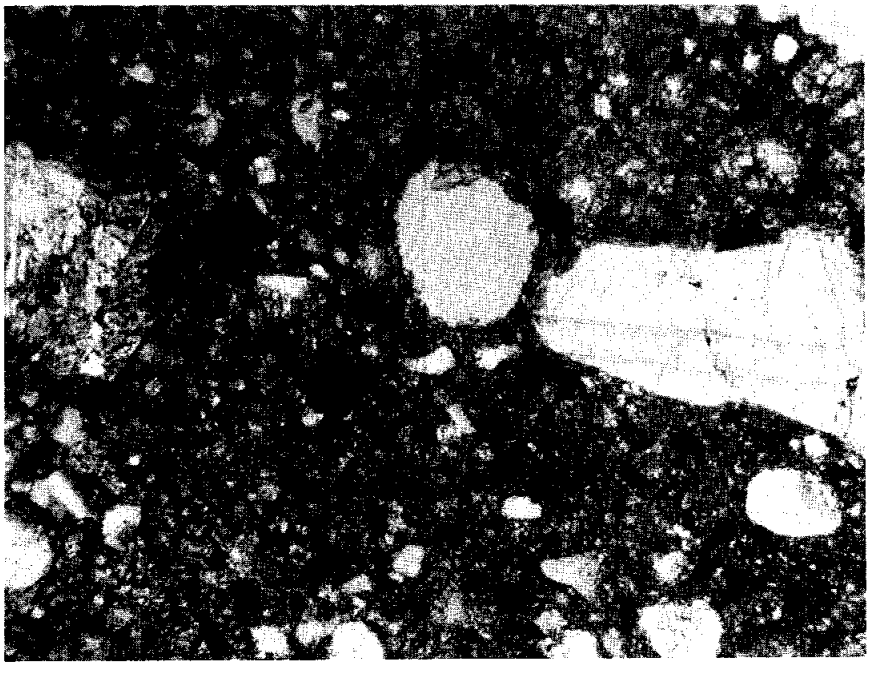
mm in size. White angular feldspar grains and angular fragments of black glass up to 0.1 mm in size are present. Olivine (?) is present in minor amounts.

14428



S-71-25194

14428, 2



.1mm

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.47 g	1.5 x 1.2 x 0.6 cm

Sample 14428 is a vesicular breccia with a crystalline matrix.

SURFACE FEATURES

There are no zap pits or fractures visible on the surface. The sample has elliptical vesicles which are 0.5 mm in diameter, and irregularly shaped vugs ranging from 0.1 mm to 0.3 mm in size. The vugs appear in zones on one side of the rock. Clear crystals line vug walls.

PETROGRAPHIC DESCRIPTION

Sample 14428 is a holocrystalline breccia. Large grains could be clasts. Less than 1% of the sample consists of grains larger than 1 mm. There are fragments of anhedral, cinnamon brown pyroxene (0.5 mm in size) present in the sample. In binocular view, the matrix appears to be composed of:

1. Clear, subhedral, medium gray pyroxene 0.1 mm in size (55%).

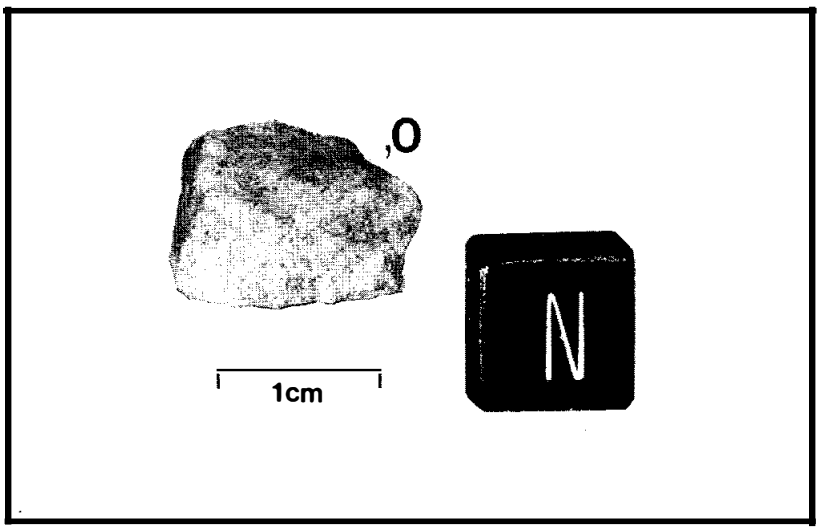
2. Clear, subhedral plagioclase 0.1 mm in size (44%).

3. Subhedral opaque minerals in grains 0.05 mm in size (< 1%).

Examination of thin section 14428,2 reveals the sample to be a vesicular CMB, according to the classification of Simonds et al. (1977). The thin section has a glass coating on one edge. Vesicles are 0.1 - 0.2 mm in diameter, and are ovoid to nearly circular in shape. Small euhedral to subhedral crystals (pyroxene?) extend into voids. Approximately 10% of the section is comprised of voids due to vesicles.

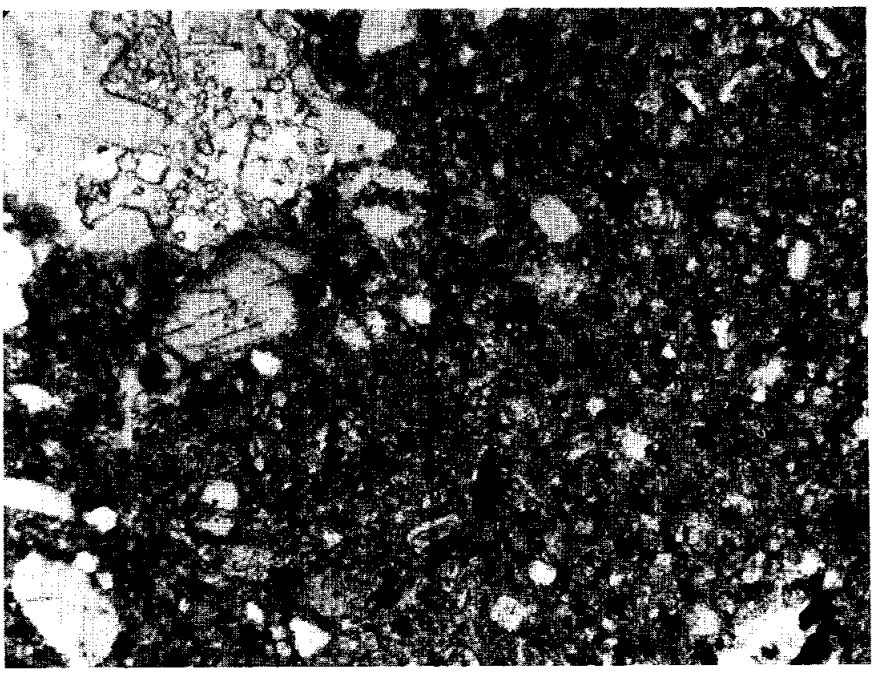
The thin section contains no fragments larger than 1 mm, and the largest fragments are plagioclase crystals which are partly granulated. A small amount of devitrified glass is present. Mineral fragments include 60% plagioclase and 40% pyroxene. Many of these crystals are highly included and reaction rims are present on many of the pyroxene crystals. The sample has a seriate texture, with grain size averaging less than 0.1 mm.

14429



S-71-26795

14429, 2



PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.03 g	1.5 x 1.4 x 0.5 cm

Sample 14429 is a slightly vesicular polymict breccia similar to 14428.

SURFACE FEATURES

Remnants of glass lined zap pits 0.5 mm in diameter are present but sparse. No fractures or vugs are present. Vesicles are small (0.1 mm) and are ovoid to nearly circular in shape.

PETROGRAPHIC DESCRIPTION

In hand specimen, sample 14429 is fine grained with grains averaging < 0.1 mm in size. It is homogeneous in texture and mineralogy. The rock is almost wholly crystalline with < 1% pale yellow-green olivine (< 1 mm in size), < 1% prisms of pale reddish brown pyroxene (0.2 mm in size), 2 - 3% tubular grains of colorless to light gray plagioclase (< 0.1 mm in size). The olivine on the exposed surface is discolored.

Fragments of feldspar are colorless to light gray and are associated with opaques and reddish brown pyroxene. A small percentage of colorless and dark brown angular glass fragments is present. Colorless fragments are < 1 mm in size. Dark shiny glass spheres are present in the matrix.

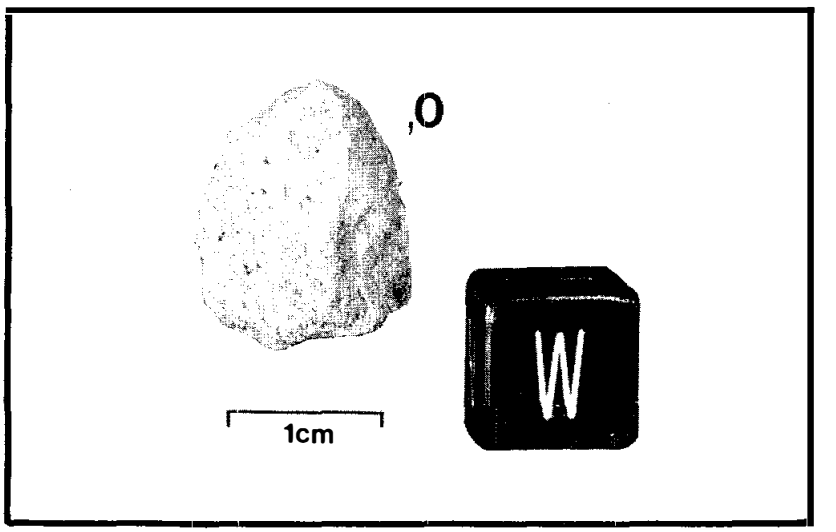
Thin section 14429,2 reveals the sample to be a vesicular CMB (using the classification system of Simonds et al., 1977) with few fragments larger than 1 mm. One large, highly modified, plagioclase crystal is present. One twin plane remains, along with discordant crystal sections set in a large, more or less single, crystal. Minor opaque minerals are visible in the crystal, also. A polymict breccia clast larger than 1 mm is composed of coarse grains of highly shocked pyroxene crystals. These show exsolution lamellae and exhibit a slight bending of the crystal. Larger crystals within the microbreccia are cemented by a seriate mixture of similar pyroxene crystals and possibly some plagioclase. All are highly modified. Several "ghost clasts" occur in the section. These have a texture and composition similar to that of the overall sample, but the contact is marked by an increase in aligned mineral fragments.

Other lithic fragments include an olivine-pyroxene-plagioclase granulite fragment, a granulitic plagioclase-rich rock fragment and a fine grained polymict breccia.

Mineral fragments visible in thin section 14429,2 include 60-70% plagioclase, pyroxene, and very minor spinel (up to 0.1 mm in size). Pyroxene crystals have reaction rings.

This section is similar to section 14428,2 except that lithic fragments are present in 14429,2. The average grain size is less than 0.2 mm. Minor olivine is present in the matrix.

14430



S-71-25889

PHYSICAL CHARACTERISTICS

Mass	Dimensions
4.81 g	2.0 x 1.4 x 1.2 cm

Sample 14430 is a medium to light gray, polymict breccia.

SURFACE FEATURES

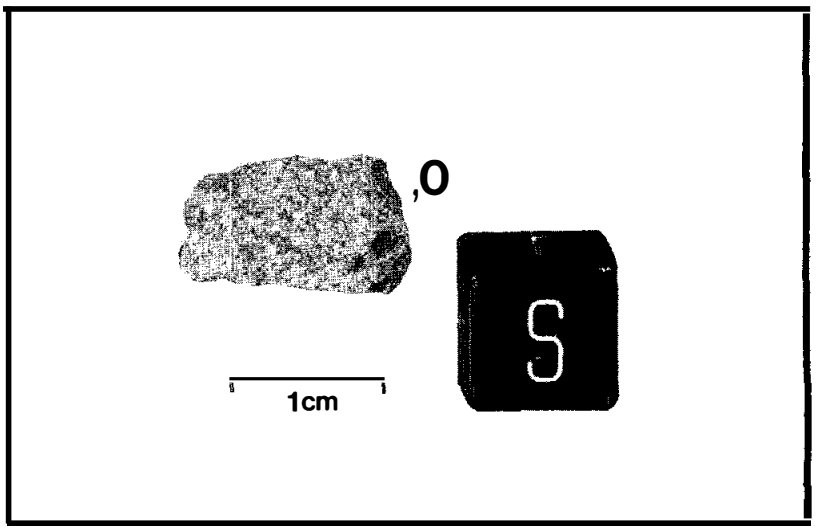
No pits are visible. The surface is moderately irregular and has glass spatter in one small area. The spatter is botryoidal and colorless. No fractures are present except for one spall.

PETROGRAPHIC DESCRIPTION

Sample 14430 is a polymict breccia with 20% clasts larger than 1 mm. One feldspar clast 3 x 4 mm in size makes up 15% of the rock. Another feldspar clast which is half as large as the first exhibits twinning and exsolution lamellae. This smaller clast has a brownish tint and possible opaque in-

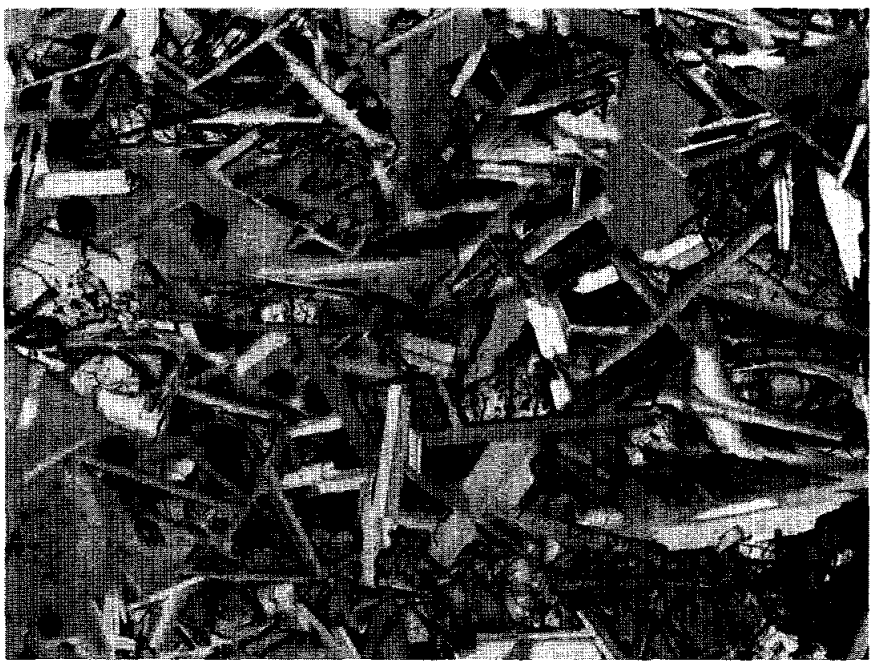
clusions. It appears to be cracked. Leucocratic lithic fragments from crystalline rocks are 75% of the sample. One slabby, angular clast (1.3 x 3.0 mm in size) is porphyritic, with a very fine grained groundmass with 1% grains of possible olivine.

14431



S-71-25408

14431, 2



.1mm

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.70 g	1.4 x 1.2 x 0.8 cm

Sample 14431 is a light gray, crystalline rock.

SURFACE FEATURES

There are no pits, fractures, surface glass, or cavities present. Areas of crushed and granulated white plagioclase in clasts may be shock induced.

PETROGRAPHIC DESCRIPTION

In hand specimen, sample 14431 is a fine grained (av. 0.05 mm), equigranular, crystalline rock with both textural and mineralogic homogeneity. It is feldspar-rich with less than 10% brown pyroxene and opaque minerals. Gray and white feldspar grains measure up to 0.8 mm in size. Most mineral grains are smaller, averaging 0.1 mm in size. Clear and turbid, subhedral brown to light gray plagioclase grains 0.5 mm in size make up 90% of the sample. Opaques ranging from < 0.1 to 1.0 mm in size are 8% of the rock, and clear, subhedral brown pyroxene grains 0.3 mm in size make up 2%.

