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# CATALOG OF APOLLO 16 ROCKS

## Part 2. 63335 - 66095

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INTRODUCTION: 63335 is polymict, consisting of differing glassy or microcrystalline breccias and intrusive fine-grained or glassy veins. It exists as several angular, coherent, medium to medium dark gray pieces (Fig. 1) which macroscopically are fairly homogeneous.

63335 was chipped from Shadow Rock, as were 60017 and 63355 accounting for its being in several pieces. Its exact location on the boulder is unknown although the general area is known. A few zap pits occur on some of the fragments.

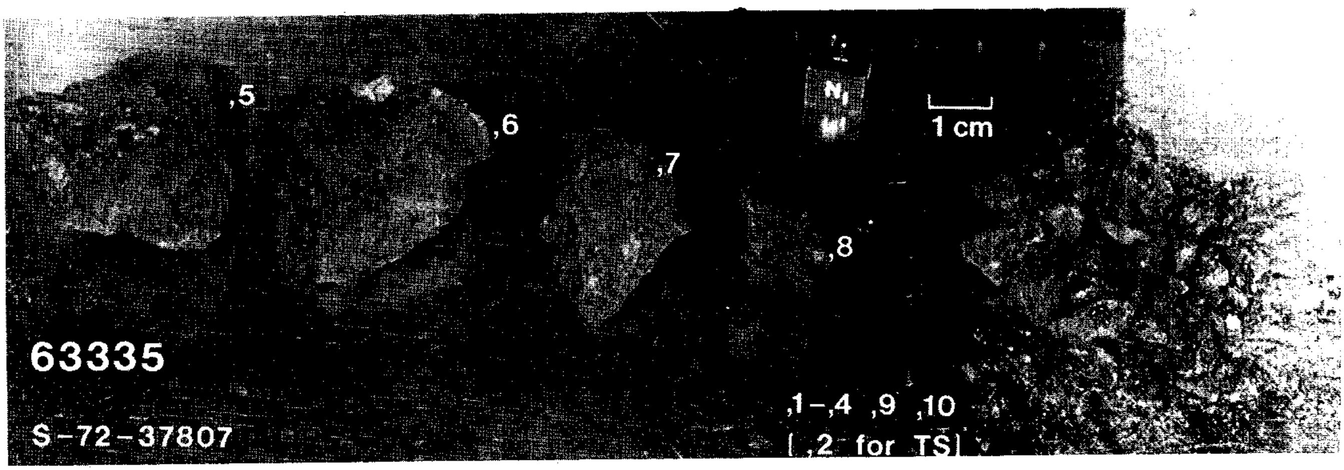



Figure 1.

PETROLOGY: Kridelbaugh et al. (1973) describe, with microprobe analyses, a thin section which appears to be typical of the rock. Nord et al. (1975) report petrographic and transmission electron microscopy (TEM) studies of a similar sample; Misra and Taylor (1975) report metal data.

The rock is complex on a microscopic scale, with various melt-breccia (including glassy) textures prominent (Fig. 2). The main(?) micro-breccia has a cryptocrystalline matrix with dendritic laths of either olivine or orthopyroxene, and about 20% fragments of anorthosite, plagioclase and gabbroic anorthosite. A few small fragments of olivine, ilmenite, troilite, and Fe-metal are also present (Kridelbaugh et al., 1973). The small plagioclases are partially resorbed. Anorthosite and anorthositic gabbro clasts have plagioclase $An_{93-97}$; the anorthositic gabbro has olivine $Fo_{85-72}$ (Kridelbaugh et al., 1973). The vein described by Kridelbaugh et al. (1973) varies from spherulitic to variolitic with plagioclase laths $An_{95}$. Nord et al. (1975) describe similar complex breccias which are essentially fine-grained with igneous textures. They did not find glass in their section.

Figure 2. 63335,32 a) melt matrix, ppl. width 2mm.
b) matrix and dark clasts, xpl. width 2mm.

Misra and Taylor (1975) report ranges of compositions for 5 metal grains, averaging 5.65% Ni and 0.55% Co (Fig. 3). They describe the sample as a mesostasis-olivine-plagioclase melt rock with devitrified glass a minor component. LSPET (1973) states that 63335 contains more than 2% ilmenite.

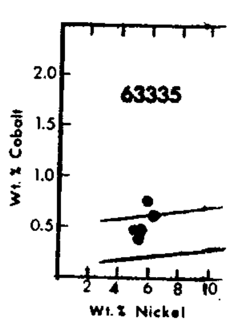



Figure 3. Metals, from Misra and Taylor (1975).

CHEMISTRY: Laul *et al*. (1974) and LSPET (1973) report major and trace element abundances, Hubbard *et al*. (1974) report trace element abundances, Ganapathy *et al*. (1974) report meteoritic siderophile and volatile element abundances,and Clark and Keith (1973) report K, U, Th and radionuclide abundances from $\gamma$-ray spectroscopy. Cripe and Moore (1975) and Moore and Lewis (1976) report S, and C and N abundances respectively. Some chemical data are presented in the work of geochronologists (below). All these analyses are for bulk rock samples. Kridlebaugh *et al*. (1973) tabulate microprobe analyses of the matrix and of the devitrified glass veins.

The bulk rock data are summarized in Table 1 and Figure 4. The sample is chemically very similar to 60017 but unlike 63355, from the same boulder. The low siderophile and rare-earth abundances are like North Ray Crater samples and unlike most polymict breccias and soils. Hubbard *et al*. (1974) note that the sample has unusually high Eu and Sr, hence a large Eu anomaly (confirmed by the Laul *et al*., 1974, data). Ganapathy *et al*. (1974) assign the sample to their meteoritic Group 4, but Hertogen *et al*. (1977) assign it tentatively to Group 2 (and abandon Group 4).

GEOCHRONOLOGY: Nyquist *et al*. (1974) report Rb-Sr isotopic data for a whole-rock sample (Table 2). The measured $^{87}Sr/^{86}Sr$ is considerably lower than most lunar polymict breccias and soils.

TABLE 2. Summary of Rb-Sr isotopic data from Nyquist *et al*.,(1974)

| Rb ppm | Sr ppm | $^{87}Sr/^{86}Sr$ | $T_{BABI}$* (b.y.) | $T_{LUNI}$* |
|---|---|---|---|---|
| 1.146 | 222.1 | .69997±5 | 4.08±.29 | 4.40±.29 |

*Values adjusted for interlaboratory bias.

Murthy (1978) reports the $^{87}Sr/^{86}Sr$ ratio of a plagioclase separate from 63335, which, adjusted for interlaboratory bias to conform with Caltech data, is 0.69907± 4. Extrapolated back to 4.6 b.y., this gives $^{87}Sr/^{86}Sr$ = 0.69890±4 *i.e*. extremely primitive (Murthy, 1978).

Alexander and Kahl (1974) report $^{40}Ar$-$^{39}Ar$ data, but no plateau was found (Fig.5) indicating extensive gas loss. Unlike most lunar samples, most of the $^{39}Ar$ was released at very high temperature. A minimum age of 3.65 b.y. can be inferred for the rock. The outgassing was possibly due to the North Ray cratering event.

EXPOSURE AGE: Alexander and Kahl (1974) report an exposure age of 41±8 m.y. from the $^{38}Ar$ method. This exposure age is similar to that of many North Ray crater breccias.

PROCESSING AND SUBDIVISIONS: 63335 was returned as several pieces (Fig.1), several of which were separated and numbered. Of the larger chips (Fig.1) ,5 and ,18 are preserved and ,6 (Fig.6) and ,7 have been subdivided.

TABLE 1

Summary chemistry of 63335 whole-rock

| | |
|---|---|
| $SiO_2$ | 45.2 |
| $TiO_2$ | 0.38 |
| $Al_2O_3$ | 31.2 |
| $Cr_2O_3$ | 0.05 |
| FeO | ~3.0 |
| MnO | |
| MgO | ~2.6 |
| CaO | 17.4 |
| $Na_2O$ | 0.63 |
| $K_2O$ | 0.05 |
| $P_2O_5$ | 0.03 |
| Sr | 223 |
| La | 2.9 |
| Lu | 0.15 |
| Rb | 1.2 |
| Sc | 4.4 |
| Ni | 26-70 |
| Co | 5+ |
| Ir ppb | <2 |
| Au ppb | <4 |
| C | 53 |
| N | 49 |
| S | 265 |
| Zn | 16.3 |
| Cu | |

Oxides in wt%; others in ppm except as noted.

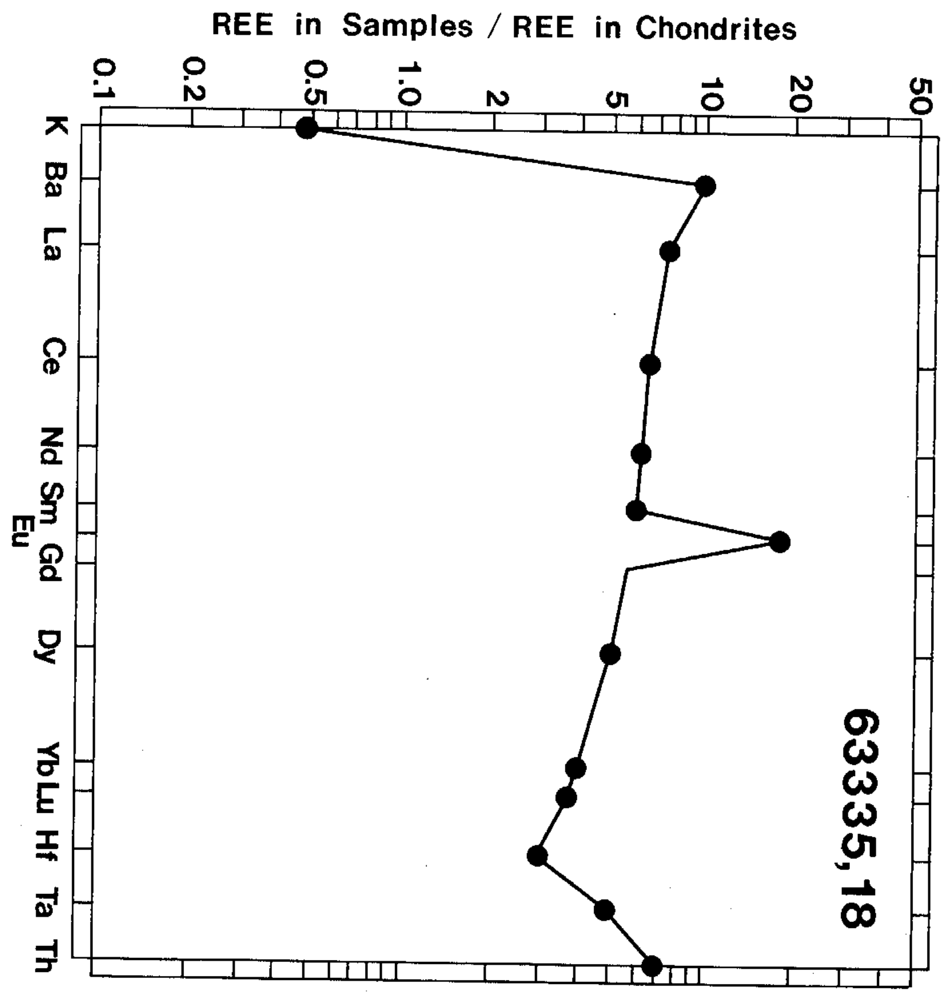



Figure 4. Rare earths, from Laul et al. (1974).

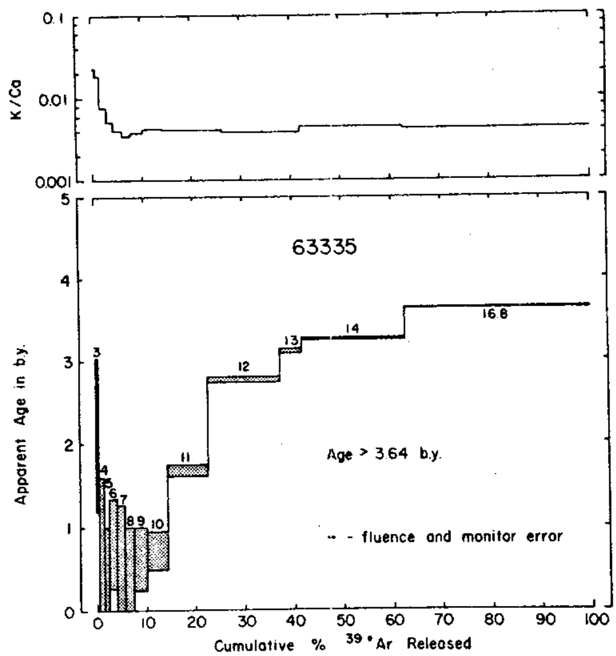



Figure 5. Ar releases, from Alexander and Kahl (1974).

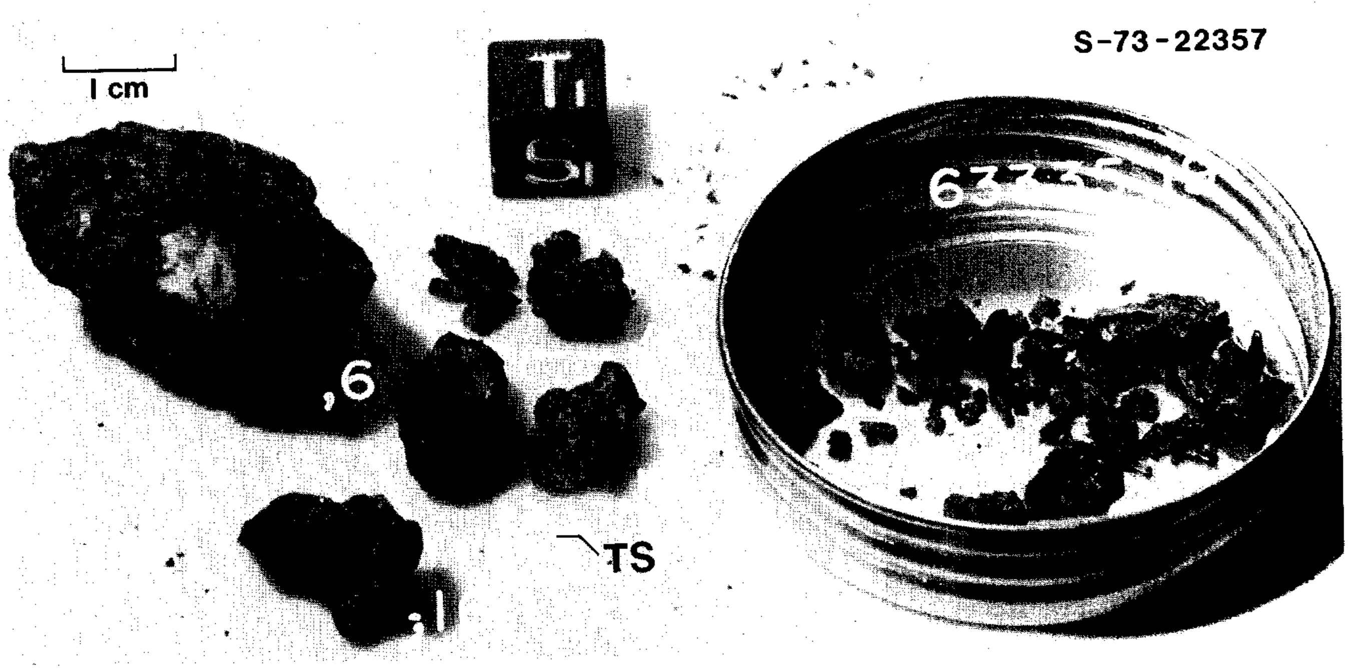



Figure 6. Subdivisions of 63335,6.

## 63355 POIKILITIC IMPACT MELT 68.2 g

INTRODUCTION: 63355 is a poikilitic impact melt with some variability in its macroscopic coloring and microscopic texture (Fig. 1).

63355 was taken from Shadow Rock with 60017 and 63335. It is fractured and consists of several chips but individual chips are tough. Patina and zap pits are present on one surface and portions of the surface are heterogeneous and bulbous. In some places where the rock has fallen apart, striations are present.

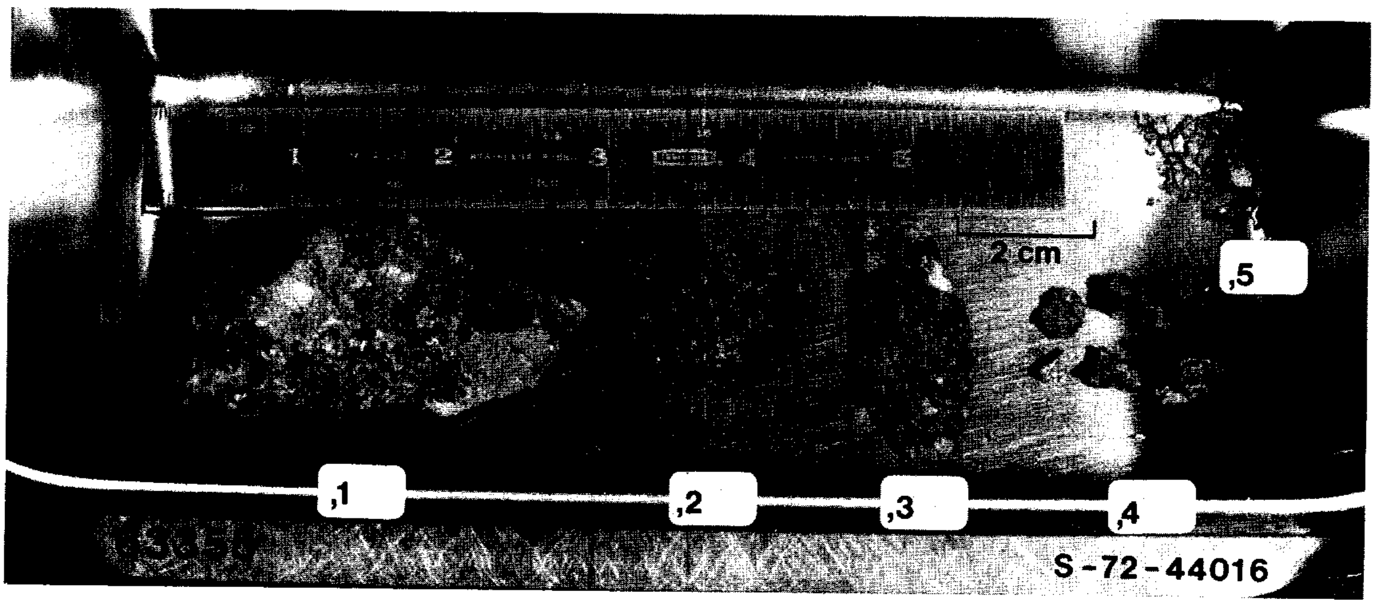



Figure 1.

PETROLOGY: Misra and Taylor (1975) report metal compositions and Nord et al. (1975) report an electron petrographic study.

63355 is a poikilitic impact melt containing clasts and schlieren of cataclastic plagioclases and lithic material (Fig. 2). The dominant crystalline matrix consists of small orthopyroxene oikocrysts (electron diffraction identification; Nord et al., 1975) less than 500 µm long dimension and crowded with irregularly shaped plagioclases. The interoikocryst areas contain glass and ilmenite. Metal and troilite blebs are abundant. The thin sections include an 8 mm clast of feldspathic granulitic impactite (Fig. 2); in places near this clast the normal matrix consists of pyroxene oikocrysts less than 500 µm in diameter but the enclosed plagioclases are larger and more lath-shaped than elsewhere. Thin brown glass veins are present and in part form the feldspathic impactite/poikilitic melt boundary. The reflectivity of these veins suggests that they are mafic. In places these veins cause vitrification of the impactite and other clasts. Sharp boundaries between variable textures in the poikilitic melt suggest that shearing has occurred.

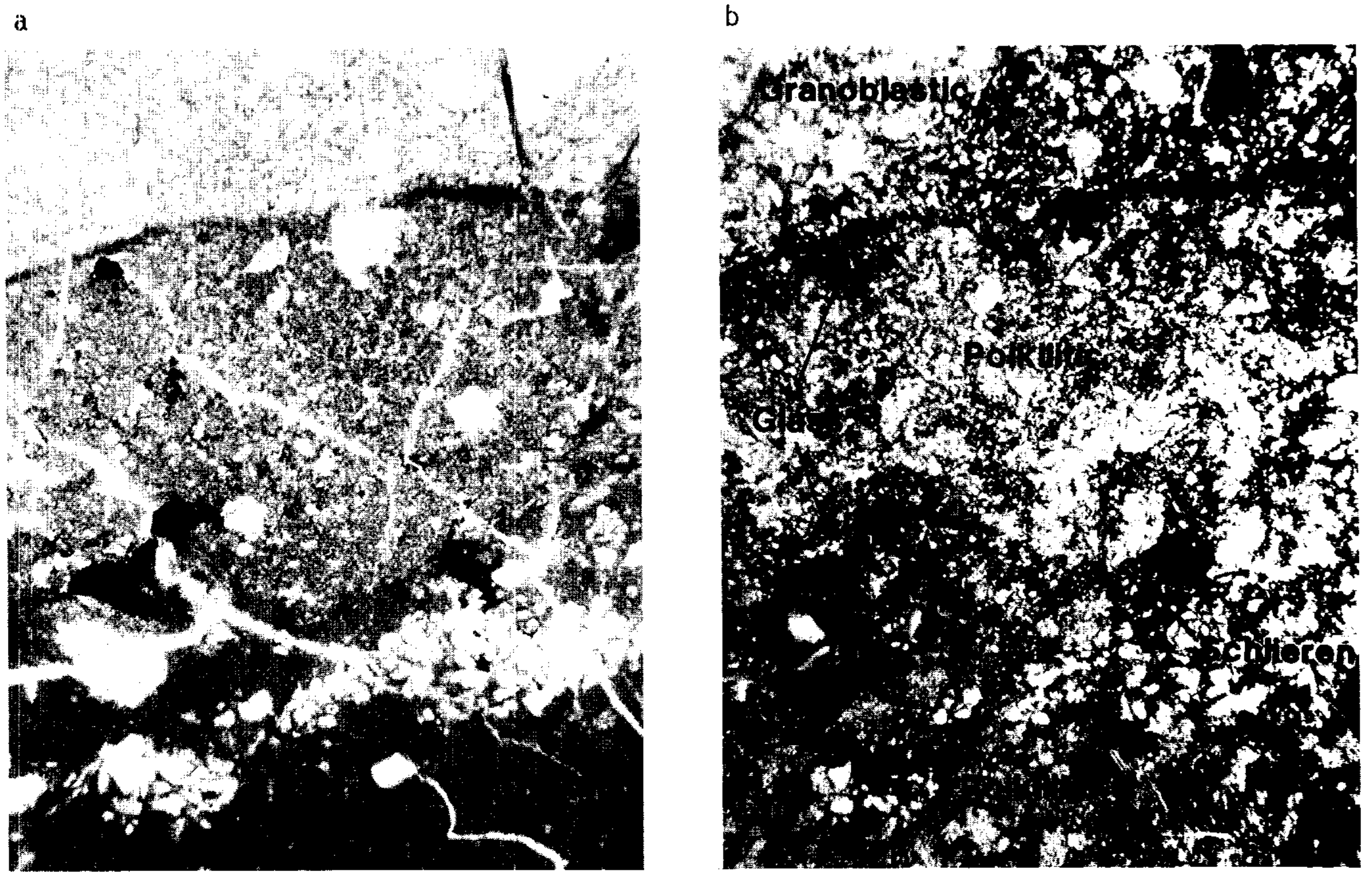



Figure 2. 63355,48 a) poikilitic matrix, granoblastic clast, glass veins, ppl. width 2mm. b) same view, xpl. width 2mm.

The metal compositions for the poikilitic melt (Misra and Taylor, 1975; referred to as light-matrix breccia) average 5.7% Ni and 0.3% Co with little variation (Fig. 3). The metal grains have a good development of polycrystalline structure due to annealing. Nord et al. (1975), referring to the melt as a dark matrix breccia, note the clast population of angular noritic and anorthositic fragments. All the plagioclase clasts show extreme deformation--maskelynite, deformation lamellae and so on. Parts of the matrix are glassy but without evidence of flow.

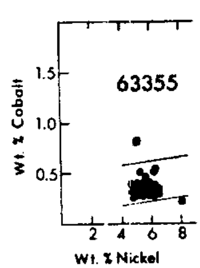



Figure 3. Metals, from Misra and Taylor (1975).

CHEMISTRY: Laul et al. (1974) report major and trace element data, Clark and Keith (1973) report K, U, Th and radionuclide abundances from γ-ray spectroscopy, and Ganapathy et al. (1974) report meteoritic siderophile and volatile abundances.

The chemistry of the bulk sample (Table 1, Fig. 4) is typical of Apollo 16 poikilitic impact melts. Ganapathy et al. (1974) place the meteoritic signature as their Group 1 (later modified to Group 1H by Hertogen et al., 1977, when Group 1 was subdivided), believed to represent the uppermost stratum of the Apollo 16 site.

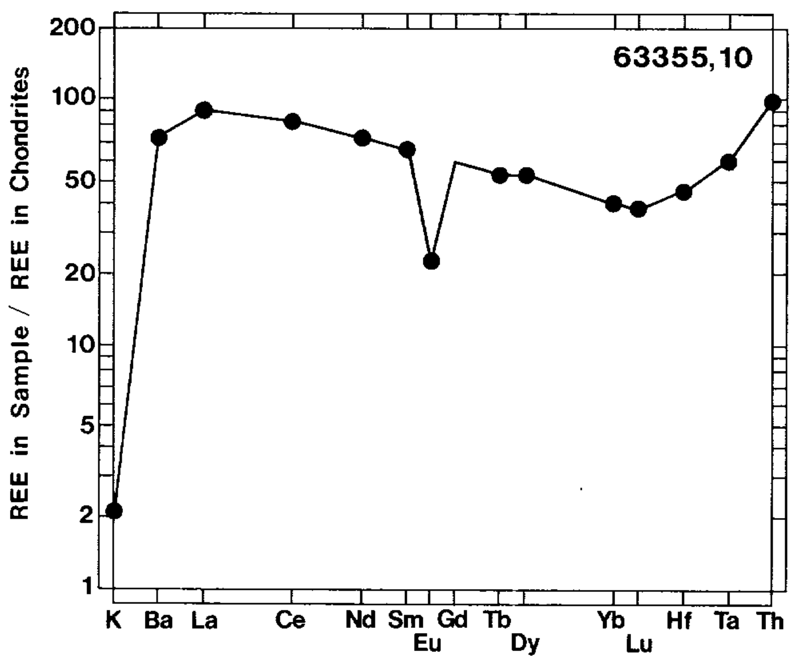



Figure 4. Rare earths, from Laul et al. (1973).

TABLE 1. Summary chemistry of 63355

| | | |
|---|---|---|
| $SiO_2$ | | |
| $TiO_2$ | | 0.88 |
| $Al_2O_3$ | | 21.5 |
| $Cr_2O_3$ | | 0.17 |
| FeO | | 8.3 |
| MnO | | 0.09 |
| MgO | | 8 |
| CaO | | 12.0 |
| $Na_2O$ | | 0.50 |
| $K_2O$ | | 0.23 |
| $P_2O_5$ | | |
| Sr | | |
| La | | 30 |
| Lu | | 1.3 |
| Rb | | 6.5 |
| Sc | | 12 |
| Ni | | 870 |
| Co | | 62 |
| Ir | ppb | 20 |
| Au | ppb | 17 |
| C | | |
| N | | |
| S | | |
| Zn | | 5.2 |
| Cu | | |

Oxides in wt%; others in ppm except as noted.

PROCESSING AND SUBDIVISIONS: The sample was received as three large pieces and several smaller chips (Fig. 1). ,1 (43 g) and ,3 (10 g) are intact. ,2 was subdivided (Fig. 5) as was ,4 (Fig. 6). More daughters than shown on Figures 5 and 6 now exist.


Figure 5. Subdivisions of 63355,2.

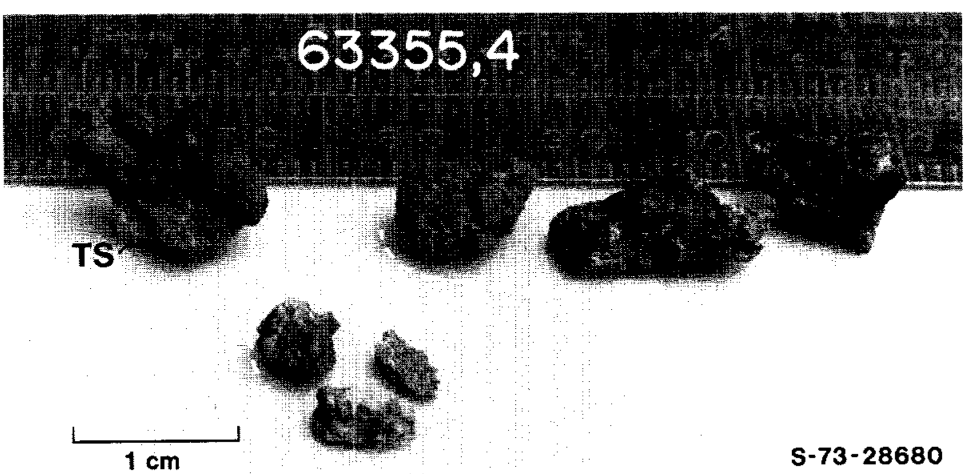



Figure 6. Subdivisions of 63355,4.

INTRODUCTION: 63505 is a dark gray, coherent, fine-grained impact melt with some white patches (Fig. 1). It was taken from a regolith sample and has a few zap pits on one surface.

PETROLOGY: 63505 is an extremely fine-grained impact melt containing slightly rounded fragments which are mainly plagioclase (Fig. 2) and have a size distribution ranging down to very tiny. The clasts are not shocked. A few lithic clasts are present. The melt is a mortar of micropoikilitic (?) material with tiny ilmenite laths and apparently free of glass.

PROCESSING AND SUBDIVISIONS: Three representative documented chips (,1; ,2; ,3) adjacent to each other were removed and ,3 made into thin sections ,13 and ,14.

Figure 1. S-72-38969.

Figure 2. 63505,13, general view, ppl. width 2mm.

INTRODUCTION: 63506 (Fig. 1) is a medium dark gray, coherent impact melt with ~90% plagioclase. It was taken from a regolith sample and has a few zap pits on one surface.

PETROLOGY: 63505 consists mainly of plagioclase in the form of jumbled laths with ragged edges and as plagioclase clasts (Fig. 2). Small intergranular mafic minerals and a few opaques are present but there is little, if any, interstitial glass.

PROCESSING AND SUBDIVISIONS: A representative chip ,1 was made into thin sections ,13 and ,14.

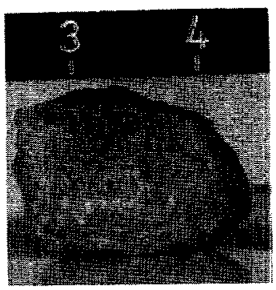


Figure 1. S-72-38968. Scale in cm.

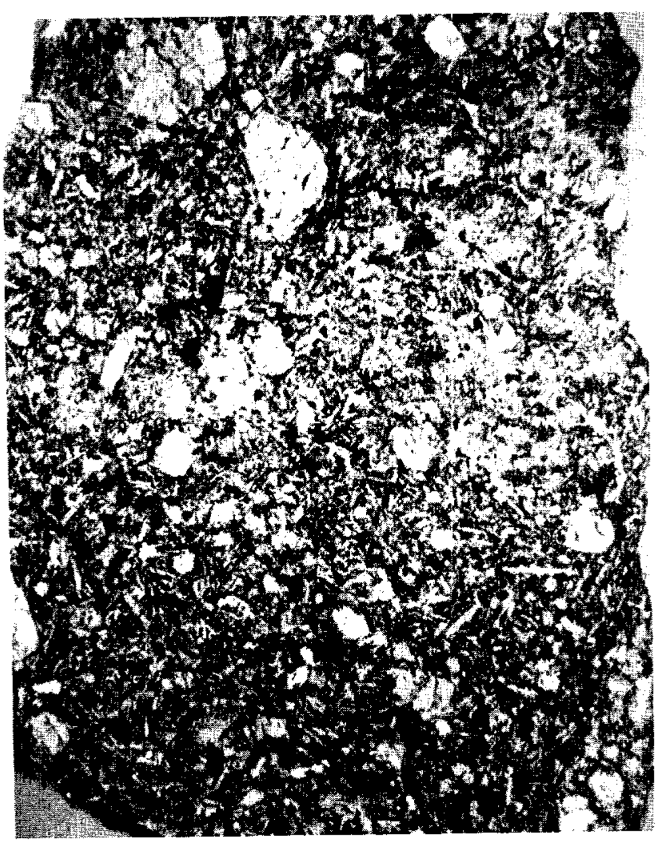


Figure 2. 63506,13, general view, ppl, width 2mm.

## 63507 FRAGMENTAL REGOLITH BRECCIA, PARTIAL GLASS COAT 2.78 g

INTRODUCTION: 63507 is an olive gray, friable breccia (Fig. 1) containing regolith-derived materials. Almost 10% of its surface is coated with black vesicular glass. It was taken from a regolith sample and lacks zap pits.

PETROLOGY: 63507 is a fragmental, fine-grained breccia. It contains numerous brown glassy/aphanitic breccia fragments, spheres (and fragments of spheres) of colorless glass, and yellow/brown devitrified and clear glasses. Some vesicular, agglutinitic glass fragments are present in the sub-100 μm size range. Lithic clasts include basaltic, aphanitic and poikilitic impact melts as well as feldspathic granulites. The sample has the characteristics of a loosely lithified regolith.

PROCESSING AND SUBDIVISIONS: A single chip (,1) of the breccia was taken to make thin sections ,13 and ,14.

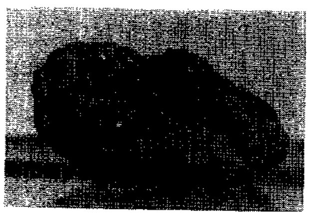


Figure 1. S-72-38969.

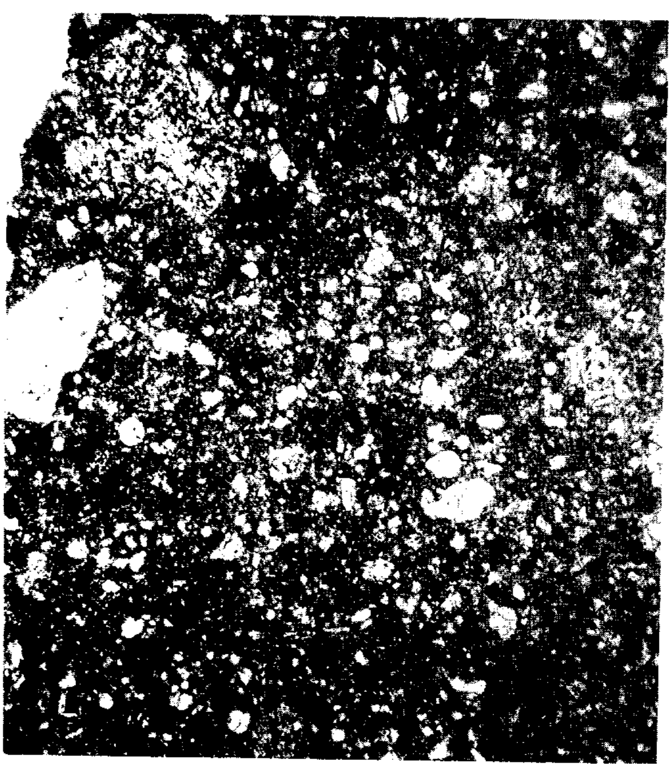


Figure 2. 63507,13, general view, ppl. width 2mm.

## 63508 FINE-GRAINED IMPACT MELT (?) 2.61 g

INTRODUCTION: 63508 is a bluish gray, coherent rock (Fig. 1) which may be an impact melt, although in the Apollo 16 Lunar Sample Information Catalog (1972) it is described as a crushed anorthosite. It was taken from a regolith sample and lacks zap pits.

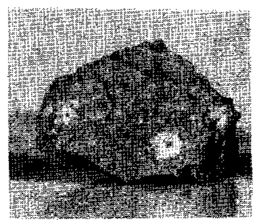


Figure 1. S-72-38968.

# 63509 FINE-GRAINED IMPACT MELT 2.05 g

INTRODUCTION: 63509 is a medium dark gray, homogeneous and fine-grained impact melt (Fig. 1). It was taken from a regolith sample and has a few zap pits on all surfaces.

PETROLOGY: 63509 is an extremely fine-grained impact melt (Fig. 2). A mortar-like matrix encloses plagioclase clasts which range down to extremely small sizes. The matrix is plagioclase-rich, contains ilmenite laths, and apparently lacks glass. In places an orientation or flow is apparent. The clasts are rounded and some are ragged. Thin sections ,5 and ,6 contain (atypically) schlieren of cataclastic anorthosite (Fig. 2).

PROCESSING AND SUBDIVISIONS: A single chip ,1, representative except for a few white streaks, was taken to make thin sections ,5 and ,6.

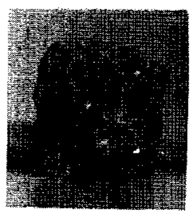


Figure 1. S-72-38968.

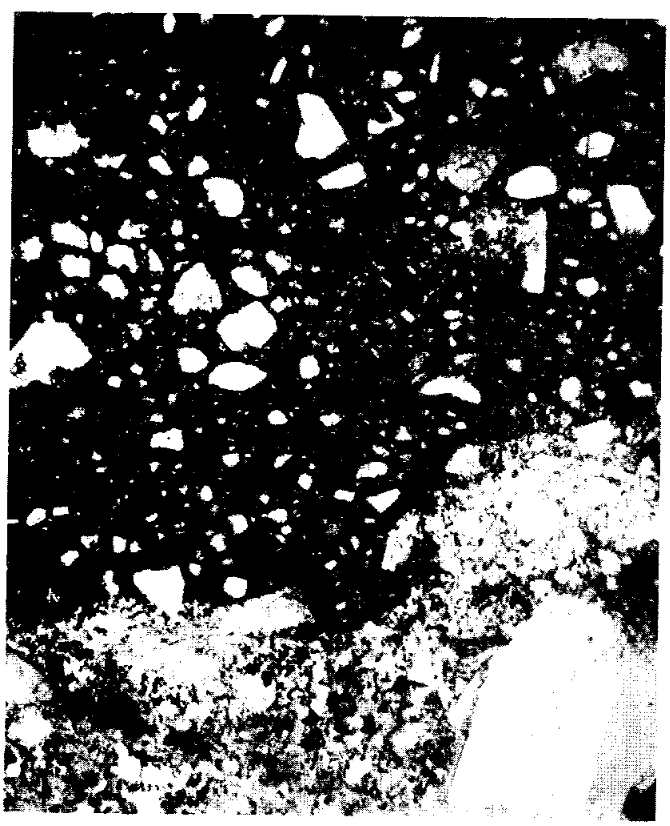


Figure 2. 63509,5, general view, ppl. width 2mm.

## 63515 FINE-GRAINED IMPACT MELT 1.32 g

INTRODUCTION: 63515 is a coherent, blocky, medium dark gray breccia (Fig. 1). A few plagioclases are as large as 1.5 mm, but most of the sample is extremely fine-grained and is probably an impact melt. The sample was taken from a regolith sample and has zap pits on one surface.


Figure 1. S-72-38968, cube is 1cm.

INTRODUCTION: 63525 is a dark, homogeneous, coherent, fine-grained impact melt (Fig. 1). It is a rake sample and has zap pits.

PETROLOGY: 63525 is a brownish fine-grained impact melt with a seriate size distribution of clasts down to very tiny (Fig. 2). The clasts are nearly all unshocked plagioclases with rounded corners, but a few small lithic clasts including basaltic impact melts, feldspathic granulites, and granoblastic anorthosites are present. In places, the mineral clasts include complexly exsolved pyroxenes. The melt matrix, which is more mafic than the clast population, contains some plagioclase laths and a flow-alignment is apparent in places. Phinney et al. (1976) in a SEM study, note that the matrix lacks glass, contains about 5% vugs and vesicles, and consists of subhedral plagioclases up to 10 μm across and anhedral low-Ca pyroxene up to 2 μm across.

PROCESSING AND SUBDIVISIONS: Two small chips (,6) macroscopically appearing to be half matrix and half clasts, were made into thin sections ,10 - ,13. The clasts apparently are the feldspathic granulites and granoblastic anorthositic materials. Two other small chips (,7 and ,8) have also been individually numbered (Fig. 1).

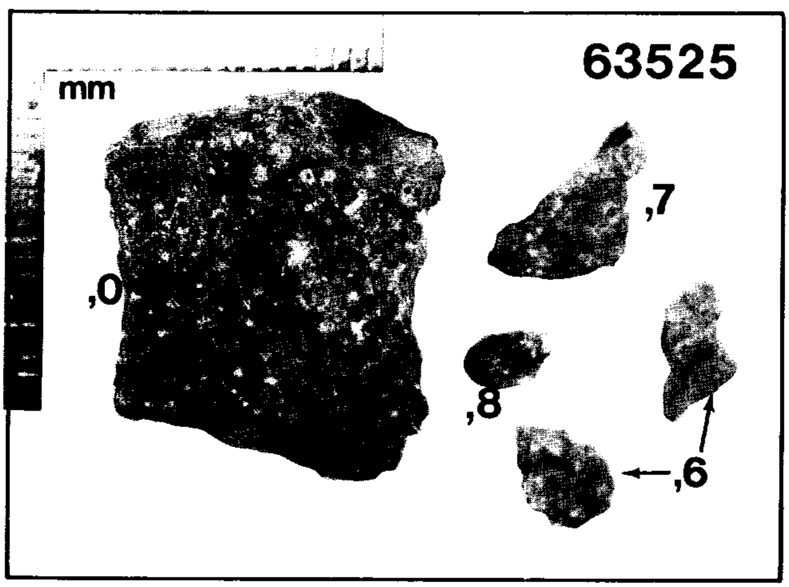



Figure 1.

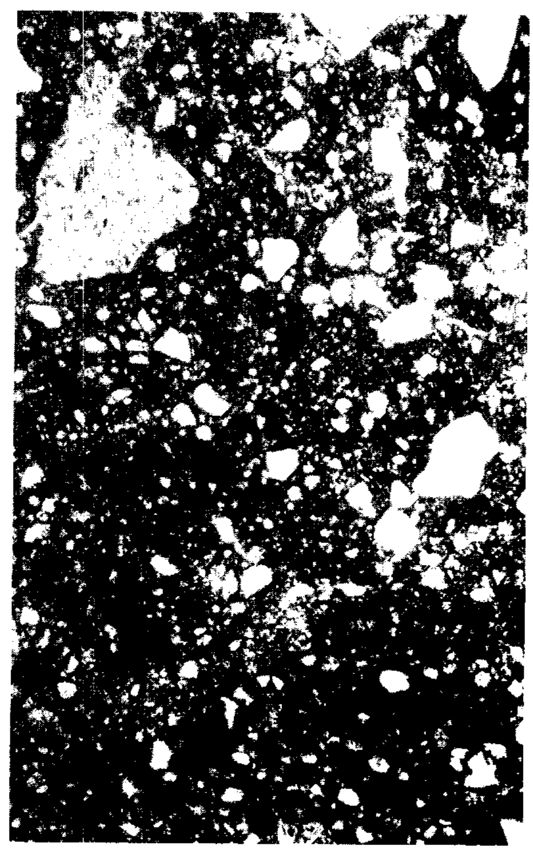


Figure 2. 63525,11, general view, ppl. width 1.5mm.

INTRODUCTION: 63526 is a dark, homogeneous, coherent, fine-grained impact melt (Fig. 1). It is a rake sample and has zap pits.

PETROLOGY: 65326 is a brownish fine-grained impact melt with a seriate distribution of clasts down to very tiny (Fig. 2). The clasts are mainly unshocked plagioclases with rounded corners and ragged edges. The lithic clasts are usually small, but in thin sections ,9 and ,10, half the area is a poikiloblastic feldspathic impactite with a heterogeneous texture (Fig. 2). Phinney et al. (1976) in a SEM study, note that the matrix lacks glass, contains about 5% vugs and vesicles, and consists of subhedral plagioclases up to 10 μm across and anhedral low-Ca pyroxene up to 2 μm across.

PROCESSING AND SUBDIVISIONS: A small representative chip ,6 was made into thin sections ,9 - ,12. Another small chip ,7 was individually numbered.

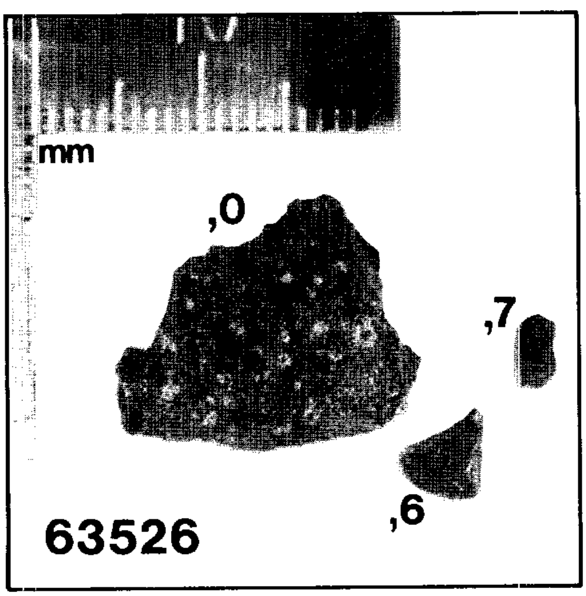



Figure 1.

Figure 2. 63526,9, general view, ppl. width 2mm.

INTRODUCTION: 63527 is a basaltic impact melt which is more mafic than most (about 50% mafic minerals) and has a variable texture. It is dark, coherent, and fine-grained (Fig. 1). It is a rake sample and has zap pits.

PETROLOGY: 63527 is a fine-grained basaltic impact melt with a patchy texture (Fig. 2) ranging from variolitic through subophitic through poikilitic. In places skeletal olivine phenocrysts (up to a few hundred microns long) are present. The sample is unusually mafic for basaltic impact melts--about 50% mafic minerals. Some interstitial glass or silica, rounded metal blebs, and plagioclase clasts are also present. A small part of thin section ,12 is a fragmental breccia, which appears to be mainly ground-up basaltic impact melt rather than polymict breccia.

PROCESSING AND SUBDIVISIONS: Two adjacent small chips (,6 and ,7) were removed (Fig. 1) and ,6 (which appeared to be mainly matrix but partly clast) was made into thin sections ,9 - ,12.