Thin section 14431,2 is that of a crystalline rock composed of 70% plagioclase and 30% pyroxene with a diabasic to subdiabasic texture. Three generations of plagioclase are present:

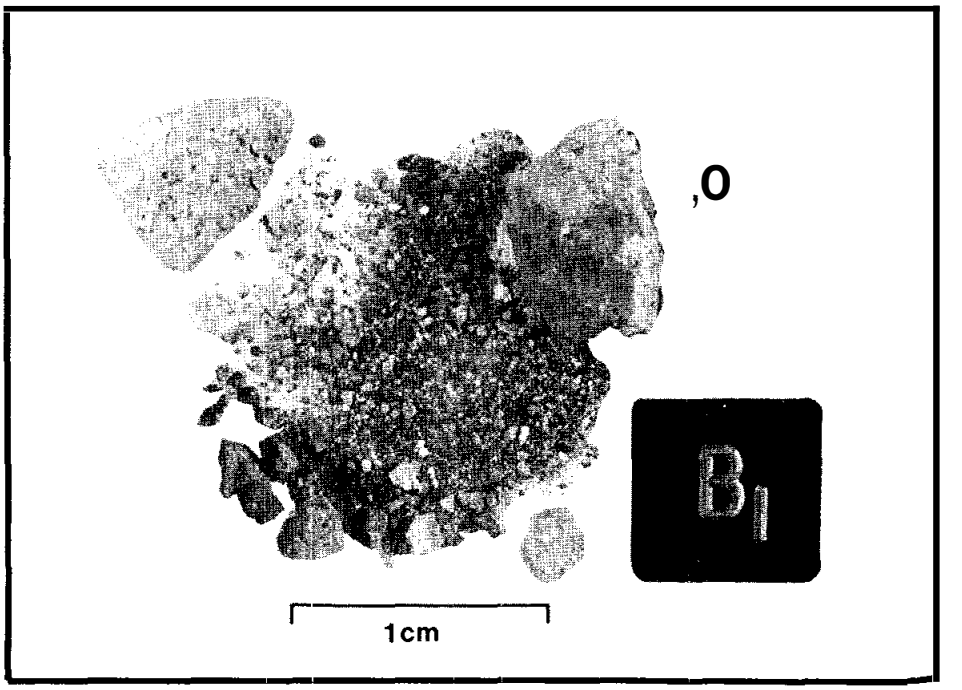
1. Large, well-formed, blocky crystals,
2. Smaller lath-shaped crystals, and
3. Anhedral masses of plagioclase interstitial to the network of other crystals.

Maskelynite is present in minor amounts and occurs in anhedral masses of plagioclase. Shock effects are present in all crystals after plagioclase.

A fair amount of polygranular opaque minerals is present. Some fine metallic grains are present. There is minor porosity noticeable because some epoxy has risen to the surface.

The features visible in thin section suggest that this rock was formed as a result of meteoritic impact.

14433



PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.23 g	1.0 x 0.8 x 0.5 cm

Sample 14433 is three pieces of friable, fractured, polymict breccia.

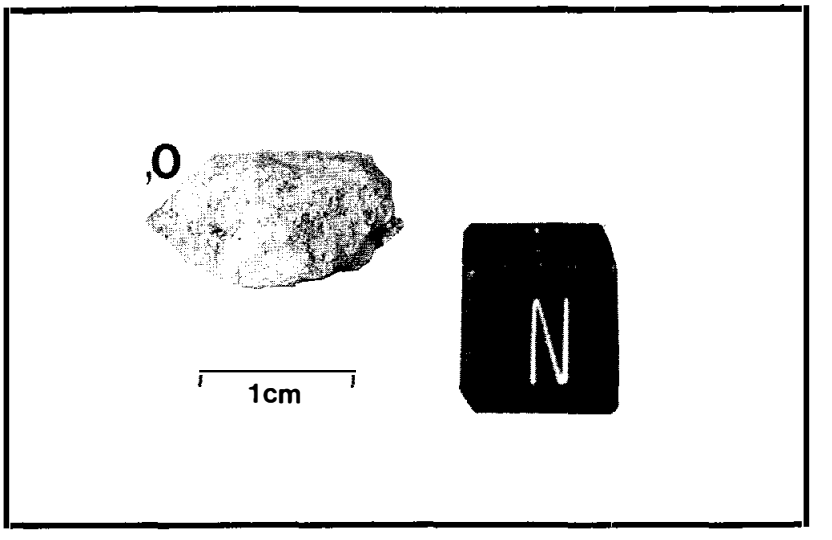
SURFACE FEATURES

There are no zap pits or cavities. Two planar fractures intersect at a 30° angle on the largest piece, which is about to break apart.

PETROGRAPHIC DESCRIPTION

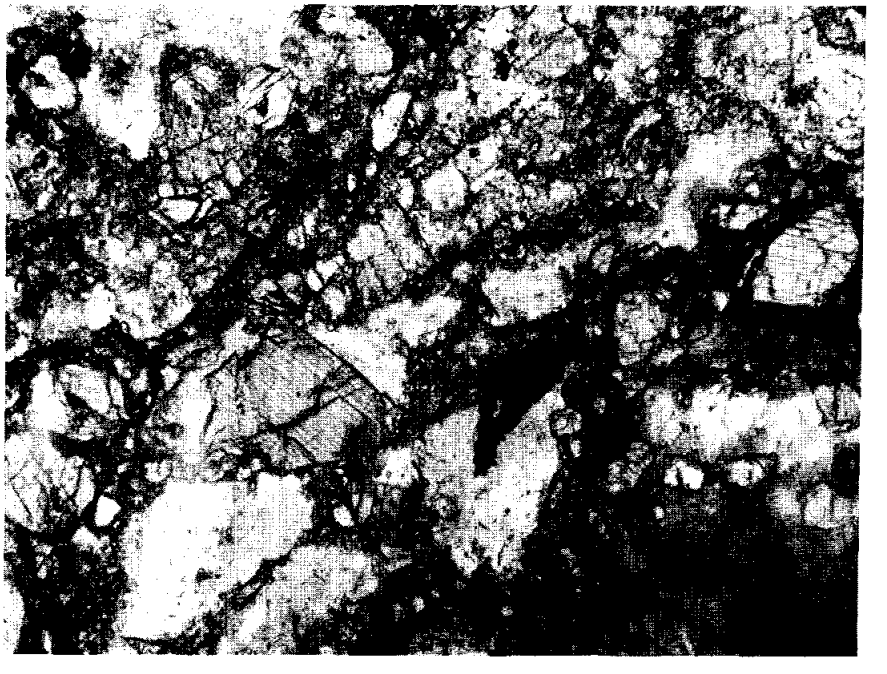
This fragmental rock is a polymict breccia with 15% clasts larger than 1 mm and 85% matrix grains. Leucocratic lithic fragments up to 0.3 mm in length make up 90% of the rock. Some lithic fragments appear gabbroic, some basaltic, and some are olivine bearing. Mineral fragments are plagioclase and cinnamon brown pyroxene. These make up less than 1% of the rock. Angular dark brown to black glass fragments make up 9% of the rock. Large olivine inclusions are in feldspathic clasts.

14434



S-71-25414

14434, 2



.1mm

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.68 g	1.7 x 0.8 x 0.6 cm

Sample 14434 is a very coarse-grained polymict breccia with 5% larger grains.

SURFACE FEATURES

No pits or cavities are visible. Two non-planar fractures occur in two sets. It is extensively dust covered.

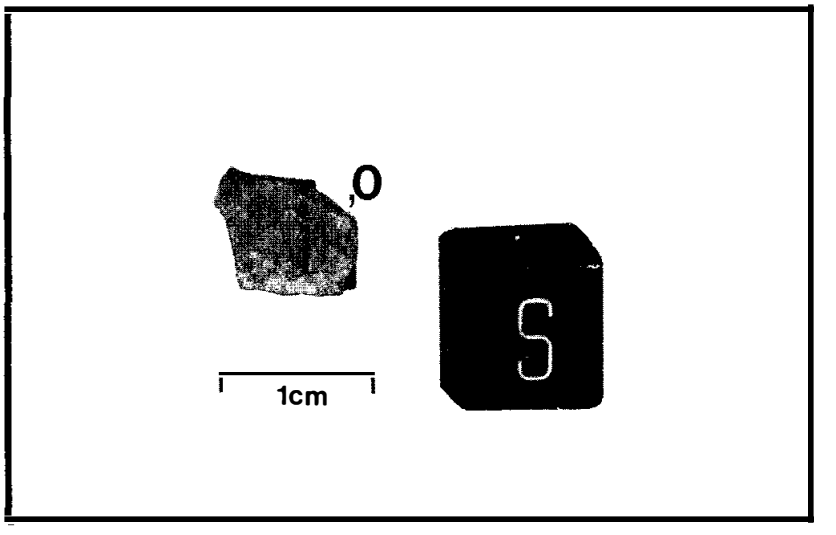
PETROGRAPHIC DESCRIPTION

In hand specimen, sample 14434 appears to be a coherent, holocrystalline rock with 5% large grains of dark gray to brownish plagioclase set in a groundmass consisting of 93% clear light gray minerals, 1% cinnamon brown pyroxene, and 1% equant opaque oxides.

Thin section 14434,2 reveals the sample to be a very coarse-grained polymict breccia with an average grain size of 0.4 mm. It is composed of 60% pyroxene, 40% shocked plagioclase (appearing as devitrified maskelynite), and a moderate amount of opaque minerals. Pyroxene crystals resemble proto-chondrules. All pyroxene crystals are twinned and deformed; many show exsolution features. One large crystal of pyroxene has been shocked to such an extent that only small, isolated domains of crystallinity remain, leaving the crystal milky brown in appearance. Only traces of free metal are visible, and there is less than 1% glass present in the section.

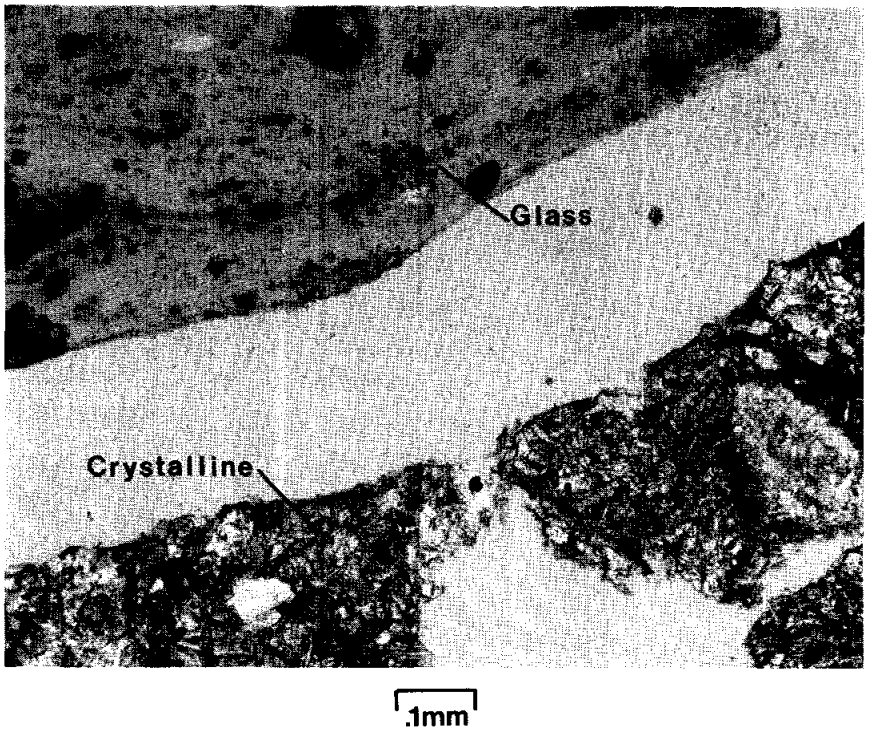
There is a hint of layering in the rock with the plagioclase forming one layer and pyroxene, another. Numerous fractures are present in the section.

14435



S-71-25402

14435,1



PHYSICAL CHARACTERISTICS

Mass	Dimensions
0.92 g	1 x 0.8 x 0.5 cm

Sample 14435 is a holocrystalline, equigranular, coherent rock which appears to have been freshly broken.

SURFACE FEATURES

No pits are present, but an irregular tube-shaped vesicle 1 mm long is present with no projecting minerals.

There is one set of fractures with one member. The fracture surface is irregular.

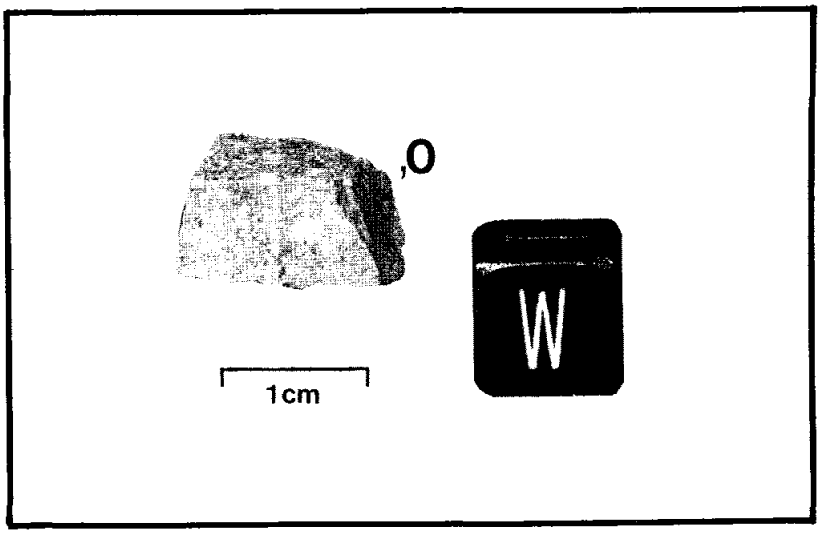
PETROGRAPHIC DESCRIPTION

In hand specimen, sample 14435 appears to be a homogeneous, holocrystalline, equigranular rock with a groundmass consisting of light gray, slightly elongated grains of plagioclase and other light minerals approximately 0.1 mm in size. Plagioclase and other light minerals form 98% of the groundmass, and equant metallic opaques make up the other 2%. Sparsely distributed grains of yellow green olivine and plagioclase account for less than 1% of the composition.

Examination of thin section 14435,1 shows the sample to be composed of numerous, small fragments. One fragment is 95% glass which exhibits flow lines, bubbles, and minor crystallites. The crystallites form bands within the glass. Fragment edges are ragged with a slight greenish cast.

Other fragments visible in thin section appear to be fragments of a crystalline rock lacking in igneous texture. Large shards and tiny lath-shaped crystals of plagioclase and some small olivine crystals are visible. The olivine crystals form a series of "chain-like" masses in the plagioclase. Some small, fine-grained fragments are present suggesting that this sample would fall under the clast-laden melt rock category in the classification of Simonds et al., 1977. Pyroxene occurs as small masses to tiny crystals in a fabric with a seriate texture. Shock effects are visible in all crystals and small spheres of metal are present in the glass. The sample is approximately 60% plagioclase and 40% pyroxene.

14436



S-71-25394

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.76 g	1.5 x 1.0 x 1.0 cm

Sample 14436 is a brownish gray sample which may be either an igneous rock or a dense, fine grained, fragmental rock.

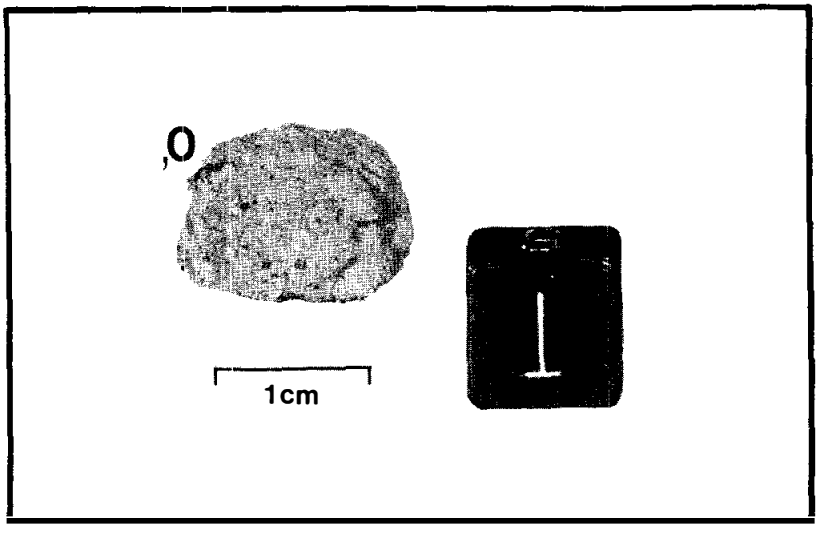
SURFACE FEATURES

There are no pits, cavities, or fractures.

PETROGRAPHIC DESCRIPTION

Sample 14436 is texturally and mineralogically homogeneous. It is fine grained, with an average grain size of approximately 0.1 mm. It consists of 2% clear plagioclase in subhedral grains 1.5 mm in size, 5% honey brown pyroxene in euhedral grains 0.5 mm in size and 1% olivine in subhedral grains of 0.3 mm size. The rest of the sample is very fine brown and gray turbid plagioclase in anhedral grains $\sim$ 0.3 mm, and 3% metallic black opaques in grains < 1 mm.

14437



S-71-25385

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.65 g	1.8 x 1.2 x 0.9 cm

Sample 14437 is a fragmental rock with all grains smaller than 1 mm and no lithic fragments.

SURFACE FEATURES

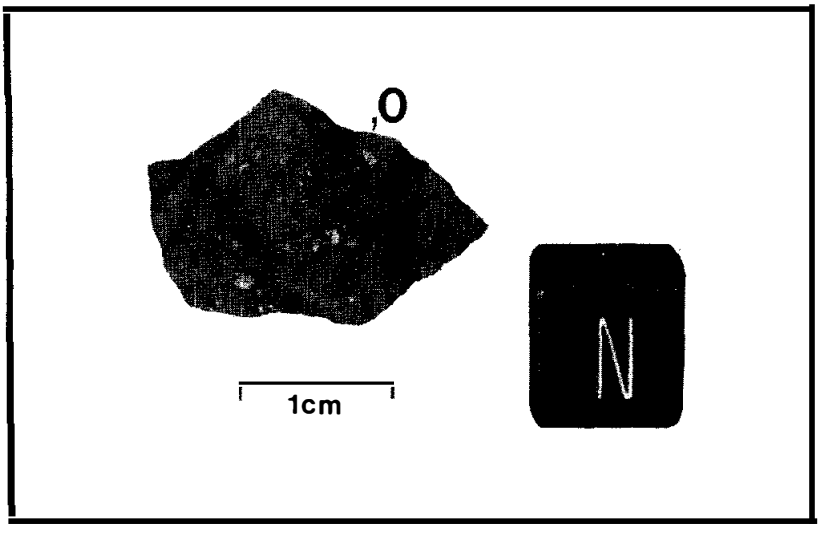
Pits are generally unlined and rare. Only one glass lined pit was observed. They are spaced 0.2 - 1 mm apart and range in size from 0.2 - 1.0 mm. Irregularly shaped clast molds ranging in size from 0.3 to 1 mm occur in clusters mostly on one side. There are no projecting minerals. They are 5 mm apart and cover 10% of the area of the side on which they occur.

PETROGRAPHIC DESCRIPTION

This rock is entirely composed of grains smaller than 1 mm. There are no lithic fragments. Mineral fragments are 30% of the rock composition. These include 2% angular, chalky white 0.3 mm plagioclase (some grains are vitreous

and turbid), and 1% brown pyroxene. Glass fragments compose 70% of the sample and occur in a variety of shapes. One is vesicular. They are dark gray, honey brown, and green.

14438



S-71-25388

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.35 g	2.2 x 1.4 x 1.0 cm

Sample 14438 is a medium to light brownish gray, fragmental rock.

SURFACE FEATURES

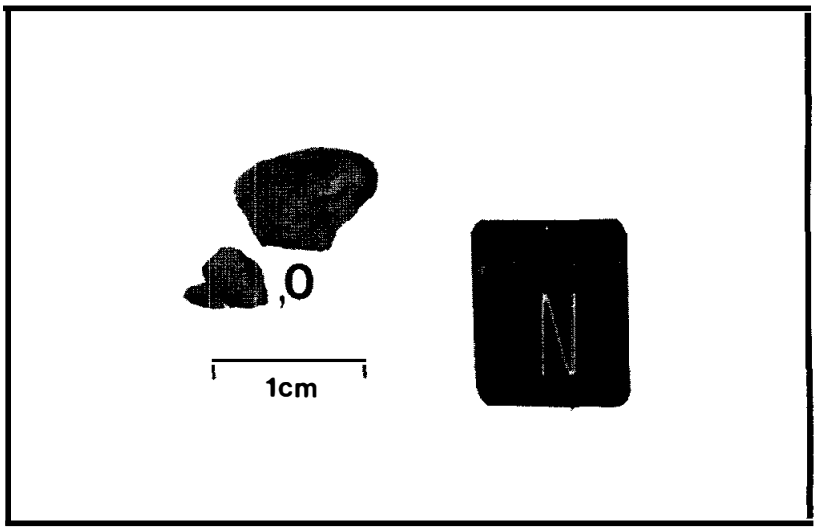
Pits are unlined and measure 0.5 mm in diameter. Only one surface is pitted. Other surfaces have irregular circular outlines which may be pits or may be lightly spattered with glass. There are no fractures.

PETROGRAPHIC DESCRIPTION

Sample 14438 is a friable, gray, polymict breccia. Less than 1% of the fragments are clasts larger than 1 mm in size. The very fine grained (< 0.1 mm) matrix is light gray to brownish gray. Five percent of the rock is composed of mineral fragments: 0.1 mm plagioclase grains (2%), 0.3 mm brown pyroxene (2%), and 0.5 mm olivine (1%). Some fragments thought to be plagioclase may actually be polycrystalline clusters of granular olivine. Leucocratic lithic

fragments make up 1% of the sample. They are almost all crystalline rock fragments. Two kinds are present. They are plagioclase fragments with 2% opaque oxide minerals (ilmenite?) and fragments which consist of plagioclase, brown pyroxene, and opaque oxides. Ten percent of the rock is glass fragments. Spherical beads of glass (< 0.1 - 0.5 mm in size) occur on 1% of fresh surfaces. Some beads are embedded, while others are loosely attached. They are clear brown, pale green, clear, and opaque, with the opaque beads smaller than the rest. Clear glass is particularly abundant.

14439



S-71-25392

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.00 g	0.9 x 0.7 x 0.3 cm

This sample consists of two, small, subequal pieces of a fragmental rock.

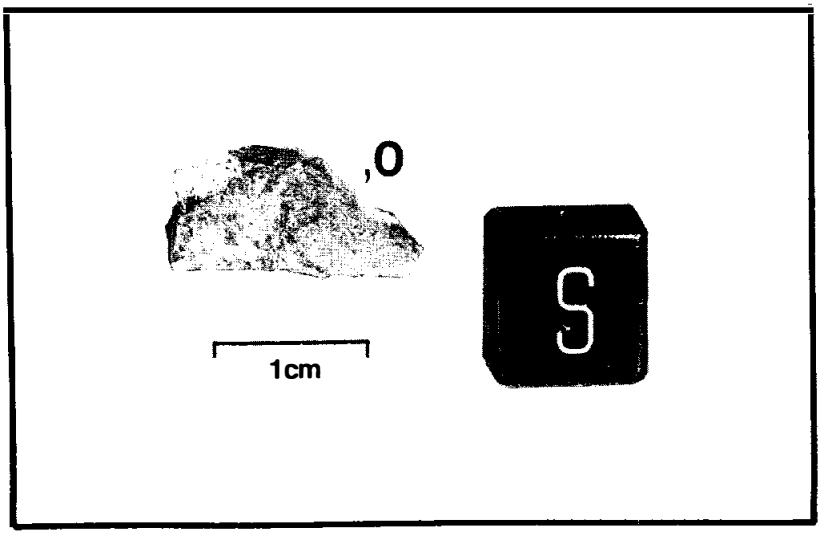
SURFACE FEATURES

There are no pits or cavities. One set of non-planar fractures with members spaced 3 mm apart parallels the length of the sample.

PETROGRAPHIC DESCRIPTION

The sample is a very friable, fine grained, fragmental rock with all of the sample composed of grains smaller than 1 mm. The average grain size is < 0.1 mm. About 86% of the sample is very fine grained. Four percent of the sample is composed of mineral fragments of white to clear plagioclase. There are no lithic fragments. Glass composes 10% of the rock. Glass spheres which are pale green to brown in color make up less than 1% of the sample. There are abundant angular glass fragments which are dark and vary in size from < 0.1 to 7 mm. The larger ones appear vesicular.

14440



S-71-26859

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.50 g	1.9 x 0.9 x 0.7 cm

This sample is a blocky, angular, medium gray, holocrystalline rock with smooth, unpitted surfaces.

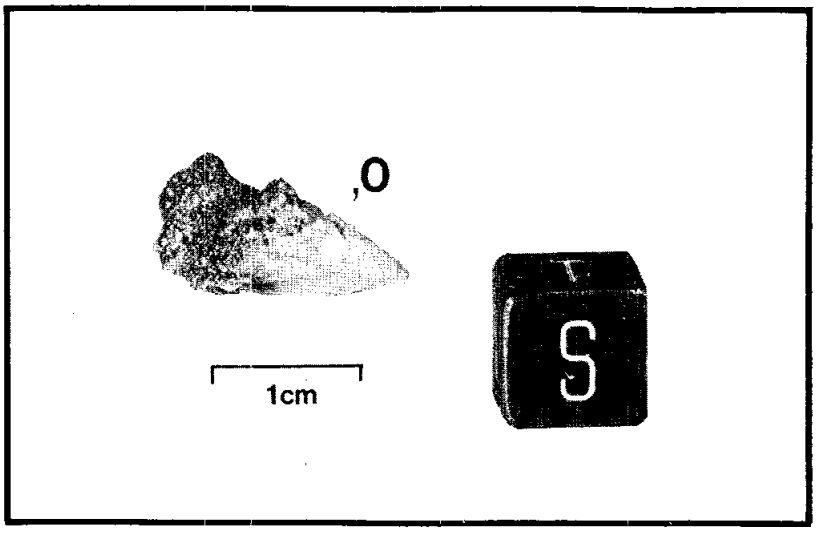
SURFACE FEATURES

No pits are present. There may be one non-planar fracture parallel to the long axis of the sample.

PETROGRAPHIC DESCRIPTION

Sample 14440 is a coherent, holocrystalline sample which has grains too fine to measure. It is texturally homogeneous, but mineralogically inhomogeneous. Three percent of the sample is clear and turbid, angular and anhedral feldspar and less than 1% opaque minerals. The remainder is aphanitic. It appears to be a largely recrystallized, clastic rock. This should be determined in thin section, however.

14441



S-71-26840

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.23 g	1.8 x 0.8 x 0.8 cm

This is a medium to dark gray, coherent, fragmental rock with a pronounced conical shape.

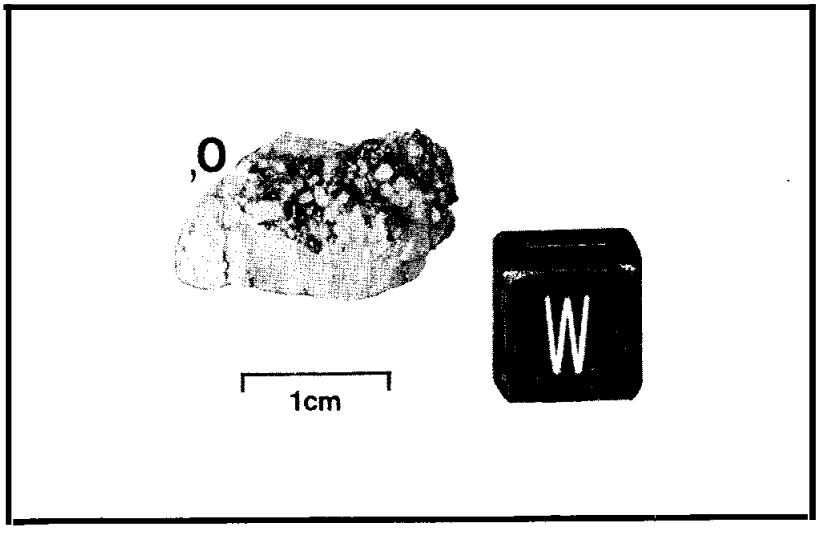
SURFACE FEATURES

There are no pits, cavities, or fractures.

PETROGRAPHIC DESCRIPTION

This sample is fragmental, with chalky white grains (probably feldspar) visible on 2% of the surface giving the sample a slight "salt and pepper" appearance. It is fine grained like siltstone in appearance and no other mineral or glass fragments can be identifyed under the binocular microscope. It is possibly a shatter cone. Glass coats the base of the rock.

14442



S-71-26848

PHYSICAL CHARACTERISTICS

Mass	Dimensions
3.51 g	2.3 x 1.4 x 1.0 cm

Sample 14442 is a small, blocky, friable, medium gray fragment which resembles siltstone in appearance.

SURFACE FEATURES

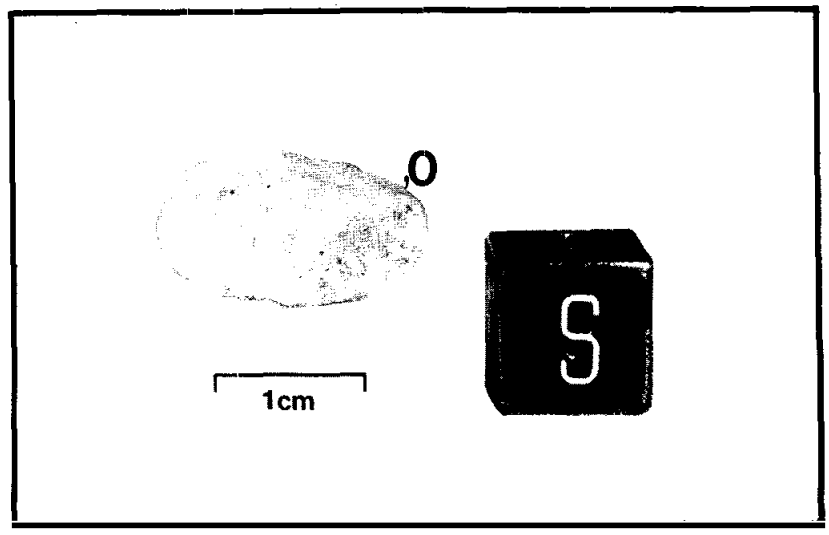
No pits or cavities were observed. There is one planar fracture with a smooth surface oriented parallel to the long axis of the rock.

Twenty percent of the rock surface is covered with vesicular, black glass. Vesicles are uniformly distributed through the glass coating and range from 0.2 to 1.5 mm in diameter.

PETROGRAPHIC DESCRIPTION

The sample is friable, very fine grained, and homogeneous in texture and mineralogy except for approximately 5% white, angular, chalky fragments and less than 1% pyroxene and olivine grains which are visible under the binocular microscope.

14443



S-71-25895

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.5 g	2.0 x 1.6 x 1.2 cm

The sample is a dust covered, slightly elongated, holocrystalline rock.

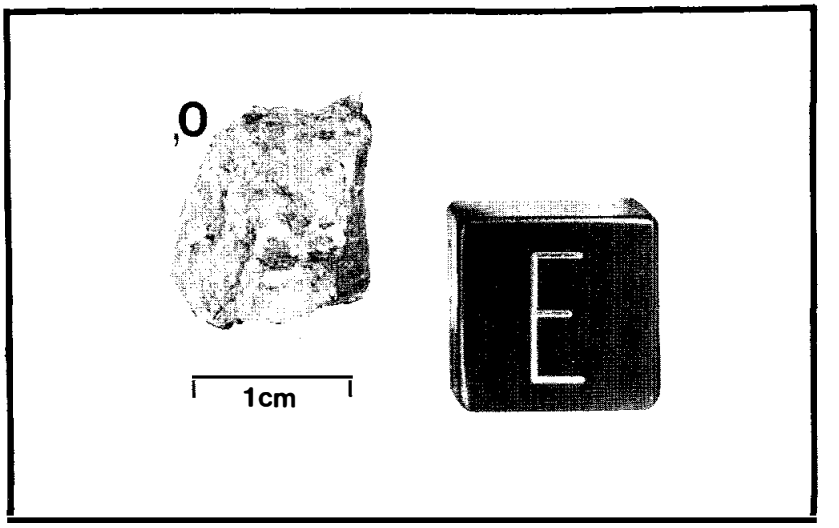
SURFACE FEATURES

There are no pits, fractures, or cavities.

PETROGRAPHIC DESCRIPTION

Sample 14443 is a coherent, very fine grained, holocrystalline rock which is homogeneous in both texture and mineralogy. It contains 45% feldspar and 55% opaque metallic oxide (ilmenite?). It appears to be almost equigranular aphanitic in texture where not obscured by dust.

14444



S-71-25994

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.6 g	1.6 x 1.1 x 0.5 cm

This is a very light gray, coherent, holocrystalline rock with 4% megacrysts.

SURFACE FEATURES

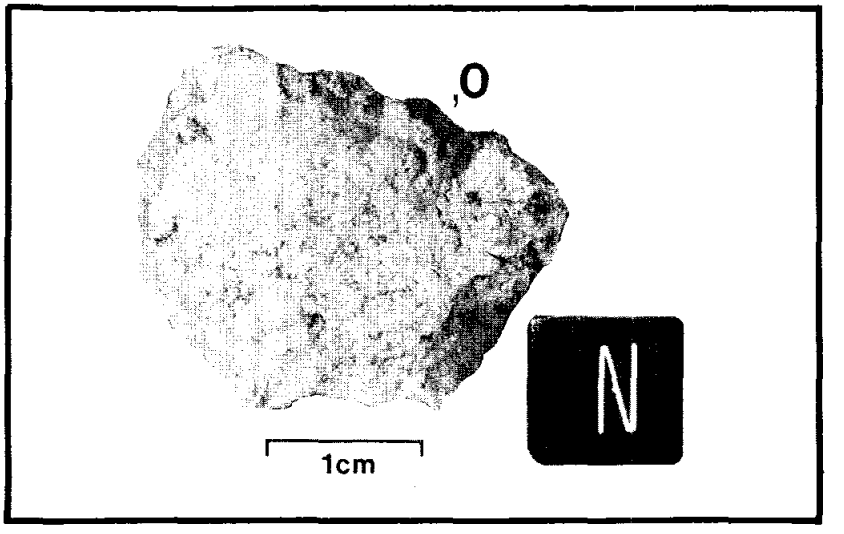
Glass lined pits of varying size cover 15% of one surface of the rock. The zap pits occur on seemingly broken surfaces. Vugs are irregular in shape and range from 0.1 to 0.5 mm in size. The vugs are homogeneously distributed and spaced 1 cm apart. Vugs account for one percent of the rock. There are no projecting minerals visible.