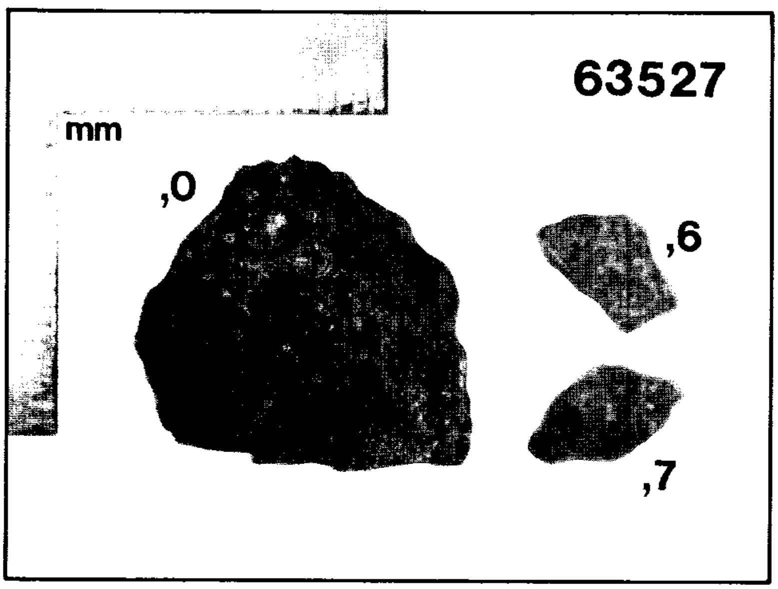



Figure 1.

Figure 2. 63527,11, general view, ppl. width 1.5mm.

INTRODUCTION: 63528 is a dark, homogeneous, coherent, fine-grained impact melt (Fig. 1). It is a rake sample and has zap pits.

PETROLOGY: 63528 is a brownish fine-grained impact melt with a seriate size distribution of clasts down to very tiny (Fig. 2). The clasts are almost all unshocked plagioclases with rounded corners; a few have flame-textures. Lithic clasts are uncommon but include basaltic impact melts and brownish devitrified (?) spherules. The melt matrix has a few plagioclase laths (up to 100 µm long) and is more mafic than the clast population. It contains very little Fe-metal or other opaque phases. Phinney et al. (1976) in a SEM study, note that the matrix lacks glass, contains about 5% vugs and vesicles, and consists of subhedral plagioclases up to 10 µm and anhedral low-Ca pyroxene up to 2 µm across.

PROCESSING AND SUBDIVISIONS: Several small chips were removed (Fig. 1) and ,6 was made into thin sections ,10 - ,13.

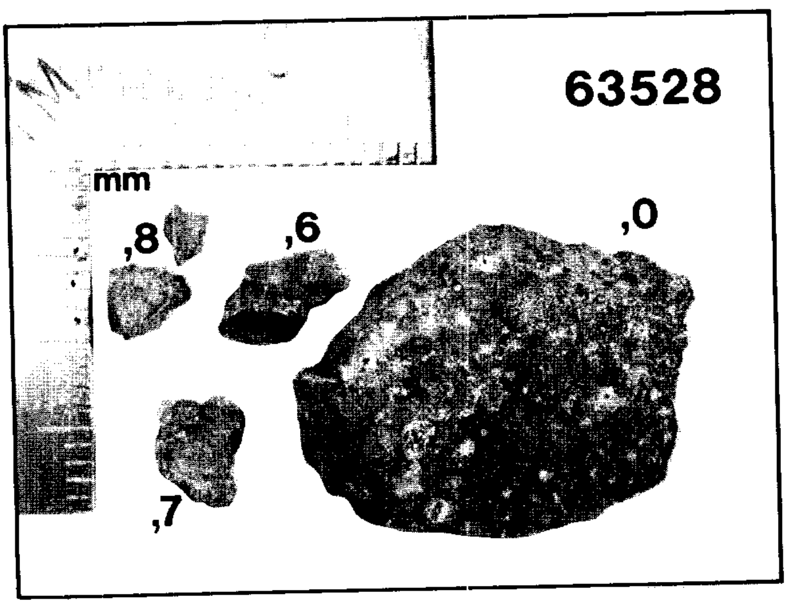



Figure 1.

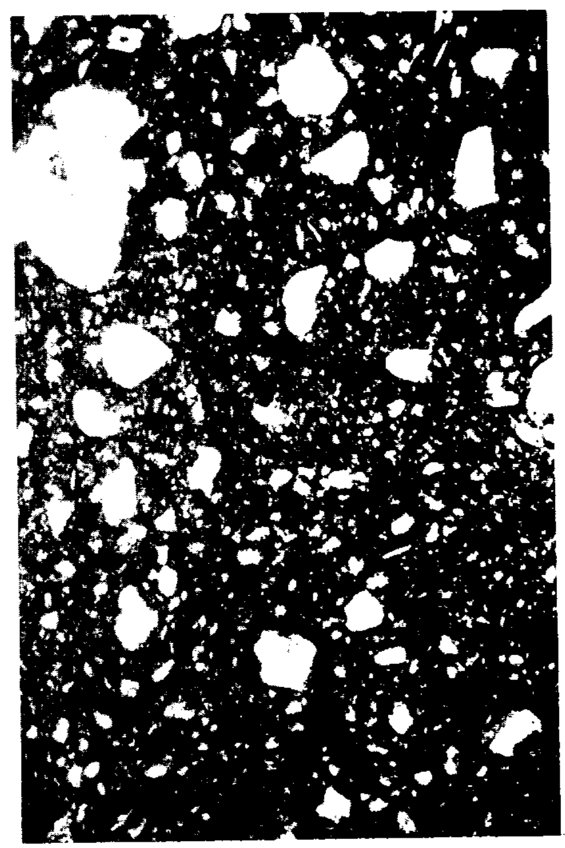


Figure 2. 63528,12, general view, ppl. width 1.5mm.

INTRODUCTION: 63529 is a dark, homogeneous, coherent, fine-grained impact melt (Fig. 1). It is a rake sample.

PETROLOGY: 63529 is a brownish, fine-grained impact melt with a seriate distribution of clasts down to very tiny (Fig. 2). The clasts are nearly all unshocked plagioclases with rounded corners. The fine-grained melt matrix contains a few laths of plagioclase and is more mafic than the clast population.

PROCESSING AND SUBDIVISIONS: Small chips (,1) were made into thin sections ,6 and ,7.

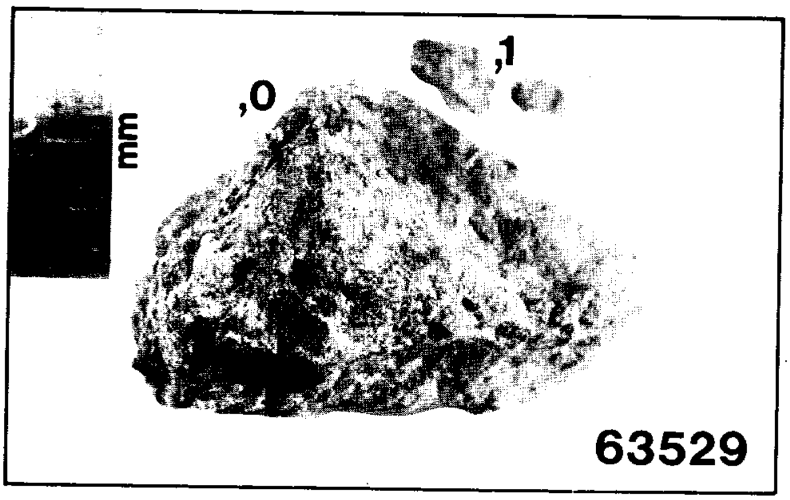



Figure 1.

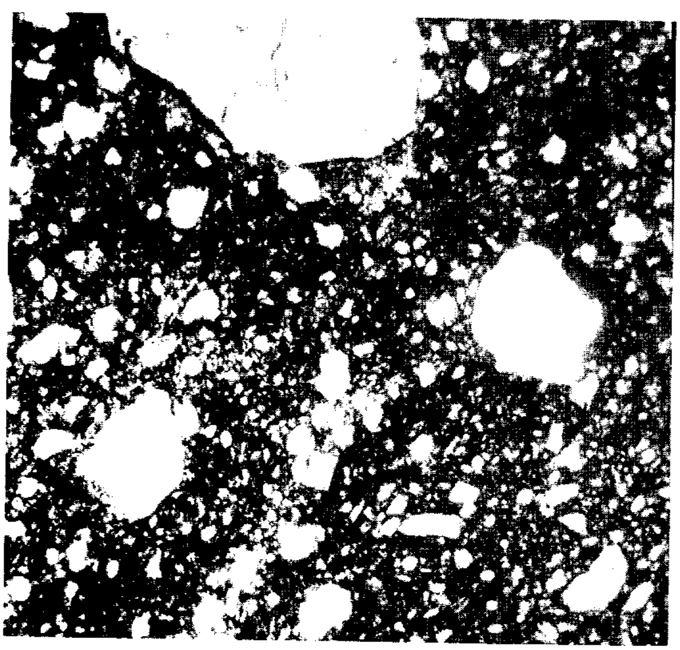


Figure 2. 63529,6, general view, ppl. width 2mm.

INTRODUCTION: 63535 is a dark gray, vesicular, fine-grained basaltic impact melt (Fig. 1). It is a rake sample and has zap pits.

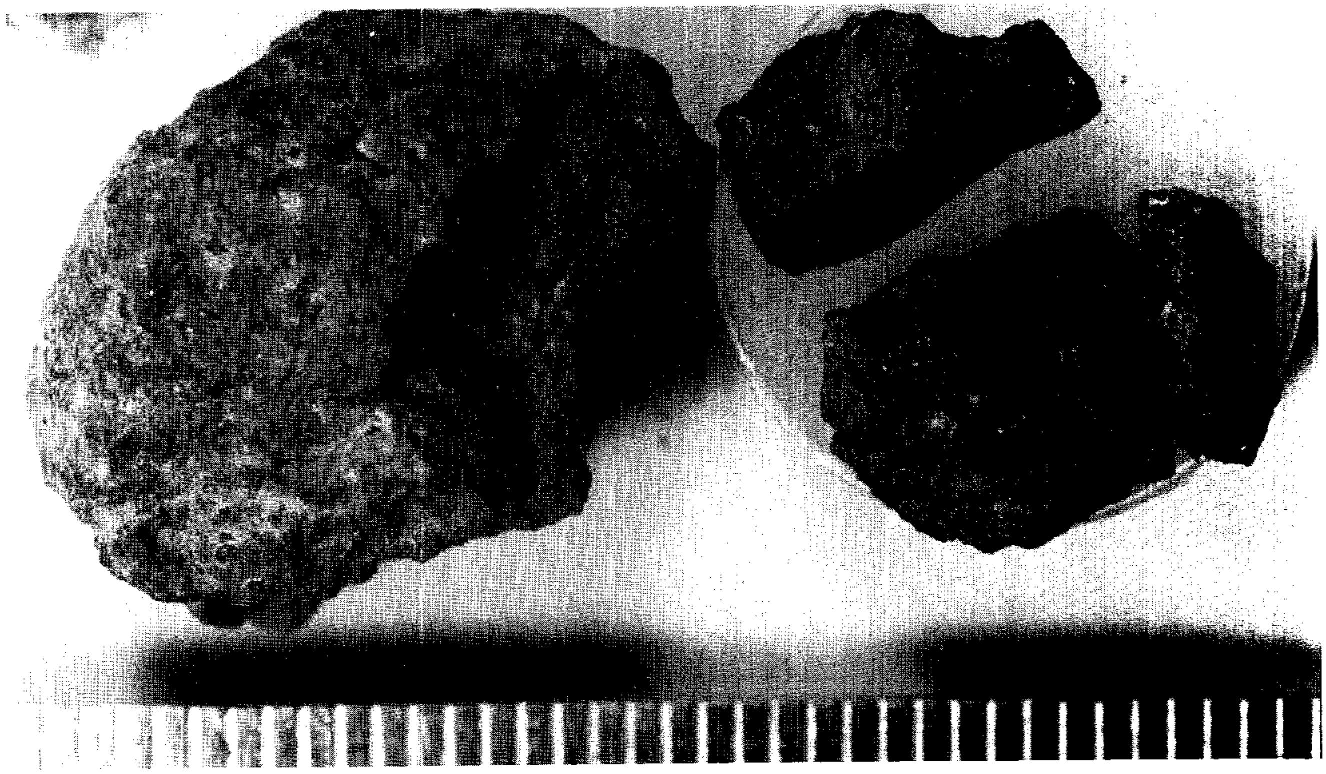


Figure 1. S-72-55391, mm scale.

PETROLOGY: Warner *et al*. (1973) classify 63535 as a quench basalt and report pyroxene compositional data. Gooley *et al*. (1973) report metal and schreibersite compositional data.

63535 is a fine-grained subophitic to intergranular impact melt with plagioclase laths 50-150 μm long (Fig. 2). Small patches of glassy mesostasis are present. Pyroxene and olivine compositions are shown in Figure 3. Warner *et al*. (1973) report that there is an absence of plagioclase phenocrysts and cognate inclusions. Many small plagioclase clasts are present.

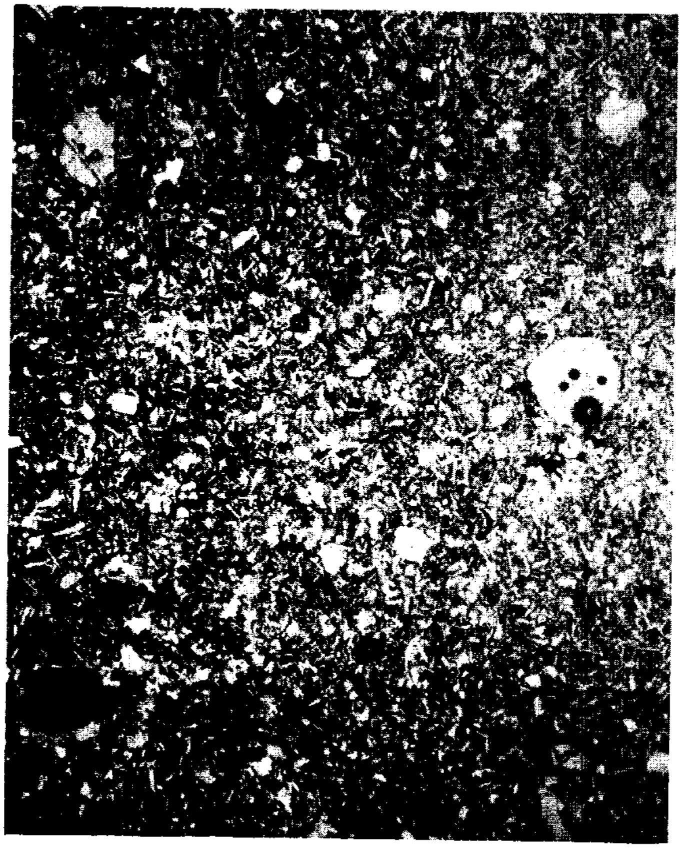


Figure 2. 63535,4, general view, ppl. width 2mm.

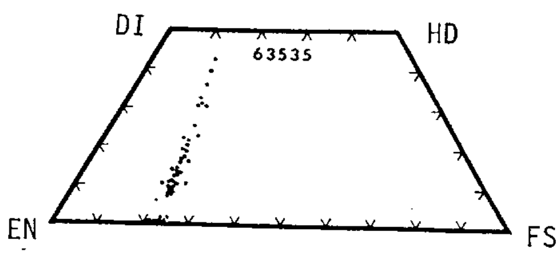



Figure 3. Mafic mineral compositions, olivine plotted along base, from Warner et al. (1973).

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report magnetic data for 63535. The sample number is listed twice, and presumably the correct data is that where 63535 is listed as a "$B_4$" breccia. The saturation remanence to saturation magnetization ratio is 0.0008. $Fe^0/Fe^{2+}$ is 0.141 and total $Fe^0$ is 0.70 wt%.

PROCESSING AND SUBDIVISIONS: Several chips have been broken off (Fig. 1), the smallest of which (,1) was made into thin sections ,3 - ,5. The potted butt of ,1 was used for the magnetic study.

# 63536 FINE-GRAINED BASALTIC IMPACT MELT 1.02 g

INTRODUCTION: 63536 is a dark, vesicular, fine-grained, coherent impact melt (Fig. 1). It is a rake sample.

PETROLOGY: 63536 is an impact melt with a subophitic texture (Fig. 2) and many small olivine phenocrysts. Plagioclase laths 100-300 μm long are partly embedded in olivines and pyroxenes 100-200 μm in diameter. Opaque minerals include chromite (embedded in olivines and plagioclases), armalcolite(?), ilmenite, and ulvöspinel. There is some interstitial glass, Fe-metal and troilite, and some clasts of plagioclase.

PROCESSING AND SUBDIVISIONS: Small chips of representative matrix (,1) were made into thin sections ,6 and ,7.

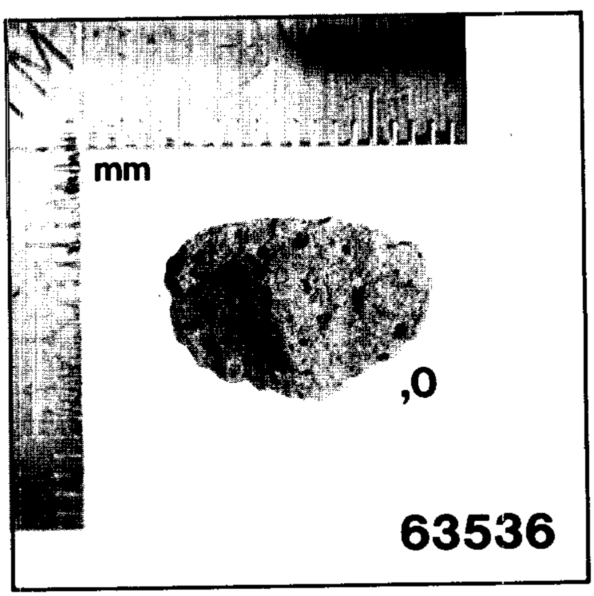



Figure 1.

Figure 2. 63536,6, general view, ppl. width 2mm.

INTRODUCTION: 63537 is a dark, coherent, fine-grained impact melt (Fig. 1). It is a rake sample and has zap pits.

PETROLOGY: 63537 is a basaltic impact melt with a subophitic to intergranular texture (Fig. 2). It is extremely plagioclase-rich (~80-85%). Most plagioclase laths are 100-200 μm long, and there is minor glass, Fe-metal, and other opaques surrounding the interstitial mafic minerals. Clastic material is inconspicuous.

PROCESSING AND SUBDIVISIONS: 63537 was first split into ,0 and ,1 as shown in Figure 1. Two small chips (,2) and a larger chip (,3) were taken from ,1. ,2 was made into thin sections ,6 and ,7.

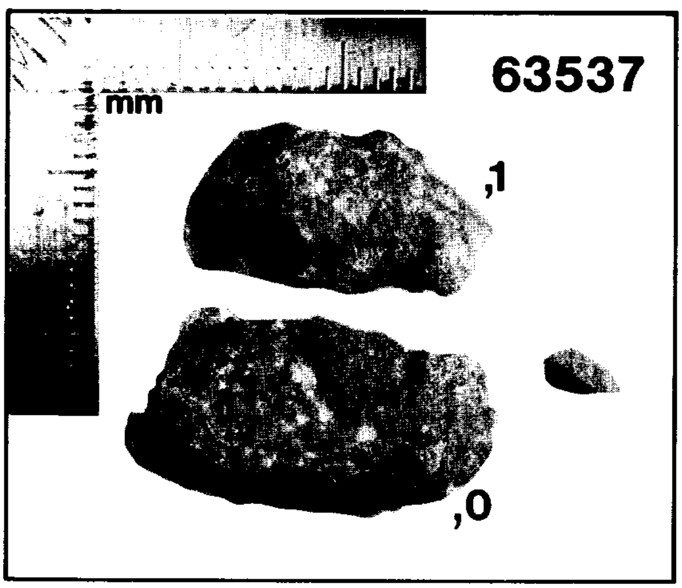



Figure 1.

Figure 2. 63537,6, general view, ppl. width 2mm.

## 63538 FINE-GRAINED IMPACT MELT AND DEVITRIFIED GLASS 35.1 g

INTRODUCTION: 63538 is a dark, coherent rock (Fig. 1), containing vesicles, which are usually elongate, and white clasts. It is extremely feldspathic with abundant shocked and flame-textured plagioclase, and in part is devitrified glass or variolitic melt. It is a rake sample and has zap pits on at least one side.

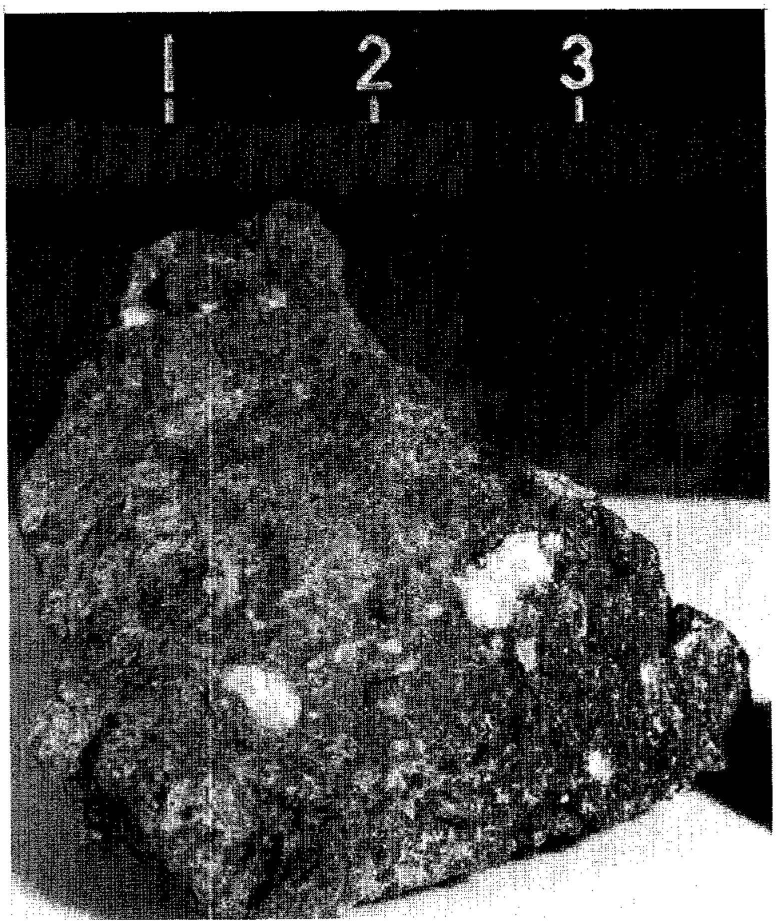



Figure 1. S-72-43501, cm scale.

PETROLOGY: Warner et al. (1973) refer to 63538 as dendritic devitrified glass plus melted matrix breccia. The latter is brown, plagioclase-rich breccia (Fig. 2) with a matrix of fine-grained melt and devitrified maskelynite. It contains abundant clasts of shocked and flame-textured plagioclases which have indistinct boundaries and there is little mafic material. In places the matrix has small subophitic patches and elsewhere cuts shocked plagioclase clasts. Thin section ,8 has a variolitic area, probably devitrified glass, which is finer-grained toward the breccia matrix; the contact varies from sharp to indistinct. The variolites consist of plagioclases up to 500 μm long.

a b

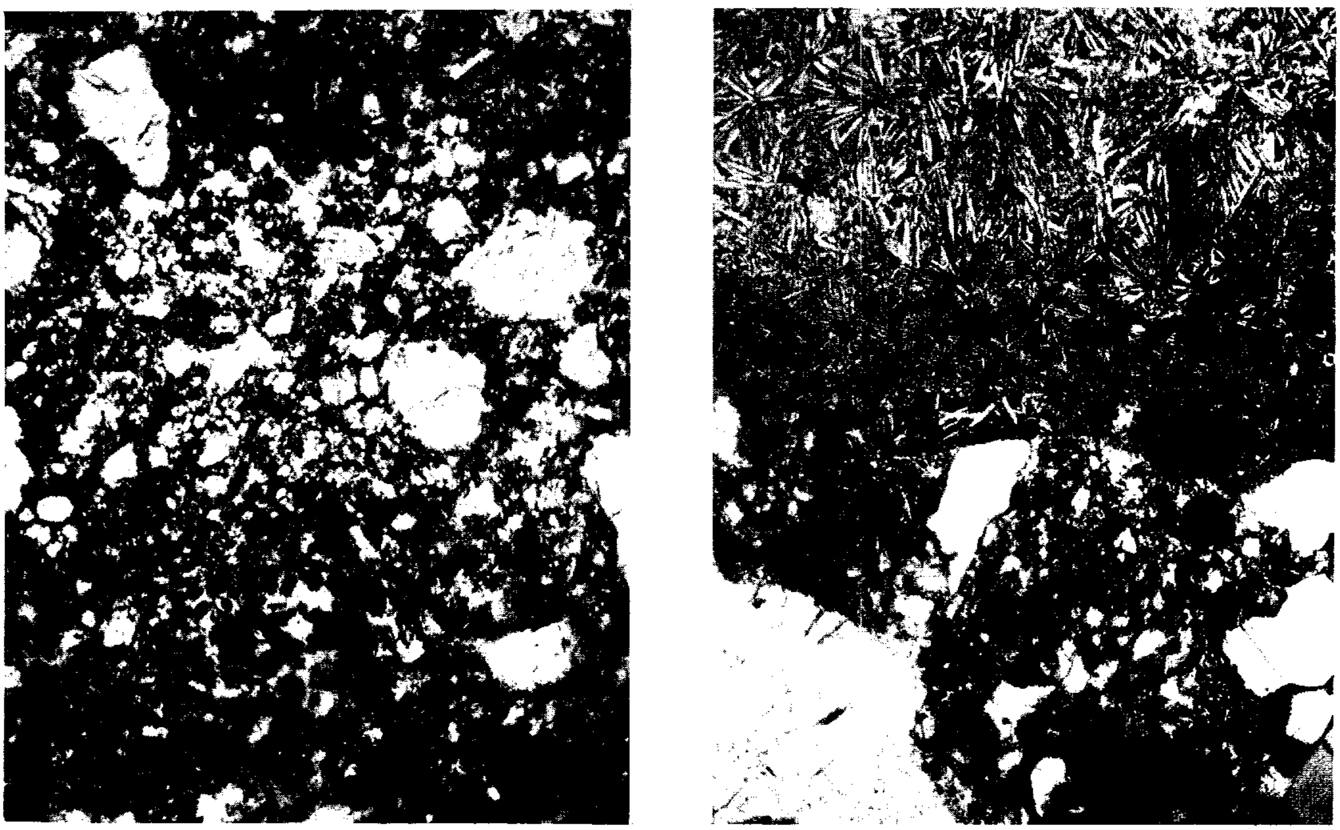


Figure 2. a) 63538,7, matrix, ppl. width 2mm.
b) 63538,8, variolitic area, ppl. width 2mm.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report magnetic data for 63538. The saturation remanence to saturation magnetization ratio is 0.0. $Fe^0/Fe^{2+}$ is 0.0103 and total $Fe^0$ is 0.024 wt%.

PROCESSING AND SUBDIVISIONS: Two small matrix chips were made into thin sections ,7 and ,9 (from ,1) and ,8 (from ,2). One of the potted butts was used for the magnetic study.

INTRODUCTION: 63539 is a gray, angular, coherent, fine-grained impact melt (Fig. 1). It is a rake sample.

PETROLOGY: 63539 is a fine-grained, brownish impact melt (Fig. 2) with a seriate size distribution of clasts down to extremely tiny. Most of the clasts are plagioclases with rounded corners and ragged edges, but some are lithic fragments including granoblastic anorthosite. The matrix is more mafic than the clast population and contains a few plagioclase laths.

PROCESSING AND SUBDIVISIONS: A single chip ,1 (Fig. 1) was made into thin sections ,6 and ,7.

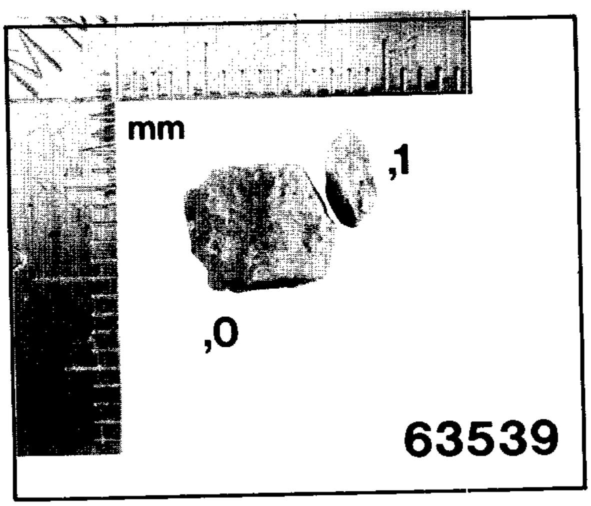



Figure 1.

Figure 2. 63539,7, general view, ppl. width 2mm.

INTRODUCTION: 63545 is a vesicular, dark, coherent, basaltic impact melt (Fig. 1). It is a rake sample with abundant zap pits.

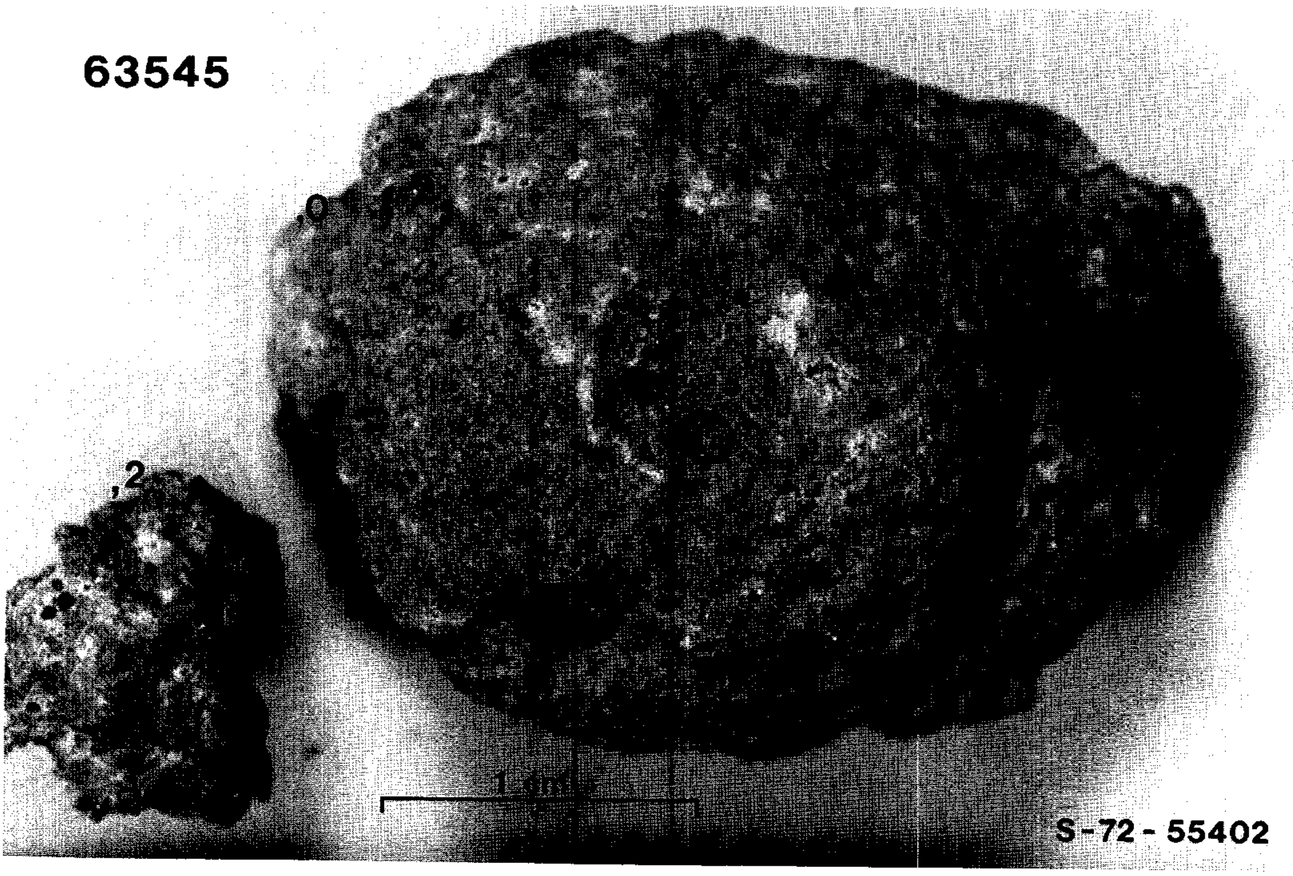



Figure 1.

PETROLOGY: Warner et al. (1973) classify 63545 as a porphyritic basalt. Delano (1977) provides a brief petrographic description. No microprobe data have been published.

63545 is a fine-grained, subophitic impact melt (Fig. 2) containing small olivine phenocrysts, a network of plagioclase laths, pyroxene, and interstitial glass. Opaque phases include chromite, armalcolite (?), ilmenite and ulvöspinel. Colorless spinel (pink spinel of Delano, 1977) is present. Most clasts are small plagioclases.

Figure 2. 63545,6, general view, ppl. width 2mm.

EXPERIMENTAL PETROLOGY: Delano (1977) determined the liquidus phase relations from 0 to 30 kbar on a synthetic analog of 63545. The results are shown in Figure 3. Spinel is the liquidus phase throughout, followed at low pressures by plagioclase. Spinel eventually reacts out. The results indicate that 63545 is an impact produced mixture rather than a partial melt of the lunar interior (whether differentiated or not) in that no significant multiple saturation point is present at any pressure.

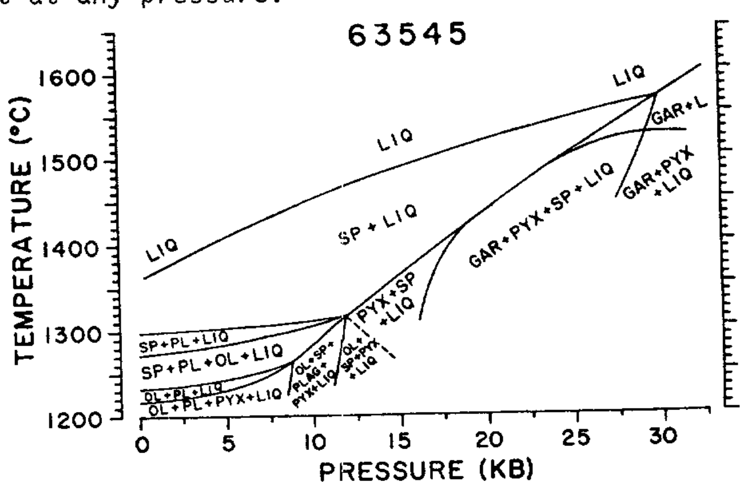



Figure 3. Melting relations, from Delano (1977).

CHEMISTRY: Hubbard et al. (1973) provide analyses of major and trace elements and Nyquist et al. (1973) provide Rb and Sr abundances. These are summarized in Table 1 and Figure 4.

TABLE 1. Summary chemistry of 63545

(from Hubbard et al., 1973; Nyquist et al., 1973)

| | |
|---|---|
| $SiO_2$ | 43 |
| $TiO_2$ | 0.96 |
| $Al_2O_3$ | 22.2 |
| $Cr_2O_3$ | 0.11 |
| FeO | ∿6.8 |
| MnO | 0.07 |
| MgO | 12.3 |
| CaO | 13.0 |
| $Na_2O$ | 0.38 |
| $K_2O$ | 0.12 |
| $P_2O_5$ | 0.17 |
| Sr | 169.8 |
| La | 19.7 |
| Lu | 0.888 |
| Rb | 3.16 |
| Sc | |
| Ni | |
| Co | |
| Ir ppb | |
| Au ppb | |
| C | |
| N | |
| S | 800 |
| Zn | |
| Cu | |

Oxides in wt%; others in ppm except as noted

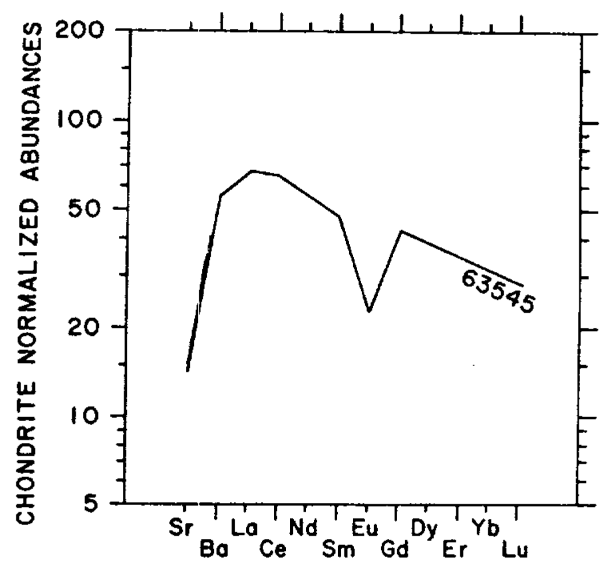



Figure 4. Rare earths, from Delano (1977), data of Hubbard et al. (1973).

RADIOGENIC ISOTOPES: Nyquist et al. (1973) provide whole rock Rb and Sr isotopic data. $^{87}Rb/^{86}Sr = 0.0539 \pm 6$ and $^{87}Sr/^{86}Sr = 0.70258 \pm 12$. Model ages of $4.50 \pm 0.20$ b.y. ($T_{BABI}$) and $4.62 \pm 0.20$ b.y. ($T_{LUNI}$) were calculated.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) measured magnetic parameters of 63545. The saturation remanence to saturation magnetization ratio is 0.0015. $Fe^0/Fe^{2+}$ is 0.131 and total $Fe^0$ is 0.54 wt%.

PROCESSING AND SUBDIVISIONS: A small typical chip (,1) was taken to make thin sections ,4 and ,6. The potted butt was used for the magnetic measurements. Chip ,2 (Fig. 1) was allocated for the chemical and isotopic studies.

INTRODUCTION: 63546 is a dark, fine-grained crystalline rock (Fig. 1) which is an impact melt. It is a rake sample with some zap pits.

PETROLOGY: 63546 is a fine-grained, brownish impact melt (Fig. 2). Plagioclase clasts have a seriate size distribution down to tiny, and are rounded. The matrix is mortar-like, enclosing the tiny plagioclase clasts, is more mafic than the clast population, and has scattered plagioclase laths up to 200 µm long. The texture approaches subophitic in places.

PROCESSING AND SUBDIVISIONS: Five small chips (,1) were removed to make thin sections ,6 and ,7.

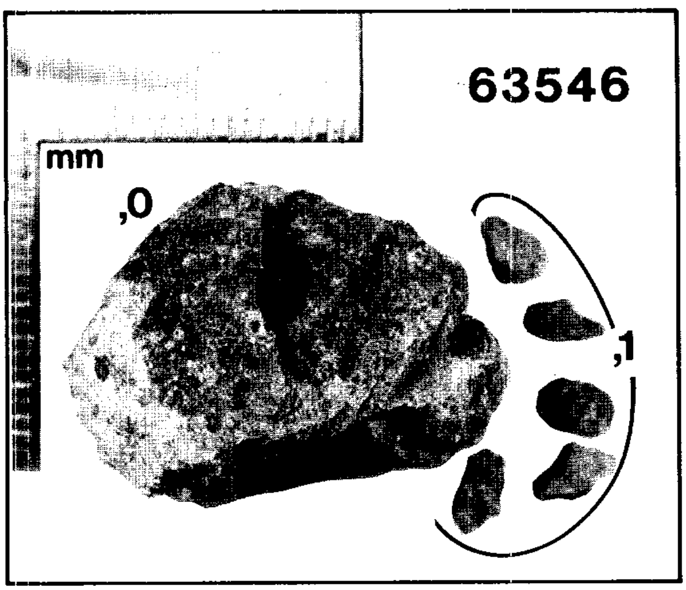



Figure 1.

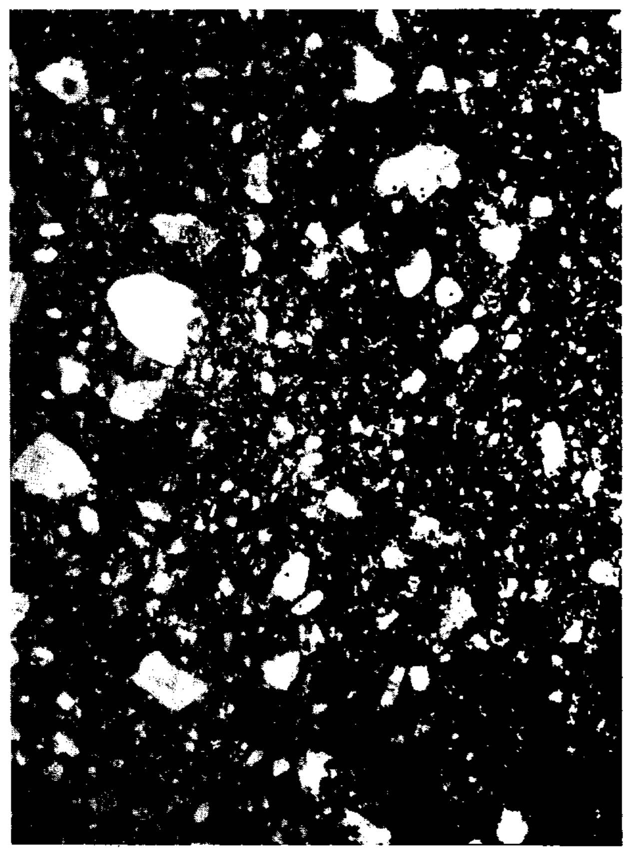


Figure 2.63546,6, general view, ppl. width 2mm.

INTRODUCTION: 63547 is a dark, coherent, poikilitic impact melt (Fig. 1). It is a rake sample and has zap pits.

PETROLOGY: Warner et al. (1973) and Simonds et al. (1973) classify 63547 as a poikilitic rock, and interpret it as an impact melt. Simonds et al. (1973) provide some petrographic and microprobe data.

The sample consists of pigeonite oikocrysts 200-400 μm across enclosing stubby plagioclases (Fig. 2). Interoikocryst areas contain ilmenite (and armalcolite ?), plagioclase, some glass, and Fe-metal blebs. A mode by Simonds et al. (1973) has 67% plagioclase and mesostasis, 25% pigeonite, and 8% olivine. Pyroxene compositions are quite restricted (Fig. 3). Most clasts are plagioclase, some are olivine; lithic clasts are absent.

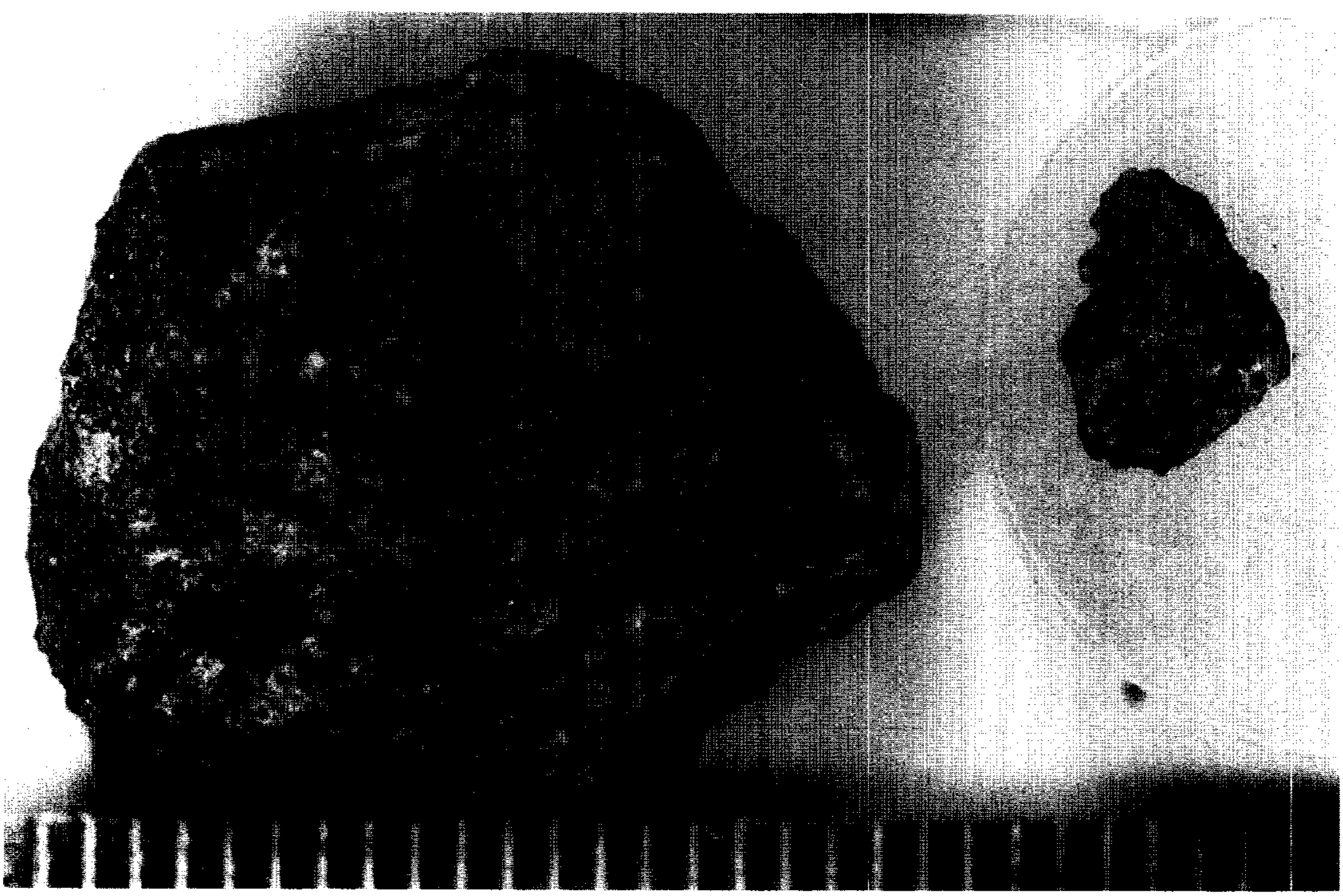
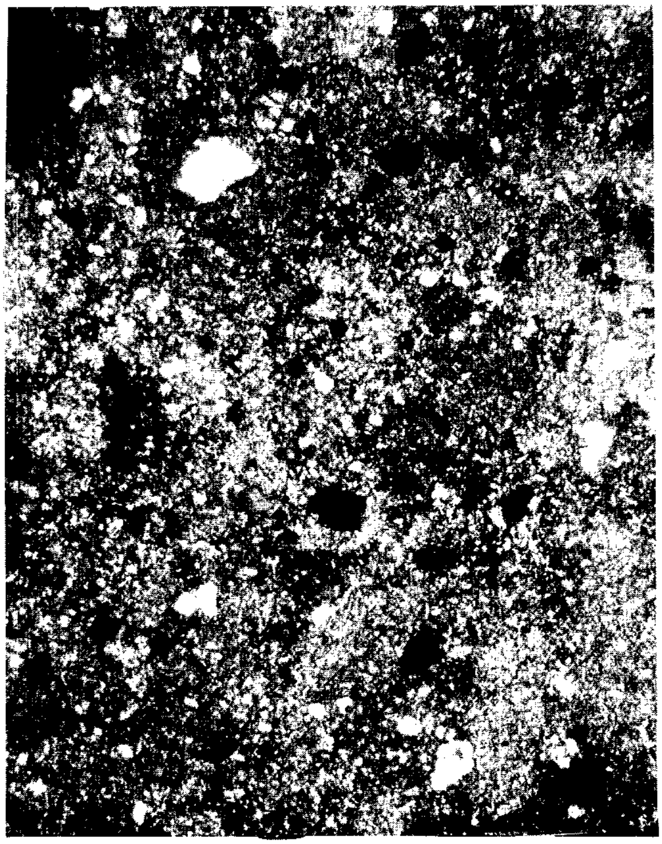


Figure 1. S-72-55389, mm scale.

a



b

Figure 2. 63547,4 a) general view,xpl. width 2mm. b) close-up, rfl. width 0.2mm.