PETROGRAPHIC DESCRIPTION

The sample consists of 1% 0.5 mm olivine with opaque inclusions, 2% pale gray to colorless plagioclase megacrysts with opaque inclusions, opaques < 0.1 mm, 3 - 5% spinel (?), < 1% pale brown pyroxene (?), and 93% fine grained (0.2 mm) pale gray to white granular groundmass. Some plagioclase laths with poly-

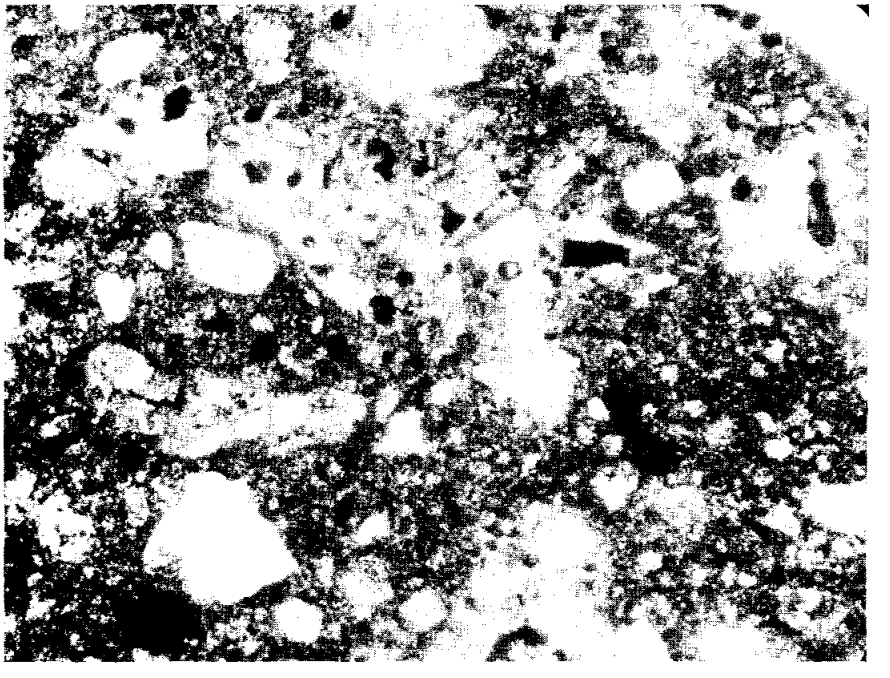
synthetic twinning are present in the groundmass. The large grains in the rock may be either phenocrysts or relicts in a recrystallized groundmass.

14445



S-71-25996

14445, 3



PHYSICAL CHARACTERISTICS

Mass	Dimensions
9.22 g	2.5 x 1.8 x 1.2 cm

Sample 14445 is a blocky, subangular, medium gray, hackly, polymict breccia with moderate cohesiveness.

SURFACE FEATURES

There are three unlined cavities which may be zap pits. Dust obscures most of the sample. There are no visible fractures. One equant clast mold 3 mm in size occurs on the rock surface. There are 3 x 2 mm slickensides exposing metallic particles present.

PETROGRAPHIC DESCRIPTION

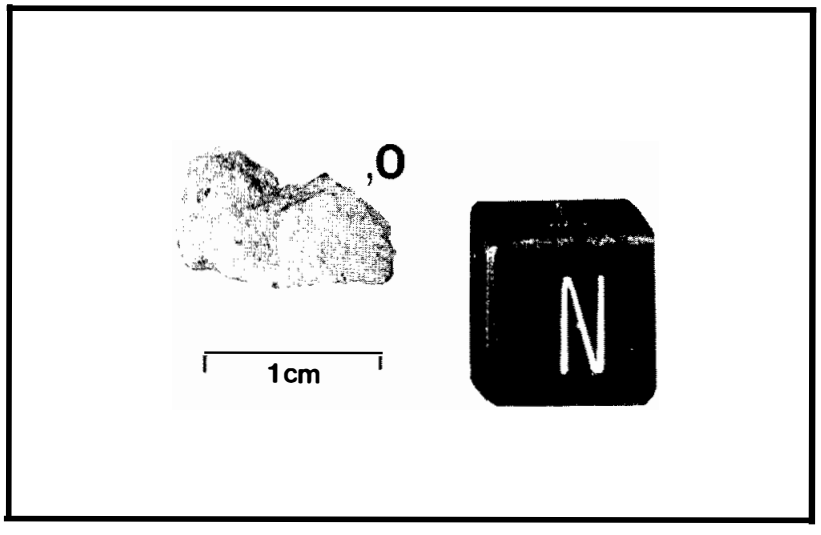
In hand specimen, sample 14445 appears to be fine grained with an average grain size from 0.1 to 0.2 mm. The texture of the matrix is seriate. The rock is not homogeneous. There are 10-15% clasts larger than 1 mm and 85-90% matrix grains. Plagioclase, pale brown pyroxene, and olivine are present, but adhering dust prevents accurate percentage estimation. Clasts are melanocratic lithic fragments, some as large as 7 mm across. They are angular to subangular. One large pyroxene (0.5 mm) is in a dark, aphanitic clast. Dust obscures the matrix.

Examination of thin section 14445,3 reveals the sample to be a glass-rich breccia with approximately 20% "glass" in the matrix (< 1 mm). Several lithic fragments are present but the predominate fragments are mineral crystal segments. The rock would fall into the VMB/LMB classification of Simonds et al. (1977).

The clasts (> 1 mm) are those of a crystalline rock composed of pyroxene and plagioclase. The texture is not classically igneous in nature, but more a random mixture of the two minerals suggesting that the clasts are melt rock fragments. There is also a large single crystal of pyroxene present which is twinned and somewhat zoned.

The matrix (< 1 mm) is composed of 10% lithic fragments, 70% mineral fragments and the 20% glassy material. Of the mineral fragments, 80% are pyroxene and 20% are plagioclase. There are small anhedral crystals of olivine in several of the pyroxene and plagioclase crystals. There is minor exsolution along the twin planes in some of the pyroxene grains. Most of the mineral fragments show some reaction with the glassy bonding material. A small amount of opaque mineral fragments are also present.

14446



S-71-26013

PHYSICAL CHARACTERISTICS

Mass	Dimensions
0.82 g	1.6 x 0.7 x 0.4 cm

This sample consists of four small chips of plagioclase-rich rock.

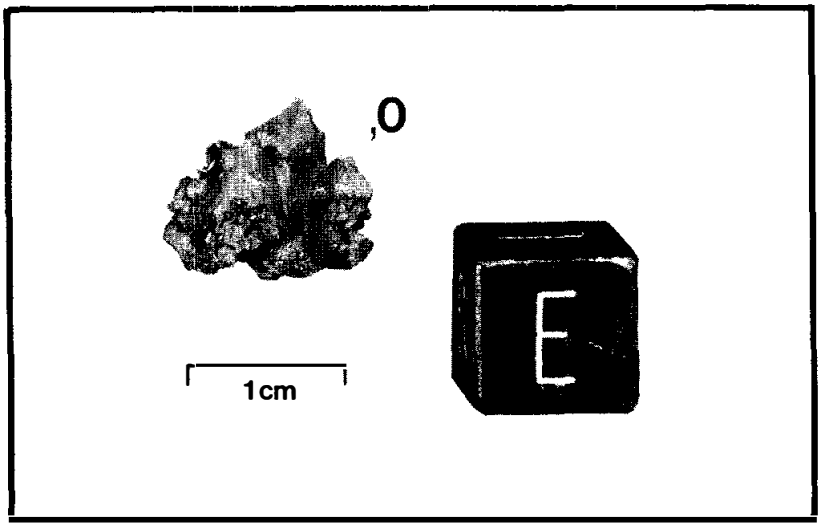
SURFACE FEATURES

The irregular surface contains no pits or fractures. Vugs which are 0.2 to 1 mm in diameter are common. They are lined with projecting plagioclase crystals.

PETROGRAPHIC DESCRIPTION

The rock is friable and fine grained with an average grain size of 0.1 mm. It consists of megacrysts of light gray, subhedral, 1 - 2 mm feldspar (5%); < 0.1 mm metallic black opaques (2 - 3%); white to pale gray, very fine grained groundmass (92%). Some plagioclase laths with polysynthetic twinning may be present in the groundmass.

14447



S-71-26017

PHYSICAL CHARACTERISTICS

Mass	Dimensions
0.91 g	1.3 x 1.0 x 0.6 cm

This small sample is blocky and angular in shape, it has a very hackly surface. It appears to be an agglomeration of fine grained clastics that is held together with glass.

SURFACE FEATURES

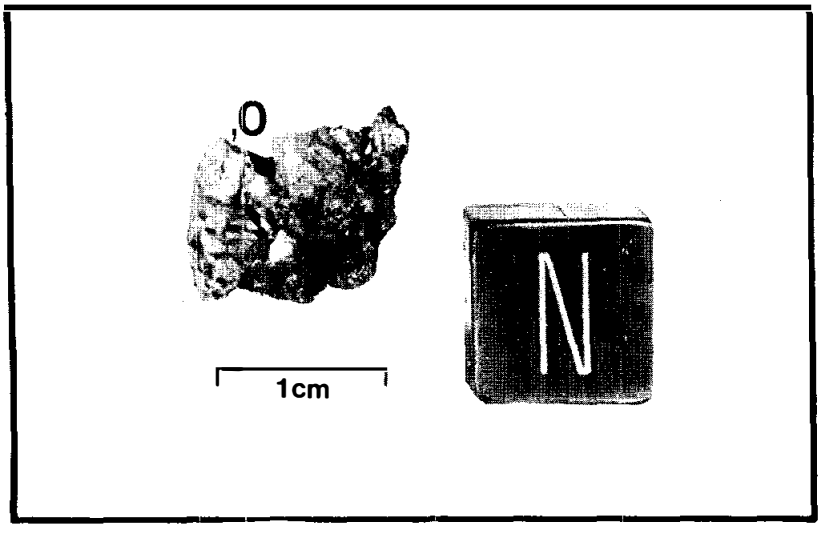
There is one slickensided surface. There are no pits. There are numerous fractures appearing in many sets spaced 1 mm apart.

The surface is 50% glass covered. The glass coating is very vesicular. Vesicles are spaced 1 mm apart and are 0.1 to 2 mm in size. Many are dust filled, others are deep, fragile and very jagged. The color of the glass on a thin edge is brownish gray to honey color. Elongate cavities which appear to be clast molds are 1 x 2 mm in size.

PETROGRAPHIC DESCRIPTION

This friable (held together by glass), polymict, fragmental rock consists of leucocratic lithic fragments. Only one or two clasts are larger than 1.0 mm. The matrix of light gray material is too fine grained (< 0.1 mm) to resolve.

14448



S-71-26021

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.06 g	1.6 x 1.3 x 0.4 cm

This sample is an agglomerate of fine grained, clastic rocks held together by spatter glass.

SURFACE FEATURES

Glass lined zap pits are present but few in number. Glass spatter is present on one surface and covers 40% of the rock. Vesicles which are filled with fine grained, clastic material occur on the surface of the glass. These range in size from 0.1 to 2.0 mm and are spaced 0.3 mm apart. Many fractures and fracture sets occur with irregular fracture surfaces.

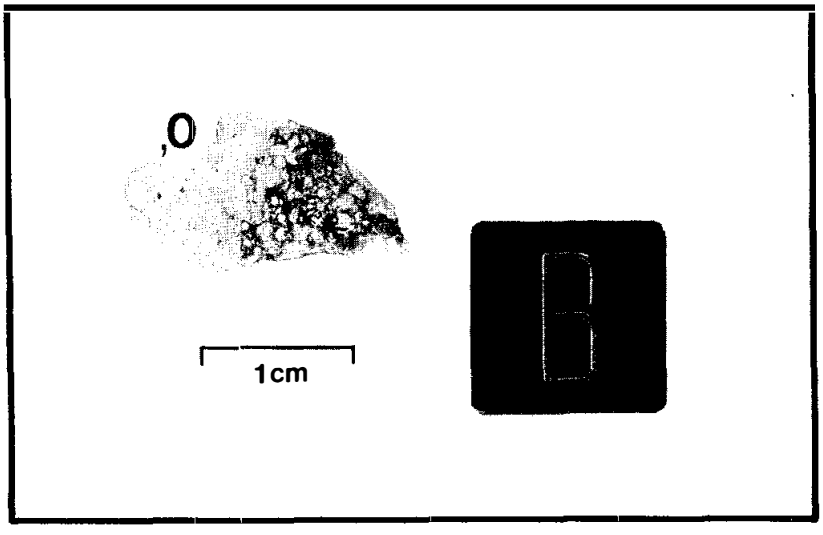
PETROGRAPHIC DESCRIPTION

Sample 14448 is an agglomerate of fine grained (< 0.1 mm), clastic rocks held together by glass and is similar to sample 14447. It is friable and inhomo-

geneous. Two percent of the fragments are clasts larger than 1 mm.

Mineral fragments are present, but are too small to identify. Lithic fragments are leucocratic and comprise 3 - 4% of the matrix. These are crystalline rock fragments. One large (2 x 4 mm) clast has specks of opaque oxides. The rest of the clast is light granular material.

14449



S-71-26866

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.7 g	1.0 x 1.0 x 1.5 cm

Sample 14449 is a gray, friable, freshly broken chip of clastic rock.

SURFACE FEATURES

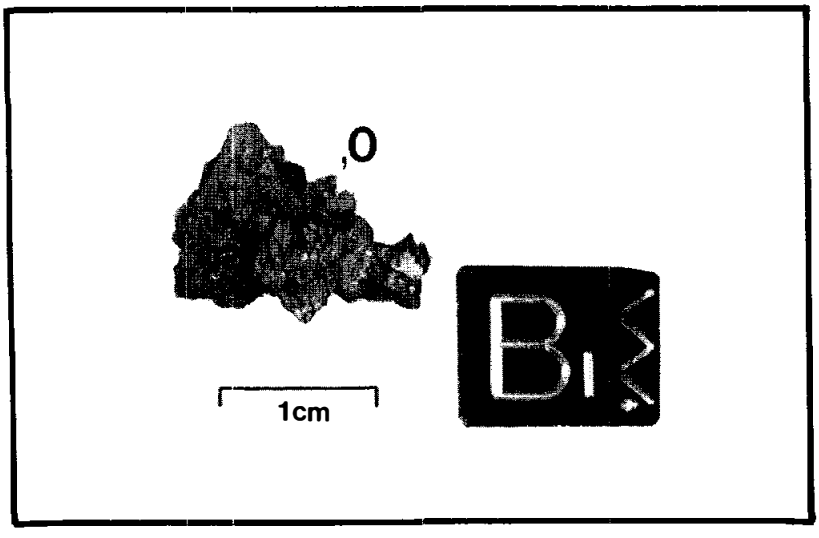
Pits less than 0.5 mm in diameter occur on 15% of the surface. A thin veneer of glass coating has a thickness of ∿ 1 mm. It occurs on a 1 cm^2 surface. Round holes in the glass are numerous and due to surface contraction during cooling. Hemispherical and cylindrical shaped cavities range from 0.5 - 1 mm in size and are approximately 1 mm in depth. They have random distribution and are 3 - 4 mm apart. There are no projecting minerals. Clast molds are also present.

Two sets of planar fractures and many tiny non-planar, hair-like cracks occur in the rock. The first set has two members spaced 2 mm apart. It is subparallel to the freshly broken surface.

PETROGRAPHIC DESCRIPTION

Sample 14449 is a friable, very fine grained (< 0.5 mm) rock. Clasts ranging in size from 1 - 3 mm are less than 5% of the rock volume. They are leucocratic, and some seem to be fragments of other clastic rocks. Ninety percent of the rock is matrix less than 0.5 mm in size. No glass fragments are visible but the 1 cm^2 glass coating with extremely low pit density is noteworthy. Only approximately 10 pits were observed.

14450



S-71-25377

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.27 g	1.8 x 1.1 x 0.6 cm

The sample is an agglomerate of friable, clastic clods bonded by dark gray to honey brown vesicular glass.

SURFACE FEATURES

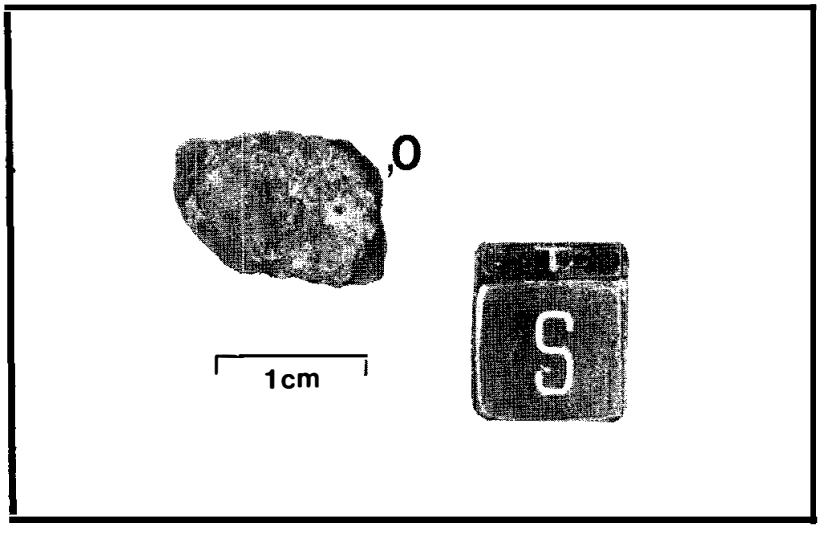
The glassy covering is smooth but the clastic portion has an irregular surface. Zap pits are present on the glass covering, which occupies 75% of the rock surface. Pits range in size from 0.1 to 0.5 mm and are unlined. The glassy covering has some vesicles which haven't reached the surface and these can be seen in the interior of the sample. One well defined planar fracture cuts both glass covering and rock interior.

PETROGRAPHIC DESCRIPTION

The sample is fine grained with an average grain size of less than 0.1 mm. It is heterogeneous in texture and mineralogy. Several clasts are larger

than 1 mm. One 3 mm lithic clast is leucocratic and contains 1% opaque oxides, the rest being fine grained, light minerals. A 2 mm clast is leucocratic with megacrysts of plagioclase and pyroxene in a very fine grained matrix which is probably rich in plagioclase with some opaque grain.

14451



S-71-25383

PHYSICAL CHARACTERISTICS

Mass	Dimensions
2.10 g	1.3 x 1.0 x 0.9 cm

This sample is a very light gray, coherent, massive, inequigranular, holocrystalline rock.

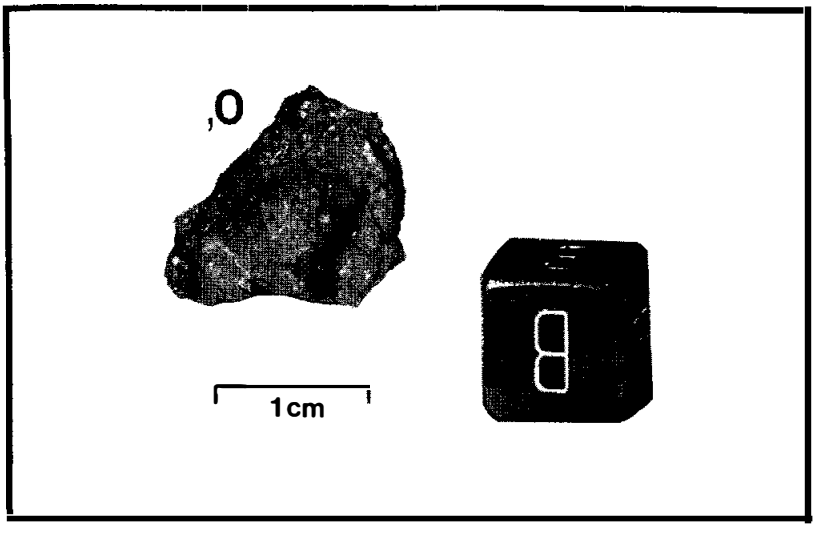
SURFACE FEATURES

The surface is dust covered, but three glass lined zap pits from 0.5 - 1.5 mm in diameter are visible occurring as remnants. They occur as white haloes in the surrounding rock on several faces. Two types of cavities are present. One is cylindrical, 0.3 mm wide and 3 mm deep, and the other is a spherical crystal mold, 2.0 x 1.5 mm in size. Remnants of olivine appear on one edge of the mold. There are no projecting minerals in the vesicle. Two planar fractures, not members of the same set, occur at 40° to one another. One fracture parallels the major and intermediate axes of the sample.

PETROGRAPHIC DESCRIPTION

Sample 14451 is a massive holocrystalline rock which is texturally and mineralogically heterogeneous. Very sparse megacrysts of olivine and of a dark brown mineral (probably pyroxene) are visible. As was mentioned previously, a large clast of olivine has fallen out leaving some olivine behind. In contrast, megacrysts of the dark brown mineral project from the surface. Small amounts of yellow green olivine or pyroxene, cinnamon brown pyroxene, and opaque oxides occur in the groundmass. Plagioclase is the dominant mineral in the matrix, occurring in nearly equant interlocking grains. Metallic black opaques are 2% of the rock, 0.1 mm olivine grains, 1%, and 0.1 mm pyroxene grains are 1% of the sample.

14452



S-71-25362

PHYSICAL CHARACTERISTICS

Mass	Dimensions
1.77 g	2.0 x 1.0 x 1.0 cm

Sample is a fine grained, gray, clastic rock.

SURFACE FEATURES

The irregular surface is 50% glass-covered. The glass is olive brown and highly vesicular with collapsed depressions. Pits appear on the side opposite the spatter and have an average size of 0.7 mm. Vesicles in the glass spatter are circular in shape with a range of < 0.1 mm to 0.2 mm in size. They are homogeneously distributed, and are in contact with one another. They cover 40% of the glass spatter. Glass drapes over the corners of the rock and appears to have dribbled down the side. This could be a possible indication of orientation.

PETROGRAPHIC DESCRIPTION

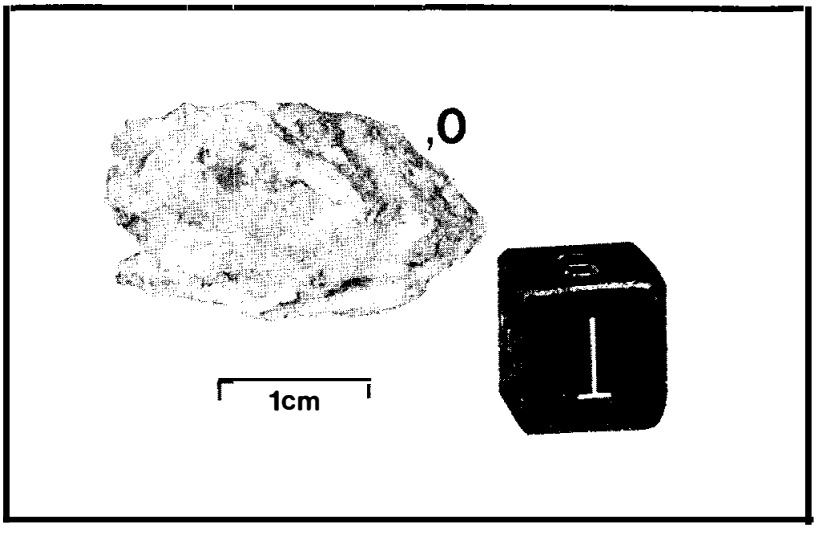
Sample 14452 is homogeneous in texture and mineralogy and is composed entirely of grains less than 1 mm. The average grain size is less than

0.1 mm. Visible as larger fragments (0.1 - 1 mm) are:

1) A powdery white clast with a delicately scalloped surface. The white mineral composes 70% of the visible grains in the clast. The other 30% consists of dark gray feldspar and a trace of opaque black minerals.
2) Angular feldspar fragments up to 0.5 mm in size.
3) Black, very irregular crystals of an opaque mineral.
4) Resinous orange-brown pyroxene present in trace amounts.
5) Possible fragments of pale greenish glass.

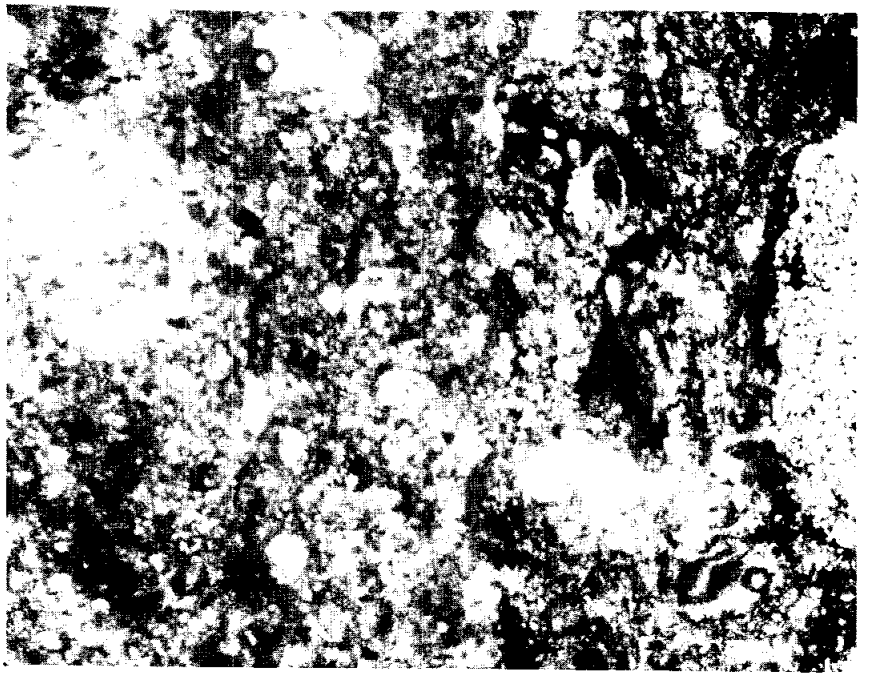
The olive-brown glass spatter which covers half the rock surface is very vesicular. Smooth lipped depressions are present where vesicles collapsed while the rock was still fluid. It may be possible to perform viscosity calculations on the glass spatter. This spatter appears to be thinner than that on Apollo 11 and 12 samples.

14453



S-71-25364

14453, 4



PHYSICAL CHARACTERISTICS

Mass	Dimensions
6.03 g	2.5 x 2.0 x 1.5 cm

This is a banded, light gray, slightly flattened, breccia chip.

SURFACE FEATURES

Pits are rare and deep. Cavities are present only where fractures intersect. These are irregular shaped clusters 0.5 - 1.0 mm in size and are approximately 10% of the sample. Multiple sets of non-planar fractures occur with irregular orientation.

PETROGRAPHIC DESCRIPTION

This sample is coherent, but the numerous fractures make it delicate. It is fine grained, with grains averaging less than 0.1 mm in size. The matrix consists of light and dark specks. Bands occur in layers 0.5 - 2.0 mm thick. They are composed of feldspar-rich clasts and dark glass. Angular feldspar clasts in the dark layers average 0.8 mm in size. Dark glass is 10% of the dark layers and 3% of the light layers. Grains 0.5 mm in size in the light layer occur in angular areas similar to the dark portion. White layers are nearly pure plagioclase. Shock features noted include chalky white fragments and clear to turbid, granulated feldspar patches.

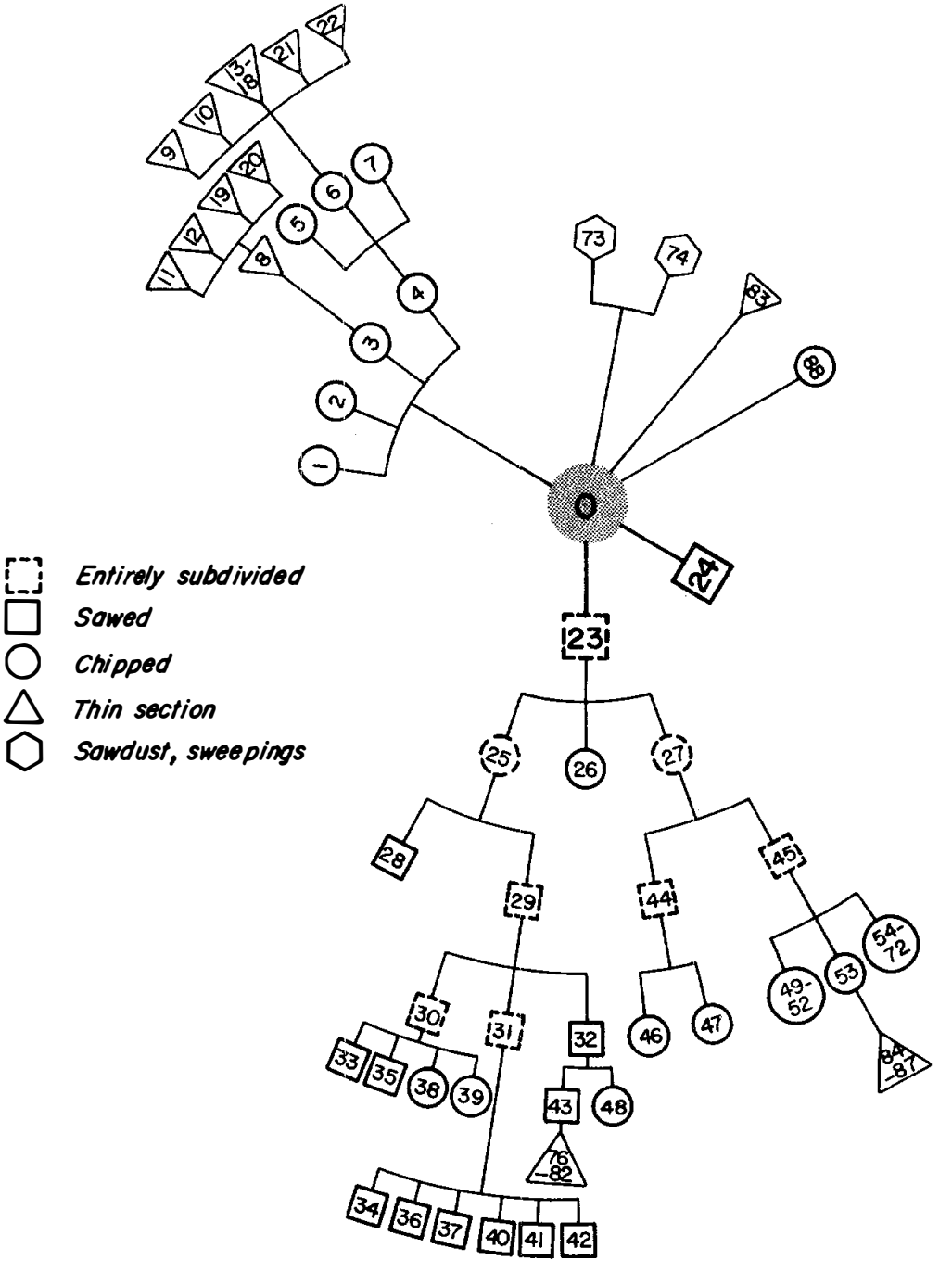
Examination of thin section 14453,4 shows that the rock is characterized by a more crystalline rim and a much "glassier" interior. It is heterogeneous in texture and mineralogy. The crystals present in the breccia clasts are too small to identify. Lithic clasts include some very fine-grained breccia masses. All the grains are less than 1 mm in size. Mineral fragments include: light green olivine (1%), clear plagioclase (3%), chalky plagioclase (2%), dark olivine (1%), white granular feldspar (trace). The fragments in the thin section are approximately 10% lithic, 60% mineral sections, and 30% glassy masses.

SAMPLE MODELS AND GENEOLOGIES

In order to facilitate the job of determining specific sample orientation and orientation within the parent, as well as for historical interest, models of the larger lunar samples have been constructed by the curatorial staff. Photographs of the models made of Apollo 14 samples are included in this section to acquaint the scientific community with their availability and to help lunar scientists identify the original location of their sample within the parent rock.

Geneologies of several Apollo 14 samples have been made and are also included. These geneologies do not reflect any processing which has taken place since the first thin section was made of each sample. It is hoped that these methods of illustrating samples will prove useful, and will become a routine part of sample documentation procedure.