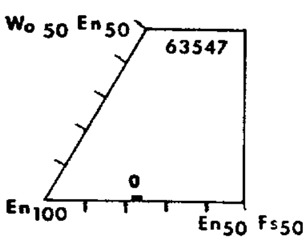



Figure 3. Mafic mineral compositions, olivine plotted along base, from Simonds et al. (1973).

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report magnetic parameters for 63547. The saturation remanence to saturation magnetization ratio is 0.0017. $Fe^0/Fe^{2+}$ is 0.224 and total $Fe^0$ is 1.05 wt%.

PROCESSING AND SUBDIVISIONS: A representative chip (,1) was used to make thin sections ,3 and ,4.

INTRODUCTION: 63548 is a gray, fine-grained, coherent impact melt (Fig. 1). It is a rake sample and has zap pits.

PETROLOGY: 63548 is a brownish fine-grained impact melt (Fig. 2). It contains a seriate size distribution of plagioclase clasts which have rounded corners and ragged edges. The melt is more mafic than the clast population and contains a few plagioclase laths.

PROCESSING AND SUBDIVISIONS: Three small matrix chips (,1) were made into thin sections ,6 and ,7. A fourth chip (,2) is unallocated.

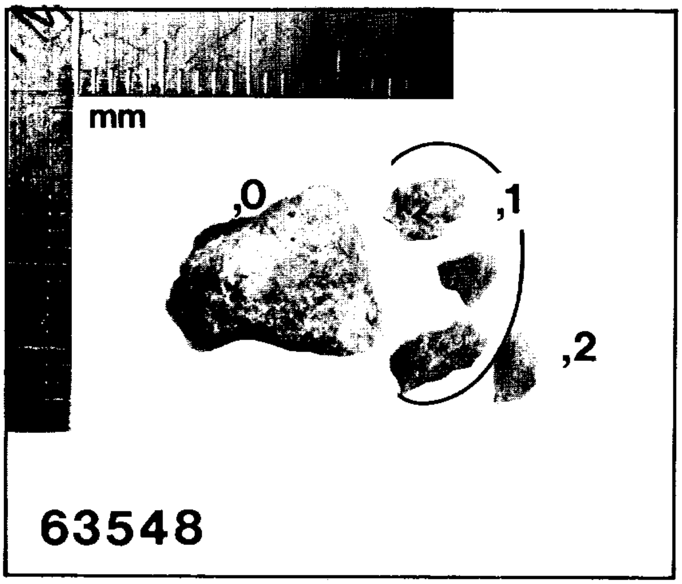



Figure 1.

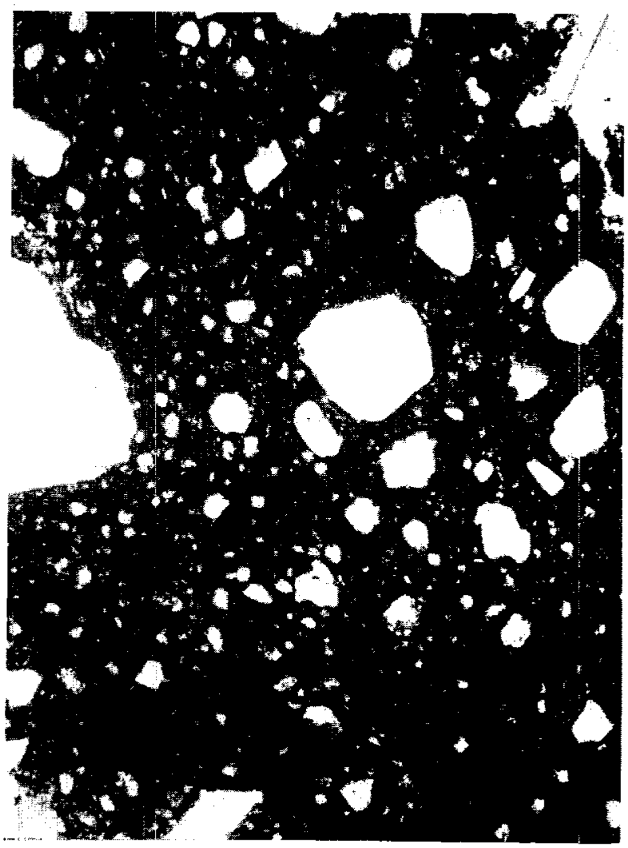


Figure 2. 63548,6, general view, ppl. width 2mm.

INTRODUCTION: 63549 is a medium gray, coherent, fine-grained basaltic impact melt (Fig. 1). It is a rake sample and has zap pits.

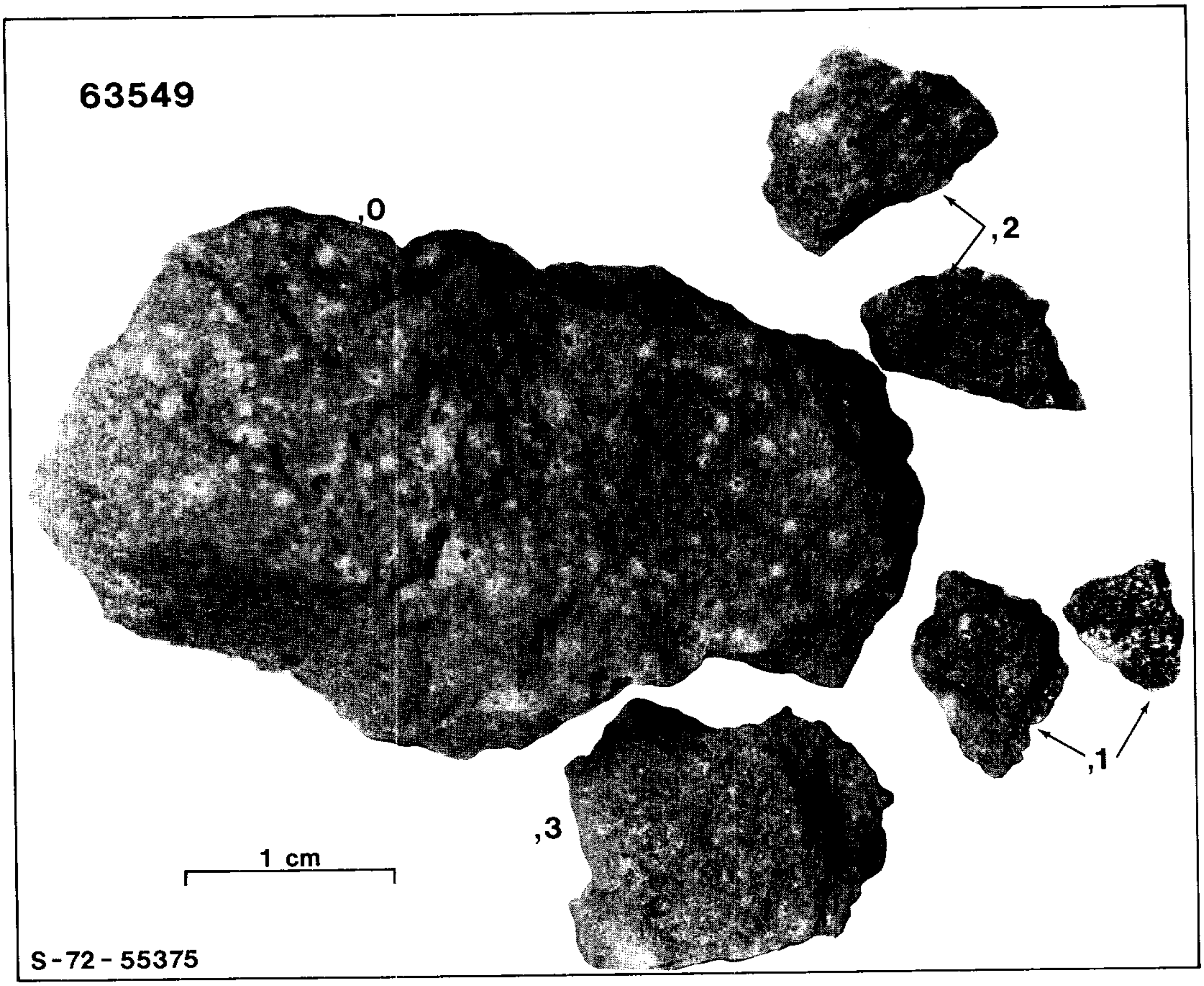



Figure 1.

PETROLOGY: 63549 is classified as a porphyritic basalt by Warner et al. (1973) and as an olivine-free, basaltic-textured melt rock by Vaniman and Papike (1981). Both papers present microprobe data. Gooley et al. (1973) present metal and schreibersite compositional and petrographic data.

63549 is a basaltic impact melt (Fig. 2) with plagioclase laths 50-100 μm long (Vaniman and Papike, 1981) partly set in pyroxene and with a glassy mesostasis. Olivine is absent. Mineral data are shown in Figure 3. Gooley et al. (1973) report metal data (Fig. 4). The metal is high in Ni; etching demonstrated that the metal was single phase. Gooley et al. (1973) note that 63549 has no relict mineral or lithic clasts i.e., it was totally molten.

Figure 2. 63549,8, general view, ppl. width 2mm.

a)

b)

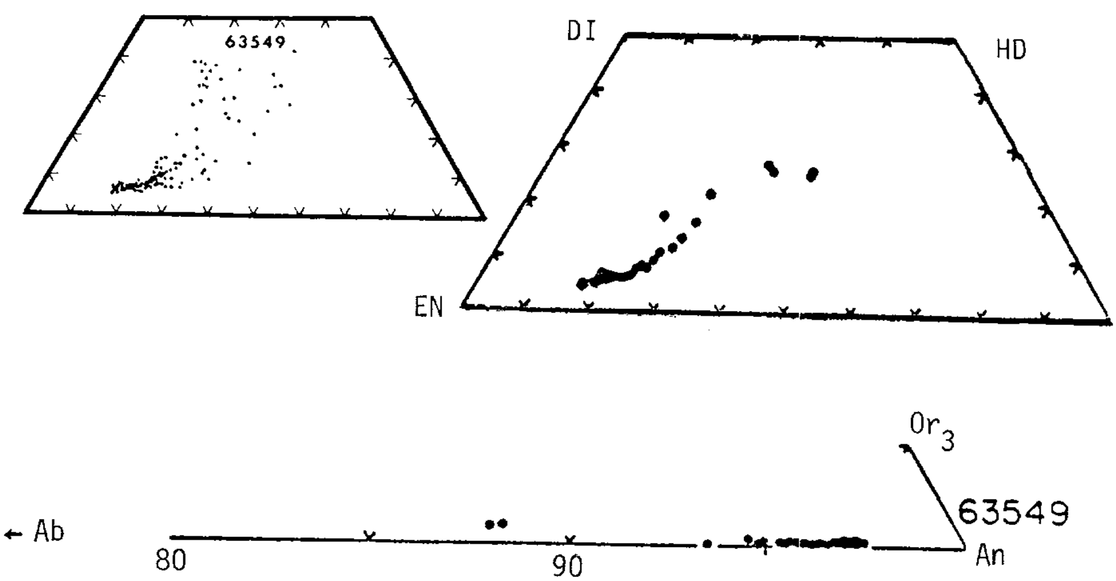



Figure 3. a) Pyroxene compositions, from Warner et al. (1973), and Vaniman and Papike (1981). b) Plagioclase compositions, from Vaniman and Papike (1981).

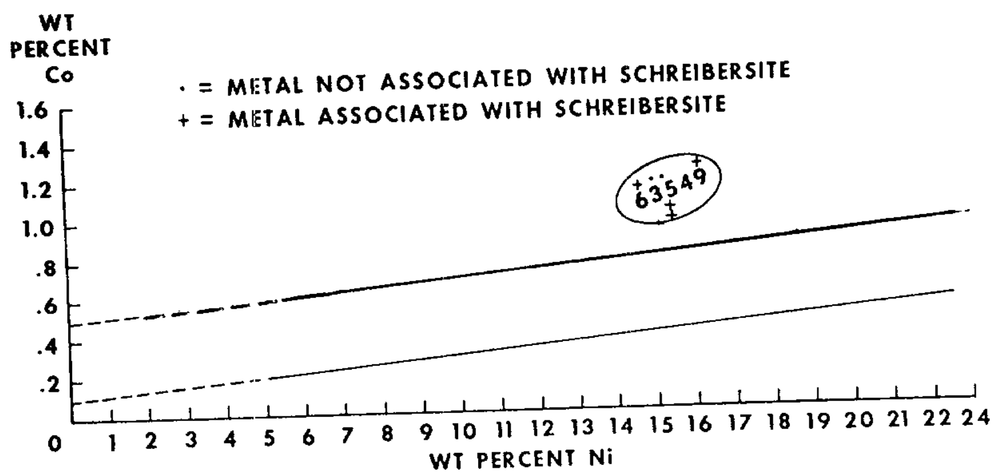



Figure 4. Metals, from Gooley *et al*. (1973).

CHEMISTRY: Hubbard *et al*. (1973) present a major element analysis and Hubbard *et al*. (1974) trace element analyses for chip ,2. Boynton *et al*. (1976) and Wasson *et al*. (1977) report comprehensive analyses, including major, siderophile, rare earth, and volatile elements, of chip ,9. Taylor and Bence (1975) report rare earth element data. The data are summarized in Table 1 and Figure 5. The basalt is more aluminous and lower in incompatible elements than local soils and most Apollo 16 basaltic impact melts. It has no significant europium anomaly (Fig. 5).

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report magnetic parameters. The saturation remanence to saturation magnetization ratio is 0.007. $Fe^0/Fe^{2+}$ is 0.0448 and total $Fe^0$ is 0.142 wt%.

PROCESSING AND SUBDIVISIONS: Several small chips were removed (Fig. 1) for thin sections and for chemical analyses. ,1 was made into thin sections ,5 and ,8. ,2 was partly consumed in the Hubbard *et al*. (1973, 1974) analyses, and ,3 was divided and partly consumed in the other chemical analyses.

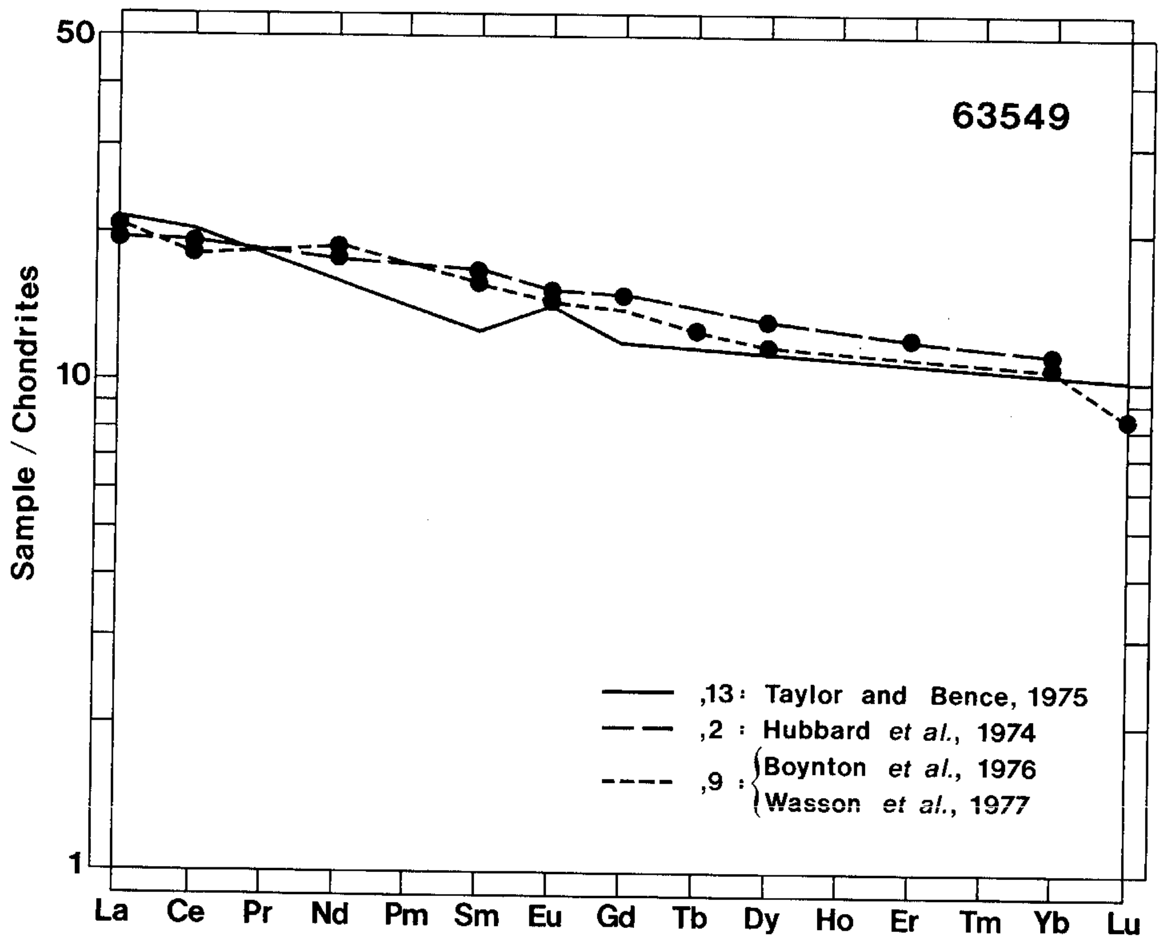



Figure 5. Rare earths.

TABLE 1. Summary chemistry of 63549

| | |
|---|---|
| $SiO_2$ | 45.7 |
| $TiO_2$ | ∿0.4 |
| $Al_2O_3$ | 29 |
| $Cr_2O_3$ | 0.09 |
| FeO | ∿4.2 |
| MnO | 0.05 |
| MgO | ∿4.3 |
| CaO | ∿15.5 |
| $Na_2O$ | 0.45 |
| $K_2O$ | 0.07 |
| $P_2O_5$ | 0.07 |
| Sr | 170.2 |
| La | 6.4 |
| Lu | 0.29 |
| Rb | 1.76 |
| Sc | 7.3 |
| Ni | 205 |
| Co | 18 |
| Ir ppb | 8 |
| Au ppb | 3.4 |
| C | |
| N | |
| S | 400 |
| Zn | 1.12 |
| Cu | 2.6 |

Oxides in wt%; others in ppm except as noted

INTRODUCTION: 63555 is a pale-colored, coherent, fine-grained crystalline rock (Fig. 1). It is a clast-rich impact melt. It is a rake sample with a thin, dark clastic(?) coat.

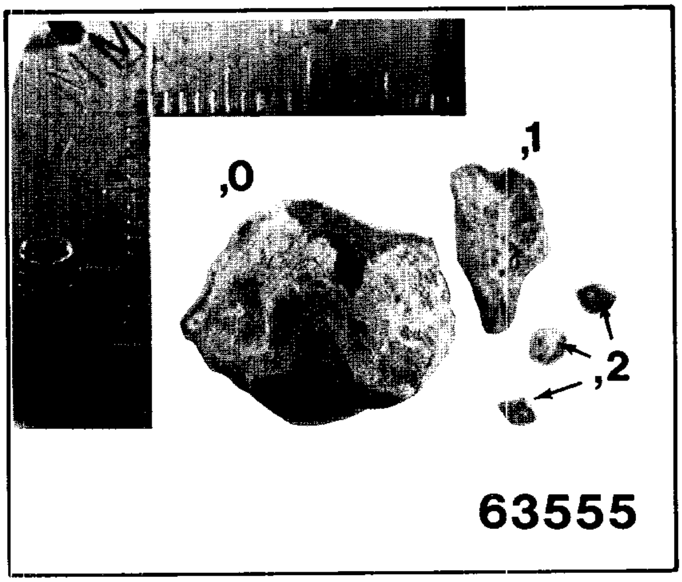



FIGURE 1. Smallest scale division in mm.

FIGURE 2. 63555,7. general view, ppl. width 2mm.

PETROLOGY: 63555 is a fine-grained, brownish impact melt which is fairly heterogeneous (Fig. 2). It contains numerous plagioclase and lithic clasts which are angular with rounded corners, with a seriate size distribution. The melt phase is more mafic than the clast population. The lithic clasts include small feldspathic granoblastic impactites and spherulitic impact melts (Fig. 2). According to an SEM study by Phinney et al. (1976), 63555 contains no glass and has 5% vesicles; the matrix consists of plagioclases up to 10 μm across and orthopyroxenes up to 2 μm.

PROCESSING AND SUBDIVISIONS: A single chip (,1) was used to make thin sections ,6 and ,7.

INTRODUCTION: 63556 is a medium gray, fine-grained, poikilitic impact melt (Fig. 1). It is a rake sample with many zap pits on one face, and few on the others.

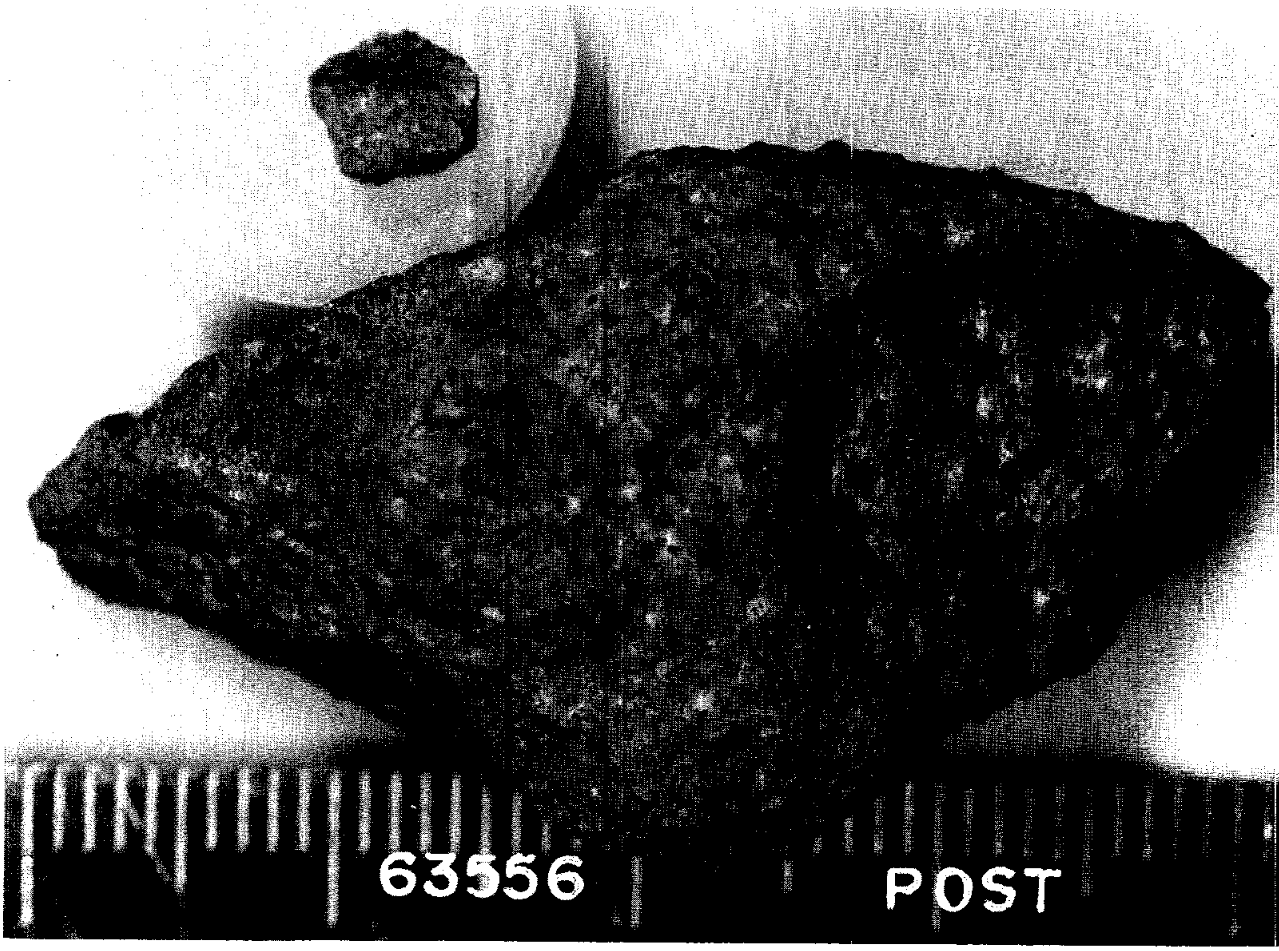



Figure 1. S-72-55401, mm scale.

PETROLOGY: Warner et al. (1973) and Simonds et al. (1973) classify 63556 as a poikilitic impact melt; the latter provide a petrographic description and microprobe data.

63556 consists of pigeonite oikocrysts 200-400 µm in diameter enclosing stubby plagioclase crystals (Fig. 2). The interoikocryst areas contain ilmenite, plagioclase, and glass. Pyroxene analyses are shown in Figure 3. A mode by Simonds et al. (1973) has 68% plagioclase plus mesostasis, 29% pigeonite, 2% olivine, and 1% opaque minerals. Olivine occurs as relict clasts, but most clasts are plagioclases. Lithic clasts are absent.

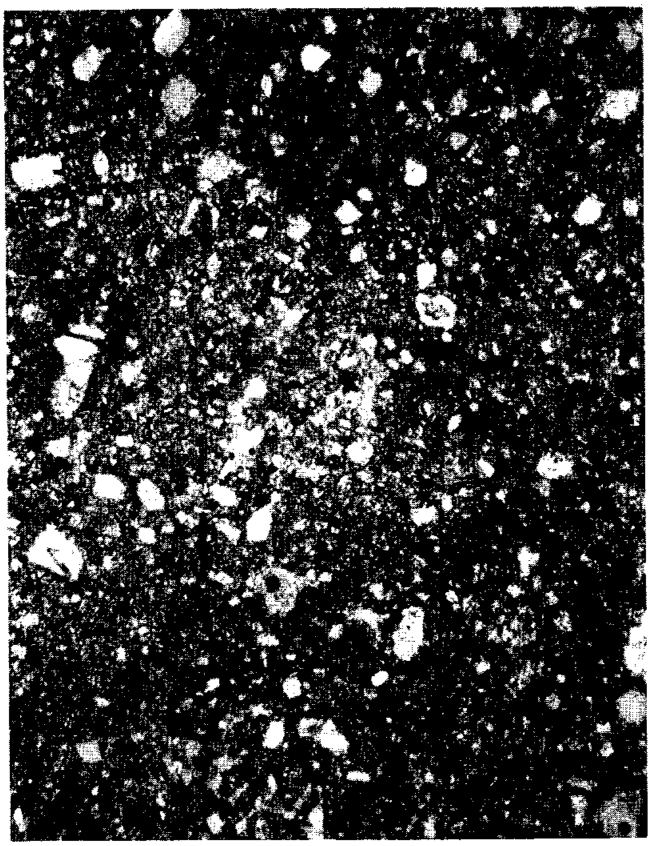


Figure 2. 63556,4, general view, ppl. width 2mm.

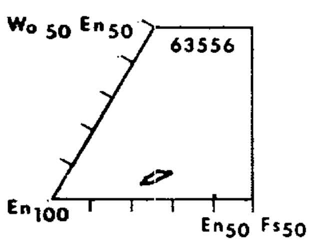



Figure 3. Pyroxene compositions, from Simonds et al. (1973).

CHEMISTRY: Wasson et al. (1977) provide two replicate major and trace element analyses of chip ,6. The replicate analyses are very similar. The data are summarized in Table 1 and Figure 4. The sample is among the highest in incompatible elements at the Apollo 16 site.

PROCESSING AND SUBDIVISIONS: A small chip ,1 was taken (Fig. 1) and made into thin sections ,2 and ,4. Other groups of small chips ,5 and ,6, were allocated for chemical analyses.

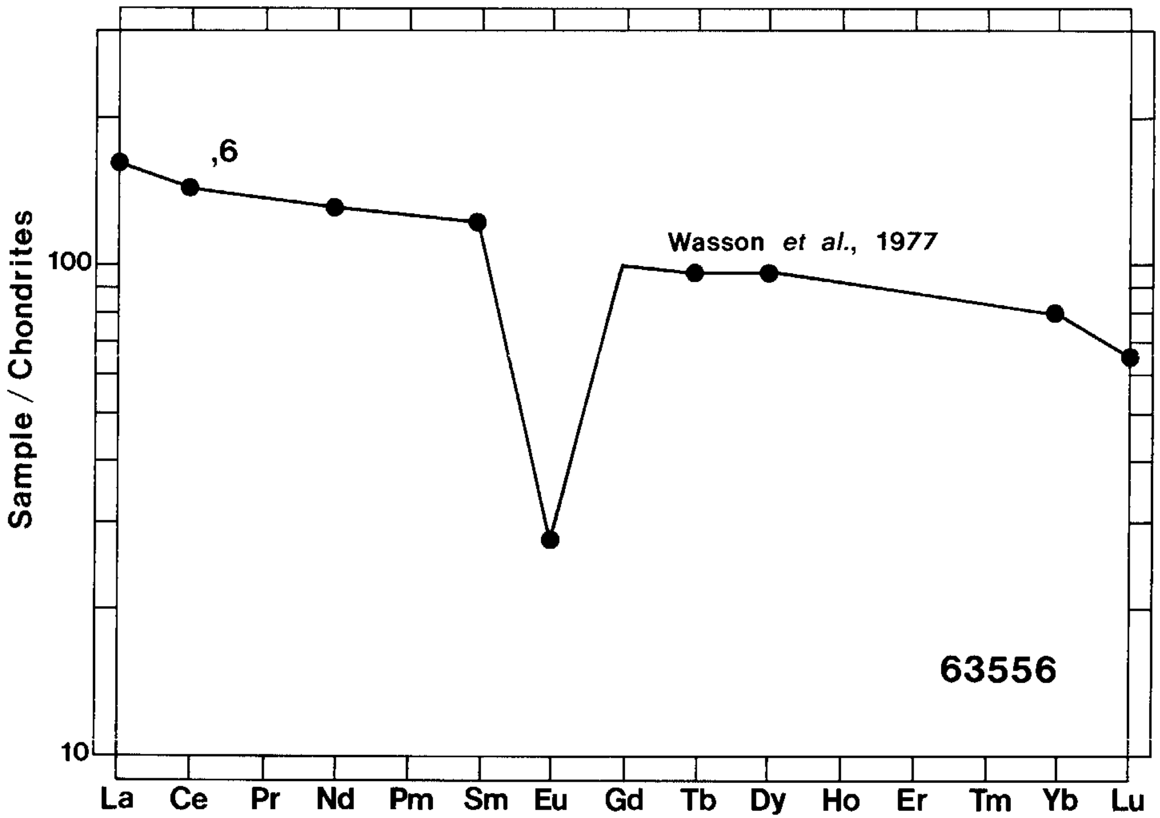



Figure 4. Rare earths.

TABLE 1. Summary chemistry of 63556
(Wasson et al., 1977)

| | |
|---|---|
| $SiO_2$ | |
| $TiO_2$ | 1.2 |
| $Al_2O_3$ | 19.7 |
| $Cr_2O_3$ | 0.18 |
| FeO | 8.5 |
| MnO | 0.11 |
| MgO | 10.3 |
| CaO | 11.9 |
| $Na_2O$ | 0.59 |
| $K_2O$ | 0.35 |
| $P_2O_5$ | |
| Sr | |
| La | 53 |
| Lu | 2.2 |
| Rb | |
| Sc | 15.4 |
| Ni | ∿540 |
| Co | ∿40 |
| Ir ppb | ∿16 |
| Au ppb | ∿9 |
| C | |
| N | |
| S | |
| Zn | ≤2.3 |
| Cu | |

Oxides in wt%; others in ppm except as noted

INTRODUCTION: 63557 is a medium dark gray, fine-grained impact melt (Fig. 1). It is a rake sample and has zap pits.

Figure 1. S-72-55382, mm scale.

PETROLOGY: Warner et al. (1973) classify 63557 as a meta-norite. Floran et al. (1976) define it as a polymict dark matrix breccia. It is a fine-grained impact melt (Fig. 2) with a matrix containing tiny ilmenite needles. The melt forms a mortar for a clast population which has a seriate size distribtuion down to very tiny. Several 300-400 μm fragments of mafic minerals, as well as a 700 μm plagioclase clast, are present in thin section ,4.

Figure 2. 63557,4, general view, ppl. width 2mm.

CHEMISTRY: Floran et al. (1976) and Blanchard (unpublished) analyzed chip ,6 for major and trace elements respectively. These are summarized in Table 1 and Figure 3. The fragment is feldspathic, with low rare earth abundances. While it is contaminated with meteoritic material, the level of contamination is not great.

PROCESSING AND SUBDIVISIONS: A chip (,1;the smallest in Fig. 1) was made into thin sections ,3 and ,4. The intermediate chip in Figure 1 was split into chips ,6 and ,7, of which the former was allocated for chemical analysis.

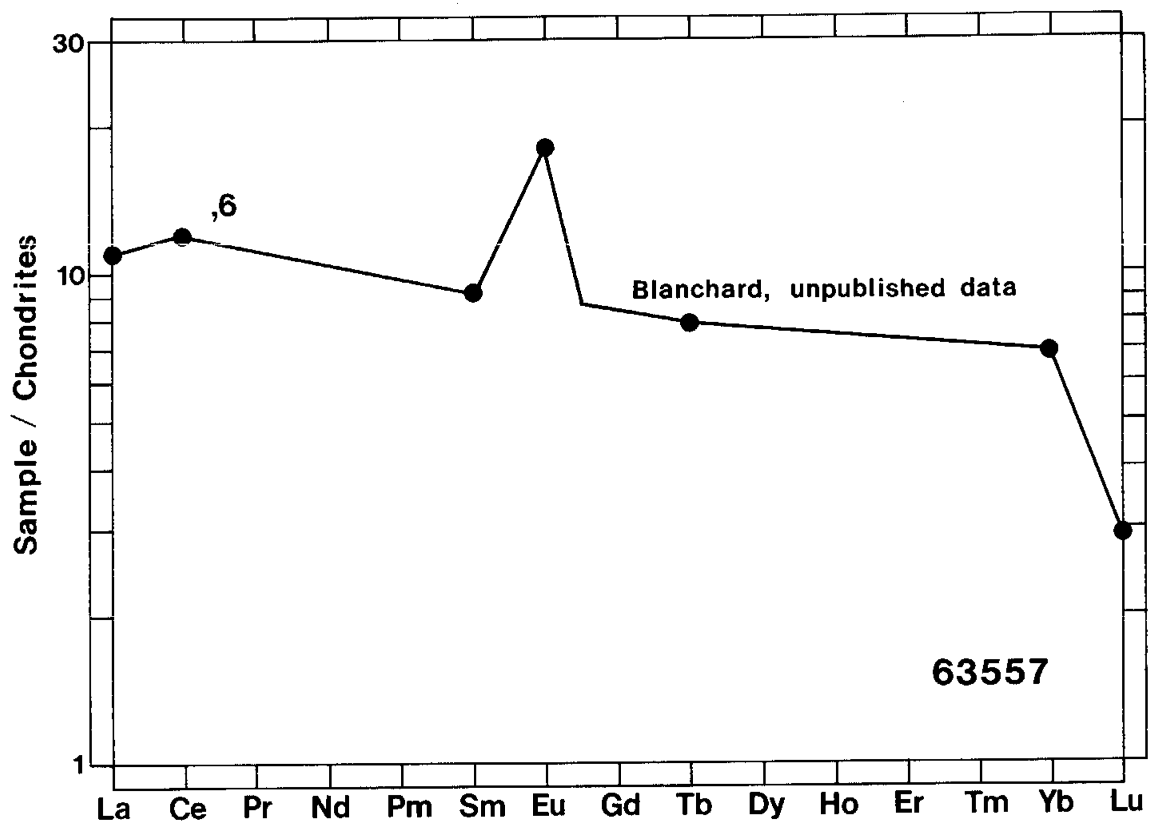



Figure 3. Rare earths.

TABLE 1. Summary chemistry of 63557

| | |
|---|---|
| $SiO_2$ | 44.7 |
| $TiO_2$ | 0.38 |
| $Al_2O_3$ | 29.8 |
| $Cr_2O_3$ | ~0.05 |
| FeO | 3.5 |
| MnO | |
| MgO | 3.2 |
| CaO | 17.0 |
| $Na_2O$ | 0.62 |
| $K_2O$ | 0.08 |
| $P_2O_5$ | |
| Sr | |
| La | 3.62 |
| Lu | 0.01 |
| Rb | |
| Sc | 6.2 |
| Ni | 44 |
| Co | 7.2 |
| Ir ppb | |
| Au ppb | |
| C | |
| N | |
| S | |
| Zn | 9 |
| Cu | |

Oxides in wt%; others in ppm except as noted

INTRODUCTION: 63558 is a medium gray, coherent rock (Fig. 1) which is a poikilitic impact melt. It is a rake sample and has many zap pits on all surfaces.

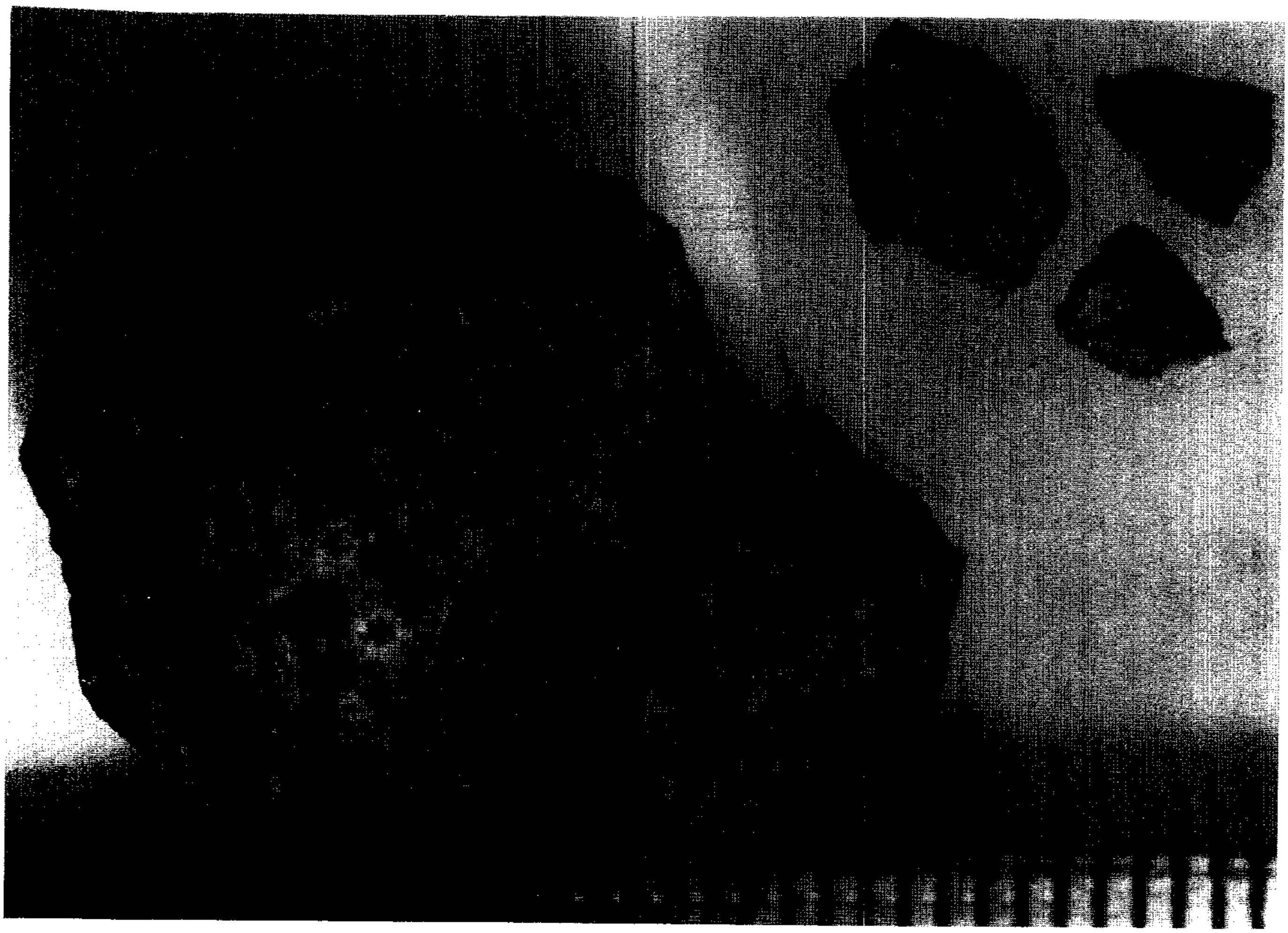


Figure 1. S-72-55397, mm scale.

PETROLOGY: Warner *et al.* (1973) and Simonds *et al.* (1973) classify 63558 as a poikilitic rock. Simonds *et al.* (1973) provide petrographic and microprobe data. The sample consists of oikocrysts of orthopyroxene and augite, most ∿600 μm in diameter, enclosing plagioclase crystals. Interoikocryst areas contain plagioclase, opaque minerals (armalcolite, and ilmenite with exsolved rutile) and glass. A mode by Simonds et al. (1973) has 56% plagioclase plus mesostasis, 32% orthopyroxene, no pigeonite, 12% augite, 2% olivine, and 2% opaques. The olivine occurs as granules of uncertain (relict?) origin. Pyroxene and olivine compositions are shown in Figure 3. One lithic clast observed by Simonds et al. (1973) has lathy feldspar as well as olivine and ilmenite.

Figure 2. 63558,4, general view, ppl. width 2mm.

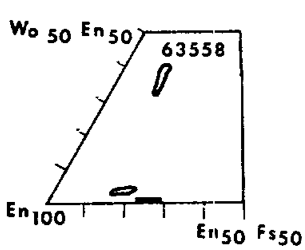



Figure 3. Mafic mineral compositions, olivine plotted along base, from Warner et al. (1973).

PROCESSING AND SUBDIVISIONS: The two smallest chips in Figure 1 (,1) were potted together and made into thin sections ,2 and ,4. The other two chips remain numbered with the parent as ,0.

INTRODUCTION: 63559 is a vesicular glass and contains small white inclusions (Fig. 1). Much of the glass has devitrified. It is a rake sample.

PETROLOGY: 63559 is a vesicular glass ranging from clear or gray to the more common devitrified brown glass (Fig. 2). In places the devitrification is intense. A few mineral and small lithic clasts are present.

PROCESSING AND SUBDIVISIONS: A single representative chip (,1; Fig. 1) was made into thin sections ,6 and ,7.

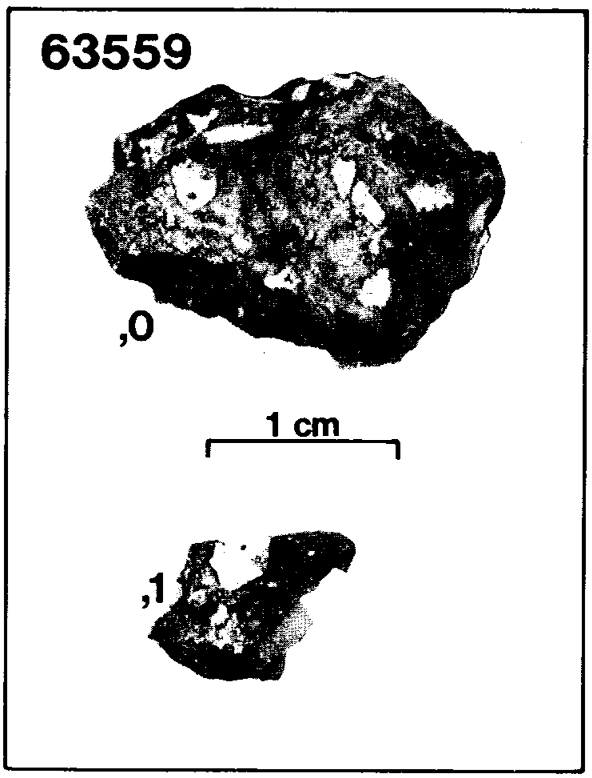



Figure 1.

Figure 2. 63559,6, general view, ppl. width 2mm.

# 63565 DEVITRIFIED GLASS, WHITE CLASTS 0.94 g

INTRODUCTION: 63565 is a dark gray, coherent and vesicular glass containing friable white inclusions (Fig. 1). Most of the glass has devitrified. It is a rake sample.

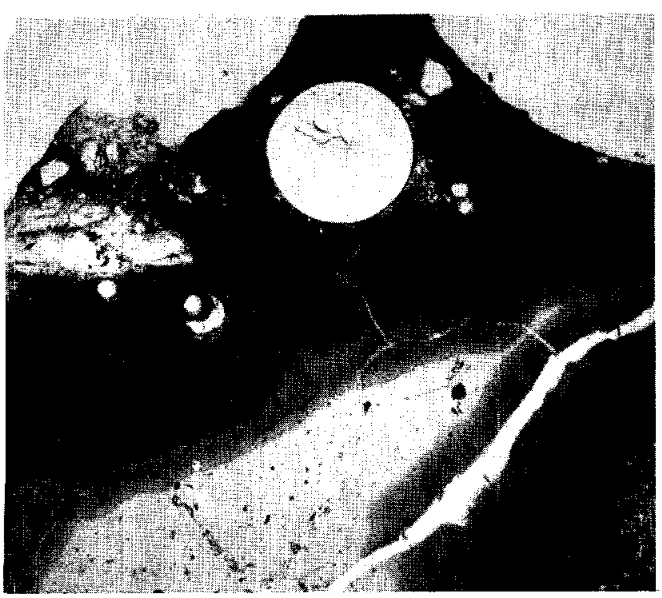
PETROLOGY: 63565 consists mainly of a brown, vesicular, devitrified glass with clasts of plagioclase-rich breccia (Fig. 2). The glass contains some clear or gray patches. Devitrification results in finer-grained products closer to the clasts. The large clast, sampled in thin section ,6, (Fig. 2) is bonded with a mortar of fine-grained melt or glass and contains Fe-metal.

PROCESSING AND SUBDIVISIONS: Two chips of glass, one containing light-colored clasts, were potted together as ,1 and made into thin sections ,6 and ,7.

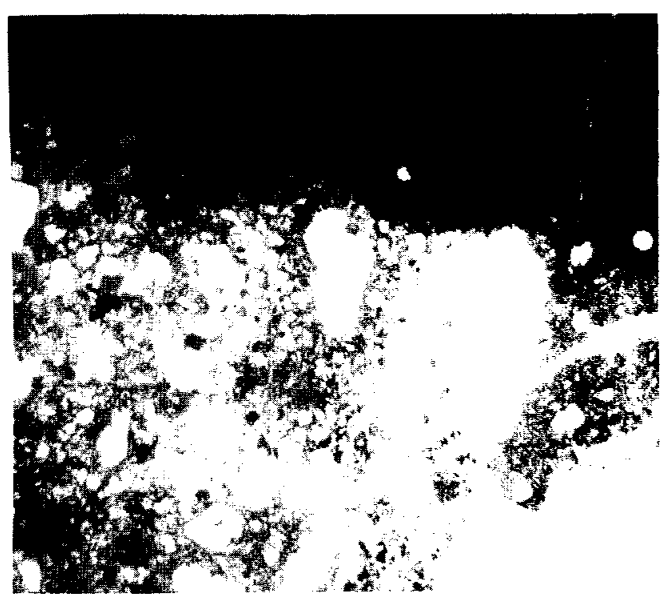
Figure 1. mm scale.

Figure 2. 63565,6 a) general view, ppl. width 2mm. b) glass and white clast, ppl. width 2mm.

a



b



## 63566 DEVITRIFIED GLASS, CATACLASTIC ANORTHOSITE CLAST 19.61 g

INTRODUCTION: 63566 is a dark gray, vesicular glass containing friable white clasts including at least one large cataclastic anorthosite (Fig. 1). The glass has a smooth surface and is mostly devitrified. It is a rake sample.

Figure 1. S-72-55385, mm scale.

a

b

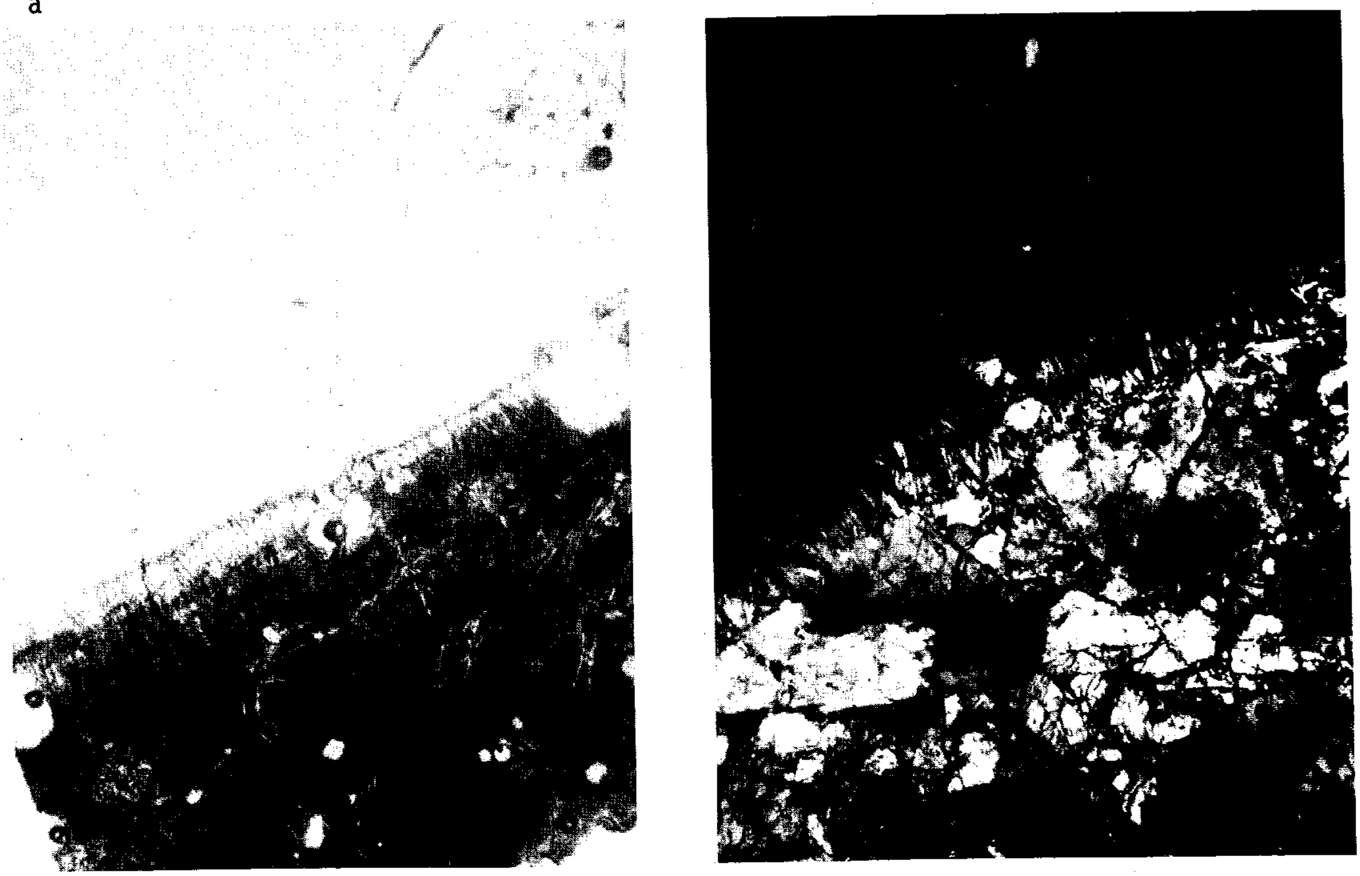


Figure 2. 63566,4 a) glass, anorthosite contact, ppl. width 2mm.
b) glass, anorthosite contact, xpl. width 2mm.

PETROLOGY: Warner et al. (1973) classify 63566 as a dendritic to spherulitic devitrified glass. The glass is brown, vesicular, and devitrified into fans and bow-tie structures (Fig. 2). The large white clast (Figs. 1 and 2) is a cataclastic anorthosite with grains larger than 1 mm, and contains more than 99% plagioclase.

PROCESSING AND SUBDIVISIONS: Part of a single chip (,1) consisting of glass matrix and part of the large white clast (Fig. 1) was made into thin section ,4.

## 63567 DEVITRIFIED GLASS, WHITE CLASTS 3.21 g

INTRODUCTION: 63567 is a vesicular glass with smooth exterior surfaces and containing white clasts (Fig. 1). The glass is devitrified. It is a rake sample.

PETROLOGY: 63567 is a brown, devitrified glass (Fig. 2) containing a few mineral and lithic clasts. The latter include plagioclase-rich breccias and shocked feldspathic granulites.

PROCESSING AND SUBDIVISIONS: Small chips (,1) were potted together and made into thin sections ,6 and ,7.

Figure 1. mm scale.

Figure 2. 63567,7, general view, ppl. width 2mm.

INTRODUCTION: 63568 is a cindery gray glass containing gray crystalline clasts (Fig. 1). At least one of the clasts is an impact melt. The glass is devitrified. 63568 is a rake sample.

PETROLOGY: The groundmass of 63568 is a brown, vesicular, devitrified glass (Fig. 2). Dusty debris is welded to its exterior. The sampled clast (,1 in Figure 1) is a fine-grained impact melt (Fig. 2) with a texture which varies from micropoikilitic to subophitic to intergranular to variolitic. It is cut by brownish-red glass veins generally about 30 μm thick but thicker in some places.

PROCESSING AND SUBDIVISIONS: Four chips (,1) were taken from the gray clast and made into thin sections ,6 and ,7. A single chip of glass (,2) was made into thin sections ,8 and ,9.

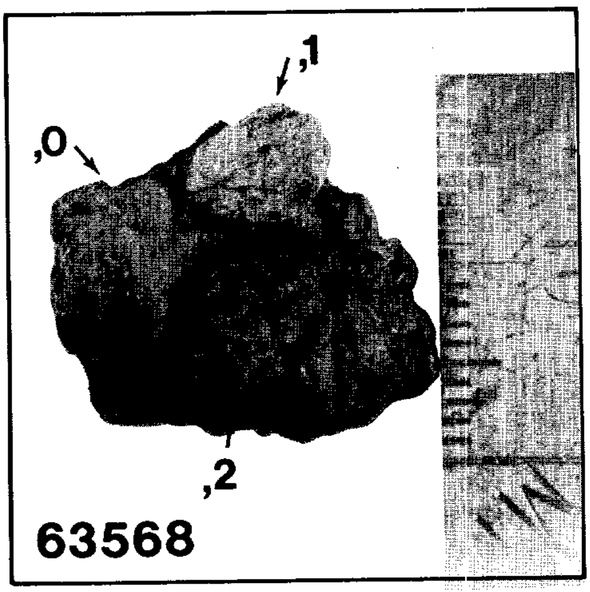
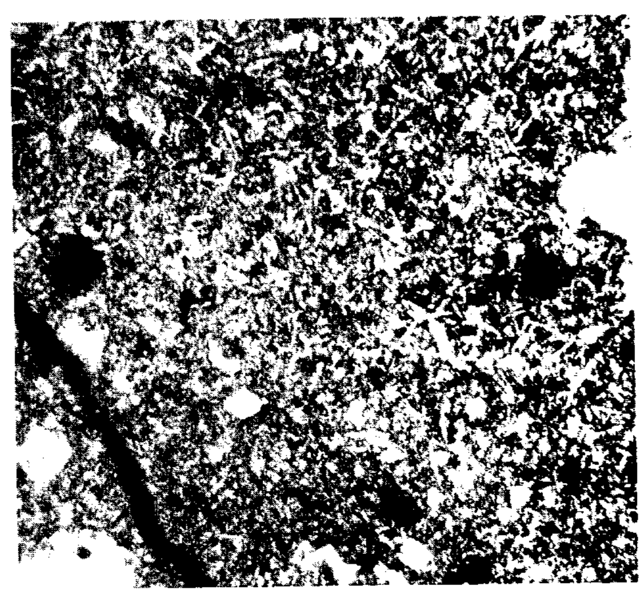



Figure 1. mm scale.

Figure 2. a) 63568,8, matrix, ppl. width 2mm. b) 63568,3, clast, ppl. width 2mm.

a

b



## 63569 DEVITRIFIED GLASS/GLASS-BONDED BRECCIA, WHITE CLASTS 0.43 g

INTRODUCTION: 63569 is a dark gray, coherent glass with white clasts (Fig. 1). The glass is mainly devitrified. It is a rake sample.

PETROLOGY: 63569 consists of a fragment-laden glass (Fig. 2) which is clear in places but mainly devitrified. The large white clast is a cataclastic anorthosite; at the clast-matrix boundary the glass contains little clastic material and is coarsely devitrified.

PROCESSING AND SUBDIVISIONS: A single chip (,1), mainly matrix but containing some white clast, was made into thin sections ,2 and ,3.

Figure 1. mm scale.

Figure 2. 63569,3 a) matrix, anorthosite clast, ppl. width 2mm. b) matrix, anorthosite clast, xpl. width 2mm.

INTRODUCTION: 63575 is essentially a glass coat on a white clast (Fig. 1). The glass is not devitrified. The clast is a fragmental breccia, probably a cataclastic anorthosite. 63575 is a rake sample.

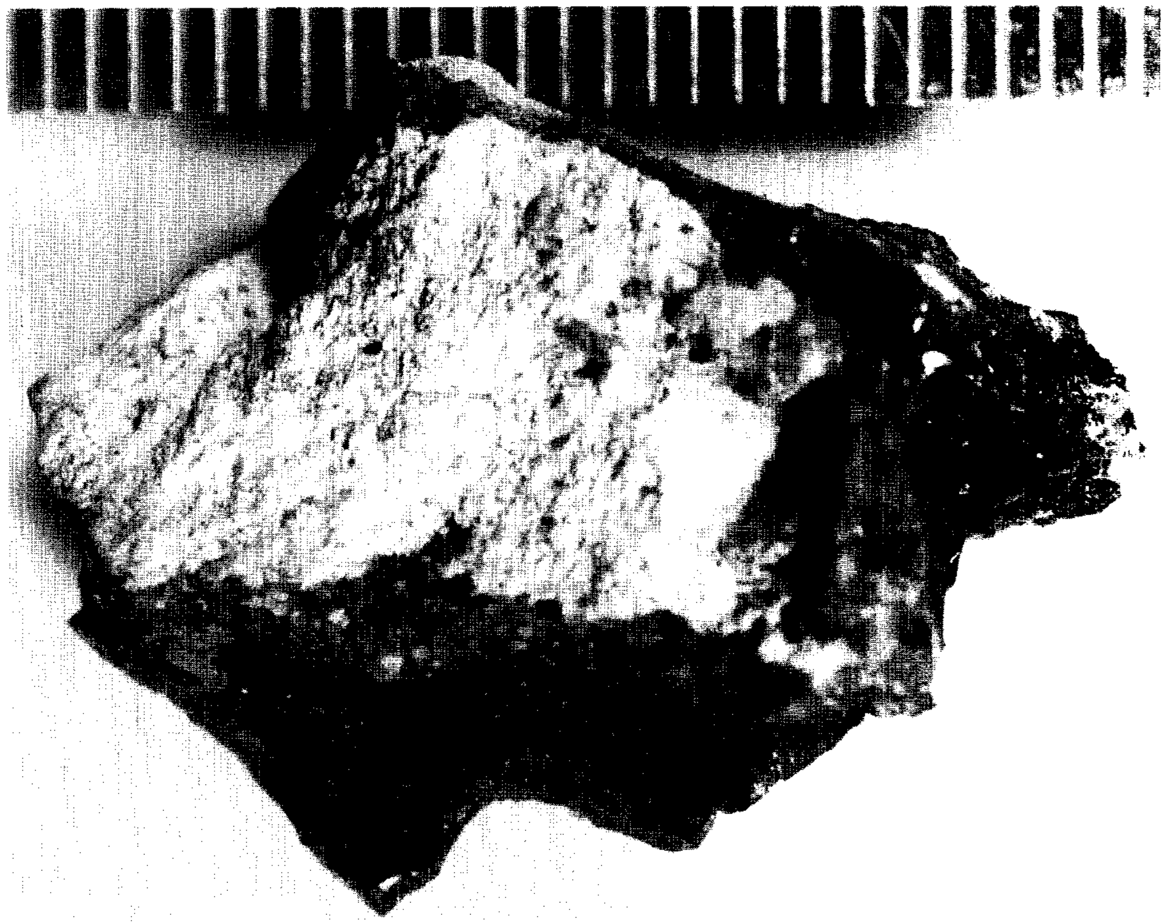


Figure 1. S-72-55384, mm scale.

PETROLOGY: Warner et al. (1973) classify 63575 as a glass cementing white clasts. It consists of a clear or gray banded glass which is devitrified only in 100 µm thick bands at clast margins (Fig. 2). The devitrification is spherulitic. The banding in the clear or gray glass is a consequence of variable concentrations of tiny metal spherules.

The clast is a fragmental breccia; a lithic relic 500 µm across suggests that it is a cataclastic anorthosite with pyroxene. At the margins of the clast it is invaded and bonded by the glass for a thickness of about 200 µm.

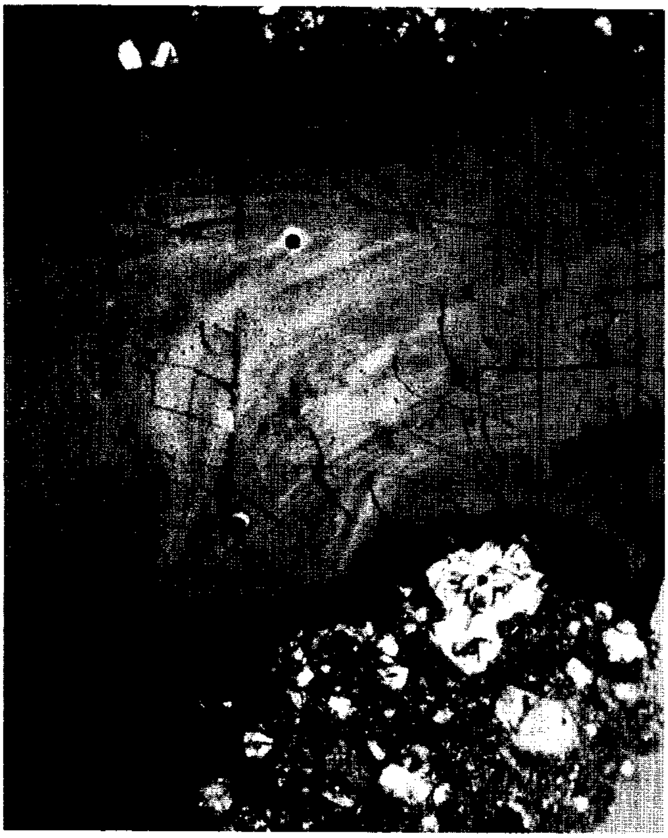


Figure 2. 63575,4, general view, ppl. width 2mm.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) tabulate magnetic parameters for 63575 as two separate splits or measurements, both listed as glasses. (However, their measurements were made on the potted butt sample which consisted of two chips, one the white clast, the other the clast and glass.) Both sets of measurements produce similar estimated $Fe^{o}$ contents (0.20 and 0.24 wt%). The ratio saturation remanence/saturation magnetization is given only for the second split and is 0.019.

PROCESSING AND SUBDIVISIONS: Two chips, one white clast and one white clast plus glass, were potted together and made into thin section ,4. The potted butt was used for the magnetic measurements.

INTRODUCTION: 63576 is a vesicular dark glass with white clasts (Fig. 1). It is a rake sample.

PETROLOGY: 63576 is a vesicular glass which is clear in patches but partly devitrified (Fig. 2). The white clast sampled is a plagioclase-rich breccia (Fig. 2) with unshocked, angular plagioclase fragments. The clast contains glass balls, chondules and brown glassy vesicular breccias, and is not porous but probably sintered or glass-bonded.

PROCESSING AND SUBDIVISIONS: Two chips, both consisting of glass and the white clast prominent to the left in Figure 1, were potted together as ,1 and thin sections ,3 and ,4 cut from them.

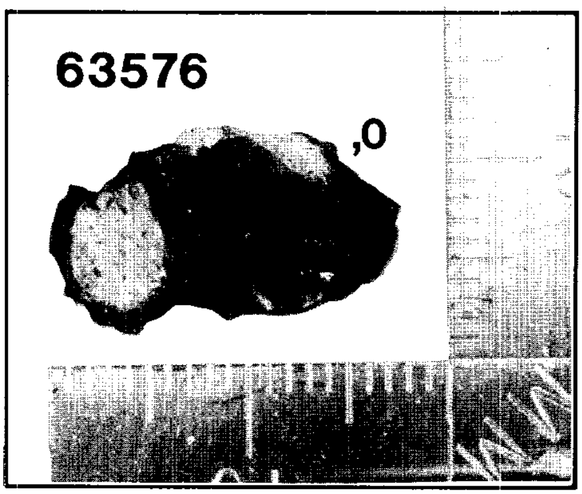



Figure 1. mm scale.

Figure 2. 63575,4, general view, ppl. width 2mm.

## 63577 CRYSTALLINE (?) POLYMICT BRECCIA 12.41 g

INTRODUCTION: 63577 is a medium gray, coherent polymict breccia (Fig. 1), much like a fragmental breccia but either melt-bonded or sintered. It is a rake sample.

PETROLOGY: 63577 superficially is similar to a fragmental breccia (Fig. 2) but is more coherent and is bonded or sintered with little pore-space. Patches of fine-grained melt or glass are visible in places. The clasts are angular and are mainly plagioclases including large shocked (and subsequently annealed) plagioclase. Lithic clasts include granoblastic and poikiloblastic impactites, basaltic impact melts, and brownish glass fragments.

PROCESSING AND SUBDIVISIONS: Four chips were potted together as ,1 and thin sections ,3 and ,4 cut from it.

Figure 1. mm scale.

Figure 2. 63577,3, general view, xpl. width 2mm.

INTRODUCTION: 63578 is a fine-grained, coherent polymict breccia (Fig. 1) which appears to be bonded with either glass or a fine-grained melt. It is angular with flat sides. It is a rake sample with zap pits.

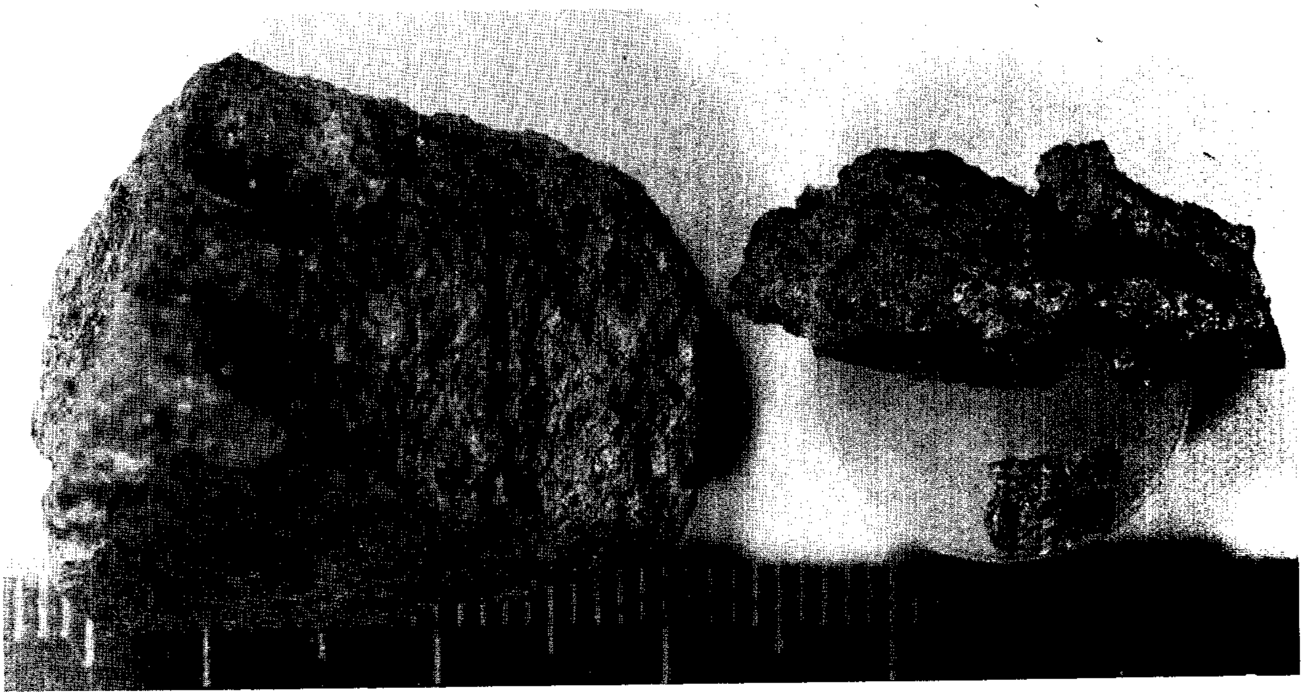


Figure 1. S-72-55400, mm scale.

PETROLOGY: Warner et al. (1973) classify 63578 as a slightly metamorphosed glassy breccia. It is a brownish, fine-grained polymict breccia with conspicuous mineral clasts, mainly plagioclase (Fig. 2). The matrix is heterogeneous with globular aggregates separated by pale-colored bands. Fine-grained melt or glassy material appears to bind the mineral fragments together.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report magnetic parameters for 63578, which they refer to as metamorphosed. The saturation remanence to saturation magnetization ratio is 0.0044. $Fe^{0}/Fe^{2+}$ is 0.0134 and total $Fe^{0}$ is 0.050 wt%.

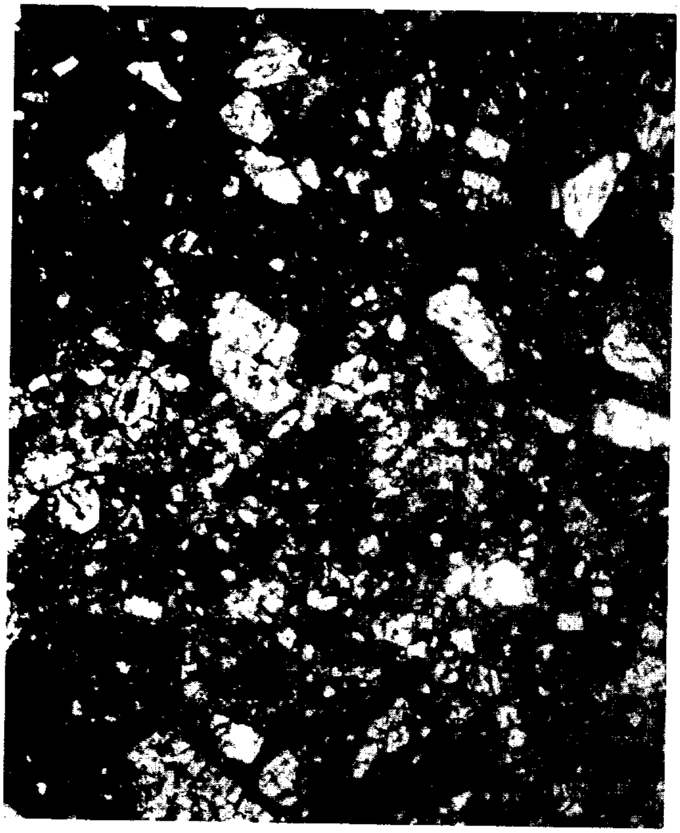


Figure 2. 63578,4, general view, xpl. width 2mm.

PROCESSING AND SUBDIVISIONS: Part of a representative chip (,1) was made into thin section ,4. Two chips (,3) shown in Figure 1 were allocated for chemical analysis. The magnetic studies were done on the potted butt of ,1.

## 63579 FINE-GRAINED IMPACT MELT 11.35 g

INTRODUCTION: 63579 is a coherent, tan-gray to white, fine-grained impact melt (Fig. 1). It is a rake sample.

PETROLOGY: 63579 is a fine-grained heterogeneous impact melt with abundant aligned plagioclase needles or laths 50-100 µm long (Fig. 2). It contains rounded plagioclase clasts, some of which are shocked. Most of the melt consists of stubby plagioclases and mafic minerals and it is difficult to distinguish tiny clasts from the melt.

PROCESSING AND SUBDIVISIONS: Five small matrix chips were potted together as ,1 and thin sections ,3 and ,4 cut from it.

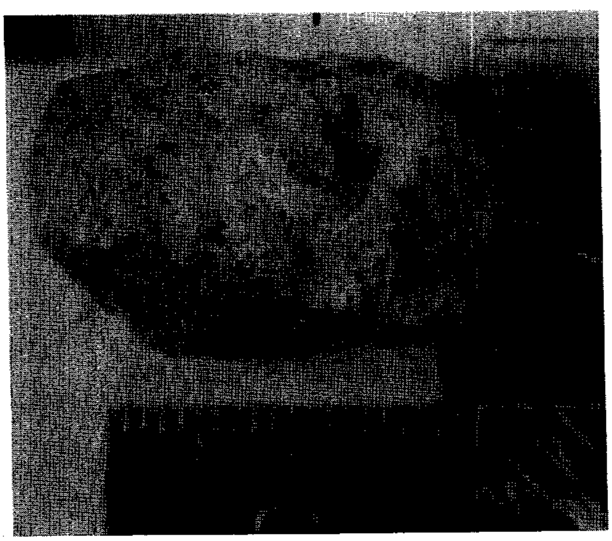


Figure 1. mm scale.

Figure 2. 63579,4, general view, ppl. width 2mm.

INTRODUCTION: 63585 is a medium gray, coherent but fractured rock (Fig. 1) which is an impact melt with a texture ranging from subophitic and intergranular to poikilitic. It is a rake sample with many zap pits.

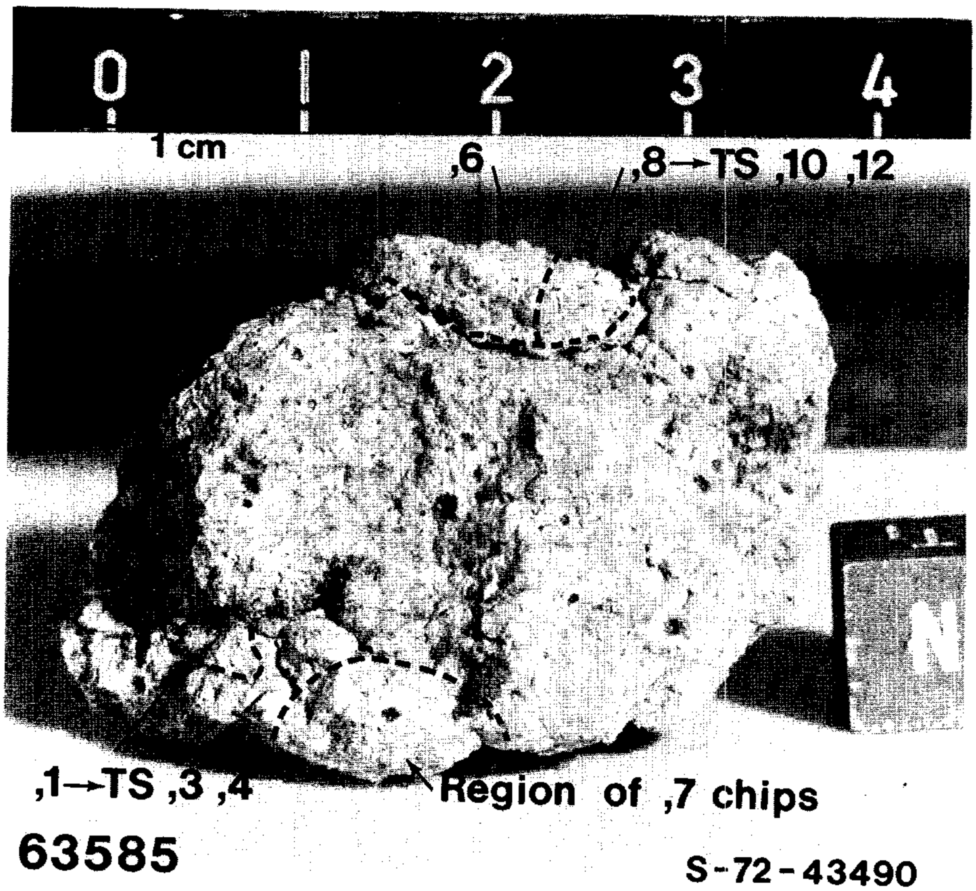



Figure 1.

PETROLOGY: Warner et al. (1973) classify 63585 as a mesostasis-rich basalt and provide microprobe data. In contrast, Englehardt (1979) classifies 63585 as a poikilitic melt. Thin sections from opposite sides of the rock (Fig. 1) are both impact melts but contrast in texture.

The area of ,1 is a fine-grained subophitic to intergranular impact melt with plagioclase laths 100-200 µm long (Fig. 2). The plagioclases are embedded in olivine, with interstitial pyroxenes and some mesostasis glass, ilmenite and tridymite (?). Analyses of mafic minerals by Warner et al. (1973) are shown in Figure 3. Clasts of plagioclase, some shocked, are present. The melt is cut by glass-filled shear zones, along which plagioclase in the melt has been converted to maskelynite. In contrast, the area of ,8 is a fine-grained poikilitic impact melt (Fig. 2) with 50-100 µm oikocrysts of mafic minerals enclosing numerous plagioclase crystals. Interoikocryst areas contain ilmenite. The melt contains plagioclase clasts.

a b

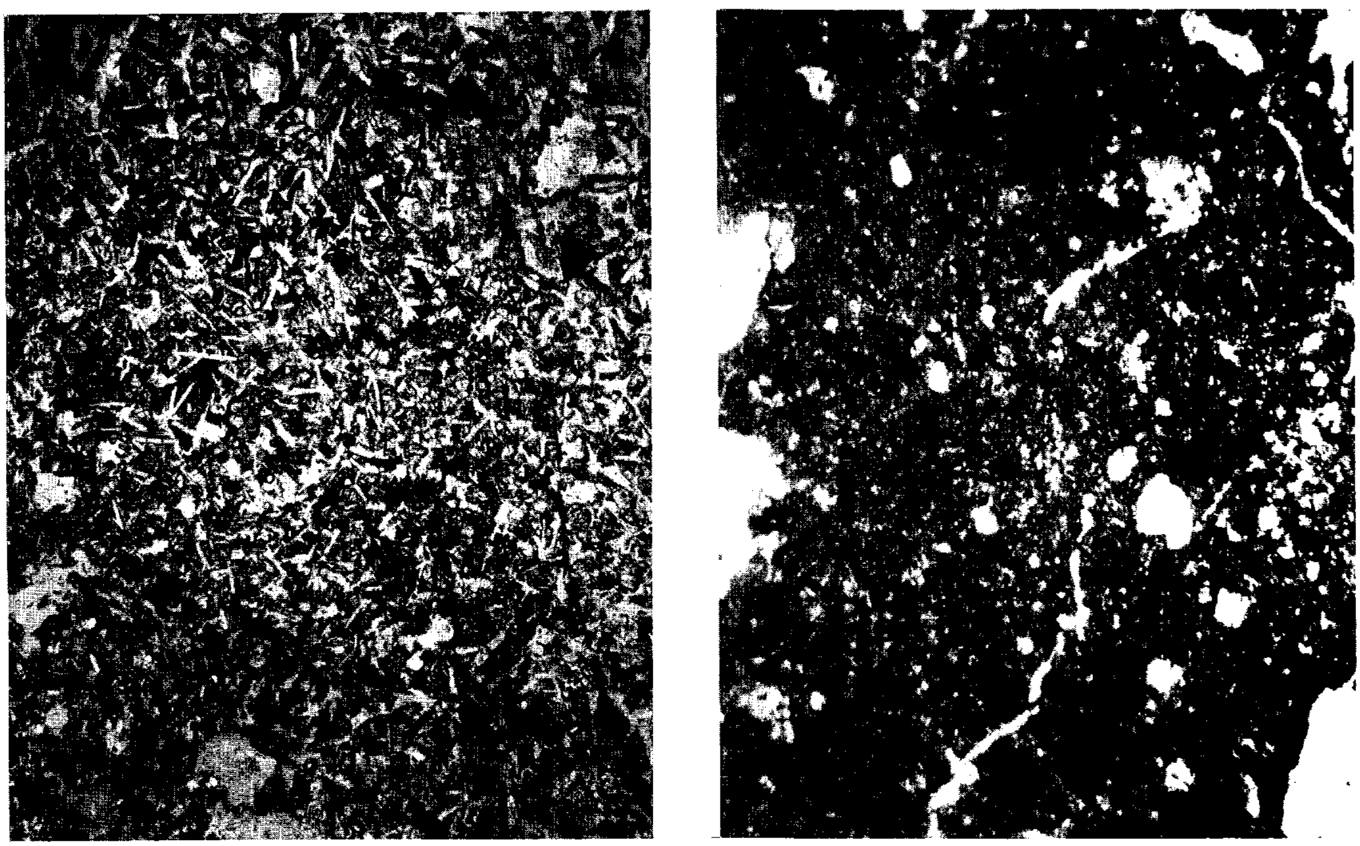


Figure 2. a) 63585,4, basaltic area, ppl. width 2mm.
b) 63585,10, poikilitic area, ppl. width 2mm.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report magnetic parameters for the potted butt of the basaltic portion (,1) of 63585. The ratio of saturation remanence/saturation magnetization is 0.0029. $Fe^0/Fe^{2+}$ is 0.0800 and total $Fe^0$ is 0.40 wt%.

PROCESSING AND SUBDIVISIONS: Several chips have been removed from 63585, mainly shown in Figure 1. Thin sections were made from ,1 (which was also used for magnetic measurements) and ,8. ,6 was allocated for rare gas studies and ,7 (numerous small chips) for chemical analysis.

INTRODUCTION: 63586 is a medium gray, heterogeneous, coherent rock (Fig. 1) which is a fine-grained impact melt. It is a rake sample and has many zap pits.

PETROLOGY: 63586 consists of rounded plagioclase clasts (some embayed) in a fine-grained impact melt (Fig. 2). The melt contains some ilmenite and plagioclase laths and is more mafic than the clast population, which has a seriate size distribution. Some of the clasts are flame-textured, one being a mosaic of grains with such textures. The pale-colored zones (Fig. 1) are schlieren of plagioclase-rich breccias.

PROCESSING AND SUBDIVISIONS: Of two chips (Fig. 1) ,1 was used to make thin sections ,4 and ,5.

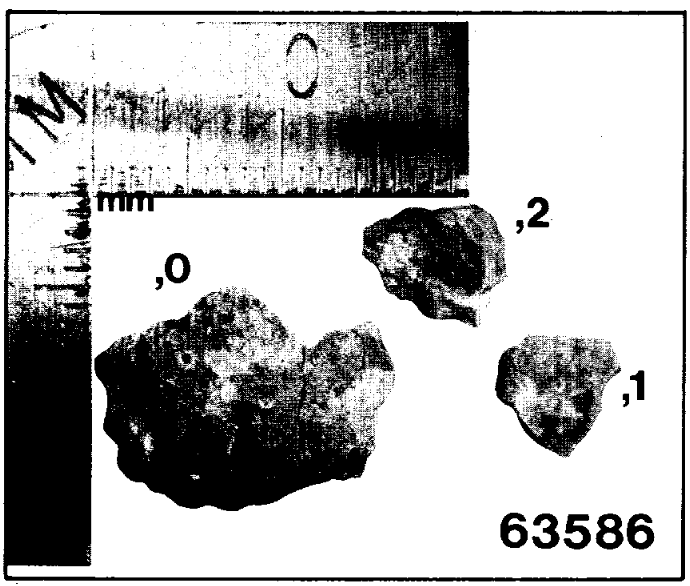



Figure 1.

Figure 2. 63586,4, general view, ppl. width 2mm.

INTRODUCTION: 63587 is a medium gray, vesicular and coherent rock (Fig. 1). It is a fine-grained impact melt with a poikilitic texture and numerous clasts. It is a rake sample and has many zap pits.

PETROLOGY: 63587 is a vesicular impact melt with abundant mineral and lithic clasts (Fig. 2). The melt consists of 200-300 μm oikocrysts (pigeonite ?, some augite) enclosing plagioclase crystals, with interoikocryst areas containing angular and lathy ilmenites. Fe-metal and troilite are also present.

Most of the clasts are plagioclases, some quite shocked. There is a wide variety of lithic clasts including cataclastic anorthosite, granoblastic feldspathic impactites, basaltic impact melts, and granoblastic dunite (one fragment, ~250 μm diameter).

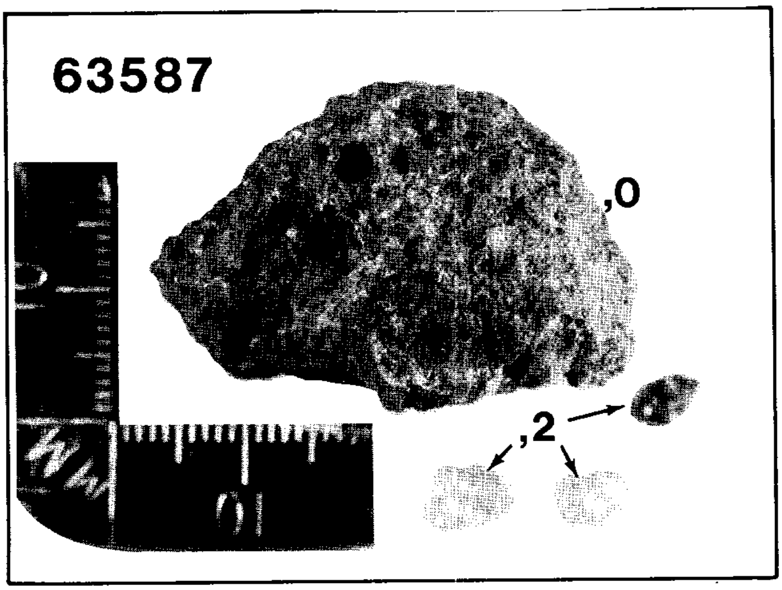



Figure 1. mm scale.

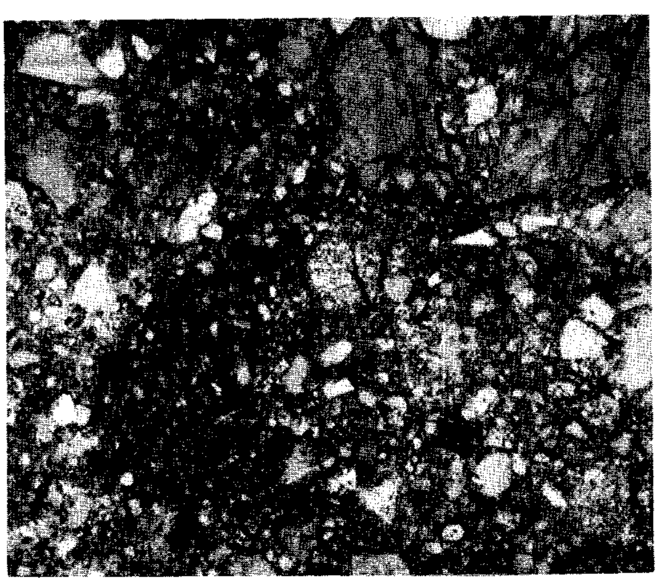


Figure 2. 63587,4, general view, ppl. width 2mm.

PROCESSING AND SUBDIVISIONS: Three matrix chips (,2; Fig. 1) were potted together and thin sections ,4 and ,5 cut from them.

INTRODUCTION: 63588 is a pale gray, moderately friable polymict breccia (Fig. 1) which is fragmental but partly bonded by fine-grained or glassy material. It is a rake sample with zap pits.

PETROLOGY: 63588 consists of angular mineral and lithic fragments (Fig. 2) bonded by sintering or fine-grained/glassy material. The clasts include brown-glass bearing fragments, chondrule-like spherules, glassy polymict breccias and poikiloblastic feldspathic impactites.

PROCESSING AND SUBDIVISIONS: Splits are shown in Figure 1. The two chips ,1 were potted together and thin sections ,4 and ,5 cut from them. Chip ,2 has a glass-lined crater.

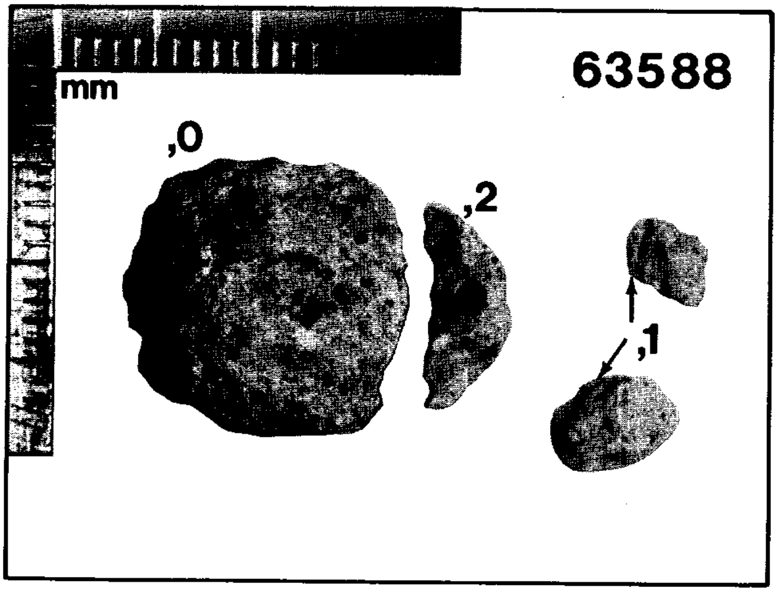



Figure 1.

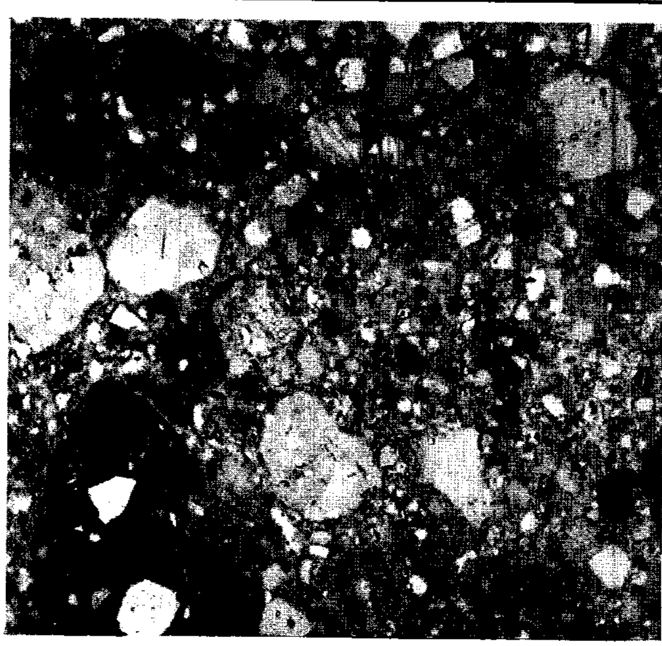


Figure 2. 63588,4, general view, ppl. width 2mm.

## 63589 FRAGMENTAL (?) POLYMICT BRECCIA 13.51 g

INTRODUCTION: 63589 is a pale gray, moderately friable, fine-grained polymict breccia (Fig. 1). The only thin section suggests that it is fragmental but it might be glass-bonded. It is a rake sample with some zap pits.

Figure 1. S-72-55398, mm scale.

PETROLOGY: Warner *et al.* (1973) classify 63589 as a glassy breccia, in which category it is deemed to have ~50% glass matrix. In contrast, Floran *et al.* (1976) classify it as a dark matrix breccia, a category whose members they state have little if any glass. The only thin section is of poor quality. Its matrix consists of angular fragments, mainly of plagioclase (Fig. 2). It appears to be fragmental, but its brown color and a few fine-grained patches suggest that it might be glass-bonded.

Figure 2. 63589,4, general view, ppl. width 2mm.

CHEMISTRY: The summary chemistry (Table 1 and Fig. 3) is taken from the major element analysis reported by Floran et al. (1976) and the trace element analysis of Blanchard (unpublished). The high alumina, low incompatible element, and low (though clearly meteorite-contaminated) siderophile abundances are similar to many of the Station 11 fragmental breccias.

PROCESSING AND SUBDIVISIONS: Two adjacent chips were separated (Fig. 1). The smaller is ,1, from which thin section ,4 was made; the larger is ,3, allocated for chemical analyses.