14301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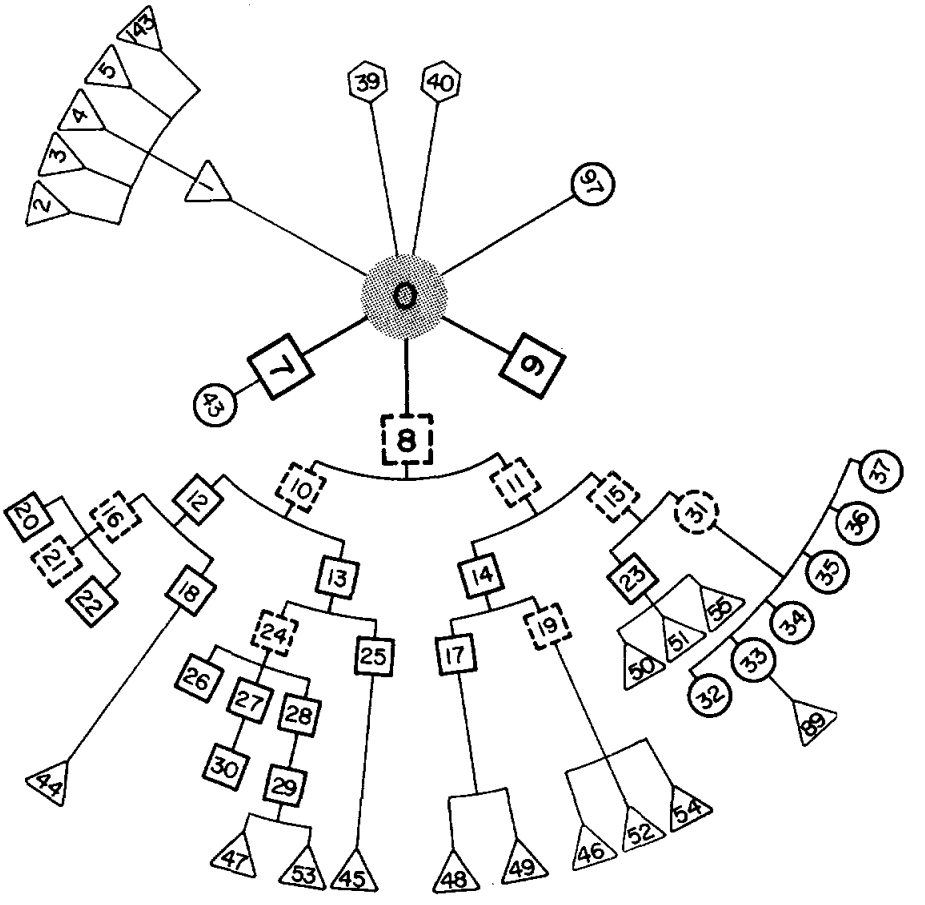
14303



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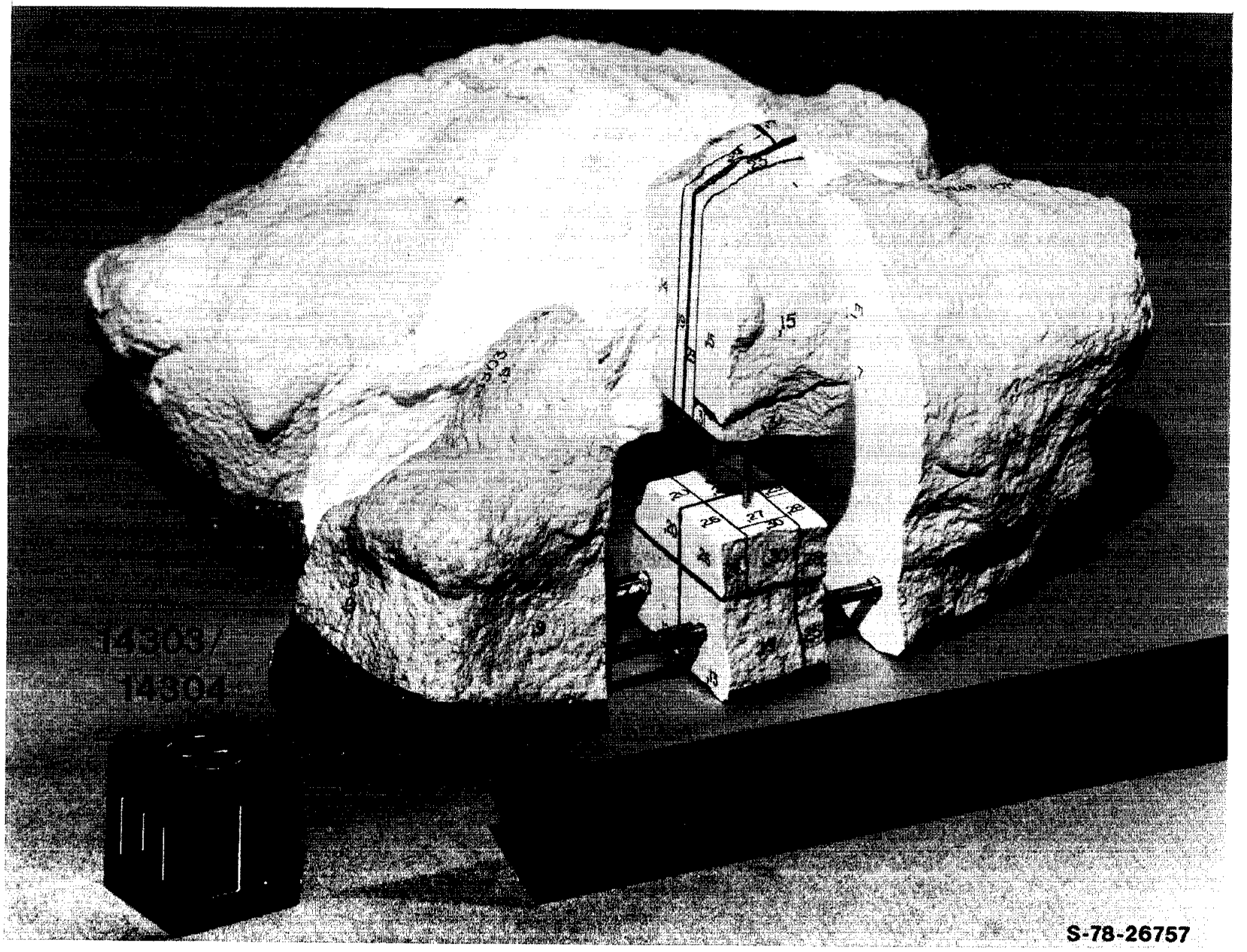
Sawdust, sweepings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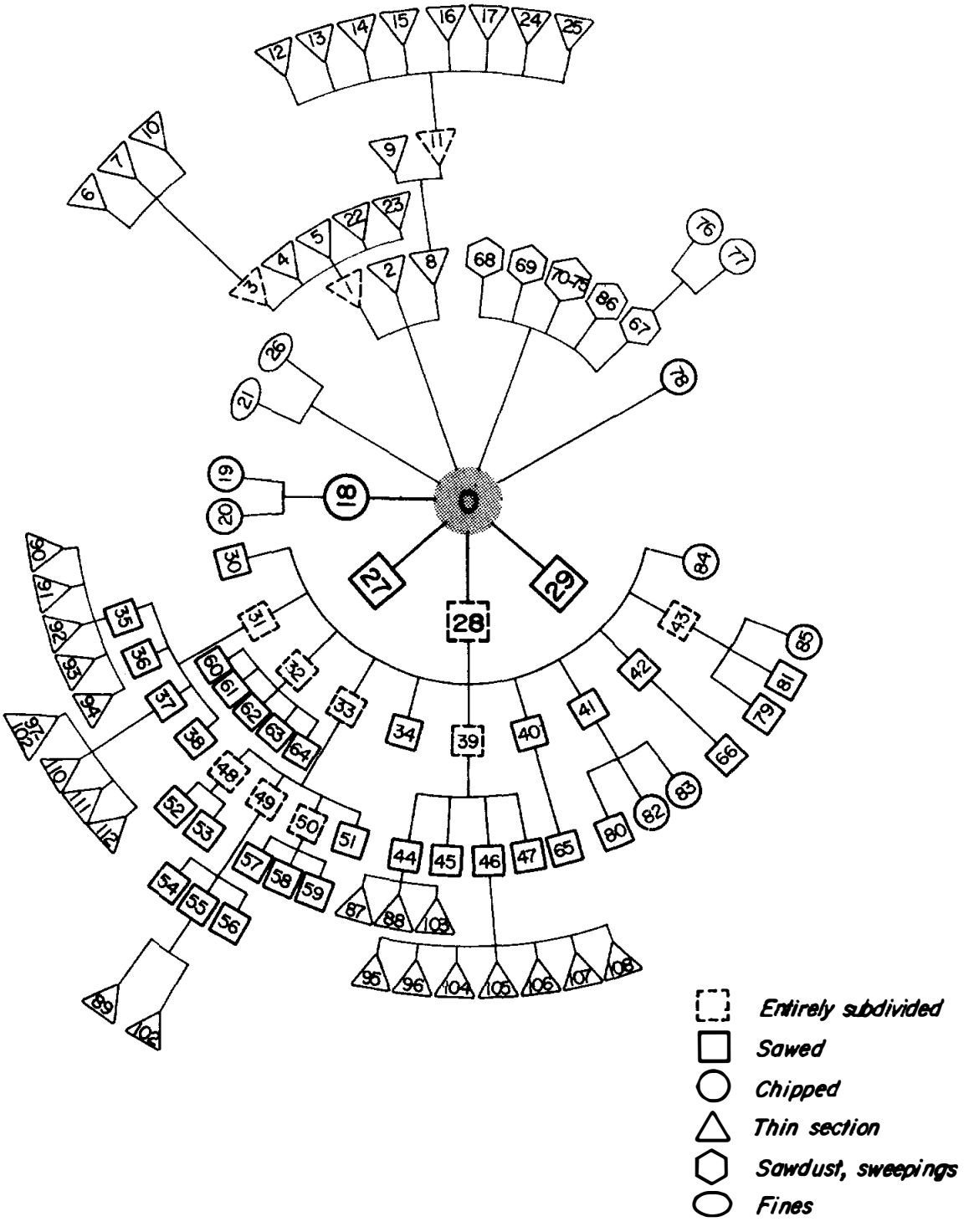
14304
S-78-26757

14305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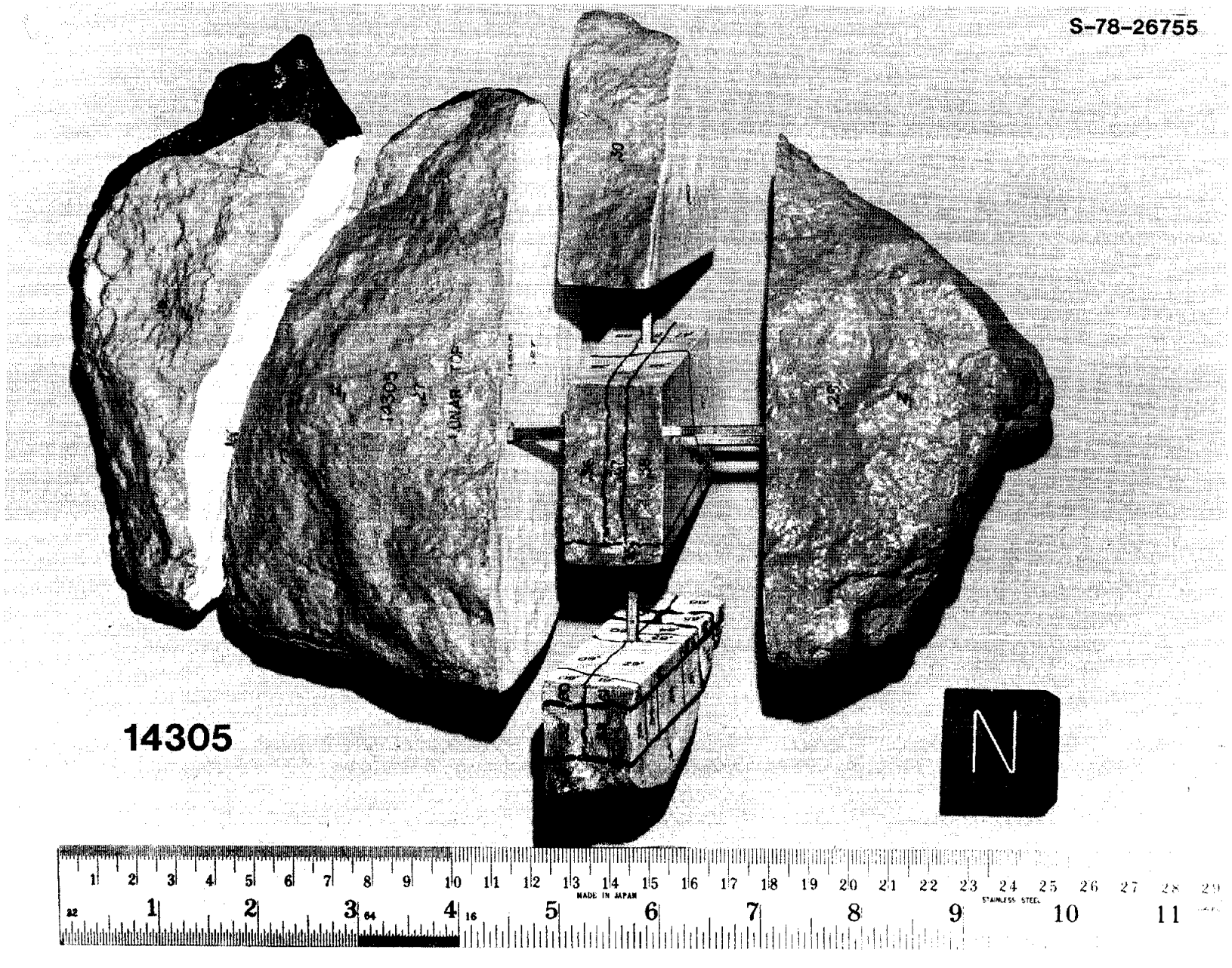
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14305
LUNAR TOP
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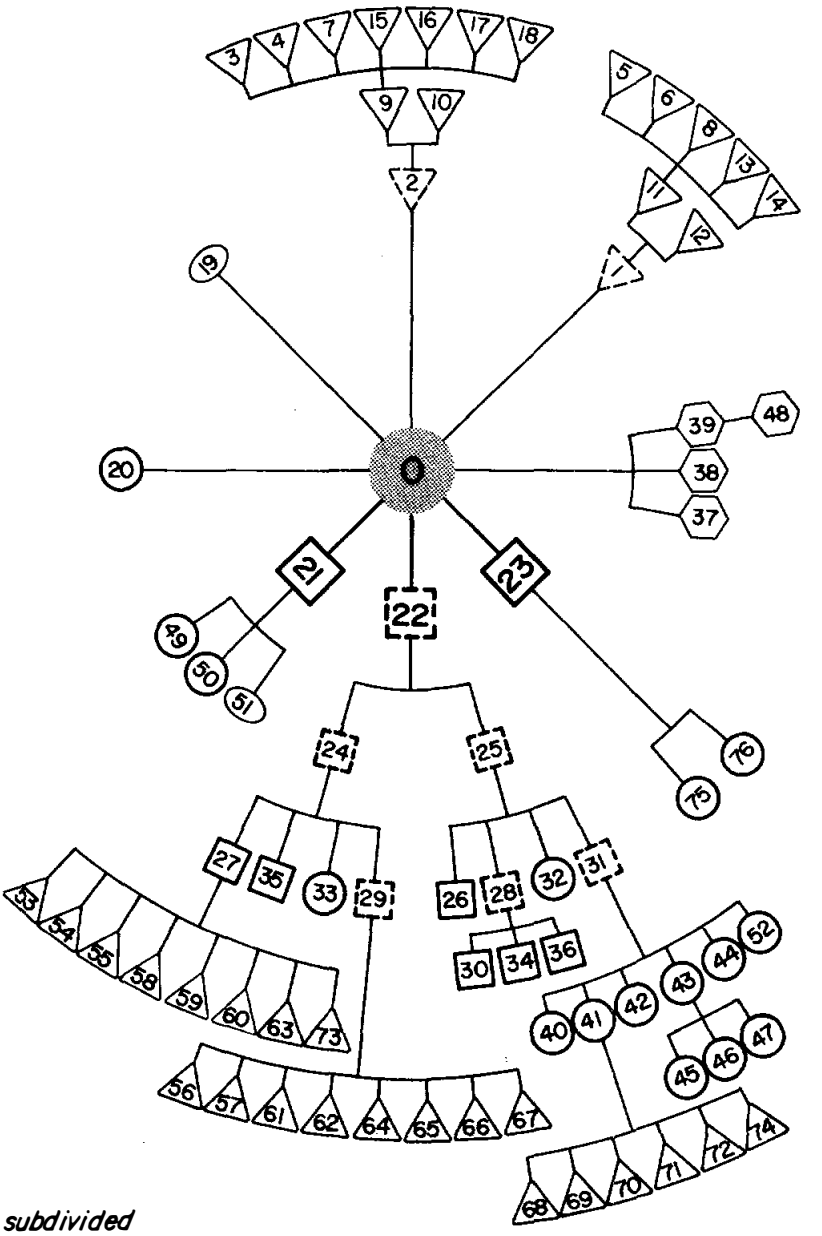
14306