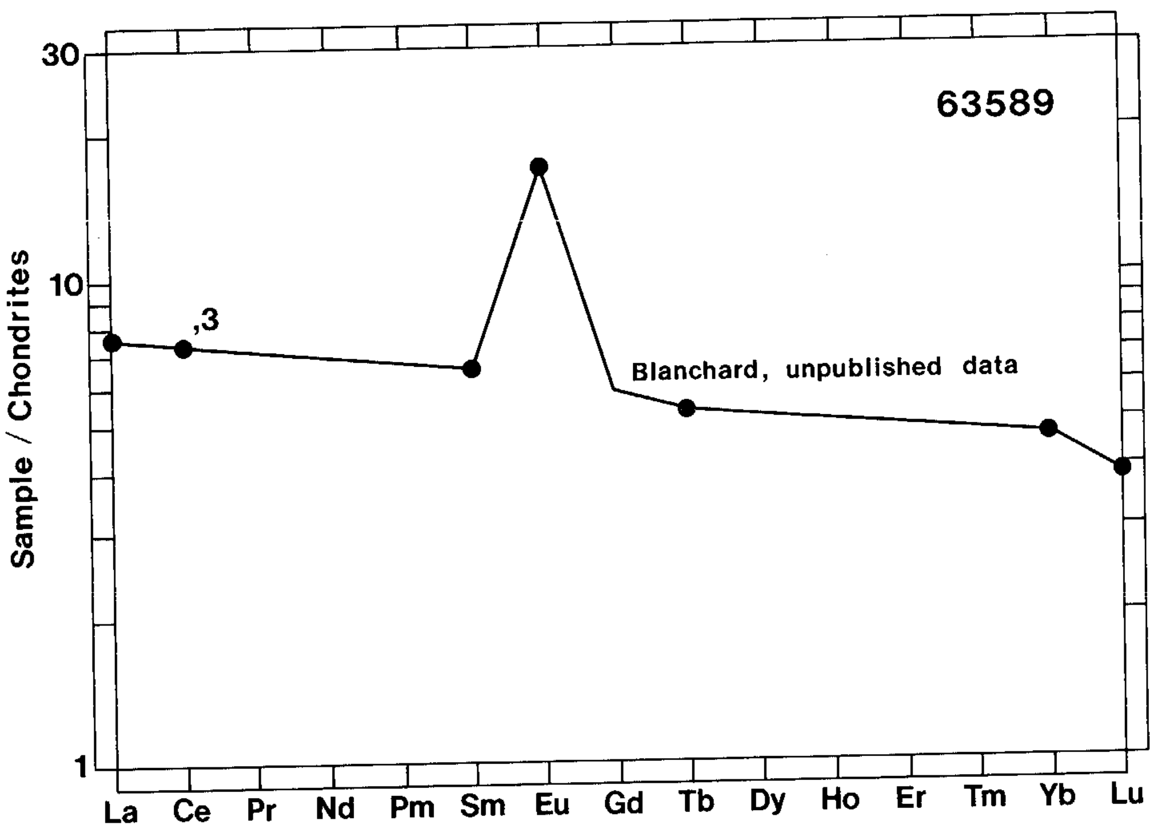



Figure 3. Rare earths.

TABLE 1. Summary chemistry of 63589

| | | |
|---|---|---|
| $SiO_2$ | | 45.2 |
| $TiO_2$ | | 0.30 |
| $Al_2O_3$ | | 30.7 |
| $Cr_2O_3$ | | 0.05 |
| FeO | | 2.8 |
| MnO | | |
| MgO | | 2.7 |
| CaO | | 17.4 |
| $Na_2O$ | | 0.59 |
| $K_2O$ | | 0.07 |
| $P_2O_5$ | | |
| Sr | | |
| La | | 2.47 |
| Lu | | 0.131 |
| Rb | | |
| Sc | | 5.6 |
| Ni | | 42 |
| Co | | 8.3 |
| Ir | ppb | |
| Au | ppb | |
| C | | |
| N | | |
| S | | |
| Zn | | |
| Cu | | |

Oxides in wt%; others in ppm except as noted.

## 63595 FRAGMENTAL POLYMICT BRECCIA 2.10 g

INTRODUCTION: 63595 is a pale gray, moderately friable polymict breccia (Fig.1) with a fragmental or lightly sintered matrix. It is a rake sample with some zap pits.

PETROLOGY: 63595 is a fragmental breccia containing angular clasts of plagioclase, brown glassy breccia, aphanitic melt breccias, and feldspathic granulites (Fig. 2). Phinney et al. (1976) from an SEM study showed that the matrix has ~35% porosity, with 2-3% matrix glass as filaments holding grains together (see their Fig. 1F). Most of the matrix is angular to subangular grains less than 10 µm in diameter

PROCESSING AND SUBDIVISIONS: Thin sections ,3 and ,4 were made from a typical matrix chip (,1; Fig. 1).

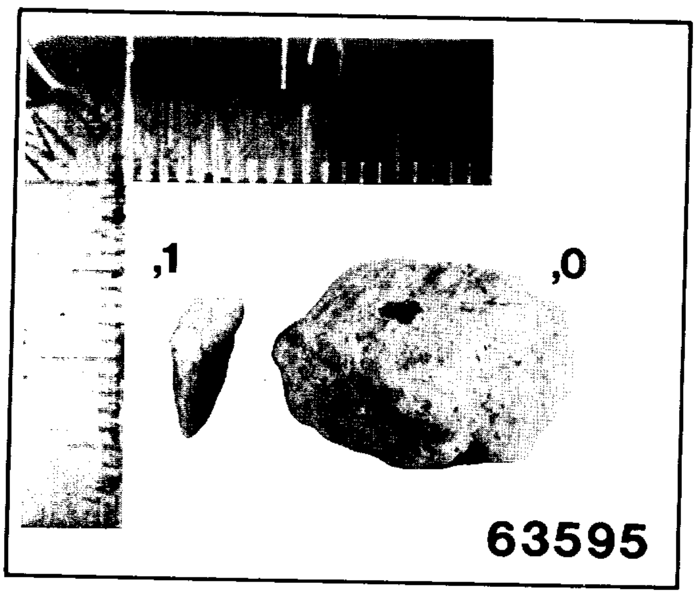



Figure 1. mm scale.

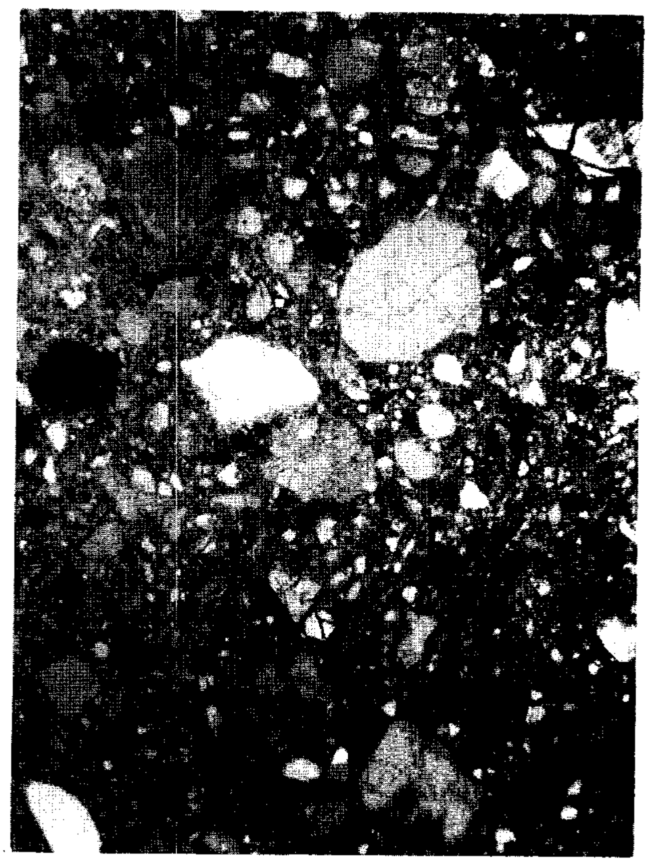


Figure 2. 63595,4, general view, ppl. width 2mm.

INTRODUCTION: 63596 is a porous, coherent gray rock (Fig. 1) which is an impact melt with a fine-grained poikilitic texture. It is a rake sample with a few zap pits.

PETROLOGY: 63596 is an extremely vesicular and fine-grained poikilitic impact melt (Fig. 2). Small (∿50 μm) oikocrysts of pyroxene (pigeonite ?) enclose plagioclase crystals. Interoikocryst areas contain ilmenite with exsolved rutile. The melt contains numerous clasts most of which are plagioclase but one clast of granoblastic feldspathic impactite is present in thin section ,4.

PROCESSING AND SUBDIVISIONS: Two small chips (,1) were potted together and made into thin sections ,3 - ,5.

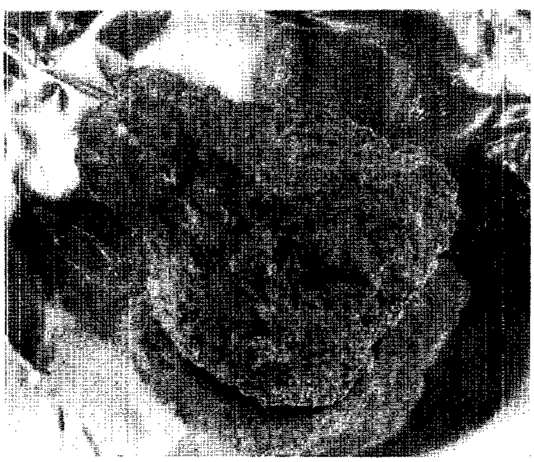


Figure 1. S-72-42082.

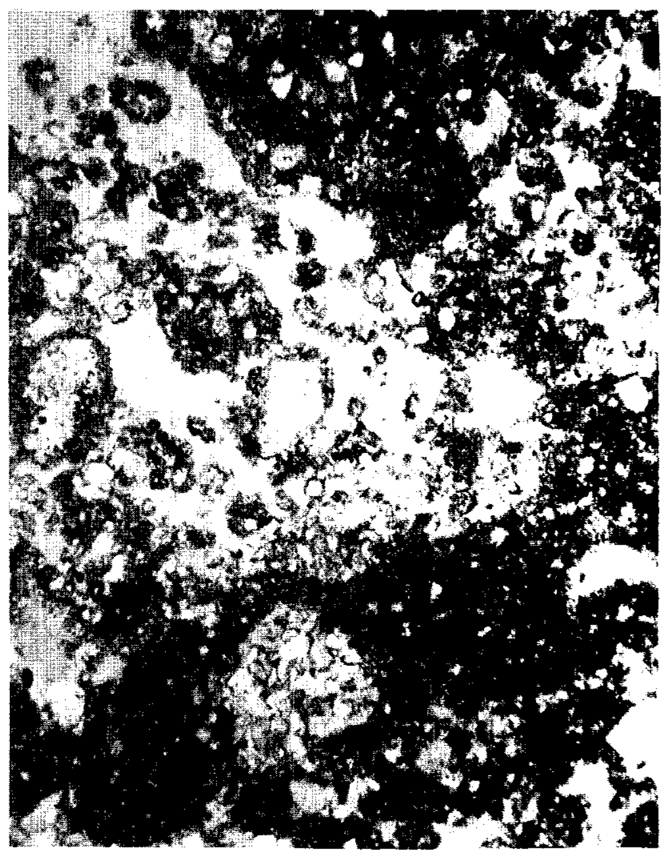


Figure 2. 63596,4, general view, ppl. width 2mm.

## 63597 VESICULAR POIKILITIC IMPACT MELT 5.67 g

INTRODUCTION: 63597 is a porous, coherent, gray poikilitic impact melt (Fig.1). It is a rake sample with a few zap pits.

PETROLOGY: 63597 is an extremely vesicular poikilitic impact melt (Fig.2). Mafic oikocrysts (∿300 µm diameter) enclose plagioclase crystals which are extremely elongate compared with the stubby crystals in most poikilitic impact melts. The texture is fairly variable from place to place. Abundant fragments of plagioclase and some lithic fragments are present.

PROCESSING AND SUBDIVISIONS: Thin sections ,3 and ,4 were cut from a single respresentative chip.

Figure 1. S-72-42082.

Figure 2. 63597,4, general view, ppl. width 2mm.

INTRODUCTION: 63598 is a porous, coherent, gray impact melt (Fig. 1) with a fine-grained poikilitic to subophitic texture. It is a rake sample with a few zap pits.

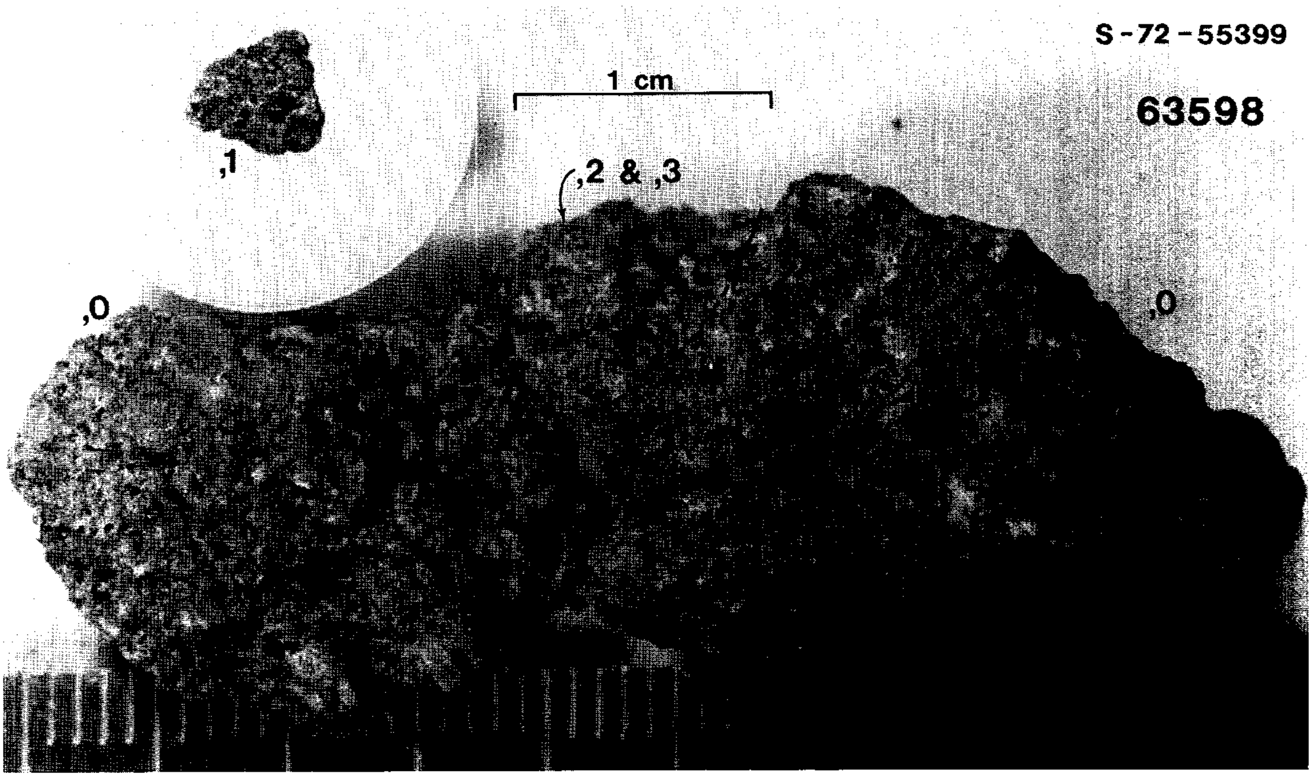



Figure 1.

PETROLOGY: Warner et al. (1973) classify 63598 as a micro-norite type mafic basalt and provide microprobe data. Floran et al. (1976) classify it generally as an impact melt, and specifically as a microcrystalline matrix breccia.

63598 is an extremely vesicular impact melt with a dominantly poikilitic texture (Fig. 2) which in places grades into a subophitic texture. Pyroxene oikocrysts are ~100 μm in diameter (although Warner et al., 1973, state that pyroxene occurs as 20 x 30 μm prisms) which enclose smaller plagioclase crystals. Pyroxene and olivine analyses from Warner et al. (1973) are shown in Figure 3. Unlike most of the basaltic impact melt samples, and like poikilitic melt samples, pyroxene analyses do not form a continuum from low-Ca to high-Ca varieties. Fe-metal and ilmenite laths (with exsolved rutile and chromite (?)) are present. Most clasts are plagioclase, but olivine (Fig. 3) and lithic relics are present.

Figure 2. 63598,4, general view, ppl. width 2mm.

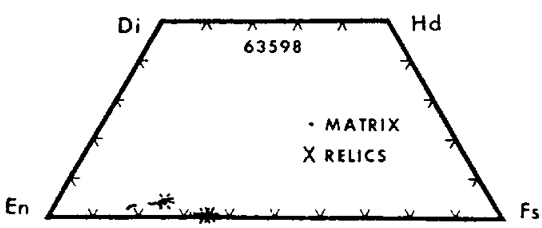



Figure 3. Mafic mineral compositions, olivine plotted along base, from Warner et al. (1973).

CHEMISTRY: The summary chemistry presented in Table 1 and Figure 4 is taken from the major element analysis by Floran et al. (1976) and trace element analyses by Blanchard (unpublished). The sample is clearly meteorite contaminated.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) present magnetic parameters measured on the potted butt from ,1. The ratio of saturation remanence/saturation magnetization is 0.002. $Fe^0/Fe^{2+}$ is 0.100 and total $Fe^0$ is 0.57 wt%.

PROCESSING AND SUBDIVISIONS: The main splits are shown on Figure 1. ,1 was used to make thin sections ,6 and ,7. The chemical analyses were made on chip ,2.

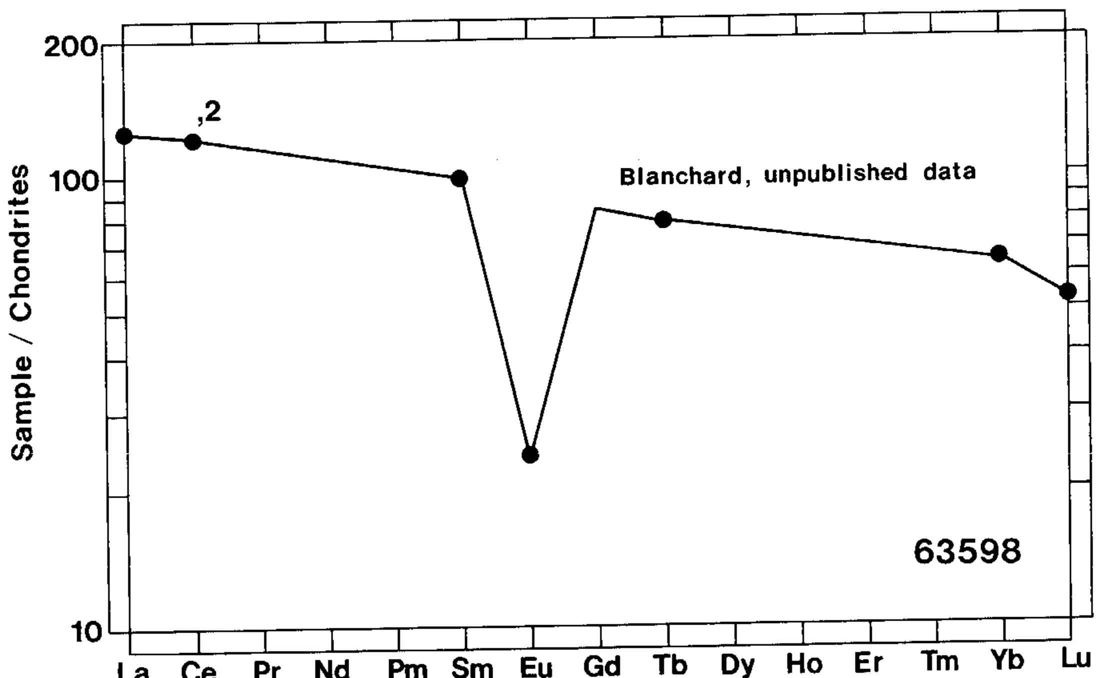



Figure 4. Rare earths.

TABLE 1. Summary chemistry of 63598

| | |
|---|---|
| $SiO_2$ | 47.0 |
| $TiO_2$ | 0.93 |
| $Al_2O_3$ | 22.5 |
| $Cr_2O_3$ | 0.14 |
| FeO | 7.1 |
| MnO | |
| MgO | 8.1 |
| CaO | 13.3 |
| $Na_2O$ | 0.57 |
| $K_2O$ | 0.31 |
| $P_2O_5$ | |
| Sr | |
| La | 41.7 |
| Lu | 1.79 |
| Rb | |
| Sc | |
| Ni | 530 |
| Co | 36.7 |
| Ir ppb | |
| Au ppb | |
| C | |
| N | |
| S | |
| Zn | 30 |
| Cu | |

Oxides in wt%; others in ppm except as noted

INTRODUCTION: 64425 is a coherent rock, apparently composed of distinct gray and white lithologies (Fig. 1). The contacts between the two lithologies are very irregular and no clast/matrix relations can be determined macroscopically. By analogy with other Station 4 dilithologic breccias (e.g., 64535-6-7), the dark material in 64425 is probably a clast-laden impact melt and the light material is brecciated anorthosite. Metal is present in both of the lithologies and a single grain of spinel (?) was observed in one of the patches of dark material (Apollo 16 Lunar Sample Information Catalog, 1972). This rock was taken from a soil sample. Zap pits are abundant on the B surface, rare on others.

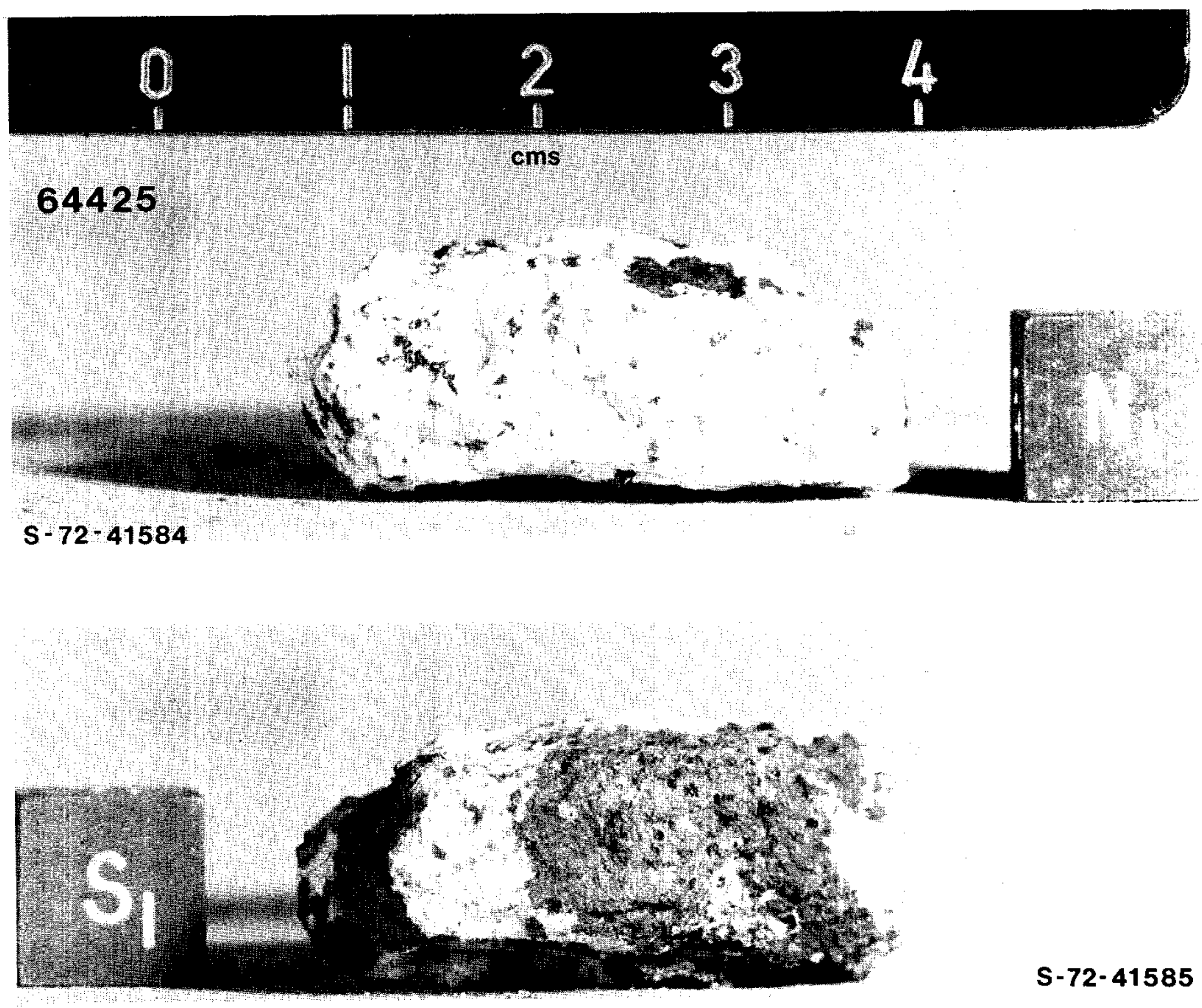



Figure 1.

INTRODUCTION: 64435 is a coherent, very light gray, heterogeneous impact melt that contains abundant clasts of pristine ferroan anorthosite (Fig. 1). A glass coat is present on the surface of the rock, which was partly buried in the lunar regolith. These protected surfaces are devoid of zap pits whereas the surfaces that were exposed on the Moon have many zap pits. The sample was collected from the northeast wall of a small, subdued crater on the northeast side of Stone Mountain. The lunar orientation is known.

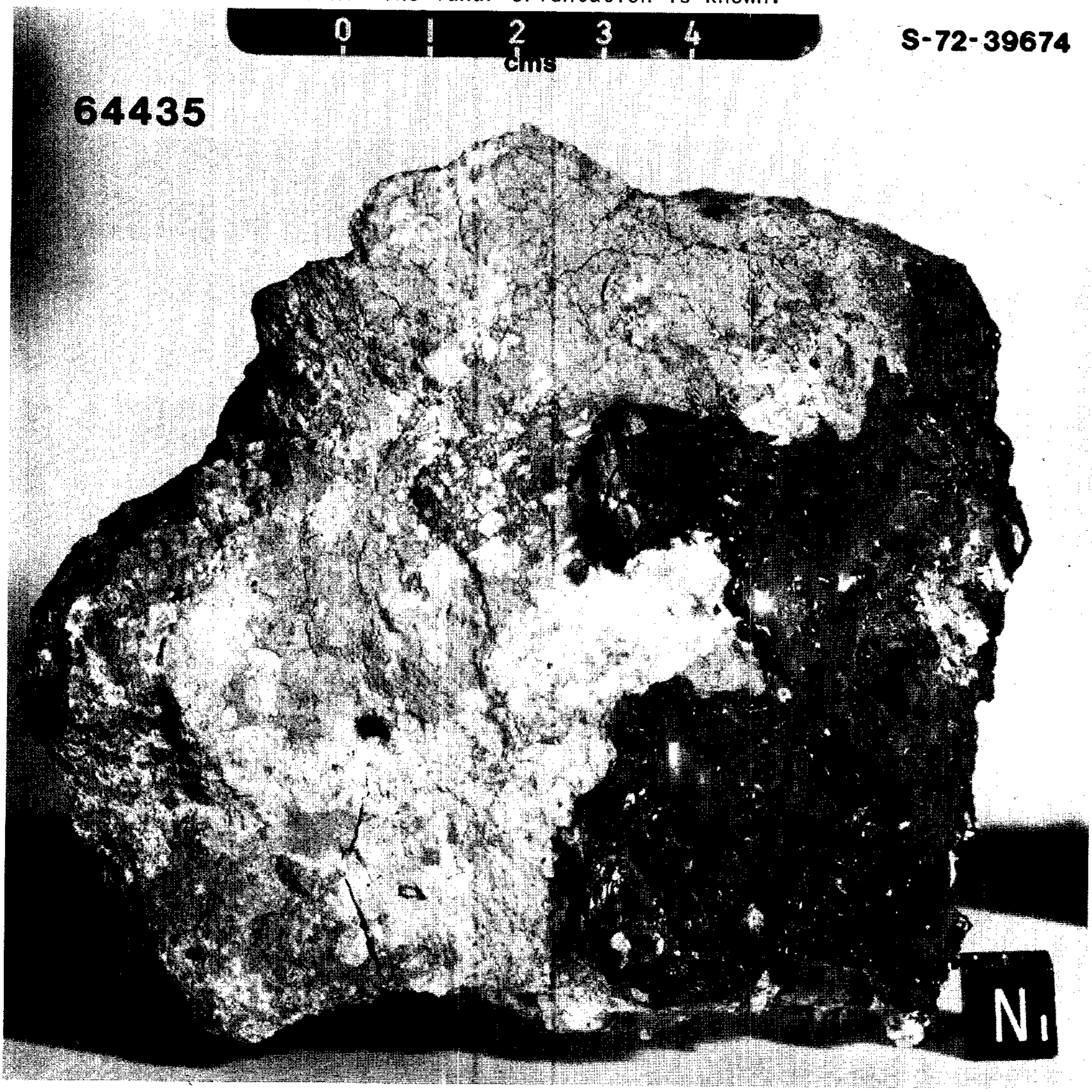



Figure 1.

PETROLOGY: 64435 consists of three main lithologies: 1) a light gray matrix of heterogeneous, plagioclase-rich impact melt, 2) anorthosite clasts and 3) a partial coating of dark glass. The Apollo 16 Lunar Sample Information Catalog (1972) and Mason (unpublished data pack information) provide petrographic descriptions.

The light gray matrix accounts for ∿ 80% of the rock and is somewhat variable in texture, often with sharp contacts between the different textures. Portions of the matrix have subhedral laths of plagioclase ($An_{95-100}$, up to ∿ 0.5 mm) suspended in a very fine-grained, clast-rich melt (Fig.2). Most of the laths and clasts have fine-grained reaction rims with the matrix. A flow alignment is often obvious. Shock effects range from moderate in the clasts to absent in the laths. Other portions of the gray matrix are more clastic with anhedral, lightly to moderately shocked clasts of plagioclase, pyroxene,and minor olivine, cemented together by a small amount of interstitial mesostasis. Very small (< 5 μm) mafics and opaques with a melt texture are concentrated in these interstices. Still other portions of the gray matrix have a variolitic to basaltic texture. Angular clasts of basaltic impact melt, metal, troilite, ilmenite and ulvöspinel (?) are inhomogeneously distributed throughout the rock. A few small brown glass veins also cut the matrix.

The anorthosite clasts consist of ∿ 98% plagioclase ($An_{95-100}$) with minor pyroxene, olivine and metal (Fig.2). Pre-cataclasis grain size was > 0.5 mm. A single grain of augite had the composition $Wo_{44}$ $En_{36}$ (Mason, unpublished), similar to those in other ferroan anorthosites. Hewins and Goldstein (1975a) find the metal in the anorthosite clasts to have Co too high to be of meteoritic origin (Fig.3) and compositionally similar to the metal in pristine anorthosite 60015. No maskelynite was observed in any of the anorthosite clasts.

The dark glass coating is present only on the surface of the rock that was buried on the lunar surface. It is somewhat vesicular and clast-rich near the rock-glass contact. Away from the rock the glass is isotropic, showing no signs of devitrification. Metal in the glass contains ∿ 30% Ni (Cisowski et al., 1976).

CHEMISTRY: Laul et al. (1974) provide major and trace element analyses of an anorthosite chip, the gray matrix and the glass coat. Major and trace element data on the matrix are also given by Hubbard et al. (1974) and S.R. Taylor et al. (1974). Mason (unpublished data pack information) determined major elements on a chip of matrix fused to a glass and on fragments of the glass coat,by electron microprobe. Moore et al. (1973), Cripe and Moore (1974) and Moore and Lewis (1976) report total C,N and S on a matrix chip. Nunes et al. (1974, 1977) provide U-Th-Pb data on the matrix.

The gray matrix is aluminous (Table 1) with its rare earths and other trace elements dominated by a small amount of KREEP (Fig. 4). A chip from the large area of anorthosite on the W surface of the rock is nearly pure plagioclase (Table 1) and has rare earth element abundances similar to other pristine anorthosites (Fig. 4). The lack of KREEP contamination and the low levels of siderophiles (Co 1.3 ppm) indicate that the anorthosite portion of this rock is chemically pristine. The glass coat is significantly different in both major and trace elements from the rest of 64435 and from the local soils. It is highly enriched in siderophiles and contains a significant KREEP component (Table 1, Fig. 4).

a

b

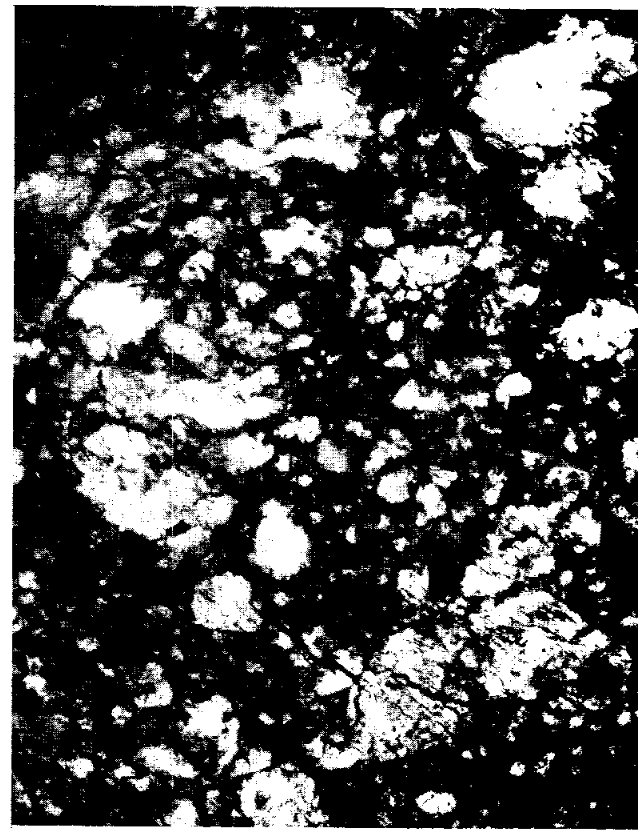
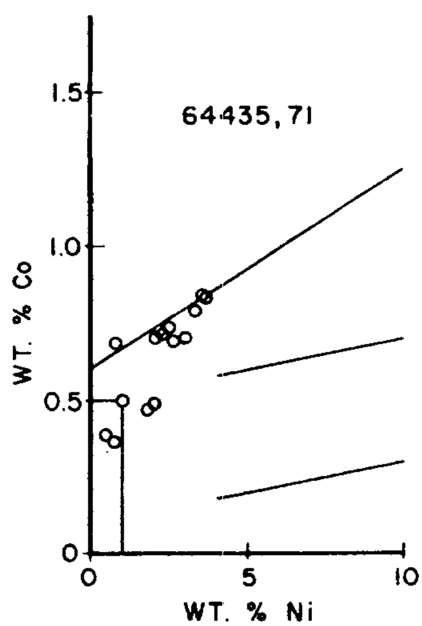


Figure 2. a) 64435,8, matrix, ppl. width 2mm.
b) 64435,73, anorthosite clast, ppl. width 2mm.

Figure 3. Metals in anorthosite clasts, from Hewins and Goldstein (1975a).



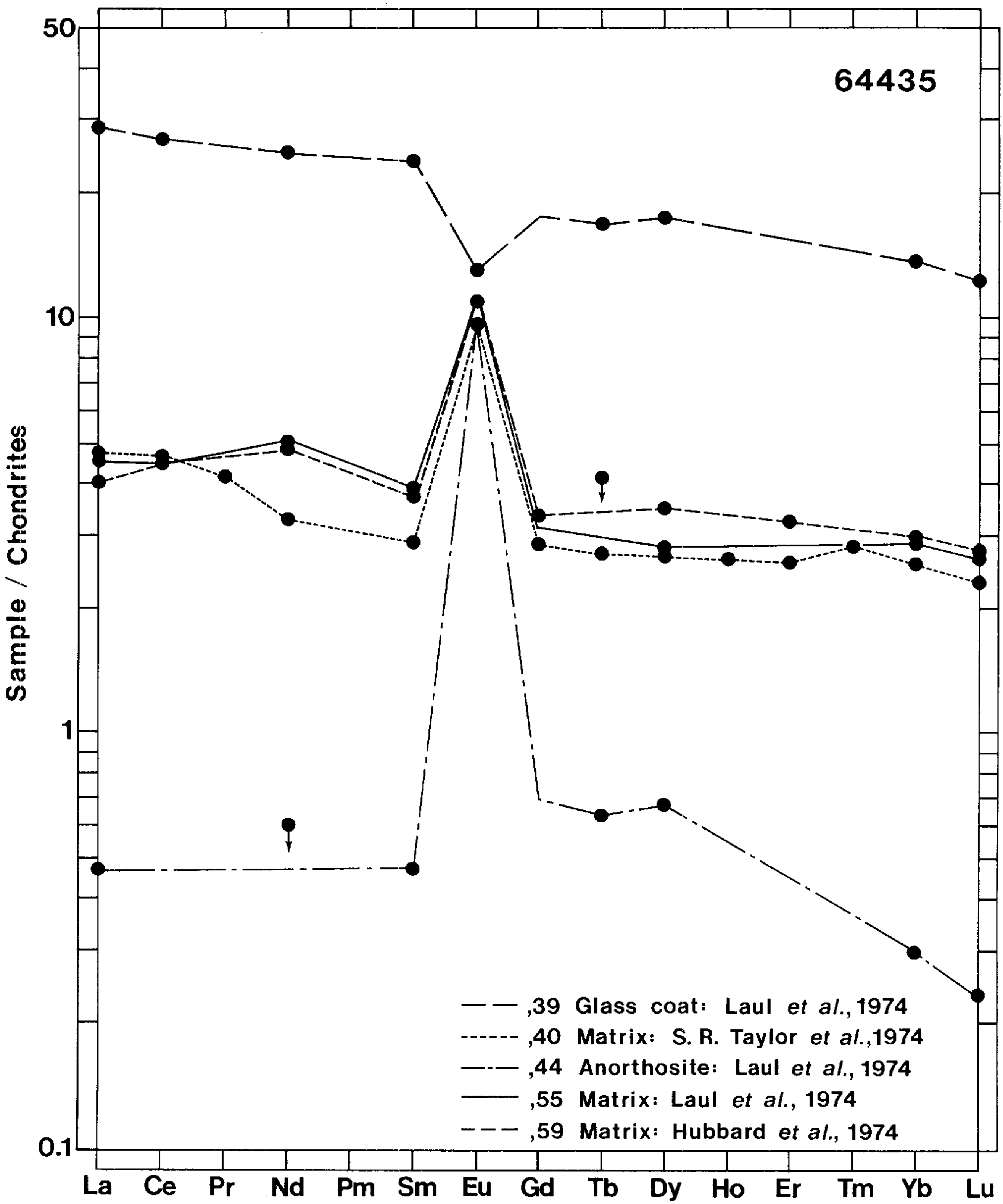



Figure 4. Rare earths.

TABLE 1. Summary chemistry of 64435 lithologies

| | Matrix | Anorthosite clasts | Glass coat |
|---|---|---|---|
| $SiO_2$ | 44.5 | | |
| $TiO_2$ | 0.19 | <0.1 | 0.5 |
| $Al_2O_3$ | 31.1 | 35.5 | 24.5 |
| $Cr_2O_3$ | 0.069 | 0.0083 | 0.170 |
| FeO | 3.18 | 0.61 | 8.0 |
| MnO | 0.04 | 0.011 | 0.105 |
| MgO | 3.3 | | 8.0 |
| CaO | 17.3 | 19.0 | 13.3 |
| $Na_2O$ | 0.34 | 0.29 | 0.55 |
| $K_2O$ | 0.025 | 0.025 | 0.086 |
| $P_2O_5$ | 0.03 | | |
| Sr | 154 | | |
| La | 1.5 | 0.16 | 9.6 |
| Lu | 0.08 | 0.008 | 0.43 |
| Rb | 0.5 | | |
| Sc | 6 | 0.9 | 6.9 |
| Ni | 56 | | 1800 |
| Co | 17 | 1.3 | 100 |
| Ir ppb | | | 50 |
| Au ppb | | | 30 |
| C | 46 | | |
| N | 56 | | |
| S | 330 | | |
| Zn | | | |
| Cu | | | |

oxides in wt%; others in ppm except as noted.

From light gas ($H_2O$, $CO_2$, $N_2$, $CO$, $SO_2$) releases at different temperatures, Gibson and Moore (1975) find evidence for possible carbonate phases in the matrix (Fig. 5). An anorthosite clast does not contain these possibly carbonate phases. Gibson and Andrawes (1978) find that nitrogen and a trace of methane are the only gases given off when chips of matrix and of an anorthosite clast are crushed under 25 tons of pressure.

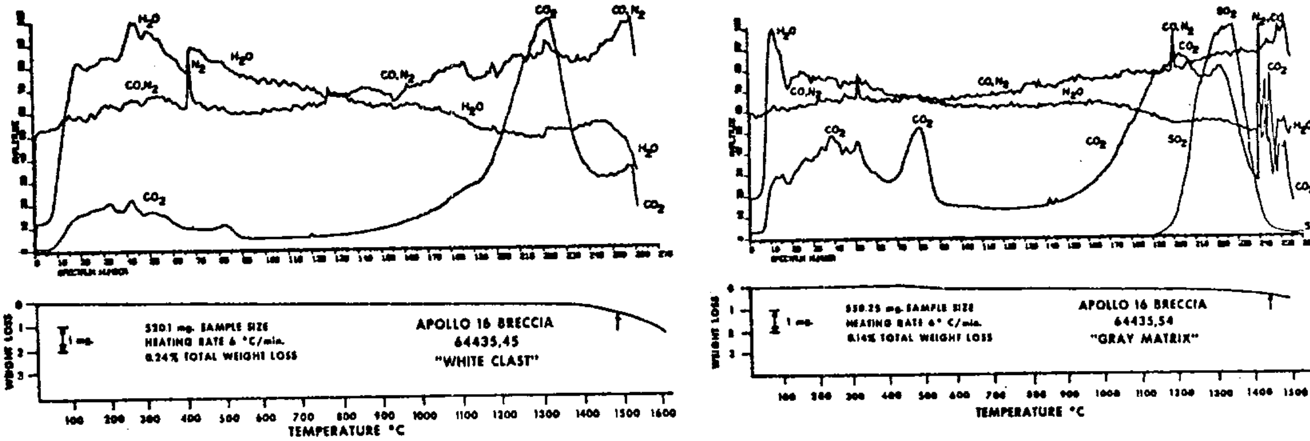



Figure 5. Gas release profiles, from Gibson and Moore (1975).

RADIOGENIC ISOTOPES AND GEOCHRONOLOGY: Nunes et al. (1974, 1977) and Rosholt (1974) provide U-Th-Pb isotopic data on the gray matrix. This lithology contains excess Pb relative to U which is isotopically very similar to, but much less abundant than, the Pb in 66095. The excess Pb is characterized by a high $^{207}Pb/^{206}Pb$ ratio (1.25) and was apparently produced in a U-rich reservoir very early in lunar history. A two-stage model age of 3.73-4.0 b.y. for the introduction of the excess Pb into the rock and a three-stage model age of 4.42 to 4.65 b.y. for the production of the U-rich reservoir were calculated by Nunes et al. (1977).

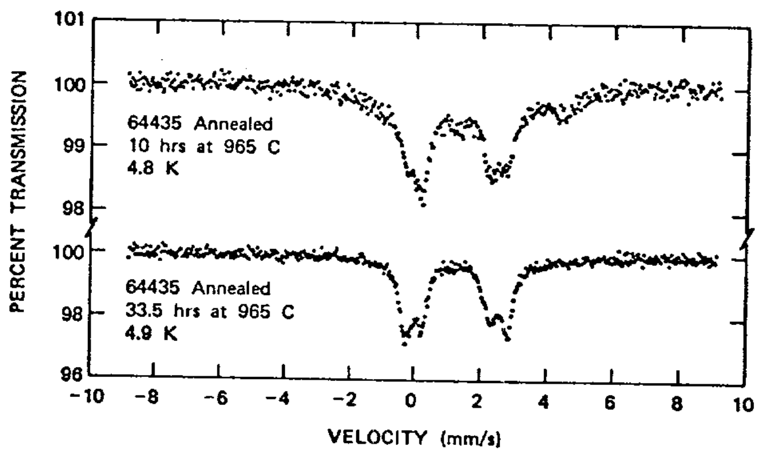
A measured $^{87}Sr/^{86}Sr$ ratio of 0.69978±6 for a matrix chip was reported by Wiesmann and Hubbard (1975).

RARE GAS/EXPOSURE AGES: Bogard et al. (1973) report He, Ne, Ar and Kr isotopic data for an interior matrix chip. From these data Bogard and Gibson (1975) calculate $^{21}Ne$ and $^{38}Ar$ exposure ages of 0.6 and 0.7 m.y. (both ± 0.3 m.y.), respectively. Bhandari et al. (1976) give an "insolation age" of 0.5 m.y. from galactic cosmic ray tracks and a crater-count exposure age of 0.2-2 m.y. for an exterior matrix chip. From $^{26}Al$ data on this same exterior chip, Bhandari (1977) calculates an exposure age of 0.5 ± 0.1 m.y. Fruchter et al. (1978) analyzed an interior matrix chip with >2 cm shielding on all sides and report $^{26}Al$ and $^{53}Mn$ exposure ages of 1.3 and 1.7 m.y. (both ± 0.3 m.y.) respectively.

PHYSICAL PROPERTIES: Basic and remanent magnetic properties of the gray matrix indicate 0.096 wt% metal and no significant residue of NRM after 150 Oe·rms demagnetization (Nagata et al., 1974). Cisowski et al. (1976) provide magnetic data on a split of the glass coat. The field acquired by the glass is similar to that presently observed at the Apollo 16 site. Schwerer and Nagata (1976) determined the size distribution of metallic particles in the range 0.003-0.015 μm (30-150 Å) by magnetic granulometry on a matrix chip. The mean grain size of fine-grained metal in the matrix is 62 Å.

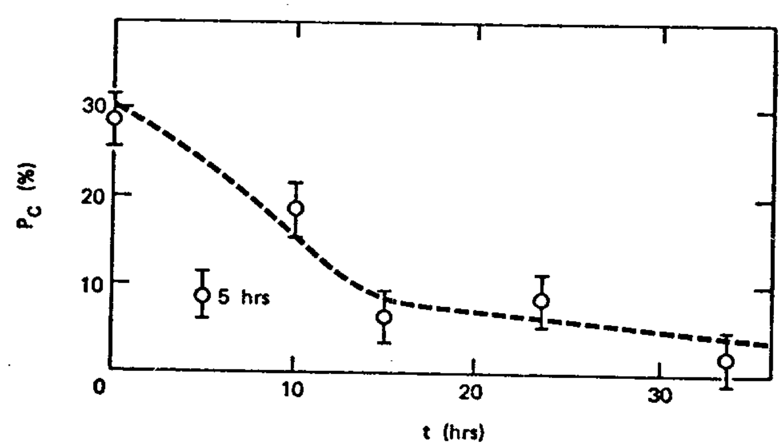
Huffman et al. (1974) report the phase distributions of iron and the metallic/ferrous iron ratio in the gray matrix as determined by Mossbauer and magnetic analyses. Huffman and Dunmyre (1975) provide data on superparamagnetic clusters of ferrous iron spins in matrix olivines and the results of heat treatments on these clusters. With increasing time of subsolidus annealing, the percentage of total iron in these clusters progressively decreases (Fig. 6).

Charette and Adams (1977) give spectral reflectance data for an interior matrix chip (Fig. 7).



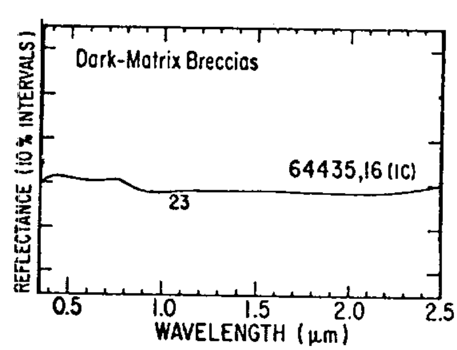

Liquid-helium spectra of 64435 after 10 and 33.5 hr of annealing at 965°C.

Figure 6. From Huffman and Dunmyre (1975).




Superparamagnetic cluster percentage as a function of annealing time at 965°C for sample 64435.

Figure 7. From Charette and Adams (1977).



PROCESSING AND SUBDIVISIONS: In 1973, 64435 was cut into three main pieces, including a slab (Figs. 8, 9, 10). The slab and the smaller butt end (,12) were extensively subdivided for allocations. Most of the slab samples consist of matrix (Fig. 9). The anorthosite clasts studied by Hewins and Goldstein (1975a) are in thin sections made from slab split ,22. The anorthosite chip (,44) analyzed by Laul et al. (1974) is from the area of massive anorthosite seen on the W and N surfaces (Fig. 1).

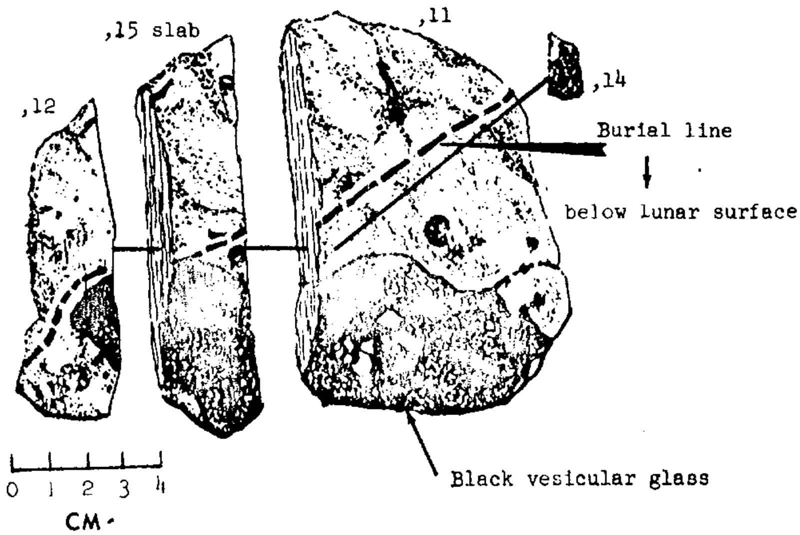



Figure 8. Cutting sketch.

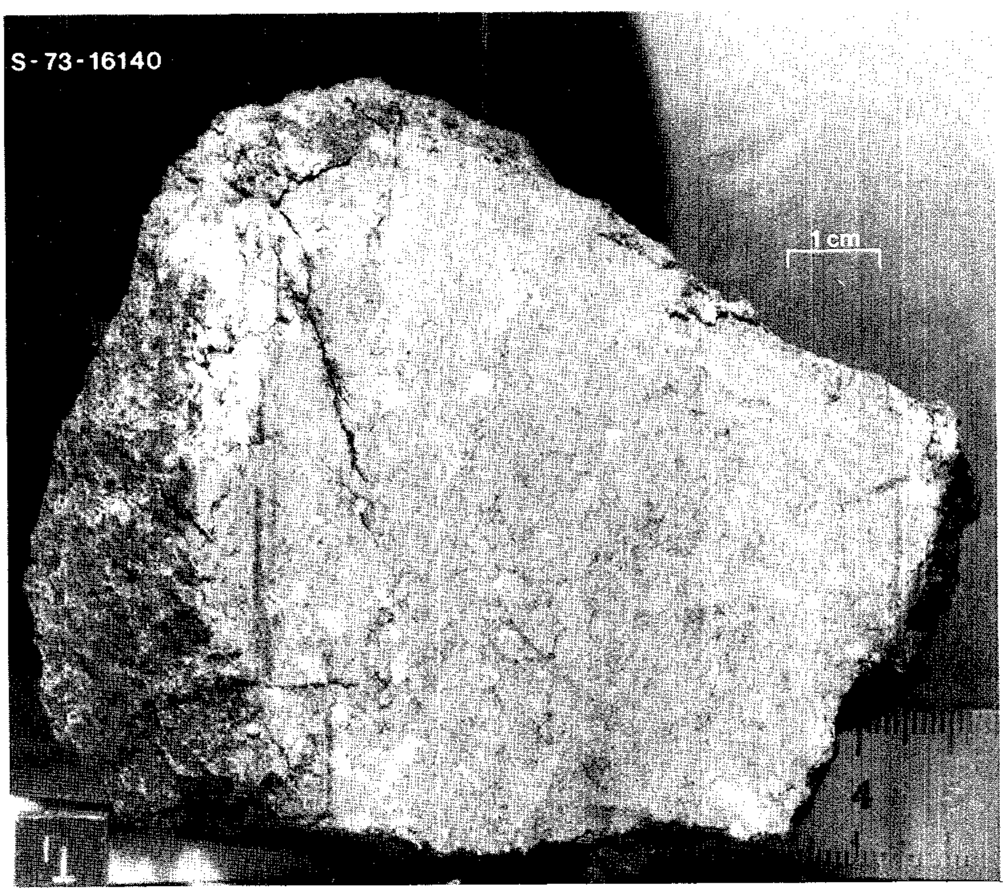



Figure 9. Slab face, prior to subdivisions.

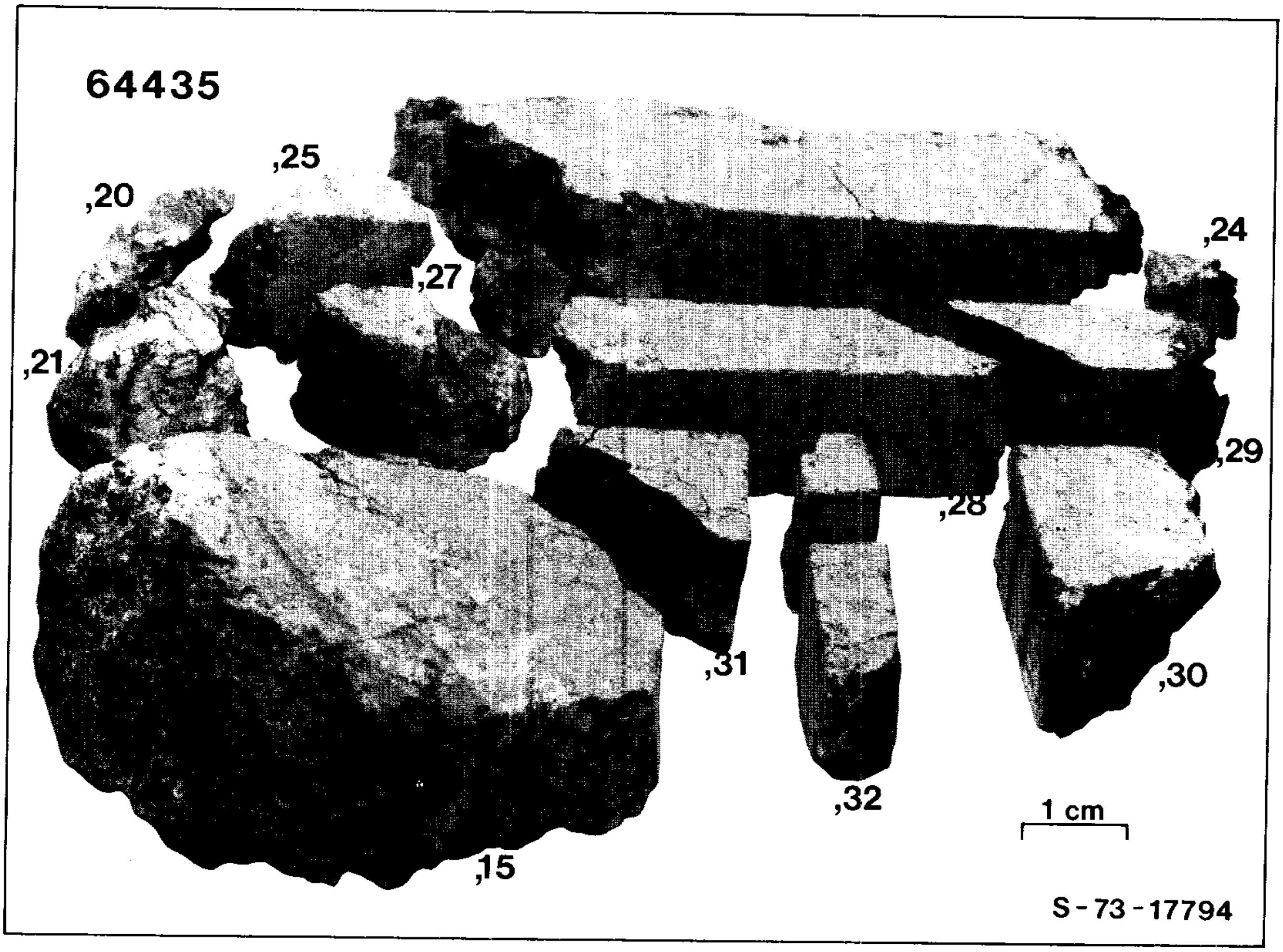



Figure 10. Slab subdivisions.

INTRODUCTION: 64455 is a basaltic impact melt with a very thick coating of smooth, dark glass (Fig. 1). The basalt is somewhat friable and the bonding between the basalt and the glass coat is generally weak. Along the basalt/glass contact the basalt has been partially melted followed by limited mixing of the melt with the glass coat. The glass coat appears to have once enclosed the entire rock, but a small area on the "lunar top" has been broken away exposing the basalt. Zap pits are present only on the "lunar top" surface. Distinct spheroids and dumbells of glass are adhering to, and coalescing with, the exterior surface of the coat. This sample was collected from the northeast rim of a subdued crater on the northeast slope of Stone Mountain.


Figure 1. S-73-22656, mm scale.

PETROLOGY: Grieve and Plant (1973), Blanford et al. (1974), Schaal et al. (1979) and Vaniman and Papike (1981) provide petrographic information. 64455 is a basaltic impact melt (Fig. 2) with a very thick glass coat. Grieve and Plant (1973) recognize four distinct textural zones within the rock: 1) a crystalline core of basaltic impact melt, 2) a zone of basalt with interstitial partial melt, 3) a thin, discontinuous crust of devitrified glass, and 4) an outer coating of fresh glass.

The basalt consists of ∿65% plagioclase ($An_{90-95}$, up to 1 mm long) with interstitial low-Ca pyroxene ($Wo_{6-13}En_{76-68}$) which is often cored by minor olivine ($Fo_{75-80}$) (Fig. 3). Accessory metal (Ni 5.1%, Co 0.3%), troilite, schreibersite, and ilmenite account for ∿5% of the rock. Several of the melt grains in the basalt are rusty.

Between the core of basalt and the glass coat there is a thin zone (∿1 mm wide) of basalt with a significant amount of interstitial glass (Fig. 2). Grieve and Plant (1973) interpret this glass as a partial melt of the basalt, citing as evidence a decrease in the modal abundance of pyroxene, partial resorption of mineral grains, and the complimentary composition of the glass compared to the crystalline residue within this zone. Quench crystals of olivine and pyroxene are common in the interstitial glass and as rims around the partially resorbed grains.

The thin (0.25 mm wide) crust of devitrified glass sandwiched between the basalt and the fresh glass coat contains numerous areas of acicular plagioclase grains and cryptocrystalline mesostasis. As pointed out by Blanford et al. (1974) these are quench crystals and not the products of subsolidus devitrification. This zone is discontinuous and cannot be recognized in every section (Fig. 2). Metal spherules with associated troilite and schreibersite are abundant, as are small vesicles which are concentrated along the basalt/glass contact.

Except for a small eroded area, the fresh glass coat (minimum 2 mm thick) completely encloses the rest of the rock. The smooth external surface of the coat indicates that it formed during free flight. Flow banding is dominantly parallel to the basalt/glass contact and is emphasized by abundant, minute spherules of metal (20.4% Ni, 0.8% Co), troilite,and schreibersite. In contrast to the basalt none of the metal grains in the glass coat are rusty. Swirls of glass around vesicles indicate movement of the melt after emplacement and prior to quenching (Schaal et al., 1979). In several places the glass penetrates the basalt forming veins which occasionally merge with the interstitial partial melt described above. A thin zone of quench crystals is also present along portions of the exterior surface of the coat.

EXPERIMENTAL PETROLOGY: Ulrich and Weber (1973) performed differential thermal analyses (DTA) on natural and synthetic samples of the fresh glass coat. The liquidus temperature of the synthetic composition was found to be 1350-1400°C, the solidus temperature is ∿1200°C. A cooling rate of 140°C/minute from 1400° was required to match the DTA data on the synthetic composition with that obtained on the natural sample.

CHEMISTRY: Major and trace element data for both the basalt and the glass coat are provided by Haskin et al. (1973). Meteoritic siderophile and volatile element abundances for these two lithologies are given by Ganapathy et al. (1974). Grieve and Plant (1973) report broad beam electron microprobe analyses (DBA) of the basalt, the glass coat, glass veins and the interior partial melt. The data are summarized in Table 1 and Figure 4.

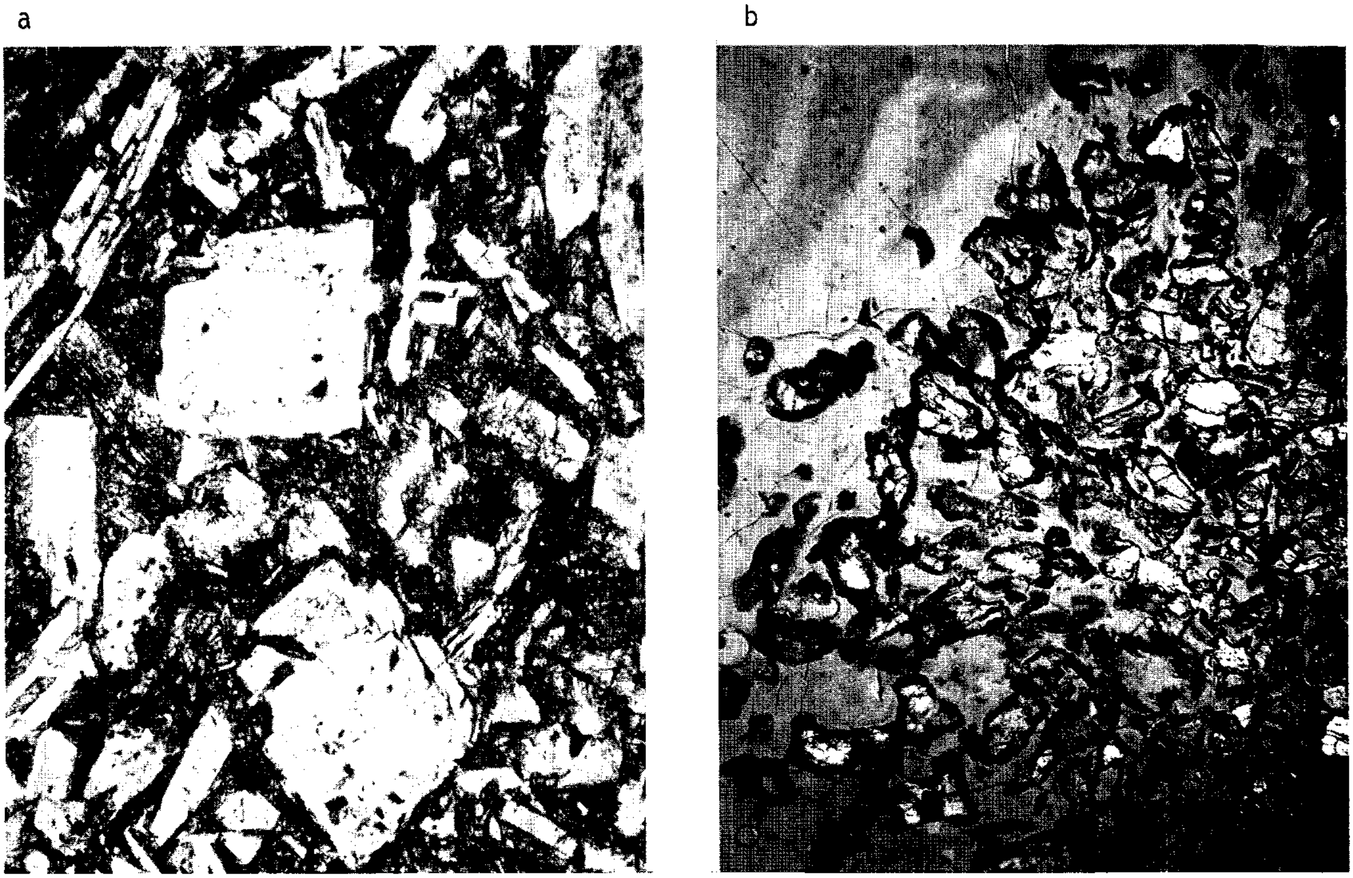



Figure 2. a) 64455,70B, basaltic melt, ppl. width 2mm.
b) 64455,38, zone of glass coat, basalt with interstitial melt, ppl. width 4mm.

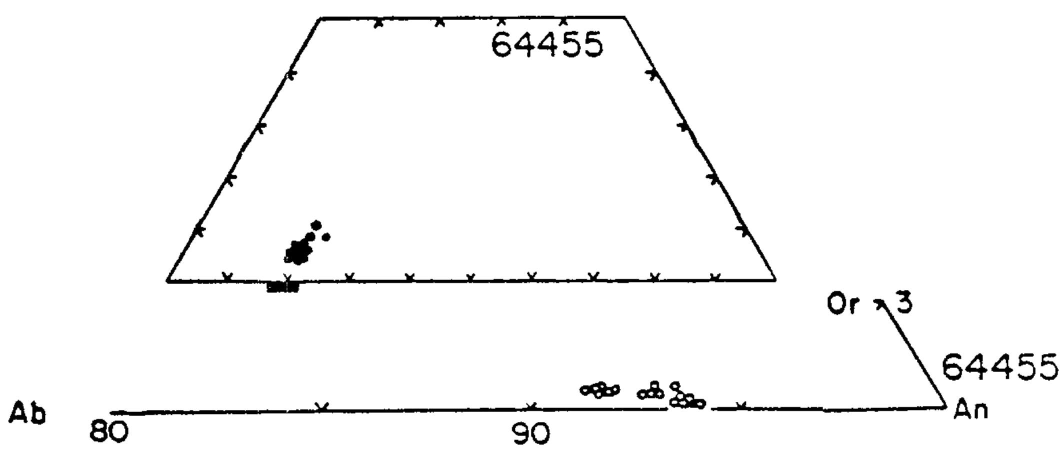



Figure 3. a) Mafic mineral compositions, olivine plotted along base. b) Plagioclase compositions, from Vaniman and Papike (1981).

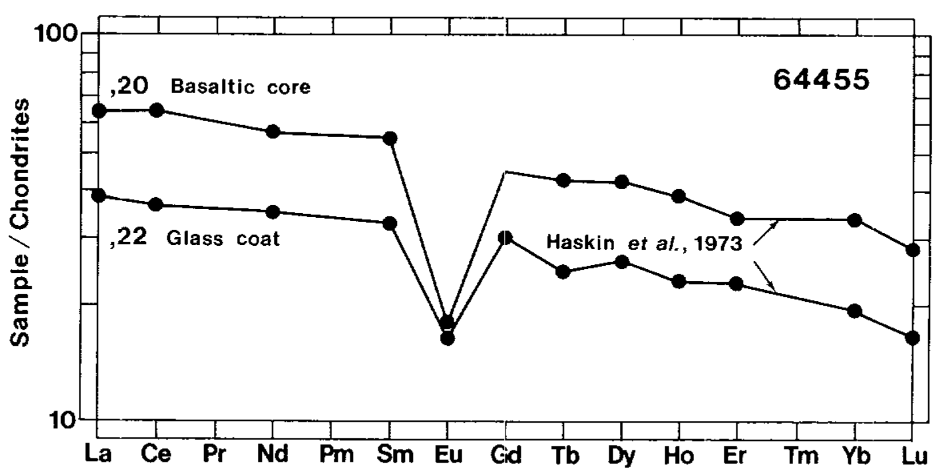
TABLE 1

Summary chemistry of basalt and glass from 64455

| | Basalt | Glass Coat | Partial Melt |
|---|---|---|---|
| $SiO_2$ | 47.8 | 44.1 | 48.6 |
| $TiO_2$ | 0.63 | 0.42 | 0.67 |
| $Al_2O_3$ | 23.6 | 25.1 | 17.5 |
| $Cr_2O_3$ | 0.15 | 0.15 | 0.25 |
| FeO | 5.4 | 6.1 | 6.5 |
| MnO | 0.07 | 0.07 | 0.07 |
| MgO | 8.5 | 8.0 | 14.0 |
| CaO | 13.5 | 14.5 | 11.3 |
| $Na_2O$ | 0.43 | 0.36 | 0.84 |
| $K_2O$ | 0.22 | 0.08 | 0.26 |
| $P_2O_5$ | | | |
| Sr | | | |
| La | 21.1 | 12.6 | |
| Lu | 0.96 | 0.56 | |
| Rb | 6.0 | 3.1 | |
| Sc | 7.8 | 7.0 | |
| Ni | 80-540 | ∿800 | |
| Co | ∿30 | ∿50 | |
| Ir ppb | 2.25 | 40.6 | |
| Au ppb | 1.56 | 12.7 | |
| C | | | |
| N | | | |
| S | | | |
| Zn | 3 | 2.4 | |
| Cu | | | |

Oxides in wt%; others in ppm except as noted.

Figure 4.
Rare earths.



Compared to the crystalline core, the glass coat on 64455 contains more alumina, lower incompatibles, and higher siderophile abundances (Table 1) and thus cannot represent simply a remelt of the basalt. Both the basalt and the glass coat approximate, but do not match, local soil compositions. Grieve and Plant (1973) find that the devitrified glass rim and the glass coat are compositionally identical (Fig. 5) and probably represent textural variations of a single melt. The areas of interior partial melt analyzed by these authors are similar in composition to the KREEP-rich, Apollo 16 poikilitic impact melts (e.g. 60315, 62235) (Table 1). Analyses along a glass vein which connects with the glass coat and penetrates into the partially melted zone show a series of intermediate compositions which span those of the coat and the partial melt (Fig. 5) (Grieve and Plant, 1973).

Hertogen et al. (1977) report different meteoritic groups for the basalt and the glass coat, based on siderophiles. The basalt belongs to meteoritic group 1H, a group largely restricted to the Apollo 16 site. The glass coat contains meteoritic group 5H and is interpreted, along with glass spheres 60095 and 65016, to represent South Ray ejecta (Hertogen et al., 1977).

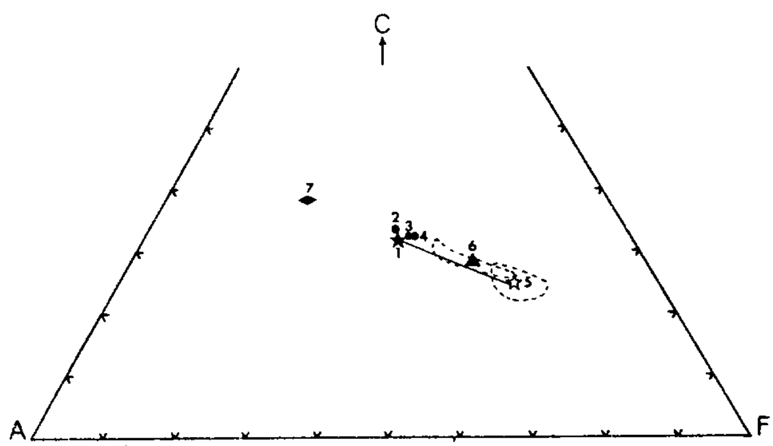



Figure 5. Mol.% ACF for various components of 64455,35. The dashed lines show the range of compositions of the partial melt and the glass vein. 1) basaltic impact melt. 2) various highland basalt glasses, other authors. 3) devitrified rim. 4) glass coat. 5) partial melt. 6) glass vein. 7) residual crystalline material in partial melt zone. From Grieve and Plant (1973).

RARE GAS/EXPOSURE AGES: Bogard et al. (1973) provide He, Ne, Ar, Kr and Xe isotopic data for a chip of basalt. From these data Bogard and Gibson (1975) calculate $^{21}Ne$ and $^{38}Ar$ exposure ages of 1.2 and 1.8 m.y., respectively. Kr isotopes yielded an exposure age of 2.01 m.y. (Marti, 1975, pers. comm. referenced in Blanford et al., 1975). These low exposure ages and the simple exposure history indicated by microcrater data are consistent with excavation of 64455 by the South Ray cratering event. Blanford et al. (1974) calculate an exposure age of 0.5-0.6 m.y. from the microcrater data of Neukum et al. (1973).

MICROCRATERS, TRACKS AND SURFACES: Neukum et al. (1973) provide size-frequency data for microcraters on 64455 (Fig. 6). A simple exposure history is indicated by the fact that only those surfaces exposed at the time of collection have microcraters. The surfaces are in production.

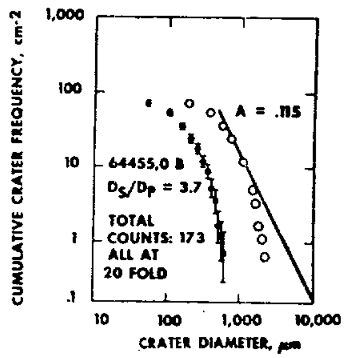



Figure 6. Microcraters, from Neukum et al. (1973).

Blanford et al. (1974,1975) report the particle track profile in the glass coat (Fig. 7) and use the data to discuss the solar energy spectrum.

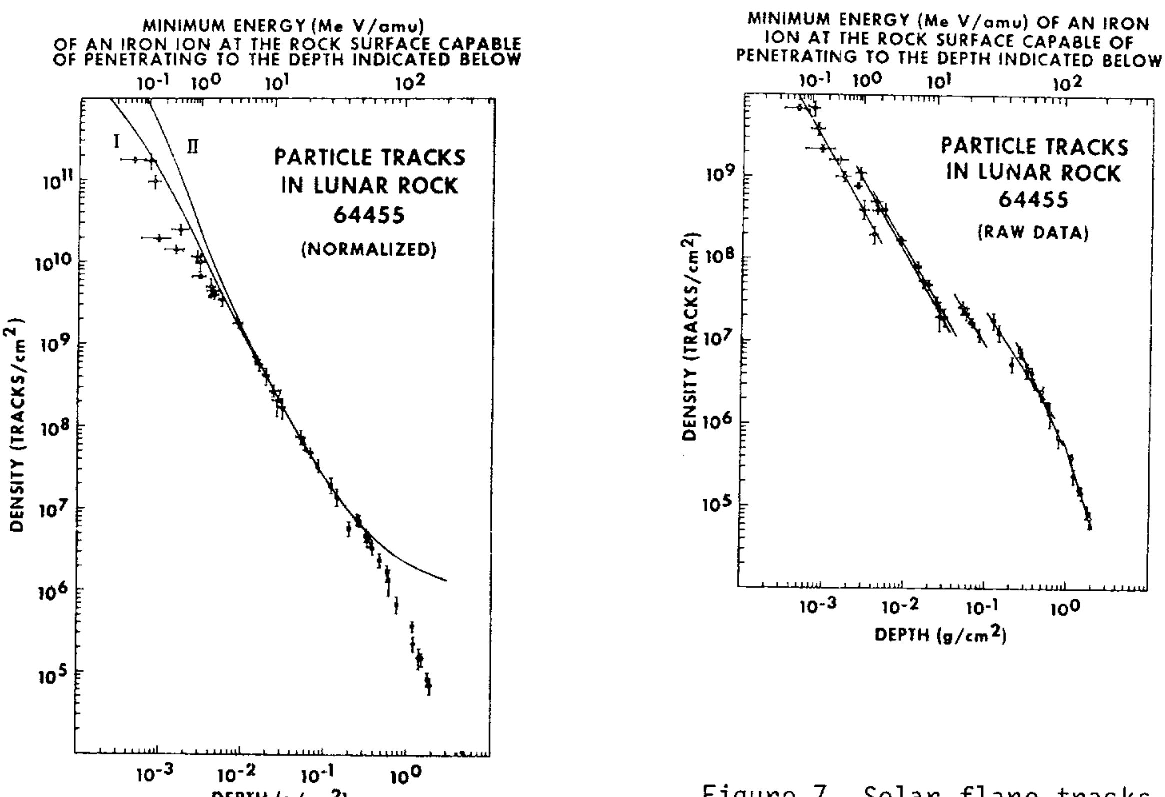



Figure 7. Solar flare tracks, from Blanford et al. (1974).

Leich et al. (1973) determined the depth distributions of H and F in exterior chips of the glass coat and the basalt (Figs. 8,9). A maximum concentration of H was detected within ∿200 Å of the exterior surface of both the rock and the glass chips. As 64455 was exposed to the atmosphere on route to earth and prior to storage in nitrogen-filled cabinets, Leich et al. (1973) consider this H to be terrestrial contamination. The H at >2000 Å within the basalt and the glass cannot be accounted for by either terrestrial contamination or directly implanted solar wind and therefore was probably inherited from a pre-irradiated component of the impact melt. A peak in the F concentration was observed ∿0.2-0.4 μm from the exterior surfaces of both the basalt and the glass, but technical problems, poor reproducibility,and the possibility of terrestrial contamination in these samples preclude any judgement as to the origin of the F (Leich et al., 1973).

An upper limit of $3x10^{15}$ atoms/$cm^2$ of solar wind implanted carbon for an exterior surface of basalt was reported by Goldberg et al. (1976).

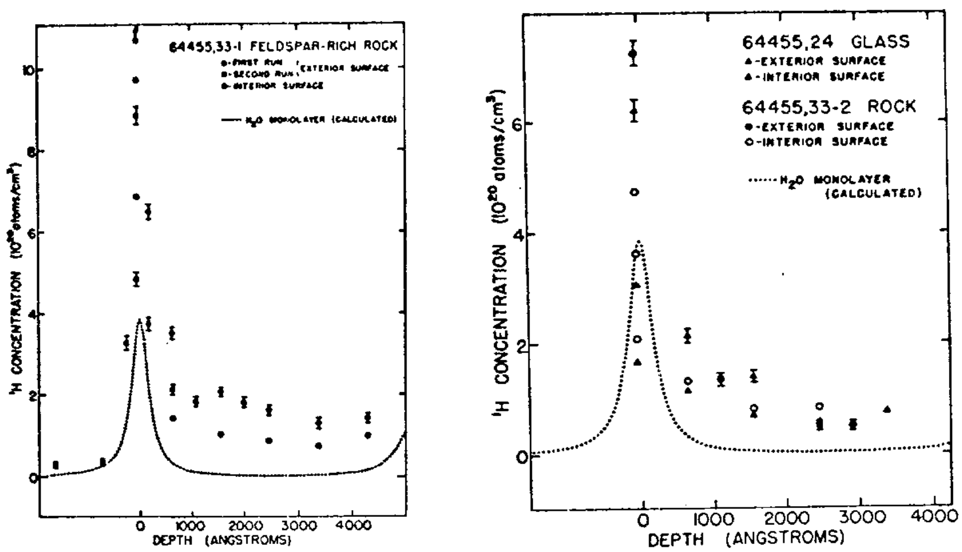



Figure 8. Hydrogen concentration v. depth, from Leich et al. (1973).

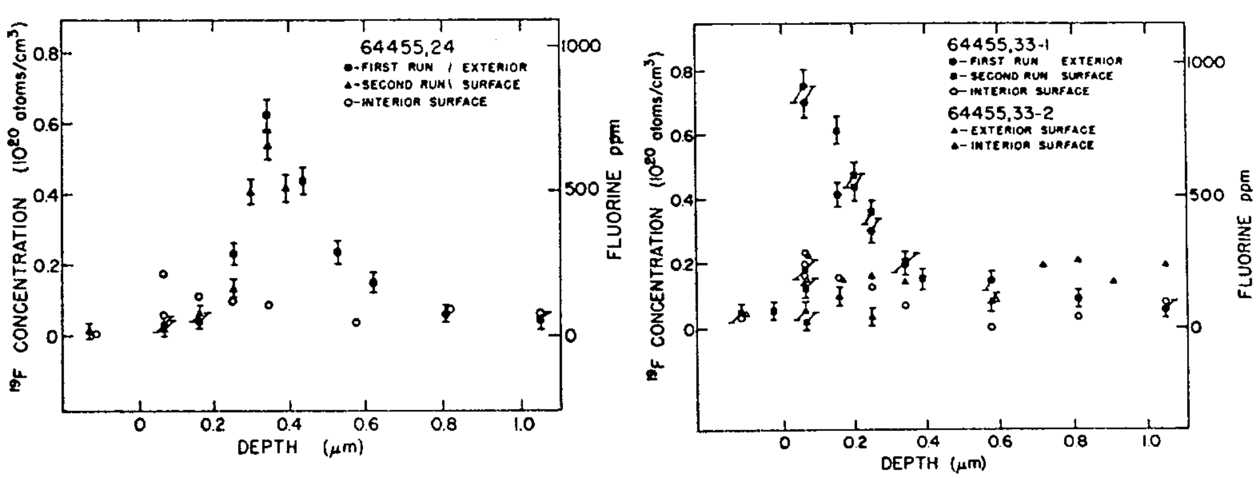



Figure 9. Fluorine concentration v. depth, from Leich et al. (1973).

PROCESSING AND SUBDIVISIONS: In 1972, 64455 was cut into three main pieces, including a slab (Fig. 10). The slab was extensively subdivided for allocations. Several chips were also allocated from the W end of the large butt end (,0).

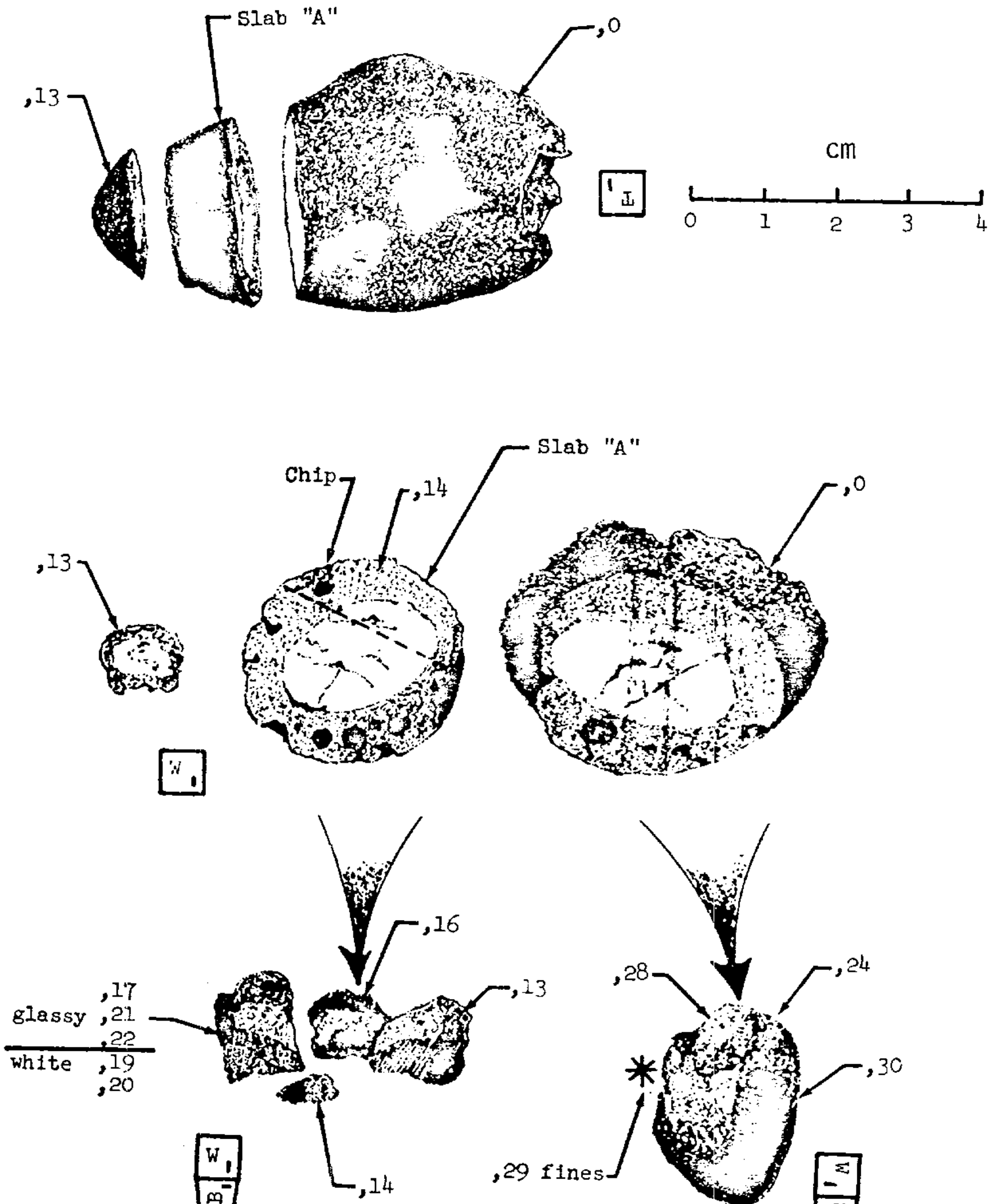



Figure 10. Cutting sketch.

INTRODUCTION: 64475 consists of a white ferroan anorthosite, parts of which may be chemically pristine, and a dark, fine-grained, basaltic impact melt. In places the two lithologies are banded, in places are distinctly separated, and elsewhere are intimately mixed (Figs. 1 and 2). In the final stages of the formation of the rock, the white phase intruded the dark.

64475 was collected from the region of two subdued shallow craters on Stone Mountain and its orientation is known. The sample is blocky and coherent with few fractures. Zap pits and patina occur predominantly on the exposed surface with none on the buried side.

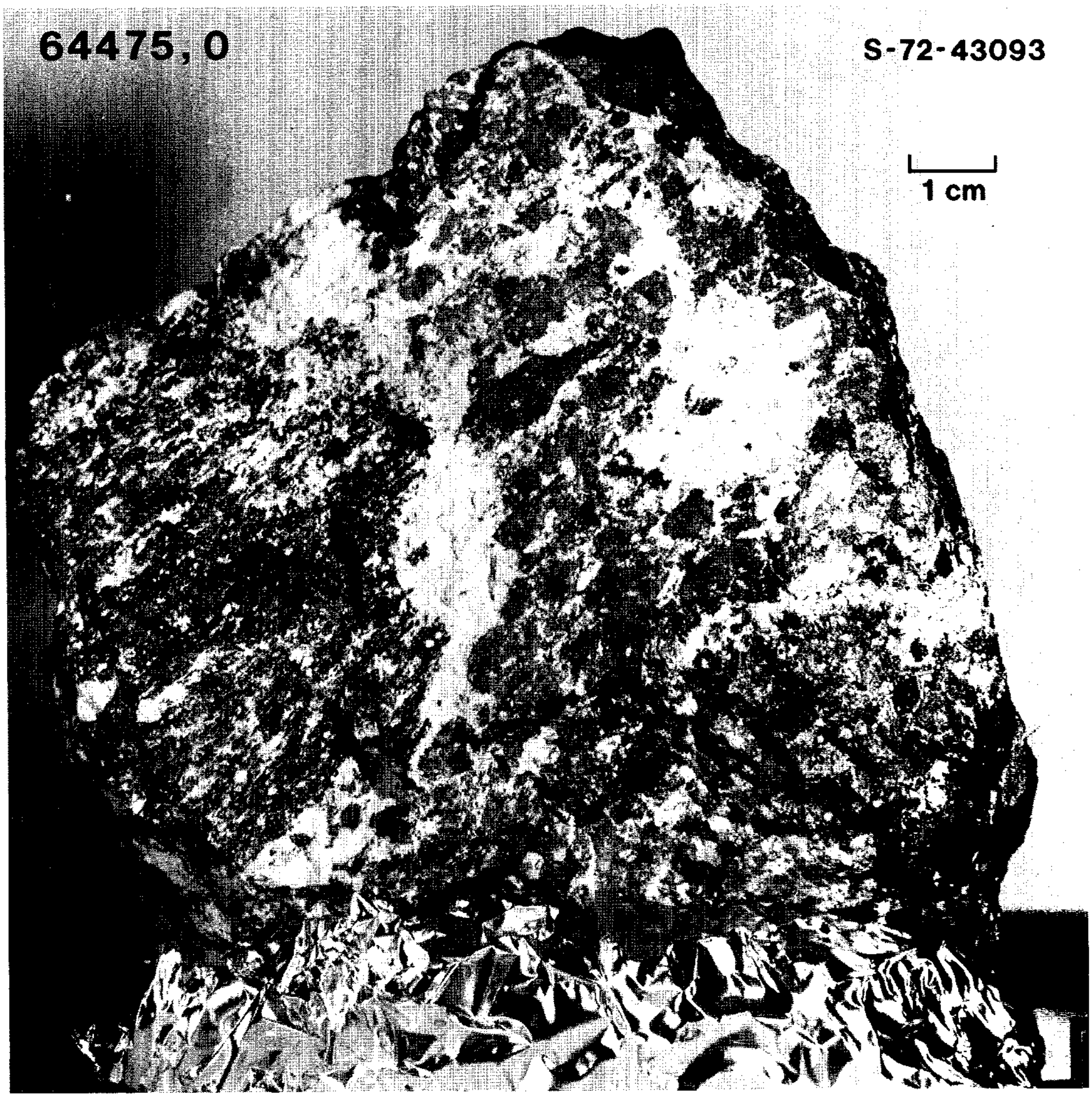



Figure 1.

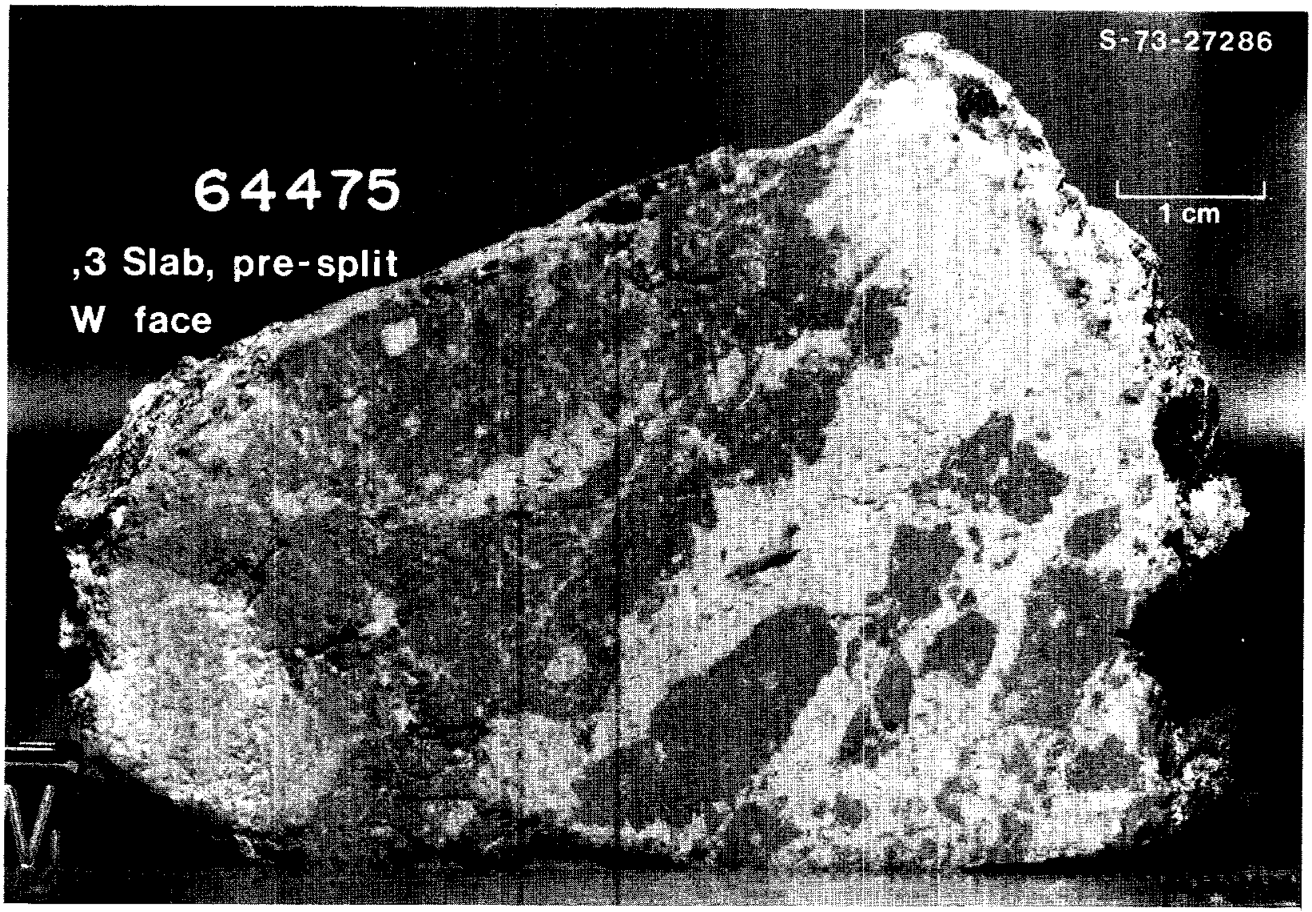



Figure 2.

PETROLOGY: All phase compositions reported below are from G.J. Taylor and R.D. Warner (pers. comm.).

The white material is 85-95% plagioclase and cataclastic though some cumulate-like textures are preserved in places (Fig. 3). It appears to be essentially monomict and is non-porous despite brecciation. Microprobe analyses show plagioclase $An_{95-96}$, exsolved pyroxenes which are mainly low-calcium ($En_{64}Wo_2$; bulk grains $\sim En_{64}Wo_{4-5}$) and minor olivine ($Fo_{66-71}$). Some pyroxenes are up to 1 mm in diameter, but most are much smaller; plagioclases were originally 3 mm or more in diameter. A few grains of Fe-metal are present, containing Ni $\sim$7%, Co $\sim$0.8% i.e. meteoritic compositions. However, metal is not present in the unbrecciated clasts and probably indicates contamination of parts of the anorthositic material.