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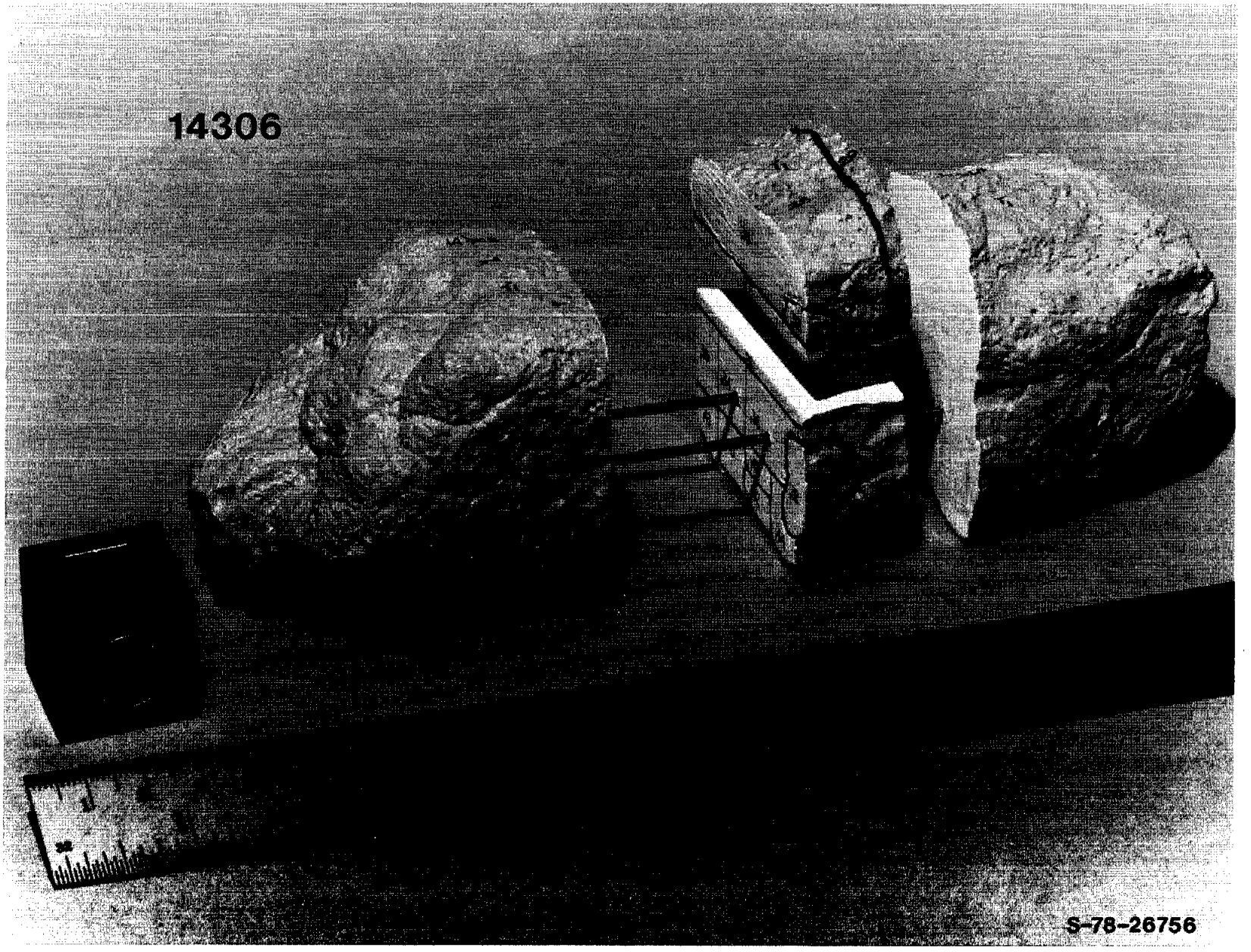
Thin section
Sawdust, sweepings
Fines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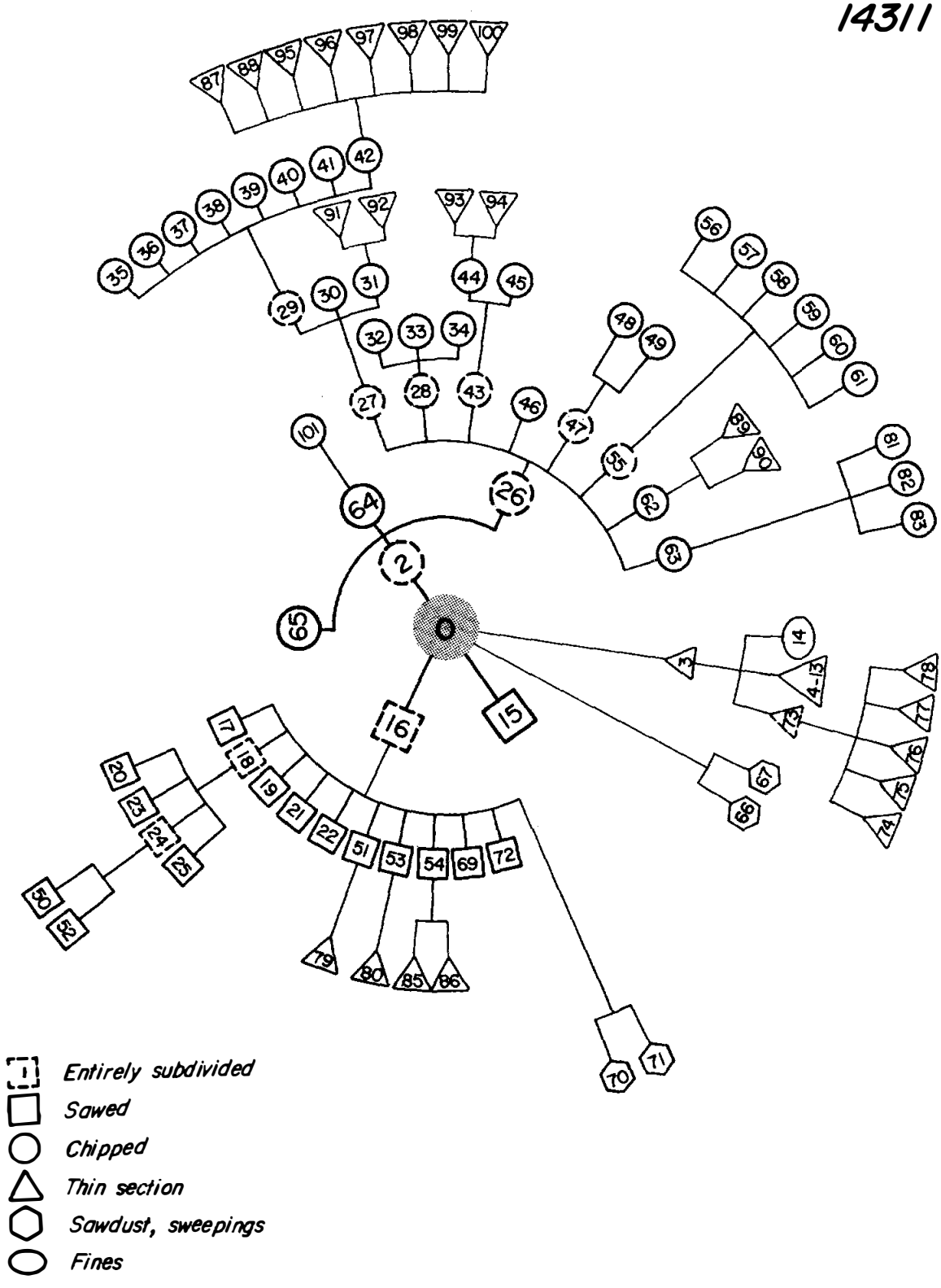
14311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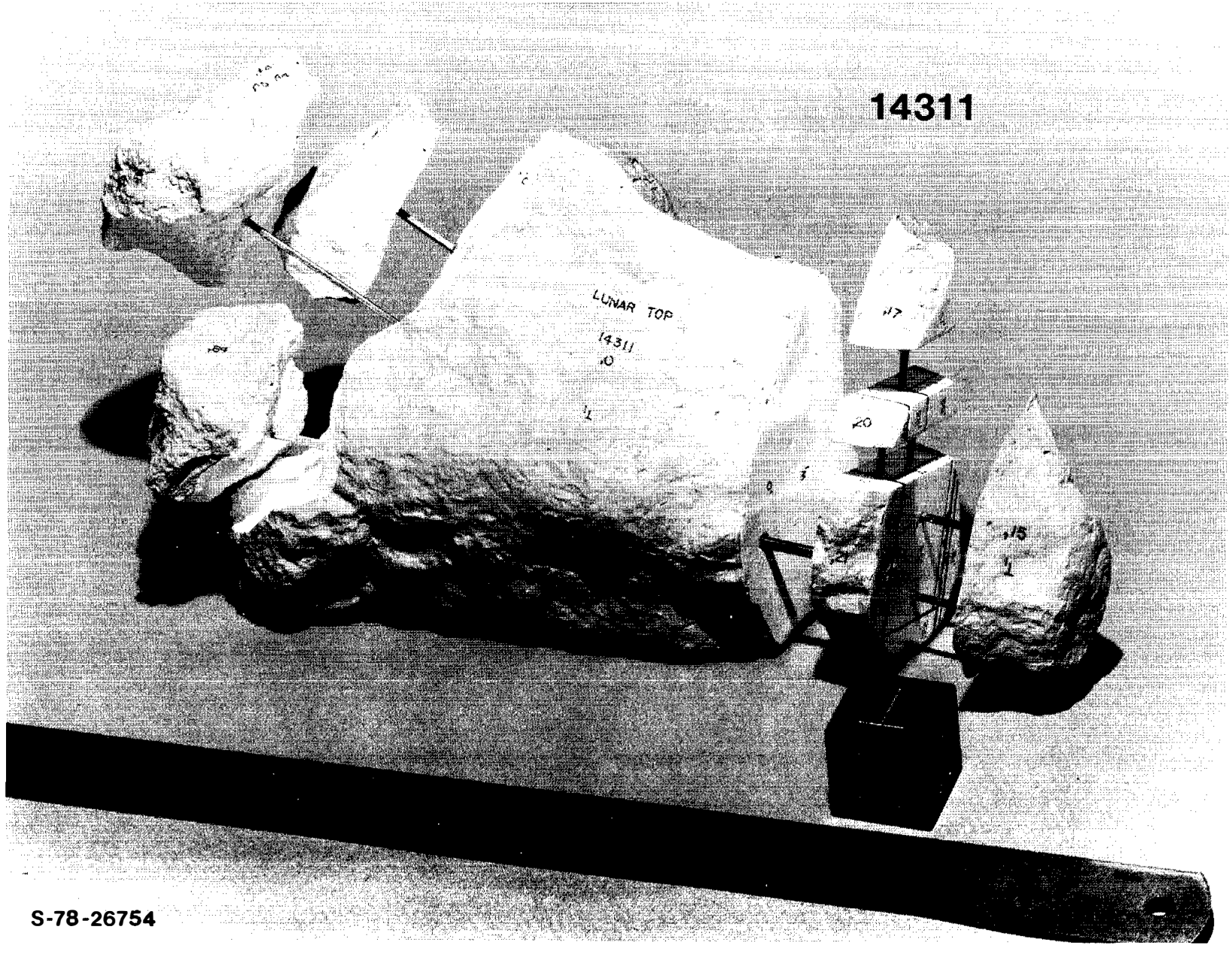

S-78-26754

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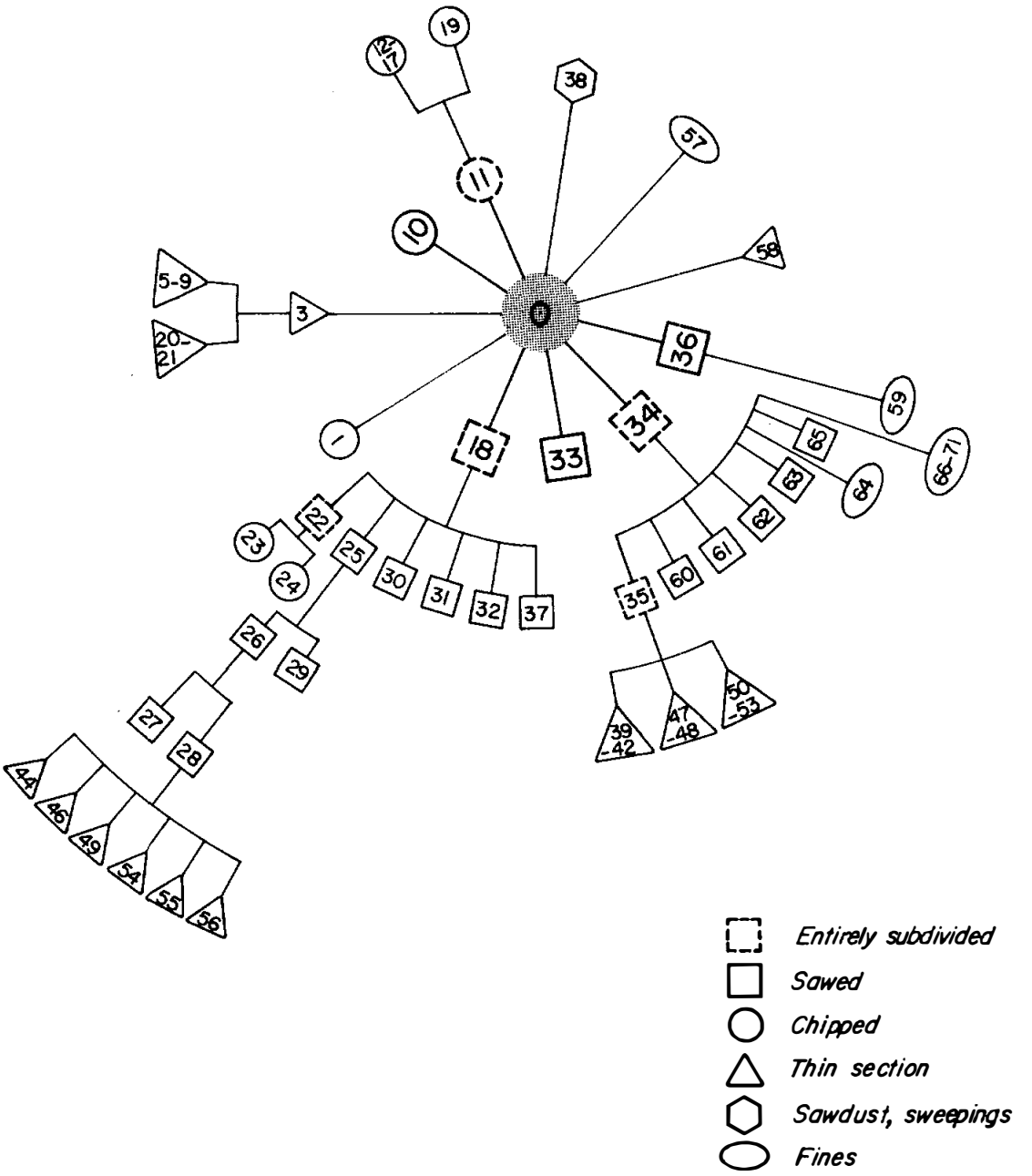
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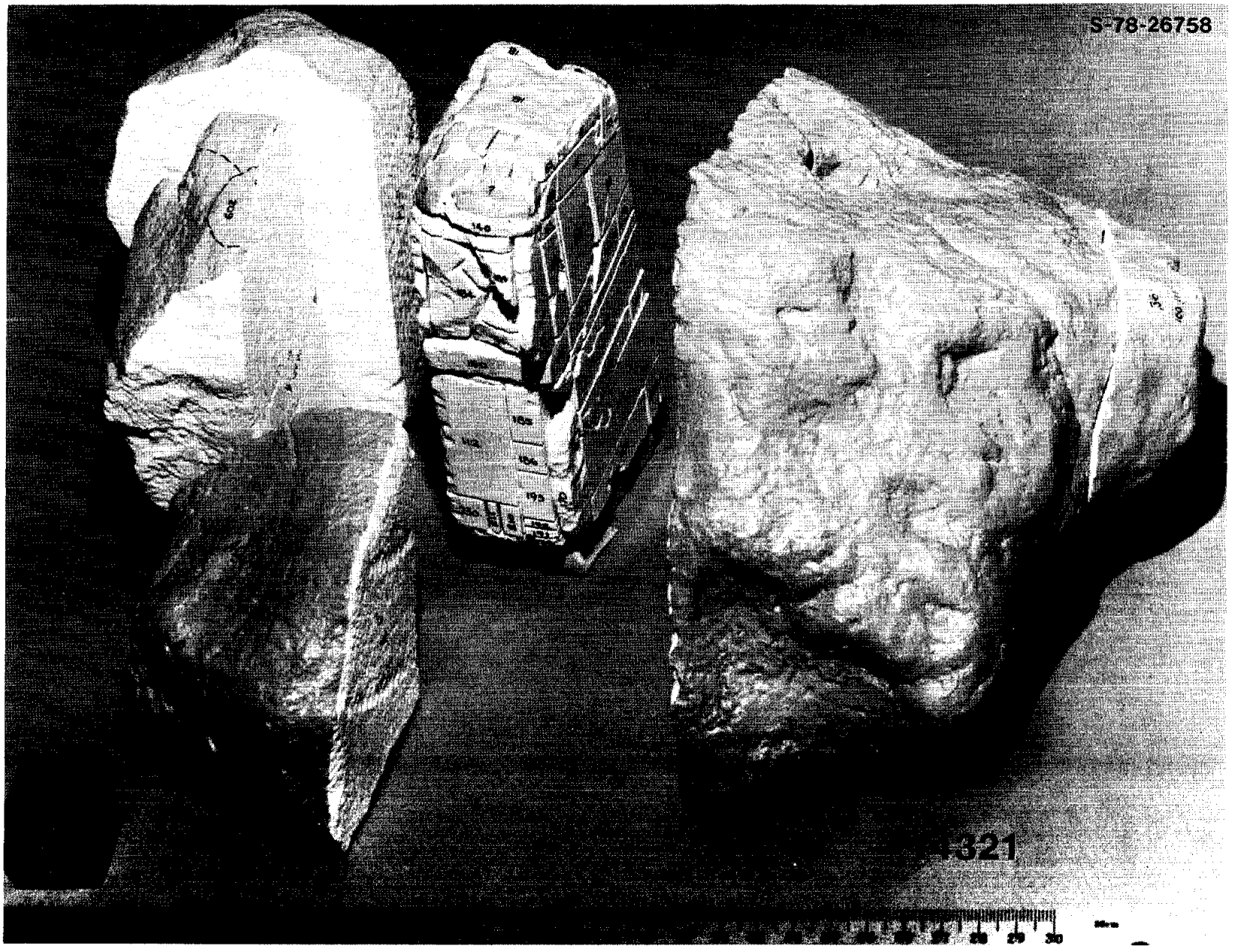
Sawed
Chipped
Thin section
Sawdust, sweepings
Fines


S-78-26758
4321

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APPENDIX I

APOLLO 14 ROCK INVENTORY SUMMARY

Apollo 14 Rock Inventory Summary

Sample #	Mass(g)	Doc.Bag	Weigh Bag	ALSRC	EVA#	Station	Type Sample	Remarks
14006	12.13	----	1039	----	1	LM	CMB	Contingency Sample
14007	3.67	----	1039	----	1	LM	Breccia	Contingency Sample
14008	4.35	----	1039	----	1	LM	Breccia	Contingency Sample
14009	1.09	----	1039	----	1	LM	Breccia	Contingency Sample
14010	1.00	----	1039	----	1	LM	Breccia	Contingency Sample
14011	0.68	----	1039	----	1	LM	Breccia	Contingency Sample
14041	166.30	3N	----	1006	2	A	VMB	
14042	103.20	3N	----	1006	2	A	VMB	Same rock as 14041
14043	5.94	3N	----	1006	2	A	Breccia	Same rock as 14041
14045	65.24	4N	----	1006	2	A	VMB	Same rock as 14041
14047	242.00	5N	----	1006	2	B	VMB	
14049	200.00	6N	----	1006	2	Bg	VMB	
14051	191.30	7N	----	1006	2	C'	CMB	
14053	251.30	14N	----	1006	2	C2	Basalt	
14055	111.00	15N	----	1006	2	E	VMB	Two rocks in Bag 15N
14056	6.38	15N	----	1006	2	E	Soil Clod	Two rocks in Bag 15N
14057	5.51	15N	----	1006	2	E	Soil Clod	Two rocks in Bag 15N
14058	4.53	15N	----	1006	2	E	Soil Clod	Two rocks in Bag 15N
14059	8.68	15N	----	1006	2	E	Soil Clod	Two rocks in Bag 15N
14060	2.50	15N	----	1006	2	E	Breccia	Two rocks in Bag 15N
14061	3.11	15N	----	1006	2	E	Breccia	Two rocks in Bag 15N
14063	135.50	16N	----	1006	2	C1	LMB	Two rocks in Bag 16N
14064	107.00	16N	----	1006	2	C1	LMB	Two rocks in Bag 16N

Apollo 14 Rock Inventory Summary (Cont.)