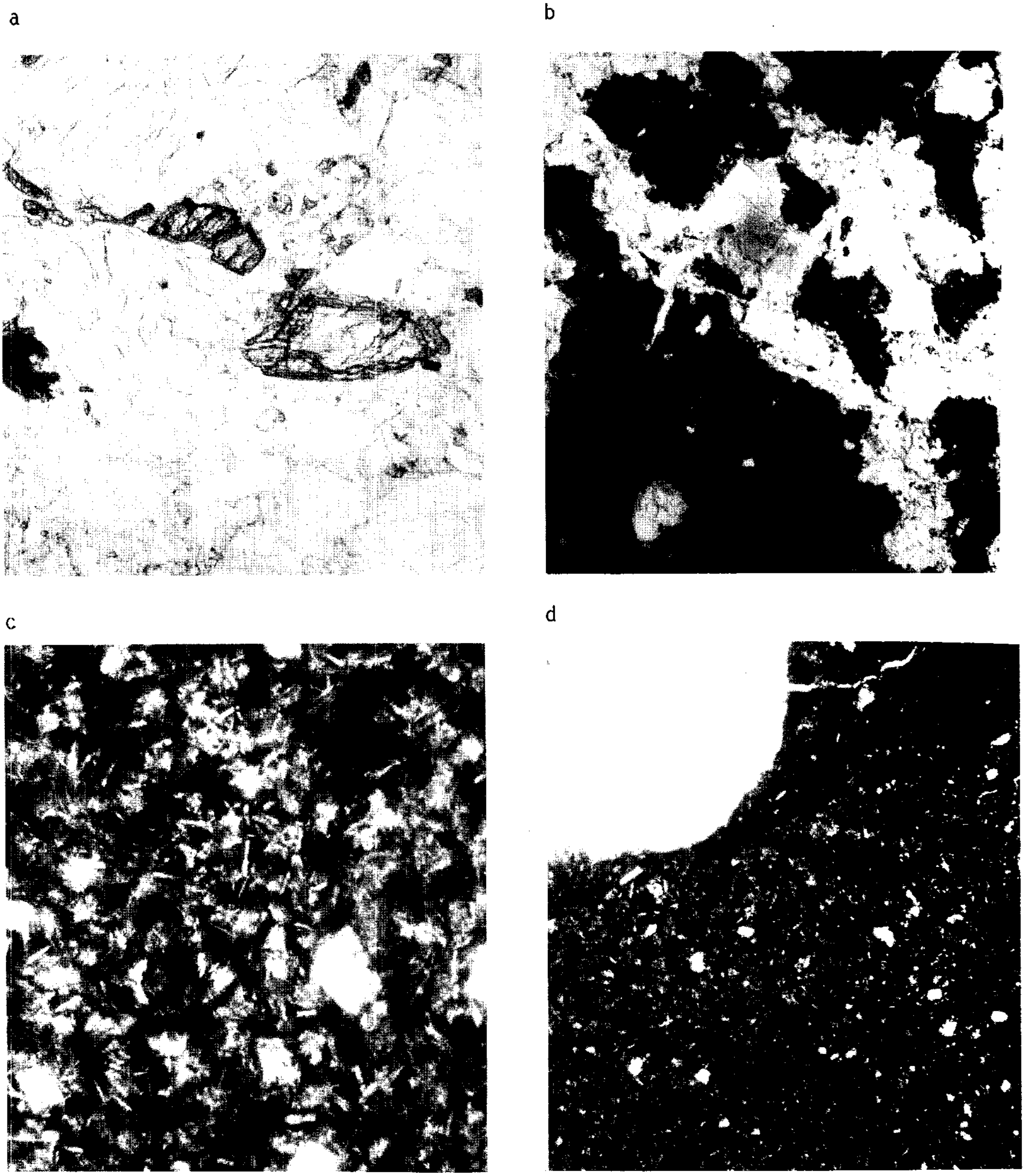



Figure 3. a) 64475,62, anorthosite, ppl. width 1mm.
b) 64475,62, basalt clasts in anorthosite, ppl. width 2mm.
c) 64475,58, basaltic impact melt, ppl. width 0.5mm.
d) 64475,58, basalt anorthosite contact, ppl. width 2mm.

The dark phase is fine-grained, mesostasis-rich basaltic impact melt containing angular plagioclase clasts (Fig. 3). Fe-metal is common and has ∿5% Ni, 0.6% Co, typical of contaminated melts. Troilite and schreibersite are also present.

The relations between the dark and light phases are complex. In most places the black fragments are angular and appear to be clasts carried in the white matrix (Fig. 3). In several places apophyses of white material clearly intrude the dark phases. However, in a few places the white material appears as rounded clasts within the black. The latter also shows textural variations which include margins apparently chilled against white material. As with some of the other "black and white" rocks, it appears that basaltic impact melt intruded the white phase and was later remobilized, with the basalt then acting as competent fragments in a fluidized, though not liquid, white phase.

CHEMISTRY: Mixed black and white chips were analyzed by Scoon (1974) for major elements and by Moore and Lewis (1976) for C and N abundances (Table 1), and reported without discussion.

TABLE 1. Summary chemistry of 64475, mixed black and white

| | |
|---|---|
| $SiO_2$ | 44.8 |
| $TiO_2$ | 0.54 |
| $Al_2O_3$ | 28.3 |
| $Cr_2O_3$ | 0.07 |
| FeO | 4.6 |
| MnO | 0.06 |
| MgO | 5.6 |
| CaO | 15.9 |
| $Na_2O$ | 0.49 |
| $K_2O$ | 0.12 |
| $P_2O_5$ | 0.15 |
| C | 55 |
| N | 92 |

Oxides in wt%; C, N in ppm

RARE GASES AND EXPOSURE AGES: Bogard and Gibson (1975) report He, Xe, Ar, and Ne isotopic data for two mixed black and white chips, one of which (,17) was mainly white, the other (,21) mainly dark. The samples contain appreciable amounts of solar wind gases. $^{21}$Ne exposure ages of 1.0 m.y. (,17) and 1.3 m.y. (,21) and a $^{38}$Ar exposure age of 1.6 m.y. (,17) are subject to ± 50% error but are consistent with South Ray rather than North Ray samples. Kr data (not reported) show dominantly atmospheric Kr.

Lambert et al. (1975) measured $^{210}$Po activity on an external surface of a mixed chip (,16) which was in contact with lunar fines, providing information on $^{222}$Rn.

PHYSICAL PROPERTIES: Stephenson et al. (1974) report natural remanent magnetization (NRM) intensities for two small blocks of mixed black and white material, summarized in Table 2.

The directions in 11A and 11B were close to those of the original chip. There is no statement in Stephenson et al. (1974) that 11A and 11B were macroscopically dissimilar. ,7 and ,11A were also subjected to alternating field demagnetization and thermal demagnetization, respectively. The NRM may not be thermoremanent in origin and paleointensity determination is unreliable. A paleointensity determination by anhysteretic remanent magnetization (ARM) methods was also unsuccessful.

TABLE 2. NRM intensities for 64475 chips

| Sample | Intensity (G $cm^3g^{-1}$) |
|---|---|
| ,7 bulk | $73 \times 10^{-6}$ |
| ,11 bulk | $88 \times 10^{-6}$ |
| ,11A | $140 \times 10^{-6}$ |
| ,11B | $59 \times 10^{-6}$ |
| ,11A + ,11B | $91 \times 10^{-6}$ |

PROCESSING AND SUBDIVISIONS: 64475 was sawn in 1973 to produce a large end piece (,1), a smaller end piece (,2) and a slab (,3). ,1 (740 g) is intact, while the other two pieces have been subdivided. The main subdivisions of the slab are shown in Figure 4.

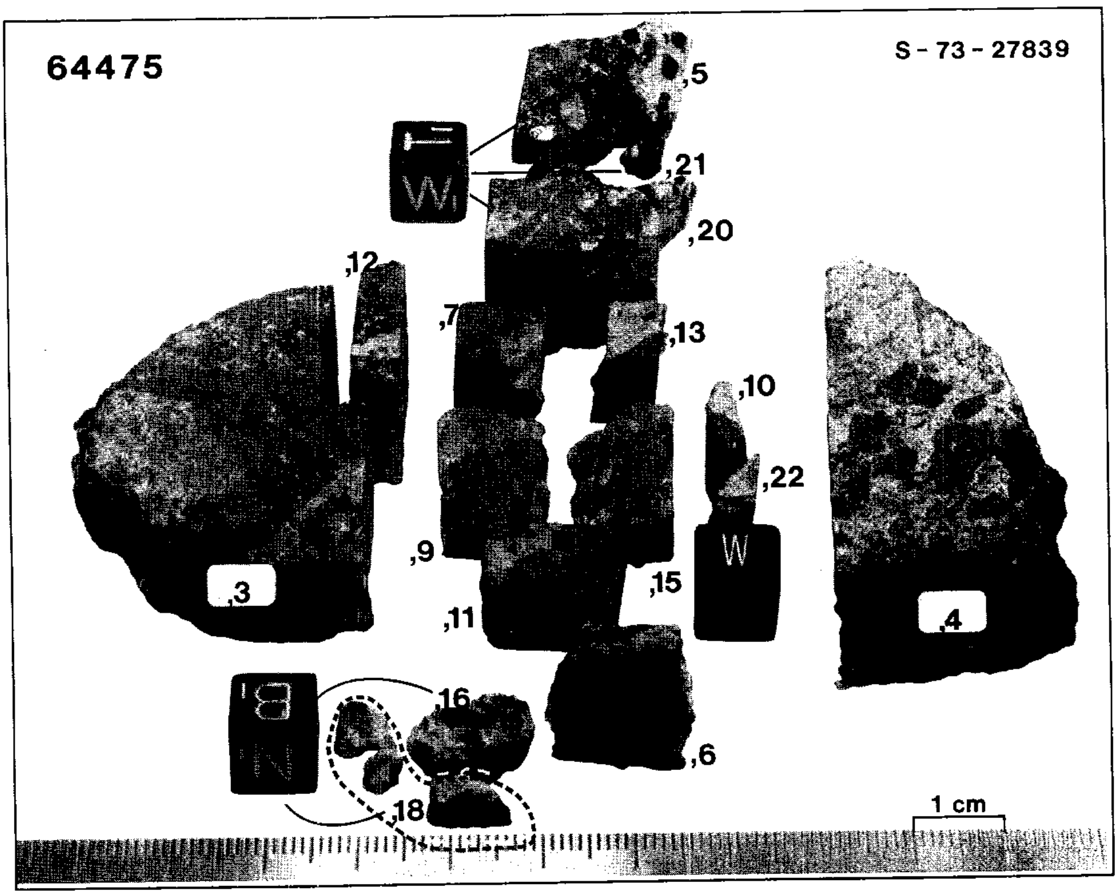



Figure 4. Slab subdivisions.

INTRODUCTION: 64476 consists of ∿70-80% cataclasized, granoblastic anorthosite, probably monomict, and ∿20-30% dark aphanitic to basaltic impact melt (Figs. 1 and 2). The latter is variable in texture and clast content and might even represent more than a single lithology. The white material clearly invades the dark in places, but elsewhere dark rims surround white clasts.

64476 was collected from the region of two subdued shallow craters on Stone Mountain. Its orientation prior to actual collection is known, but the sample may have been moved prior to its being photographed. The sample is angular and coherent with few fractures. A few zap pits are present on three sides, including the lunar top as photographed.

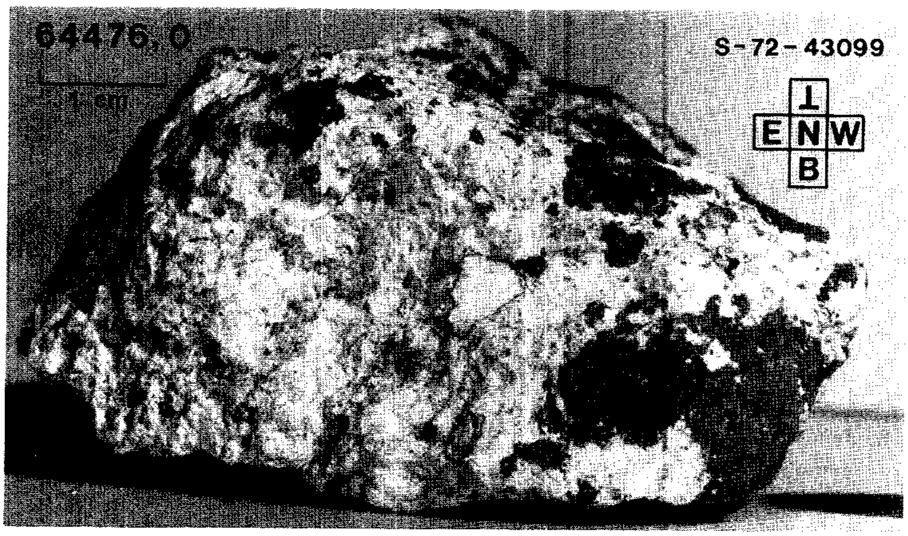



Figure 1.

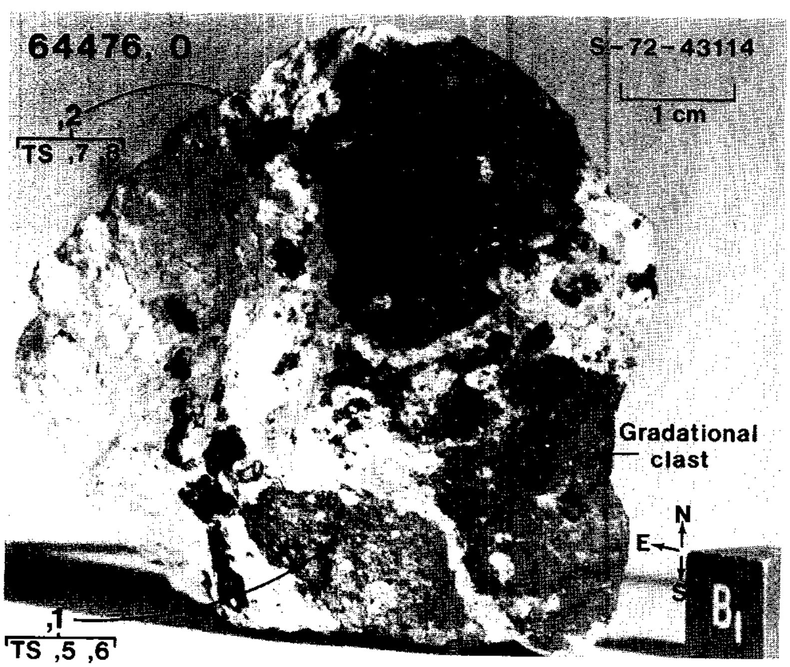



Figure 2.

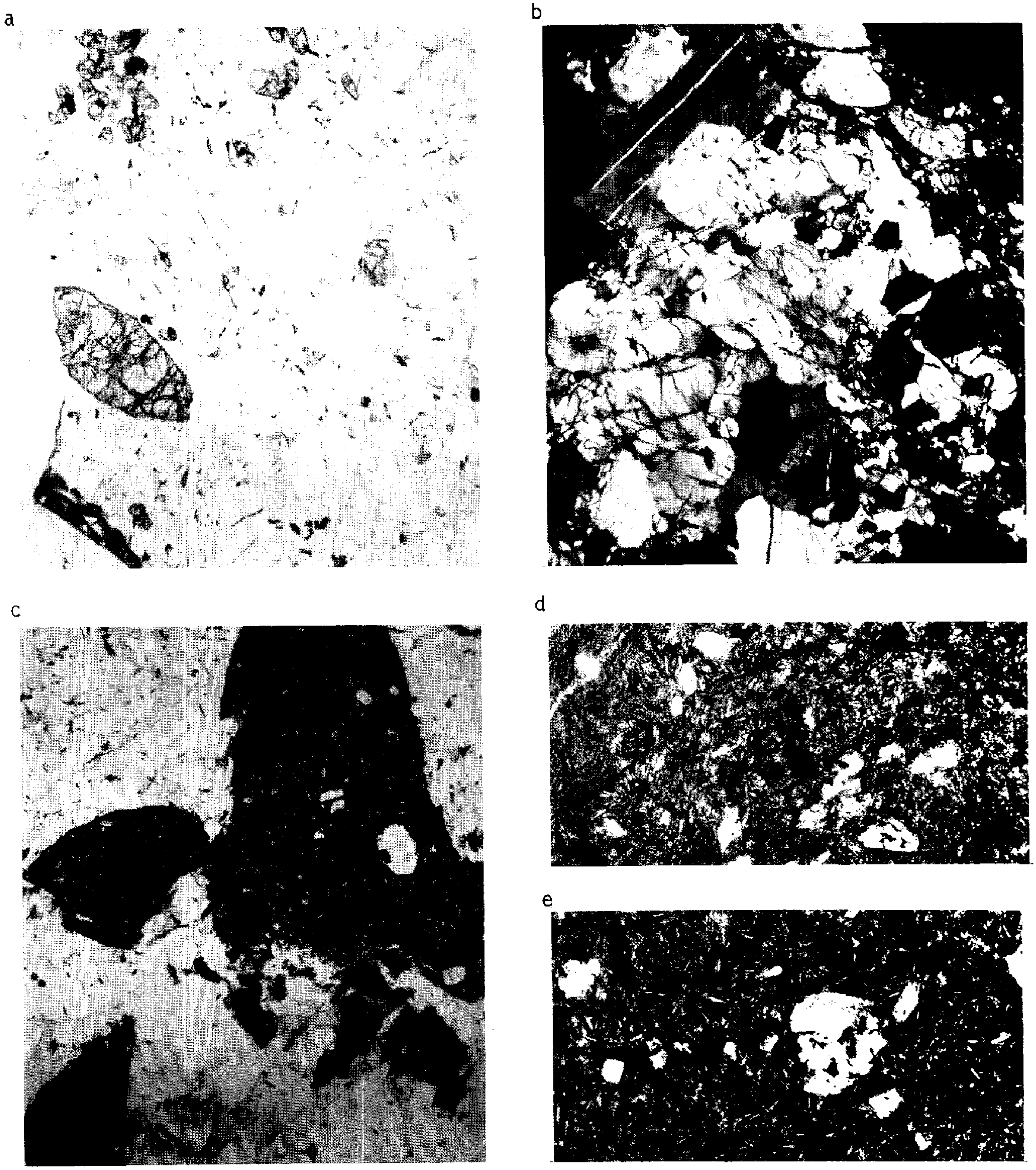



Figure 3. a) 64476,8, anorthosite, ppl. width 2mm.
b) 64476,8, anorthosite, xpl. width 2mm.
c) 64476,7, basalt clasts in anorthosite, ppl. width 2mm.
d) 64476,5, finer-grained basaltic impact melt, ppl. width 1mm.
e) 64476,8, coarser-grained basaltic impact melt, ppl. width 1mm.

PETROLOGY: The white phase is homogeneous, macroscopically containing sparse yellow-green minerals. Thin sections show it to be apparently monomict, non-porous, brecciated anorthosite (Fig. 3) with more than 90% plagioclase. Both olivine and pyroxene grains appear to be present. The preserved texture is granoblastic with triple junctions but most plagioclases are shocked. Plagioclase grains are up to 2 mm in diameter and mafic grains are less than 500 μm in diameter.

The dark phase is variable. One type is clast-rich, fine-grained, and consists of skeletal olivines in a felsic groundmass (Fig. 3). The clasts are nearly all shocked plagioclases and lithic clasts are absent. A second type is darker-colored, coarser-grained, mesostasis-rich basaltic impact melt with few clasts (Fig. 3). Both types contain Fe-metal. One large clast (shown in Figure 1) appears macroscopically to have a gradation between the two types.

The relations between the white and dark lithologies are complex. In some places the angular black fragments are clearly intruded by white matrix, but selvages of dark material around white material, and the plagioclase clasts in the dark material suggest that the latter is the host. Wilshire and Moore (1974) suggest that originally the dark phase formed the matrix but a later event reversed this relationship by mobilizing the white phase.

CHEMISTRY: Clark and Keith (1973) analyzed the bulk rock for K (0.066%), U (0.31 ppm), Th (1.19 ppm) and radionuclides using γ-ray spectroscopy. The analysis indicates that the white phase is extremely low in KREEP elements.

PROCESSING AND SUBDIVISIONS: The rock has not been sawn and most of it remains as ,0 (124 g). Only ,1 and ,2 have been removed, and both were made into thin sections. ,1 was from the clast-rich melt area (Fig. 1) and ,2 consisted of loose chips of black and white material, unlocated but believed to be generally from the area at the top of Figure 1.

## 64477 HETEROGENEOUS GLASSY BRECCIA 19.32 g

INTRODUCTION: 64477 is a coherent, medium gray breccia with abundant white clasts (Fig. 1). Several penetrating fractures cut the rock. It was collected from the rim of a subdued doublet crater, near several larger, similar-appearing rocks. Lunar orientation is unknown. Zap pits are abundant on three surfaces, absent from the other surfaces.

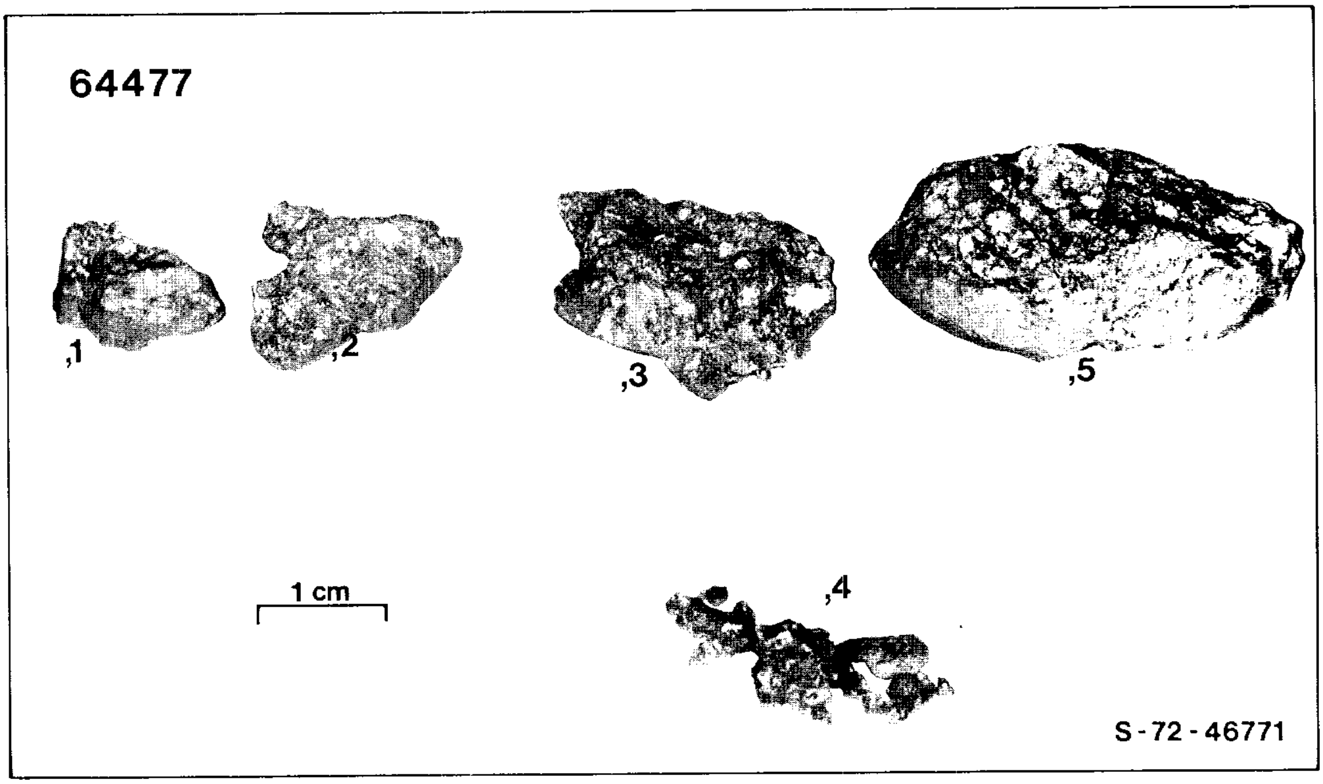



Figure 1.

PETROLOGY: 64477 is a plagioclase-rich breccia with a continuous, but heterogeneously distributed glassy matrix (Fig. 2). Fragments of plagioclase are the most abundant clast-type. Several angular clasts of fine-grained poikilitic impact melt, a few clasts of glassy breccia,and rare mafic mineral fragments are also present. Troilite is unusually abundant,and is usually associated with the glassy matrix. Some Fe-metal is also present.

Portions of the rock are nearly devoid of the glassy matrix and, in these places, the rock approaches a cataclastic anorthosite. This rock may have been a dilithologic breccia (cataclastic anorthosite + poikilitic impact melt) that was shocked and invaded by glass.

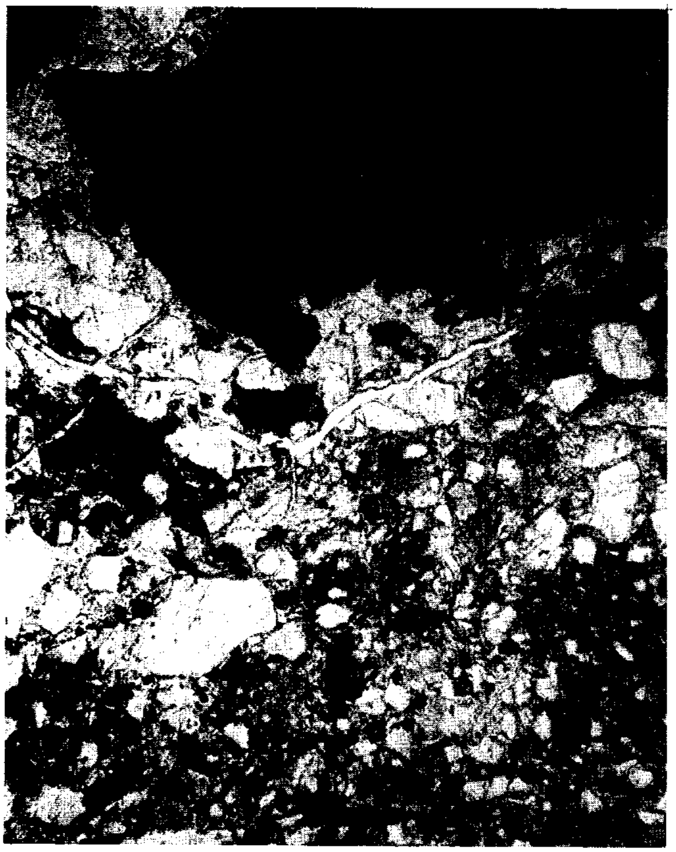


Figure 2. 64477,13, general view, ppl. width 4mm.

PROCESSING AND SUBDIVISIONS: 64477 was removed from its documented bag as four pieces (,1-,3 and ,5) which were found to fit together, and some chips and fines (,4). ,1 was allocated for thin sections.

INTRODUCTION: 64478 is a coherent, medium dark gray breccia with abundant clasts, coated with a highly vesicular glass (Fig. 1). The matrix is probably poikilitic impact melt. It was collected from the rim of a subdued doublet crater. Zap pits are absent.

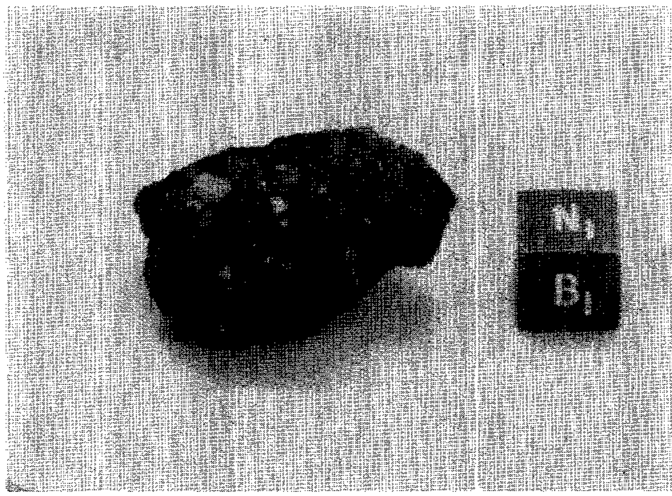



Figure 1. cube is 1cm.

PETROLOGY: The thin sections of this rock are dominated by a coarse-grained (plagioclases up to 2 mm) anorthositic breccia partially surrounded by fine-grained poikilitic impact melt (Fig. 2). The breccia is probably a clast in the impact melt. Brown glass veins cut both the breccia and the impact melt.

PROCESSING AND SUBDIVISIONS: In 1972 three small chips (,1) were removed and made into thin sections ,13 and ,14.

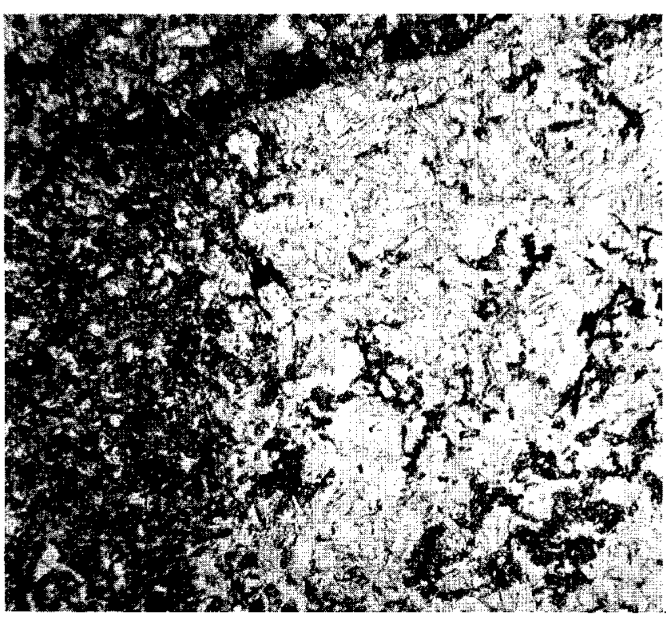


Figure 2. 64478,13, general view, ppl. width 2mm.

## 64505 FRAGMENTAL(?) POLYMICT BRECCIA 5.39 g

INTRODUCTION: 64505 is a medium pale gray, polymict breccia, containing small light and dark clasts (Fig. 1) including glass shards. It is fairly coherent and possibly held together with glass. Conspicuous slickensides occur on two surfaces.

The fragment was taken from a regolith sample collected near the rim of a subdued 15 m crater. A few zap pits are present.

Figure 1. mm scale.

# 64506 FINE-GRAINED BASALTIC IMPACT MELT(?); PARTLY GLASS COATED 5.08 g

INTRODUCTION: 64506 is a coherent, angular chip of medium pale gray impact melt (Fig. 1). The melt contains plagioclase laths $\sim$ 100 $\mu$m long and schlieren of white clasts. Black, vesicular glass coats one surface; adjacent to the rock it is crystalline or devitrified.

64506 was taken from a regolith sample collected near the rim of a subdued 15 m crater. Zap pits are common on the basaltic melt, but the glass coat has a smooth surface.

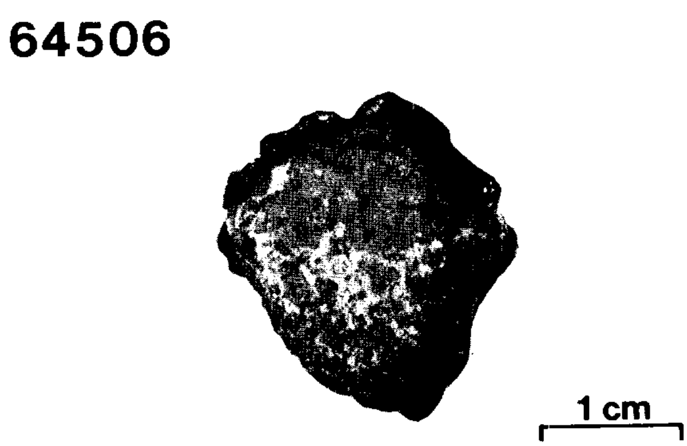



Figure 1.

# 64507 DILITHOLOGIC (GLASSY IMPACT MELT AND CATACLASTIC ANORTHOSITE ?) BRECCIA — 4.47 g

INTRODUCTION: 64507 is a coherent, angular fragment, with about 70-80% dark colored material and the remainder white clasts (Fig. 1). The dark material is a gray, fine-grained to black glassy melt, and the white appears to be pure cataclastic anorthosite. The white clasts range up to several mms in places, but elsewhere are small (< 1 mm) and rounded. The fragment is cut by glassy veins.

64507 was taken from a regolith sample collected near the rim of a subdued 15 m crater. It lacks zap pits.

Figure 1. mm scale.

## 64508 DILITHOLOGIC (CATACLASTIC ANORTHOSITE AND GLASSY IMPACT MELT ?) BRECCIA — 4.17 g

INTRODUCTION: 64508 is an angular, coherent fragment. It is about 90% white material and the remainder is dark (Fig. 1) The white appears to lack mafic minerals, hence it is probably a cataclastic anorthosite. The black material is a fine-grained to glassy impact melt which forms rounded blebs in the anorthosite, and in places forms rinds around white clasts. A few of the black blebs have glassy selvages.

64508 was taken from a regolith sample collected near the rim of a subdued 15 m crater. It lacks zap pits.

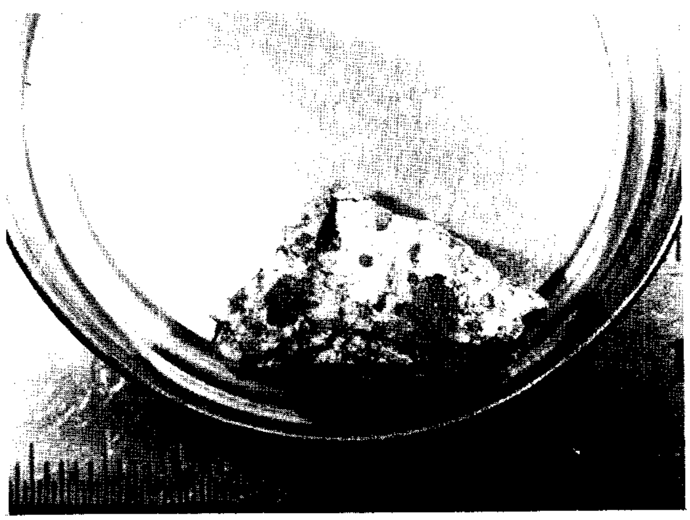


Figure 1. mm scale.

## 64509 FRAGMENTAL POLYMICT BRECCIA 3.15 g

INTRODUCTION: 64509 is a rounded, medium gray, friable polymict breccia (Fig. 1). It contains small light and dark clasts, including glassy shards. One white clast, ~ 8 mm in diameter, is a coherent, coarse-grained anorthosite, lacking mafic minerals.

64509 was taken from a regolith sample collected near the rim of a subdued 15 m crater. It lacks zap pits.

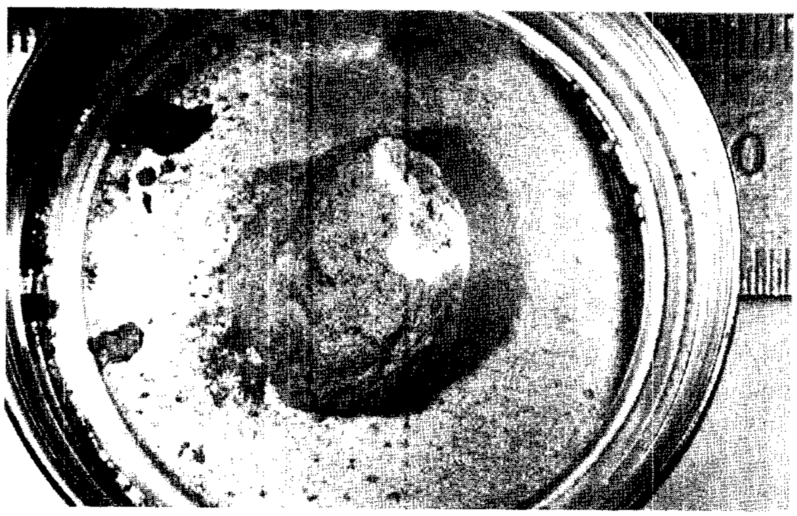


Figure 1. mm scale.

INTRODUCTION: 64515 is an angular, coherent, medium dark gray, crystalline fragment (Fig. 1). It contains plagioclases ∿ 0.5 mm in diameter but dust on the rock surface obscures the textures. It contains vesicles up to a few mms diameter, troilite and rusty blebs, and lacks obvious clasts.

64515 was taken from a regolith sample collected near the rim of a subdued 15 m crater. It lacks zap pits.

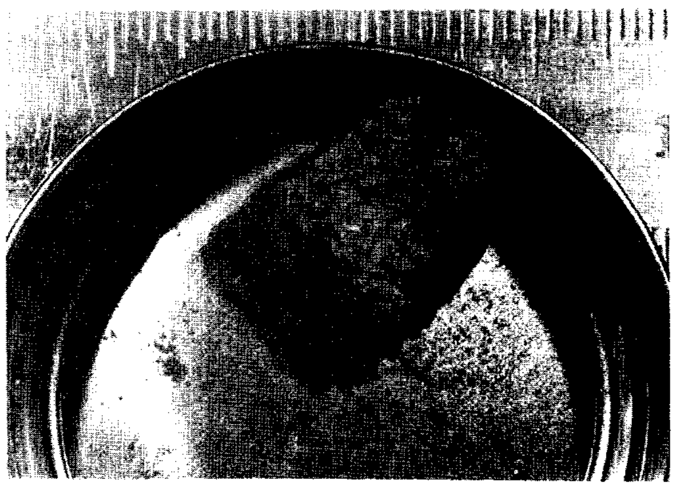


Figure 1. mm scale.

INTRODUCTION: 64516 is a friable, pure white fragment (Fig. 1). It lacks mafic minerals and is probably a cataclastic anorthosite. Rare tiny black flecks may be either opaque minerals or metal in the anorthosite, or extraneous material. The plagioclase appears to be in grains much less than 1 mm in diameter.

64516 was taken from a regolith sample collected near the rim of a subdued 15 m crater. Its friable surface lacks zap pits.

Figure 1. mm scale.

# 64517 FINE-GRAINED CRYSTALLINE BRECCIA 1.55 g

INTRODUCTION: 64517 is a coherent chip, about 80% of which is a medium light gray, fine-grained crystalline breccia and the remainder a white clast with coarse pyroxene(?) and black veins (opaque minerals or glass ?). The latter veins do not cut the host breccia. The fragment was taken from a regolith sample collected near the rim of a subdued 15 m crater. It lacks zap pits.

Figure 1. mm scale.

INTRODUCTION: 64518 is an angular, coherent, medium dark gray fragment (Fig. 1). It is fine-grained and crystalline; some tiny vesicles suggest that it is an impact melt. It contains no obvious clasts. The fragment was taken from a regolith sample collected near the rim of a subdued 15 m crater. It lacks zap pits.

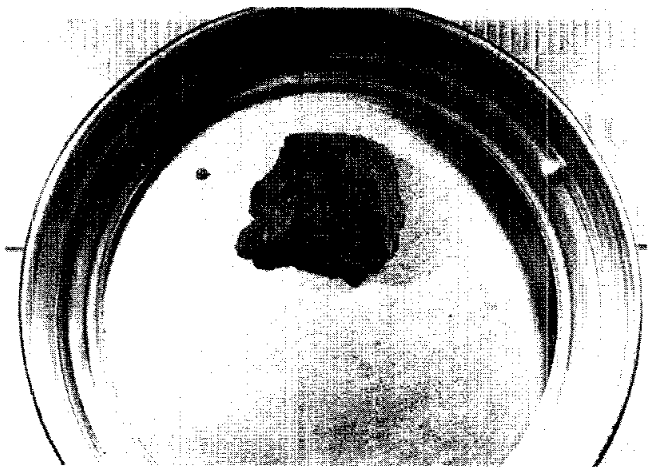


Figure 1. mm scale.

INTRODUCTION: 64519 is a friable, pure white, rounded fragment (Fig. 1). No mafic mineral grains are apparent and it is probably a cataclastic anorthosite. It was taken from a regolith sample collected near the rim of a subdued 15 m crater. Its friable surface lacks zap pits.

Figure 1. smallest scale subdivision 0.5mm.

INTRODUCTION: 64525 is a white, rounded, friable sample (Fig. 1). It contains no mafic minerals or lithic clasts but rare black flecks are present. It is almost certainly a cataclastic anorthosite. It was taken from a soil sample collected near the rim of a subdued 15 m crater. It lacks zap pits.

Figure 1. smallest scale subdivision 0.5mm.

64535 DILITHOLOGIC (CATACLASTIC ANORTHOSITE AND VITROPHYRIC IMPACT MELT) BRECCIA 257 g

INTRODUCTION: 64535 is a dilithologic breccia made up of ∿ 90% white, friable, anorthositic material and the remainder a dark, coherent, glassy impact melt that coats and intrudes the anorthosite (Fig.1). A mixed zone along the contact on the B surface is apparent. The mottled clast-like areas within the anorthosite (Fig.1) can best be interpreted as intrusive veins related to the glass coating. The morphologic similarity to the mixed contact zone is apparent and macroscopic examination reveals at least one direct connection between the glass coat and a clast-like area very similar to those in Figure 1, but on the S surface. These areas appear to be restricted to the exterior of the rock: none were observed along cracks that penetrate to the interior of the anorthosite.

This rock was collected as a rake sample from the upper slope of Stone Mountain, on the rim of a small, subdued crater. Lunar orientation is unknown. Zap pits and patina are present on the N, E, S and T surfaces.

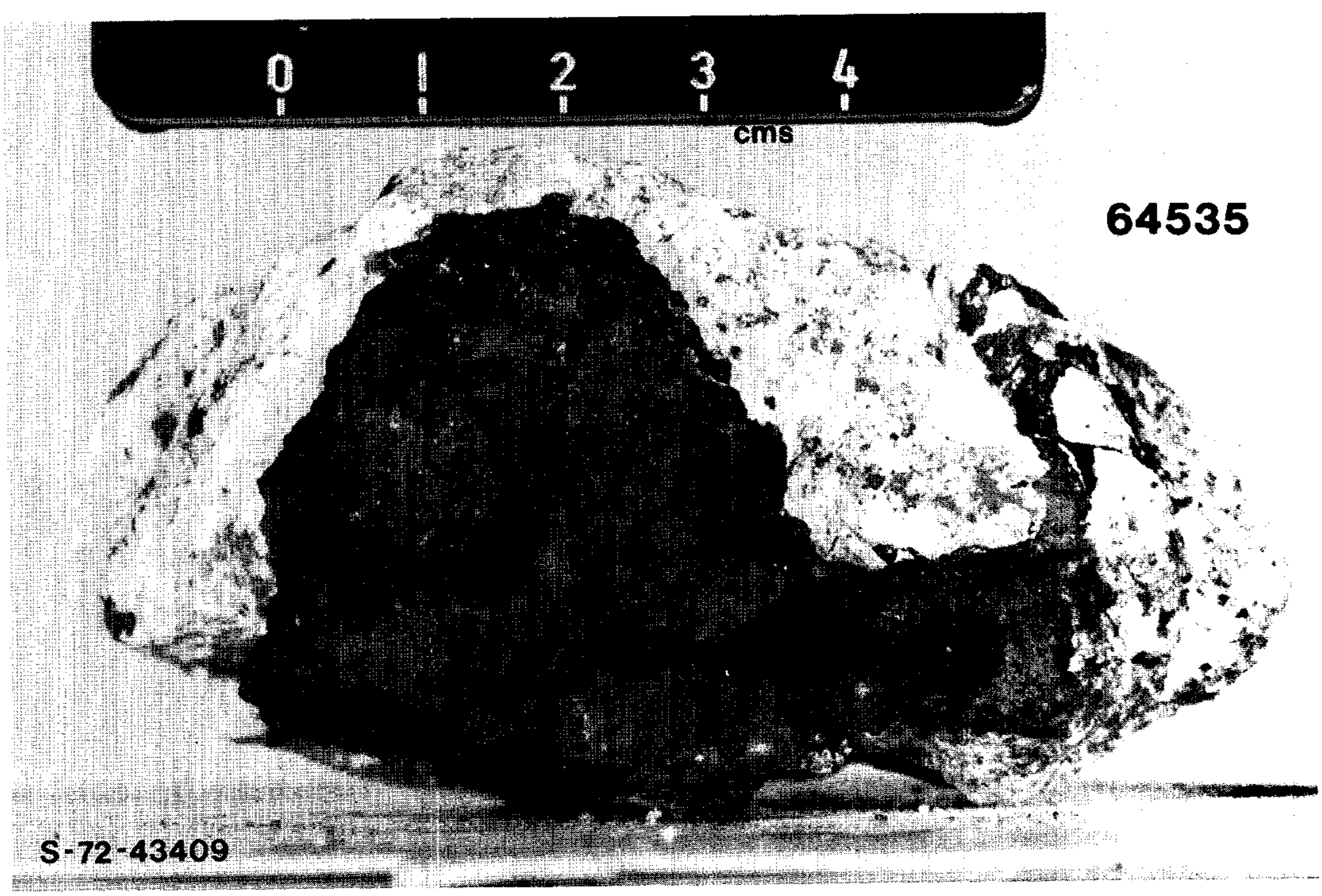



Figure 1a.

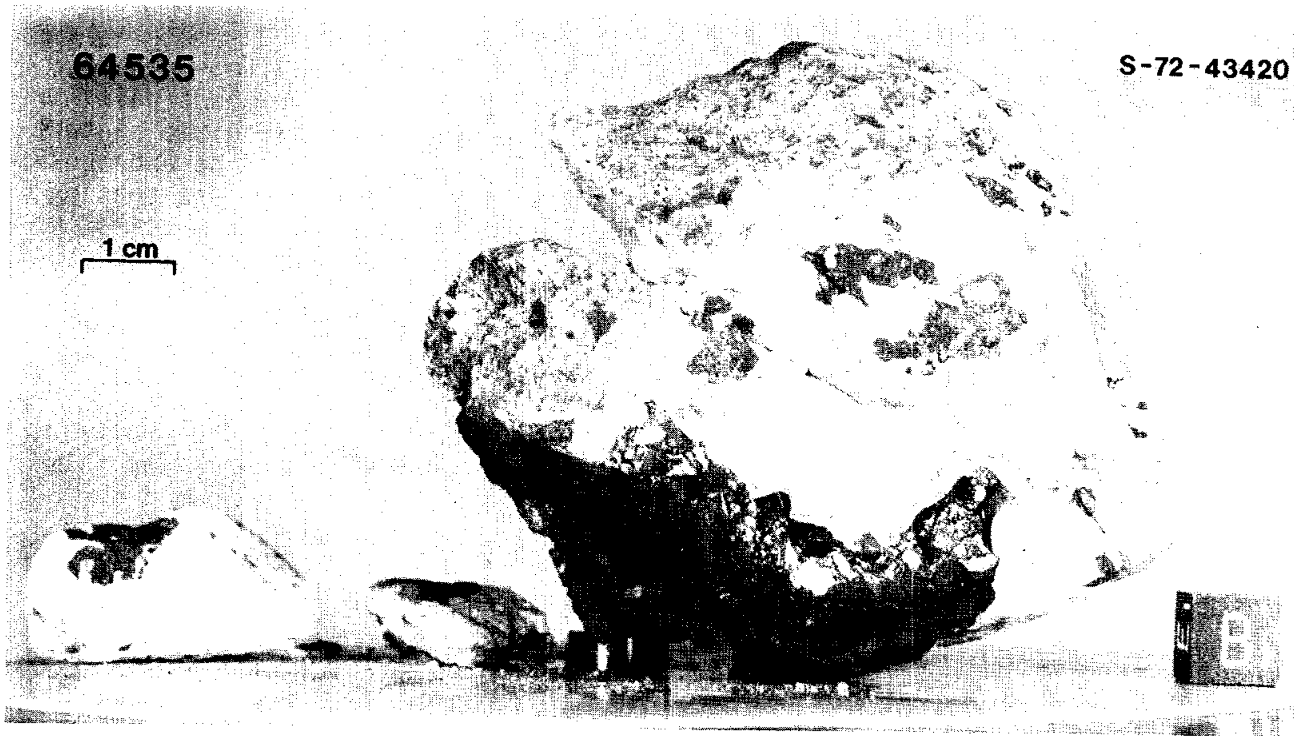



Figure 1b.