Sample #	Mass(g)	Doc.Bag	Weigh Bag	ALSRC	EVA#	Station	Type Sample	Remarks
14066	509.80	17N	----	1006	2	F	CMB	
14068	35.47	10N	----	1006	2	C'	Melt Rock	
14069	24.87	10N	----	1006	2	C'	CMB	
14070	36.56	10N	----	1006	2	C'	CMB	
14071	2.16	10N	----	1006	2	C'	Crystalline	
14072	45.06	10N	----	1006	2	C'	Basalt	
14073	10.35	20N	----	1006	2	G	Melt Rock	Bottom of trench
14074	5.16	20N	----	1006	2	G	Melt Rock	Bottom of trench
14075	4.66	20N	----	1006	2	G	Breccia	Bottom of trench
14076	2.00	20N	----	1006	2	G	Breccia	Bottom of trench
14077	2.77	20N	----	1006	2	G	Crystalline	Bottom of trench
14078	8.30	20N	----	1006	2	G	Melt Rock	Bottom of trench
14079	3.17	20N	----	1006	2	G	Melt Rock	Bottom of trench
14080	1.94	21N	----	1006	2	G	Breccia	Middle of trench
14081	0.84	21N	----	1006	2	G	Breccia	Middle of trench
14082	62.63	13N	----	1006	2	C1	LMB	White rock
14083	13.37	13N	----	1006	2	C1	LMB	Same as 14082
14169	78.66	---	1027	----	1	ALSEP	CMB	*FSR Chips
14170	26.34	---	1027	----	1	ALSEP	Breccia	FSR Chips
14171	37.79	---	1027	----	1	ALSEP	CMB	FSR Chips
14172	32.10	---	1027	----	1	ALSEP	CMB	FSR Chips
14173	19.59	---	1027	----	1	ALSEP	Breccia?	FSR Chips

*FSR = Football size rocks

Apollo 14 Rock Inventory Summary (Cont.)

Sample #	Mass(g)	Doc.Bag	Weigh Bag	ALSRC	EVA#	Station	Type Sample	Remarks
14174	11.62	---	1027	----	1	ALSEP	CMB	FSR Chips
14175	7.48	---	1027	----	1	ALSEP	CMB	FSR Chips
14176	4.12	---	1027	----	1	ALSEP	Breccia	FSR Chips
14177	2.32	---	1027	----	1	ALSEP	Breccia	FSR Chips
14178	2.88	---	1027	----	1	ALSEP	Breccia	FSR Chips
14179	3.03	---	1027	----	1	ALSEP	Cumulate	FSR Chips
14180	4.75	---	1027	----	1	ALSEP	Breccia?	FSR Chips
14181	2.48	---	1027	----	1	ALSEP	Troctolitic	FSR Chips
14182	2.29	---	1027	----	1	ALSEP	Breccia	FSR Chips
14183	1.40	---	1027	----	1	ALSEP	Breccia	FSR Chips
14184	1.48	---	1027	----	1	ALSEP	Breccia	FSR Chips
14185	1.52	---	1027	----	1	ALSEP	Breccia	FSR Chips
14186	1.26	---	1027	----	1	ALSEP	Breccia	FSR Chips
14187	1.09	---	1027	----	1	ALSEP	CMB	FSR Chips
14188	1.60	---	1027	----	1	ALSEP	Breccia	FSR Chips
14194	4.28	---	1031	----	2	Dg,G	Breccia	14301,306,308,310,311 Chips
14195	2.77	---	1031	----	2	Dg,G	Breccia	14301,306.308.310,311 Chips
14196	3.93	---	1031	----	2	Dg,G	Breccia	14301,306,308,310,311 Chips
14197	1.63	---	1031	----	2	Dg,G	Breccia	14301,306,308,310,311 Chips
14198	1.63	---	1031	----	2	Dg,G	Melt Rock	14301,306,308,310,311 Chips
14199	1.88	---	1031	----	2	Dg,G	Breccia	14301,306,308,310,311 Chips
14200	1.24	---	1031	----	2	Dg,G	Basalt	14301,306,308,310,311 Chips
14201	1.56	---	1031	----	2	Dg,G	Breccia	14301,306,308,310,311 Chips

Apollo 14 Rock Inventory Summary (Cont.)

Sample #	Mass(g)	Doc.Bag	Weigh Bag	ALSRC	EVA#	Station	Type Sample	Remarks
14250	4.06	---	1039	----	1	ALSEP	VMB	Comprehensive chips
14251	1.51	---	Comp.Bag	1007	1	ALSEP	Breccia	Chips from comp. fines
14252	0.86	---	Comp.Bag	1007	1	ALSEP	Breccia	Chips from comp. fines
14253	1.23	---	Comp.Bag	1007	1	ALSEP	CMB	Chips from comp. fines
14254	1.01	---	Comp.Bag	1007	1	ALSEP	Breccia	Chips from comp. fines
14255	22.15	---	Comp.Bag	1007	1	ALSEP	VMB	Chips from comp. fines
14264	117.90	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14265	65.79	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14266	6.95	---	1039	----	1	ALSEP	CMB	Comprehensive rocks
14267	54.77	---	1039	----	1	ALSEP	Breccia	Comprehensive rocks
14268	23.12	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14269	17.19	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14270	25.59	---	1039	----	1	ALSEP	CMB	Comprehensive rocks
14271	97.41	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14272	46.64	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14273	22.40	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14274	15.18	---	1039	----	1	ALSEP	CMB	Comprehensive rocks
14275	12.46	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14276	12.75	---	1039	----	1	ALSEP	Basalt?	Comprehensive rocks
14277	7.59	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14278	7.60	---	1039	----	1	ALSEP	Breccia?	Comprehensive rocks
14279	5.67	---	1039	----	1	ALSEP	CMB	Comprehensive rocks
14280	6.20	---	1039	----	1	ALSEP	VMB	Comprehensive rocks

Apollo 14 Rock Inventory Summary (Cont.)

Sample #	Mass(g)	Doc.Bag	Weigh Bag	ALSRC	EVA#	Station	Type Sample	Remarks
14281	12.03	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14282	1.89	---	1039	----	1	ALSEP	CMB	Comprehensive rocks
14283	1.25	---	1039	----	1	ALSEP	VMB	Comprehensive rocks
14284	1.47	---	1039	----	1	ALSEP	Breccia	Comprehensive rocks
14285	2.23	---	1039	----	1	ALSEP	Breccia	Comprehensive rocks
14286	4.42	---	1039	----	1	ALSEP	Breccia	Comprehensive rocks
14287	1.07	---	1039	----	1	ALSEP	Breccia	Comprehensive rocks
14288	3.44	---	1039	----	1	ALSEP	Breccia	Comprehensive rocks
14294	3.43	---	1038	----	2	H	Breccia	Residue, Bag 1038
14295	1.24	---	1038	----	2	H	Breccia	Residue, Bag 1038
14296	2.26	---	1038	----	2	H	Breccia	Residue, Bag 1038
14297	1.73	---	1038	----	2	H	Breccia	Residue, Bag 1038
14301	1361.0	---	1038?	----	2	G1	VMB	
14302	----	---	1027	----	1	ALSEP	Breccia	Renumbered 14305,18
14303	898.4	---	1027	----	1	ALSEP	CMB	Mated to 14304 (FSR)
14304	2499.0	---	1027	----	1	ALSEP	CMB	Mated to 14303 (FSR)
14305	2498.0	---	1027	----	1	ALSEP	CMB	Mated to 14302 (FSR)
14306	584.50	26N	1031	----	2	G	CMB	
14307	155.00	25N	1031	----	2	G	VMB	
14308	----	---	1031	----	2	D	VMB	3 pieces renumbered 14311
14309	42.40	---	1031	----	2	?	Breccia?	Broken from unknown rock
14310	3439.00	---	1031	----	2	G	Melt Rock	Near trench
14311	3204.00	---	1031	----	2	D	CMB	Mated to 14308

Apollo 14 Rock Inventory Summary (Cont.)

Sample #	Mass(g)	Doc.Bag	Weigh Bag	ALSRC	EVA#	Station	Type Sample	Remarks
14312	299.00	---	1038	----	2	H	CMB	
14313	144.00	27N	1038	----	2	G1	VMB	
14314	115.70	---	1038	----	2	H	CMB	
14315	115.00	---	1038	----	2	H	VMB	
14316	38.20	---	1038	----	2	H	VMB	
14317	16.10	---	1038	----	2	H	VMB	
14318	600.20	---	1038	----	2	H	VMB	
14319	211.60	---	1038	----	2	H	CMB	
14320	64.90	---	1038	----	2	H	CMB	
14321	8998.00	---	1038	----	2	C1	CMB	Big Bertha
14425	.79	---	2	1007	1	LM	8mm Spherule	Bulk Sample
14426	1.59	---	2	1007	1	LM	Breccia	Bulk Sample
14427	4.47	---	2	1007	1	LM	Breccia	Bulk Sample
14428	1.47	---	2	1007	1	LM	CMB	Bulk Sample
14429	3.03	---	2	1007	1	LM	CMB	Bulk Sample
14430	4.81	---	2	1007	1	LM	Breccia	Bulk Sample
14431	1.70	---	2	1007	1	LM	Melt Rock	Bulk Sample
14433	1.23	---	2	1007	1	LM	Basalt?	Bulk Sample
14434	1.68	---	2	1007	1	LM	CMB	Bulk Sample
14435	0.92	---	2	1007	1	LM	CMB	Bulk Sample
14436	3.76	---	2	1007	1	LM	Basalt?	Bulk Sample
14437	2.65	---	2	1007	1	LM	Breccia	Bulk Sample

Apollo 14 Rock Inventory Summary (Cont.)

Sample #	Mass(g)	Doc.Bag	Weigh Bag	ALSRC	EVA#	Station	Type Sample	Remarks
14438	2.35	---	2	1007	1	LM	Breccia	Bulk Sample
14439	1.00	---	2	1007	1	LM	Breccia	Bulk Sample
14440	1.50	---	2	1007	1	LM	Basalt	Bulk Sample
14441	1.23	---	2	1007	1	LM	Breccia	Bulk Sample
14442	3.52	---	2	1007	1	LM	Breccia	Bulk Sample
14443	2.54	---	2	1007	1	LM	Basalt	Bulk Sample
14444	1.56	---	2	1007	1	LM	Basalt	Bulk Sample
14445	9.22	---	2	1007	1	LM	Breccia	Bulk Sample
14446	0.82	---	2	1007	1	LM	Basalt	Bulk Sample
14447	0.91	---	2	1007	1	LM	Breccia	Bulk Sample
14448	1.06	---	2	1007	1	LM	Breccia	Bulk Sample
14449	1.70	---	2	1007	1	LM	Breccia	Bulk Sample
14450	1.27	---	2	1007	1	LM	Breccia	Bulk Sample
14451	2.10	---	2	1007	1	LM	Basalt	Bulk Sample
14452	1.77	---	2	1007	1	LM	Breccia	Bulk Sample
14453	6.03	---	2	1007	1	LM	Breccia	Bulk Sample

Original number of samples was 227.

Original mass of returned sample was 42,284.71.

APPENDIX II

APOLLO 14
LUNAR SURFACE DOCUMENTATION

APPENDIX II

Apollo 14 Lunar Surface Documentation
(Swann *et al.*, 1977)

Sample	Lunar Surface Photo #	Location Status	Orientation
14006-14011	65-9206 LM Pan B 65-9325 LM Pan A 66-9339 LM Pan A	Approx.	N/A
14041	68-9409 DSB	Known	Unknown
14042	68-9410 XSB		
14043 14045	68-9411 XSB 68-9412 XSA 68-9413 LOC		
14047	64-9073 XSB 64-9074 XSB	Known	Known
14049	None	Approx.	Unknown
14051	68-9443 XSB 68-9444 XSB 68-9445 DSB 68-9446 XSA 68-9447 LOC	Known	Known
14053	64-9130 XSB 64-9131 XSB 64-9132 XSB 64-9133 XSB	Known	Surface Pitting
14055 14056 14057 14058 14059 14060 14061	None	Approx.	Unknown
14063 14064	None	Approx.	Unknown
14066	64-9137 Pan B May include sample	Approx.	Unknown
14068 14069 14070 14071 14072	64-9125 XSB 64-9126 XSB 64-9126 XSB None None	Known	Tentative

APPENDIX II (continued)

Sample	Lunar Surface Photo #	Location Status	Orientation
14073	64-9158 XSB	Known	N/A
14074	64-9159 XSB		
14075	64-9160 XSA		
14076	64-9161 XSA		
14077	64-9162 XSA		
14078	64-9163 XSA		
14079	64-9164 XSA		
14080	64-9165 XSA		
14081	64-9166 DSA		
14082	68-9452 XSA	Known	Surface Pitting only
14083	68-9453 XSA		
14169-14188	67-9388 USB	Approx.	N/A
	67-9389 DSB		
14194-14201	No Photos	Unknown	Unknown
14250-14288	67-9388 USB	Approx.	N/A
	67-9389 DSB		
14294-14297	Not Identified	Tentative	Unknown
14301	64-9188 DSLOC,B	Known	Known
	68-9466 XSB		
	68-9467 XSA		
14303		Approx.	Surface Pitting
14304	67-9390 XSB		Known
	67-9391 XSB		
14305/14302	67-9392 XSB		
	67-9393 XSB		
14306	68-9459 DSB	Known	Known
	68-9460 XSB		
	68-9461 XSB		
	68-9462 XSA		
	68-9463 XSA		
	68-9464 LOC		
14307	No Photos	Approx.	Surface Pitting only
14311/308	No Photos	Approx.	Surface Pitting only
14309	No Photos	Unknown	Unknown
14310	No Photos	Approx.	Surface Pitting only

APPENDIX II (continued)

Sample	Lunar Surface Photo #	Location Status	Orientation
14312	68-9472 XSB 68-9473 XSB 68-9474 XSB 68-9475 XSB 68-9476 XSA 68-9478 Pan A 68-9479 Pan A	Known	Known
14313	64-9188 DSLOC,B 68-9465 XSB 68-9466 XSB 68-9467 XSA	Known	Known
14314	68-9472 XSB 68-9473 XSB 68-9474 XSB 68-9475 XSB 68-9476 XSA	Tentative	Unknown
14315	68-9468 XSB 68-9469 XSB 68-9470 XSA 68-9471 XSA	Known	Tentative from lab model
14316 14317	Not identified in North Boulder Field photographs	Tentative	Unknown
14318	68-9468 XSB 68-9469 XSB 68-9470 XSA 68-9471 XSA	Known	Known
14319	68-9472 XSB 68-9473 XSB 68-9474 XSB 68-9475 XSB 68-9476 XSA 68-9478 Pan A 68-9479 Pan A	Known	Known
14320	Not identified in North Boulder Field photographs	Tentative	Unknown
14321	64-9128 XSB 64-9129 XSB	Approx.	Known
14425 14453	Probably in LM window photographs but not identified	Unknown	N/A

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