PETROLOGY: 64535 is composed of essentially two lithologies: a white, cataclastic anorthosite and a dark, intruding impact melt (Fig. 2). The latter is referred to as mesostasis-olivine-plagioclase rock by Warner *et al*. (1973) who provide an analysis of its mesostasis.

The cataclastic anorthosite appears to be monomict and may be pristine but no mineral or chemical analyses have been published. Pre-cataclasis grain size ranged to >1 mm. In places a granoblastic texture has been preserved (Fig. 2). Mafic minerals are very rare (<2%) and generally occur as discrete grains interstitial to plagioclase.

The impact melt is a very fine-grained vitrophyre with tiny (a few μm's), blocky to lathy plagioclase crystals in a glassy matrix. Irregularly shaped Fe-metal grains (up to ∿1 mm) with associated troilite and a more-poorly-reflecting opaque are common. Angular xenocrysts of plagioclase and, less commonly, mafic minerals are also present. The contact between the two lithologies is irregular but sharp (Fig.2). No chilled margins were observed.

CHEMISTRY: The only published chemical data on 64535 are Ca and K abundances on a white chip (,7) by Jessberger *et al*. (1977). K is very low (123 ppm) and the Ca abundance (16.2% CaO) is consistent with this split being virtually pure anorthosite.

a

b

c

Figure 2. a) 64535,13, anorthosite and impact melt, xpl. width 2mm.
b)64535,13, anorthosite, pre-cataclasis texture, xpl. width 2mm.
c) 64535,14, anorthosite, impact melt contact, ppl. width 1mm.

GEOCHRONOLOGY: An $^{40}Ar$-$^{39}Ar$ plateau age of 3.98±0.02 b.y. on a white chip (Fig. 3) is reported by Jessberger *et al*. (1977).

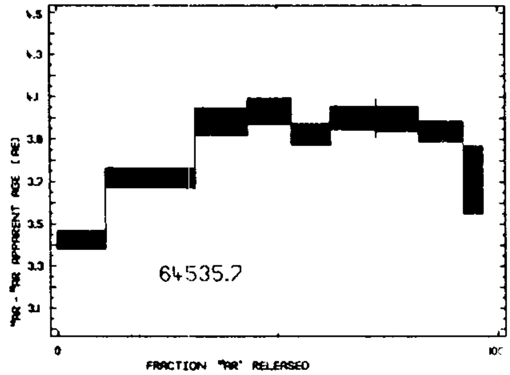



Figure 3. Ar releases, from Jessberger *et al*.(1977).

EXPOSURE AGE: An $^{38}Ar$ exposure age of 1.9±0.2 m.y.on a white chip (,7) (Jessberger *et al*., 1977) is consistent with the excavation of 64535 by the South Ray Crater event.

PROCESSING AND SUBDIVISIONS: In 1975 a large chip (,3) was taken from the E face and subdivided (,3-,10) for allocations (Fig.4). In 1979 a second round of allocations was made by subdividing ,9 and by taking a few chips of both anorthosite and glass from ,0. The largest single piece remaining is ,0 (233.0 g).

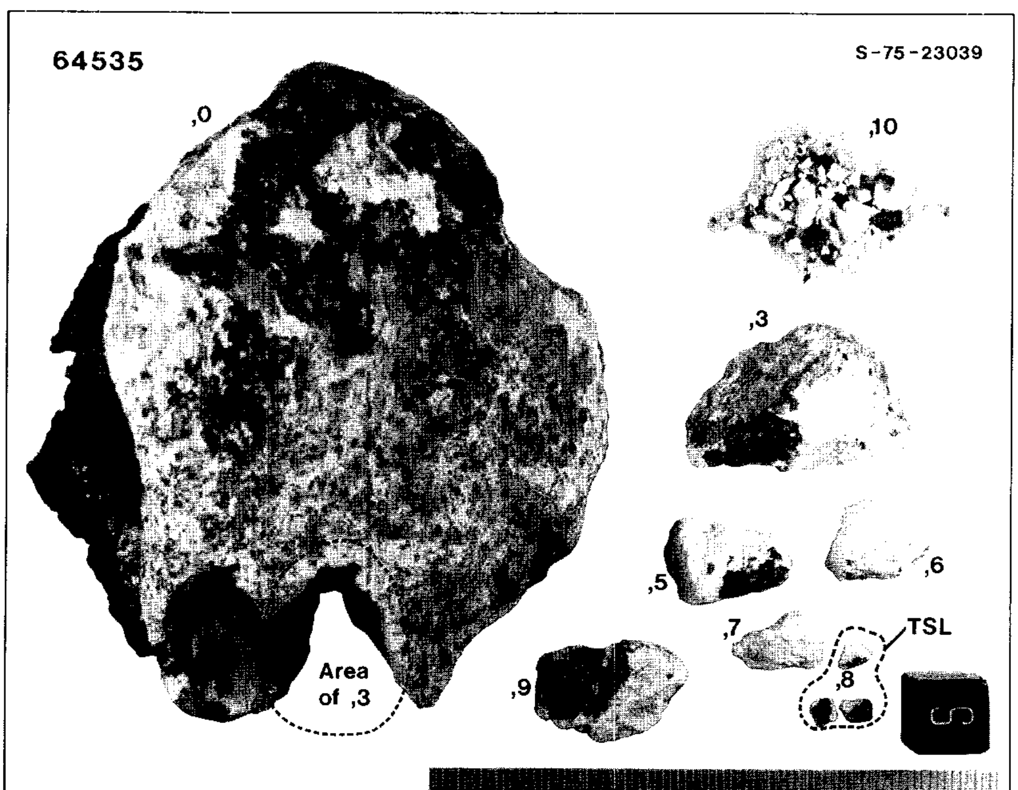



Figure 4.

# 64536 DILITHOLOGIC (ANORTHOSITE AND FINE-GRAINED IMPACT MELT) BRECCIA 177.5 g

INTRODUCTION: 64536 is composed of two lithologies: white, friable, cataclastic anorthosite and dark, coherent, glassy impact melt (Fig. 1). Clast/matrix relations of the two lithologies are obscure. The impact melt is not simply a splash coating and seems to occur as clasts within the anorthosite. Apparently both lithologies were somewhat mobile during their emplacement in this rock.

This sample was collected as a rake sample from the rim of a small, subdued, crater on the upper slope of Stone Mountain. Lithologically it is very similar to 64535 and 64537, both rake samples from the same locality. Patina and a few zap pits are present on the T surface of 64536.


Figure 1.

PETROLOGY: The white lithology is a coarse-grained,apparently monomict, cataclastic anorthosite with rare interstitial mafics (Fig.2). Pre-cataclasis grain size ranged up to ~ 1 cm. Troilite is the only opaque phase present.

The dark lithology is a very fine-grained, glassy impact melt. Grain size is somewhat variable, but is never greater than ~ 0.1 mm. Relatively coarser-grained areas have a basaltic texture (Fig.2) while the finer-grained portions are faintly poikilitic. Metal and troilite are common. Angular clasts of plagioclase and mafics are also present.

a

b

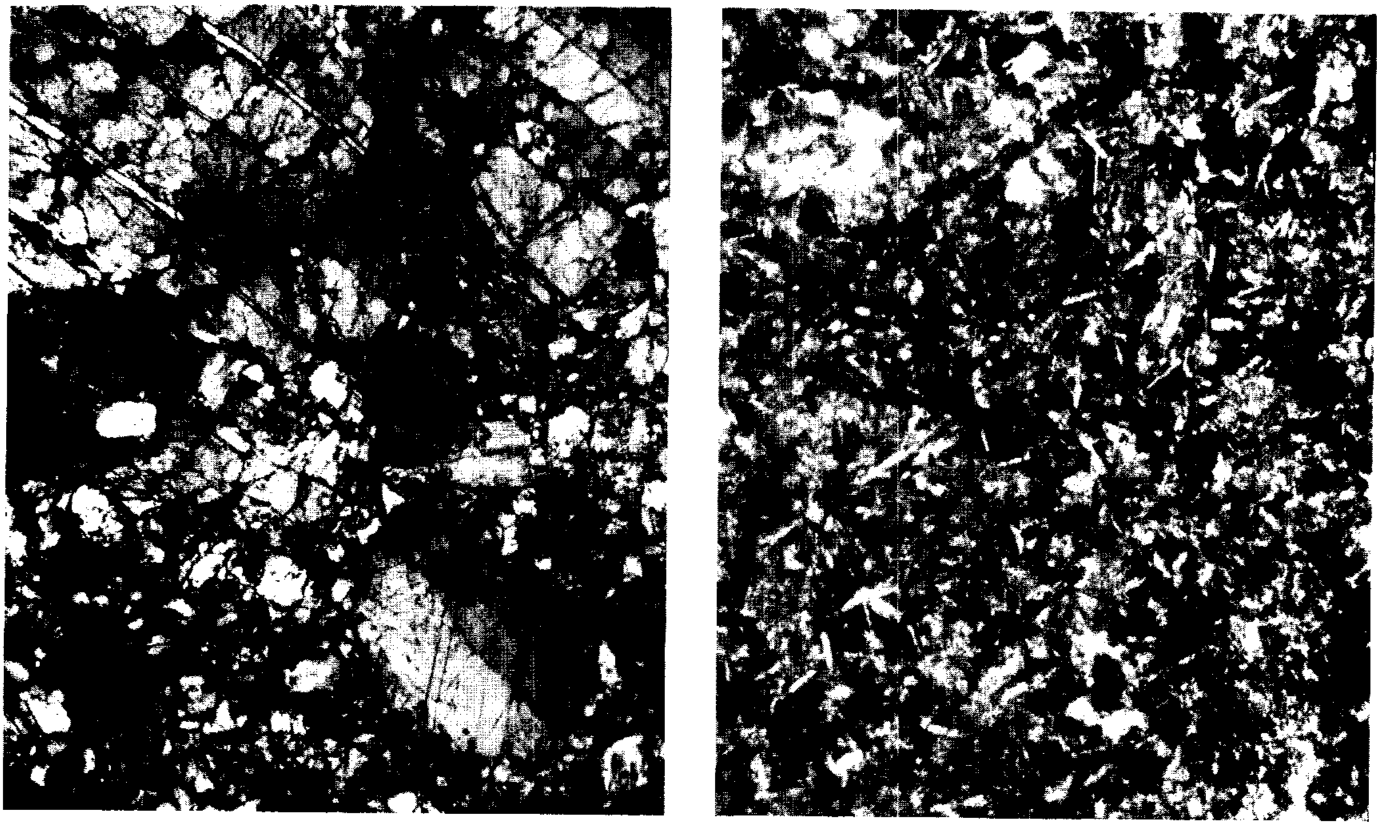


Figure 2. a) 64536,23, anorthosite, xpl. width 2mm.
b) 64536,25, impact melt, ppl. width 0.5mm.

CHEMISTRY: Ca and K data on the anorthosite (,3) and the impact melt (,12) are given by Jessberger et al. (1977). The anorthosite appears to be virtually pure plagioclase (16.7% CaO, 265 ppm K), while the impact melt is much less feldspathic and considerably more potassic (9.4% CaO, 1410 ppm K).

RADIOGENIC ISOTOPES/GEOCHRONOLOGY: Jessberger *et al.* (1977) report K-Ar isotopic data on the anorthosite (,3) and the impact melt (,12). An $^{40}Ar$-$^{39}Ar$ plateau age of 3.97±0.01 b.y. was obtained from the anorthosite (Fig. 3). The impact melt did not yield a good plateau: two apparent age regimes are present. A low temperature fraction(3-47% $^{39}Ar$) gives an age of 4.14±0.02 b.y. while a high temperature fraction (57-99% $^{39}Ar$) gives an age of 3.83±0.02 b.y. The geochronological significance of either age is "spurious at present" (Jessberger *et al.*, 1977).

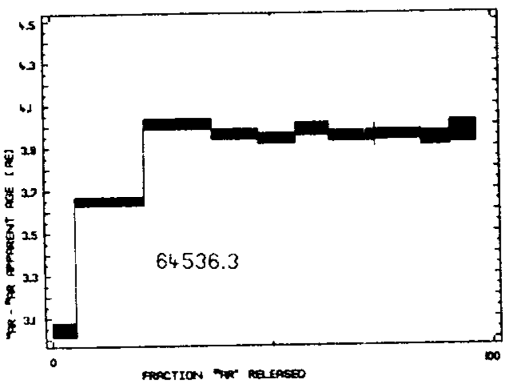



Figure 3. Ar releases, from Jessberger *et al.* (1977).

EXPOSURE AGES: $^{38}Ar$ exposure ages of 1.7±0.2 m.y. and 2.4±0.3 m.y. for the anorthosite (,3) and the impact melt (,12), respectively (Jessberger *et al.*, 1977), are consistent with the excavation of 64536 by the South Ray Crater event.

PROCESSING AND SUBDIVISIONS: In 1975 several small pieces were chipped from 64536 for allocations (Fig. 4). Many of these chips and the parent (,0;147.24 g) remain in stock at JSC.

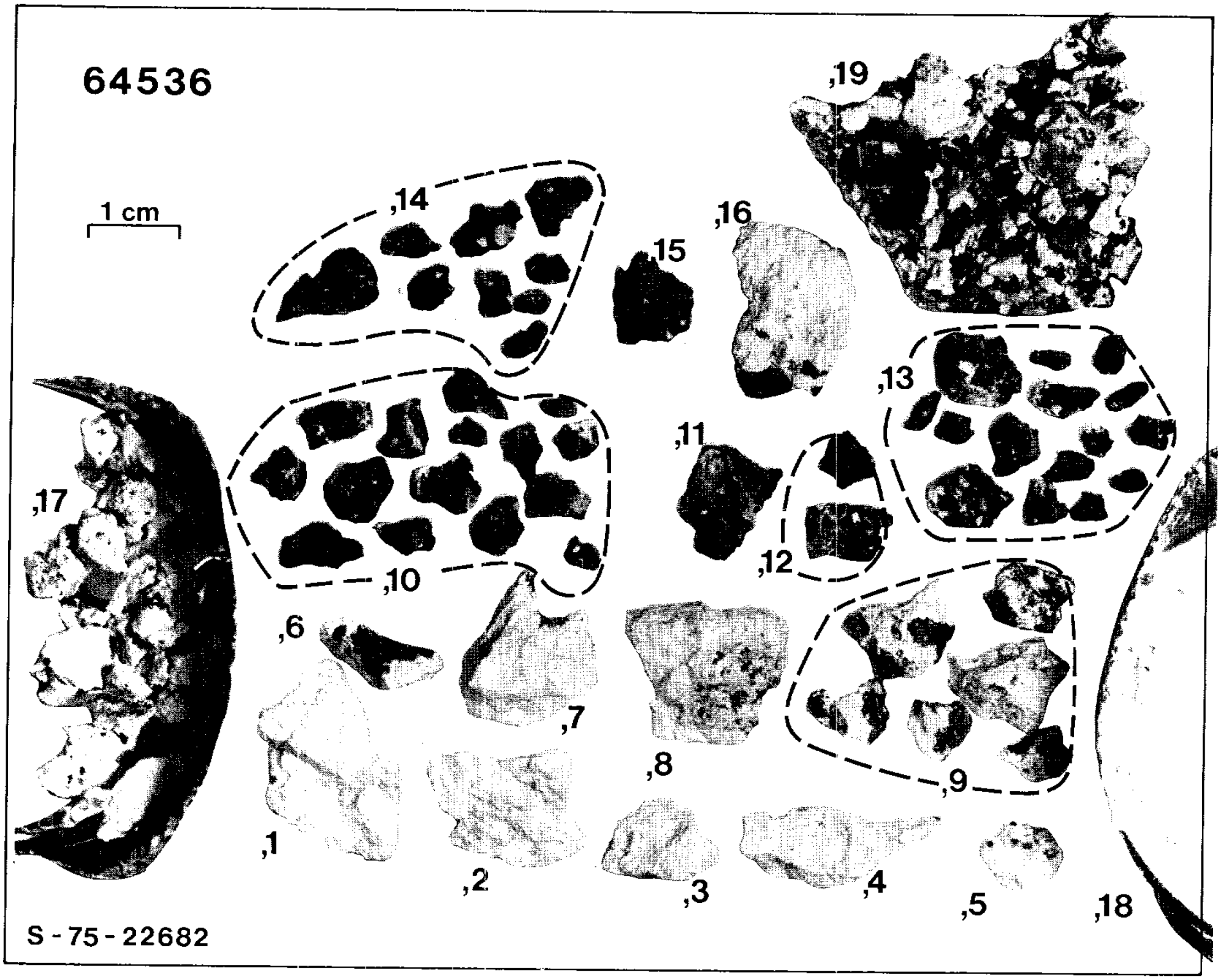



Figure 4.

## 64537 DILITHOLOGIC (CATACLASTIC ANORTHOSITE AND POIKILITIC IMPACT MELT) BRECCIA

124.3 g

INTRODUCTION: 64537 is dominated by two lithologies: a coherent, dark gray, crystalline impact melt and a coherent, white, cataclastic anorthosite (Fig. 1). The impact melt appears to intrude the anorthosite and coarsens away from the contact. Vesicles are very rare in the impact melt, absent from the anorthosite. A few thin glass veins cut the impact melt.

This rock is a rake sample collected from the rim of a subdued doublet crater on Stone Mountain. Zap pits and patina are present on all surfaces indicating a complex exposure history.

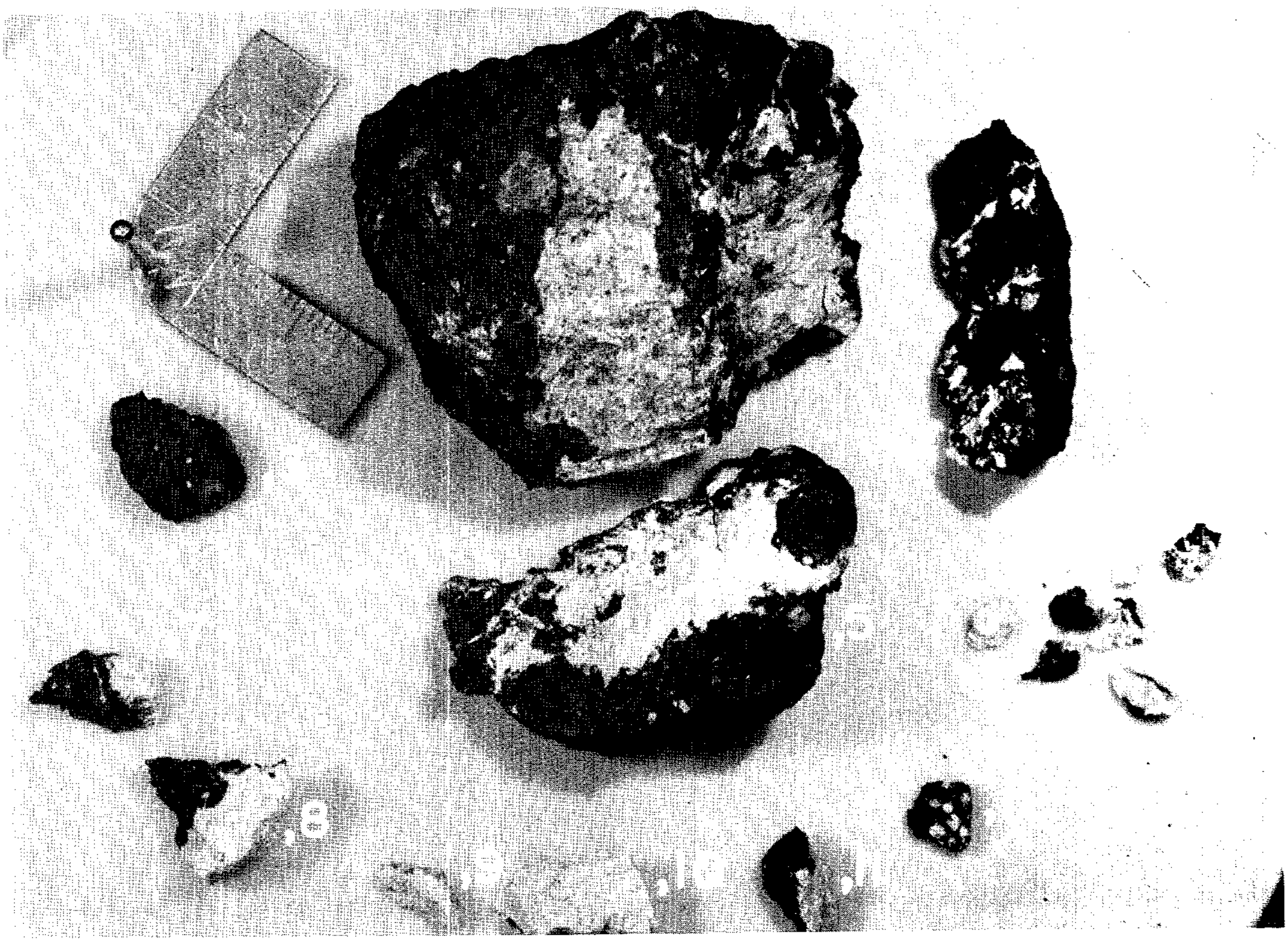


Figure 1. S-75-20885, mm scale.

PETROLOGY: Two distinct lithologies compose the bulk of 64537: a fine-grained impact melt and a cataclastic anorthosite (Fig. 2). Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples.

The impact melt has a fine-grained poikilitic texture and appears to intrude the anorthosite. Oikocrysts (up to ~0.2 mm) are choked with tiny plagioclase laths (most 0.05 mm). Angular plagioclase clasts (rarely up to 2 mm) are present. A single clast of basaltic impact melt was observed. Accessory phases include ilmenite, Fe-metal with associated troilite and schreibersite, and rare euhedral spinel(?).

The anorthosite has been cataclasized and mildly recrystallized. It is probably monomict. Plagioclase grains range up to ~2 mm long. A few grains (<5%) of exsolved pyroxene are present, sometimes retaining original grain boundaries and showing a relict cumulate texture. Blebby intergrowths of troilite and silica(?) rim some pyroxenes. Fe-metal and chromite(?) are extremely rare.

a

b

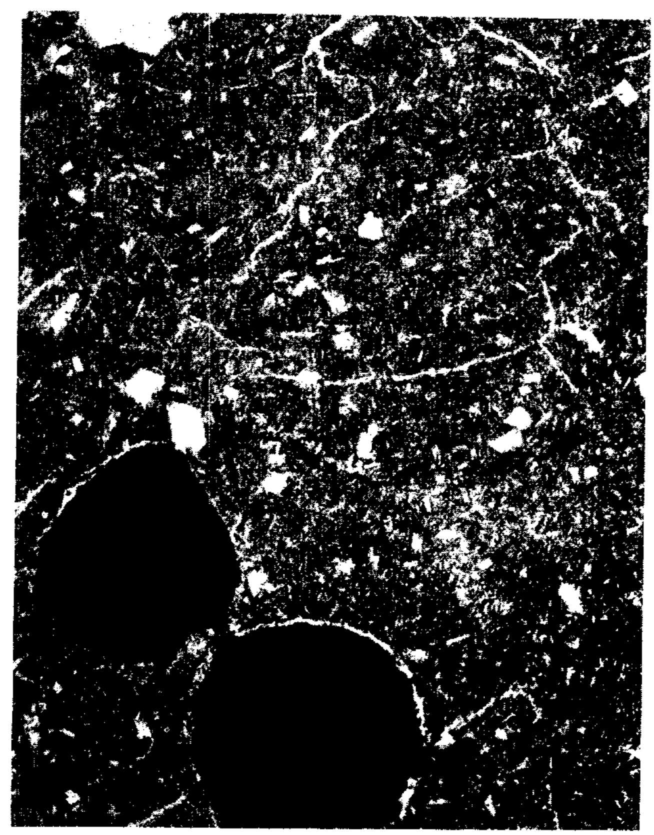


Figure 2. a) 64537,4, anorthosite, impact melt contact, ppl. width 2mm.
b) 64537,18, impact melt, ppl. width 1mm.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on a potted butt containing both the dark and light lithologies. The very small saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.005) indicates that most of the ferromagnetic phases in this rock occur as >300 Å, multidomain particles. $Fe^0/Fe^{2+}$ is 0.086 and total $Fe^0$ is 0.46 wt% (Pearce and Simonds, 1974).

PROCESSING AND SUBDIVISIONS: In 1972 five small pieces were removed and one of these (,1) allocated for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1. In 1975 the rock was split into several pieces for further allocations (Fig. 1). The largest single piece remainting is ,0 (91.13 g). ,5 (19.55 g) is stored at the Brooks Remote Storage Vault.

INTRODUCTION: 64538 is composed of three distinct lithologies in sharp contact: a coherent, medium gray, glassy matrix breccia; a coherent, dark gray, crystalline impact melt; and a moderately coherent, white, anorthositic breccia (Fig. 1). Thin, glassy veins cut the glassy breccia and the impact melt.

This rock is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are common on all surfaces indicating a complex exposure history.

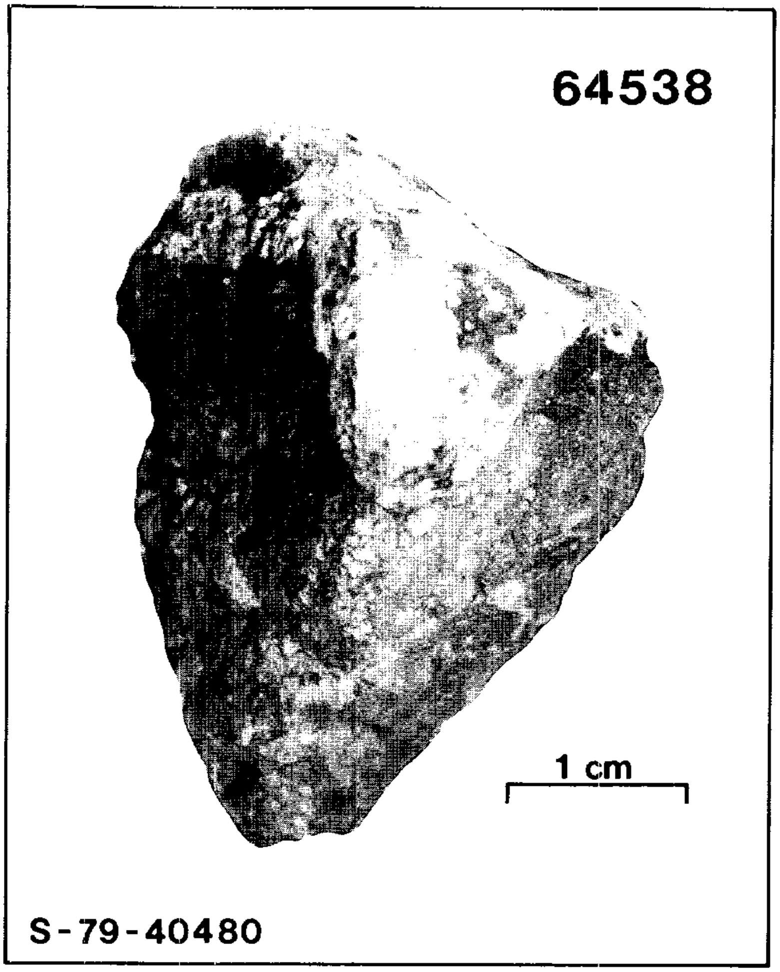



Figure 1.

PETROLOGY: The glassy matrix breccia makes up the bulk of 64538 and is composed of many clasts of plagioclase and cataclastic anorthosite welded together by a continuous matrix of partially crystallized glass (Fig. 2). Rare mafic minerals also occur as clasts. Accessory phases include Fe-metal, troilite and ilmenite.

The impact melt is very fine-grained with a faintly poikilitic texture. Clasts of plagioclase, rare mafic grains and Fe-metal (some rusty) are present. The contact with the anorthositic breccia is very angular (Fig. 2) indicating that some remobilization of these lithologies has probably occurred. Portions of the impact melt appear to have been frozen while being sheared off into the anorthositic breccia.

The anorthositic breccia consists of a cataclastic anorthosite with several clasts of crystalline impact melt that are probably related to the lithology described above (Fig. 2). Olivine and pyroxene are interstitial to the larger plagioclase grains. Rare Fe-metal is present.

PROCESSING AND SUBDIVISIONS: In 1979 two chips (,1 and ,2) that sampled all three lithologies were allocated for thin sections.

a b

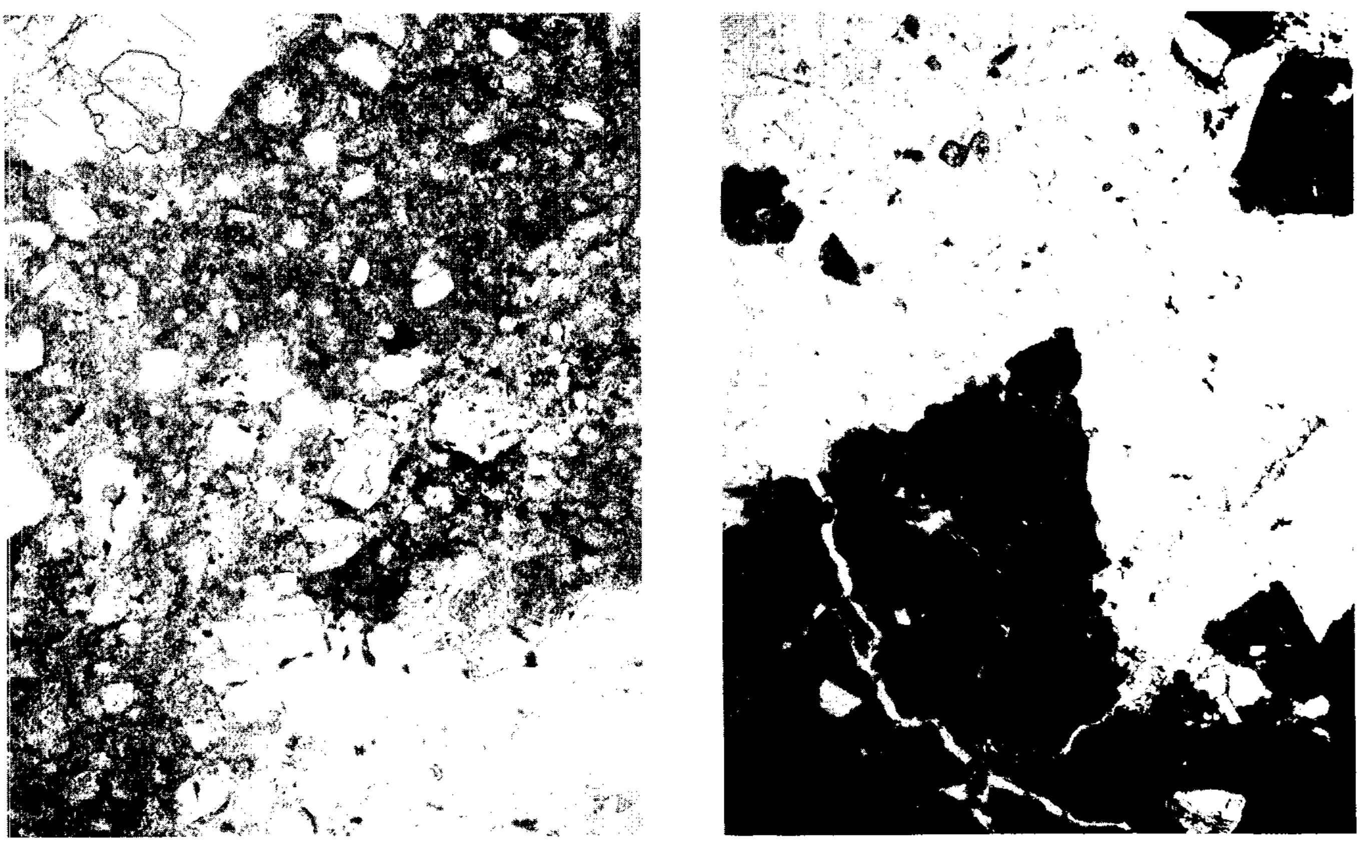


Figure 2. a) 64538,5, glassy matrix breccia, ppl. width 1mm.
b) 64538,6, impact melt and anorthositic breccia, ppl. width 2mm.

## 64539 DILITHOLOGIC BRECCIA 17.76 g

INTRODUCTION: 64539 consists of two distinct lithologies: a coherent medium gray material with white clasts and a moderately coherent white material with dark clasts (Fig. 1). Macroscopically it is very similar to the other dilithologic breccias from Station 4 (e.g., 64535-6-7). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are rare or absent.

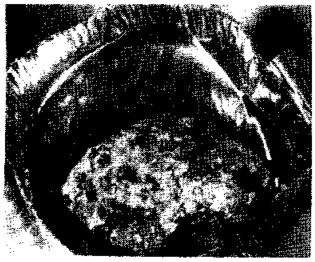


Figure 1. S-72-42558.

INTRODUCTION: 64545 is composed of two distinct lithologies: a coherent, medium gray material with white clasts and a moderately coherent, white material with rare dark clasts (Fig. 1). Macroscopically it is very similar to the other Station 4 dilithologic breccias (e.g., 64535-6-7). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Patina and a few zap pits are present.

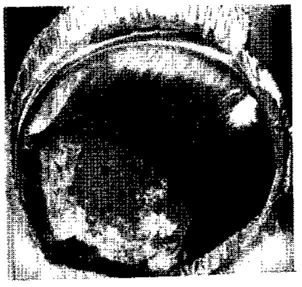


Figure 1. S-72-42557.

## 64546 DILITHOLOGIC (CATACLASTIC ANORTHOSITE AND POIKILITIC IMPACT MELT) BRECCIA 12.80 g

INTRODUCTION: 64546 is a coherent breccia composed of two lithologies: white cataclastic anorthosite and dark gray poikilitic impact melt (Fig. 1). It was collected as a rake sample. Zap pits are absent.

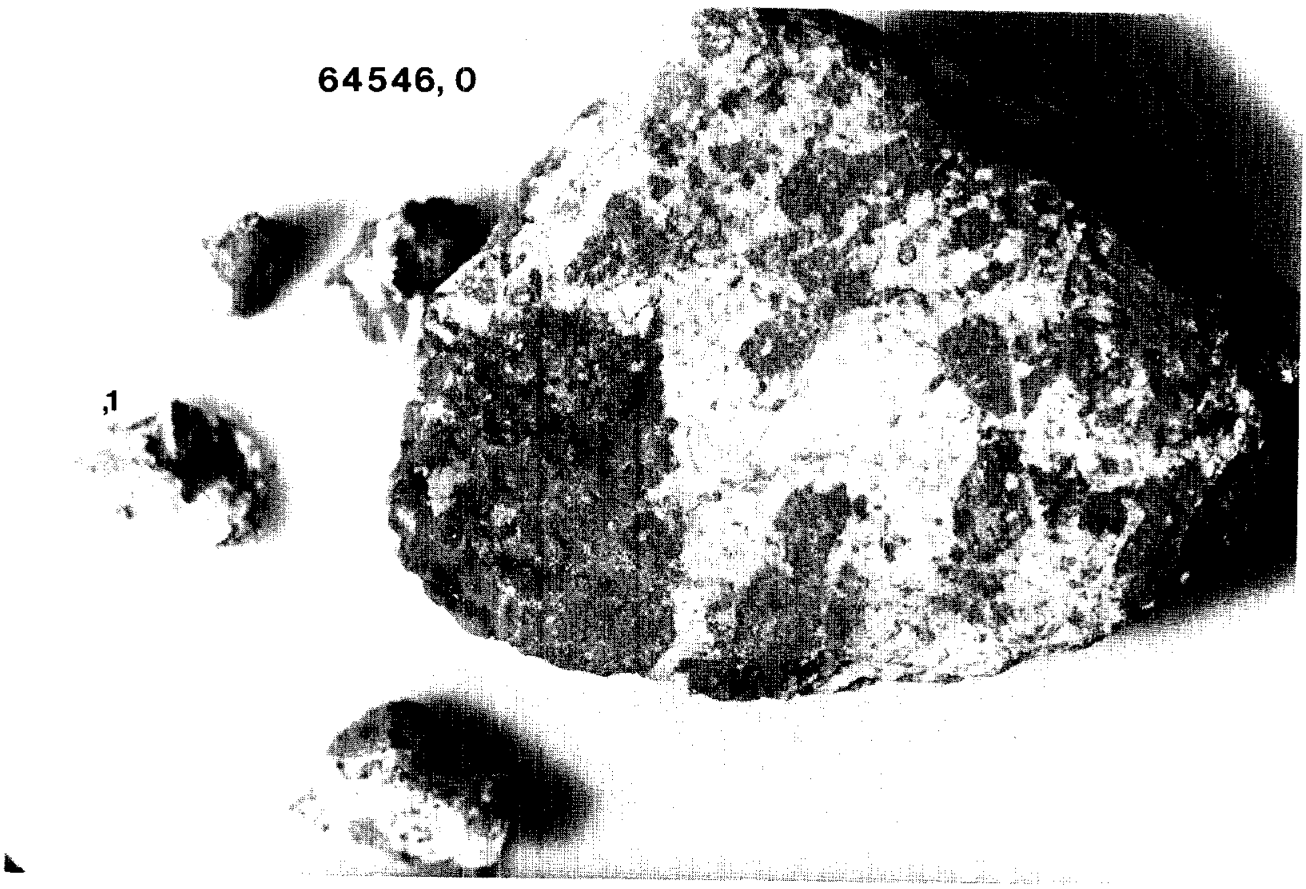



Figure 1.

PETROLOGY: 64546 is a typical "black and white" rock, being composed of only two lithologies: cataclastic anorthosite and fine-grained poikilitic impact melt (Fig. 2). The anorthosite is coarse-grained (up to ~2 mm) with rare interstitial mafic minerals. The poikilitic impact melt contains clasts and laths of plagioclase and elongate oikocrysts (~0.4 mm long). It appears to occur chiefly as angular clasts within the anorthosite. Fe-metal is an accessory phase in both lithologies but is more common in the poikilitic melt. Gooley *et al.* (1973) provide compositional data for metal in the melt (Table 1).

TABLE 1. Compositions of metal and coexisting schreibersite (wt%)

| | Ni | Co | Fe | P | S |
|---|---|---|---|---|---|
| metal (without schreibersite) | 6.6-7.4 | 0.6 | -- | 0.0-0.03 | 0.02 |
| metal (with schreibersite) | 5.0 | 0.7 | 93.1 | 0.1 | 0.01 |
| schreibersite | 18.6 | 0.3 | 66.2 | 15.4 | 0.1 |

PROCESSING AND SUBDIVISIONS: In 1972 a small chip (,1) was allocated to Phinney for thin sectioning and petrography.

Figure 2. 64546,4, anorthosite, impact melt contact, ppl. width 2mm.

## 64547 FRAGMENTAL POLYMICT OR DILITHOLOGIC BRECCIA 10.90 g

INTRODUCTION: 64547 is a moderately coherent, white breccia with a few dark clasts (Fig. 1). Macroscopically the clasts and the matrix of this rock resemble the two distinct lithologies in other Station 4 dilithologic breccias (e.g., 64535-6-7). 64547 may represent an "end member" of a series of dilithogic breccias, being completely dominated by one of the components, in this case the white material.

It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits and patina are present.

Figure 1. S-72-42557.

INTRODUCTION: 64548 is a moderately coherent, white, anorthositic breccia with abundant dark, angular clasts (Fig. 1). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are rare or absent.

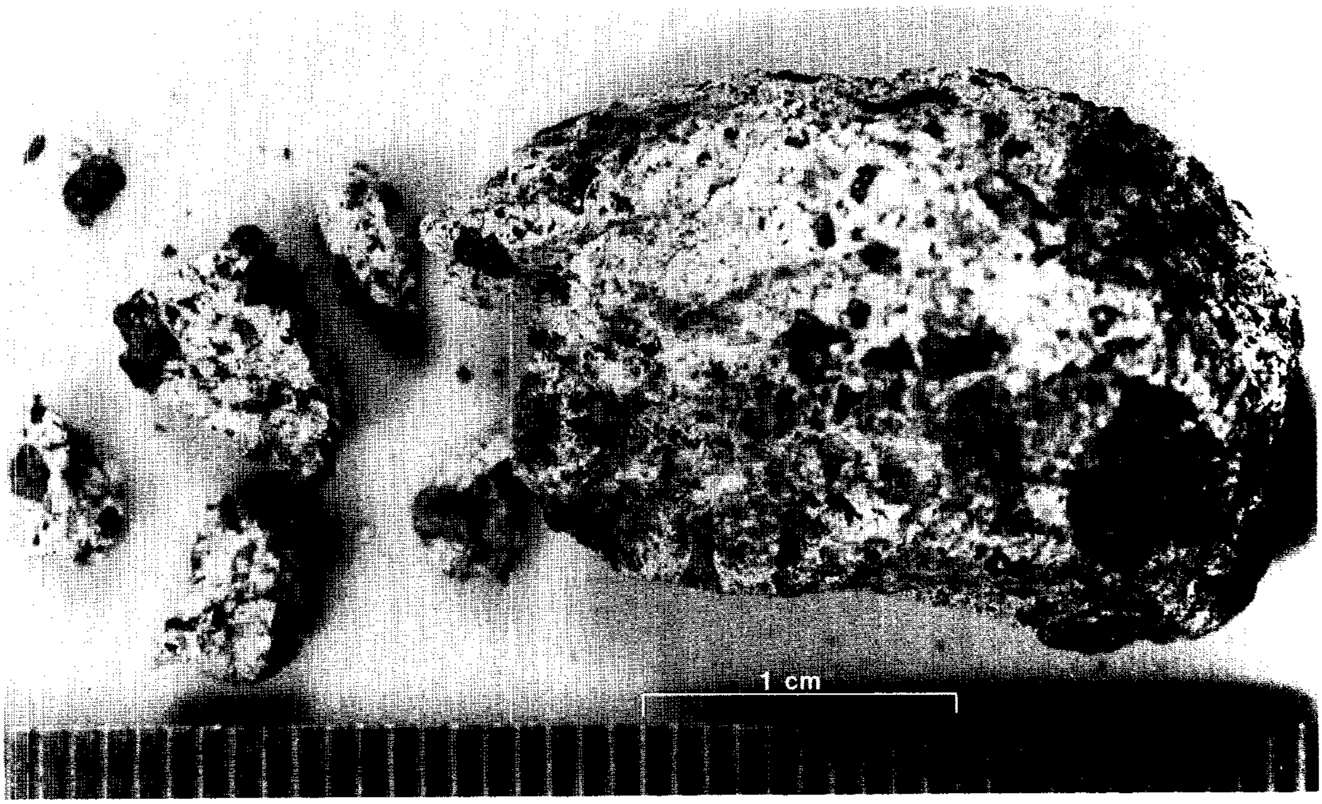



Figure 1.

PETROLOGY: Warner et al. (1973) include 64548 in a general petrographic discussion of Apollo 16 rakes. Two lithologies appear to dominate 64548. The white matrix is largely brecciated anorthosite (Fig. 2). The dark clasts are virtually all fine-grained impact melt with a faintly poikilitic texture. The anorthositic material and the impact melt appear to have been intimately mixed (Fig. 2), making a separation of pure anorthosite extremely difficult. Gooley et al. (1973) provide compositional data for metal with and without coexisting schreibersite in the impact melt. These data are reproduced in Table 1.

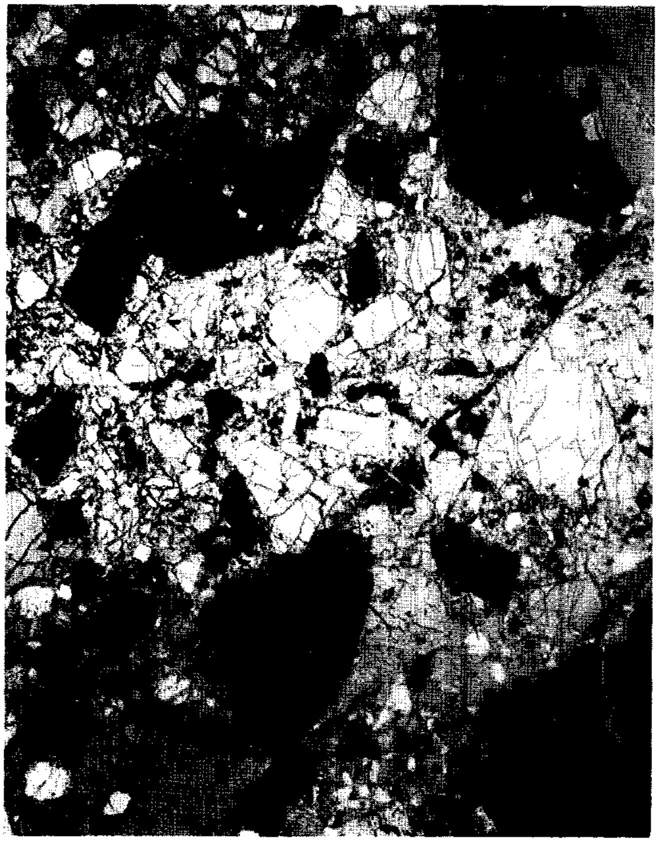


Figure 2. 64548,4, general view, ppl. width 2mm.

TABLE 1. Compositions of metal and coexisting schreibersite for 64548

| | Ni | Co | Fe | P | S |
|---|---|---|---|---|---|
| Metal (without schreiberstite) | 6.6-7.4 | 0.6 | - | 0.0-0.3 | 0.02 |
| Metal (with schreibersite) | 3.5 | 0.6 | 96.4 | 0.2 | 0.01 |
| Schreibersite | 11.4 | 0.2 | 73.8 | 15.5 | 0.1 |

CHEMISTRY: Floran et al. (1976) present major element data obtained by electron microprobe analysis of natural rock powder fused to a glass (except FeO and $Na_2O$, by instrumental neutron activation). Blanchard (unpublished data) provides a bulk rock trace element analysis and the FeO and $Na_2O$ data quoted by Floran et al. (1976). These data indicate that 64548 is similar to the local mature soils in both major and trace element composition (Table 2, Fig. 3).

| TABLE 2. Summary of chemistry of 64548 | |
|---|---|
| $SiO_2$ | 45.28 |
| $TiO_2$ | 0.43 |
| $Al_2O_3$ | 27.67 |
| $Cr_2O_3$ | 0.098 |
| FeO | 4.47 |
| MnO | |
| MgO | 5.67 |
| CaO | 15.79 |
| $Na_2O$ | 0.464 |
| $K_2O$ | 0.13 |
| $P_2O_5$ | |
| Sr | |
| La | 14.6 |
| Lu | 0.67 |
| Rb | |
| Sc | 6.78 |
| Ni | 380 |
| Co | 24.5 |
| Ir ppb | |
| Au ppb | |
| C | |
| N | |
| S | |
| Zn | |
| Cu | |

Oxides in wt%;

others in ppm except as noted.

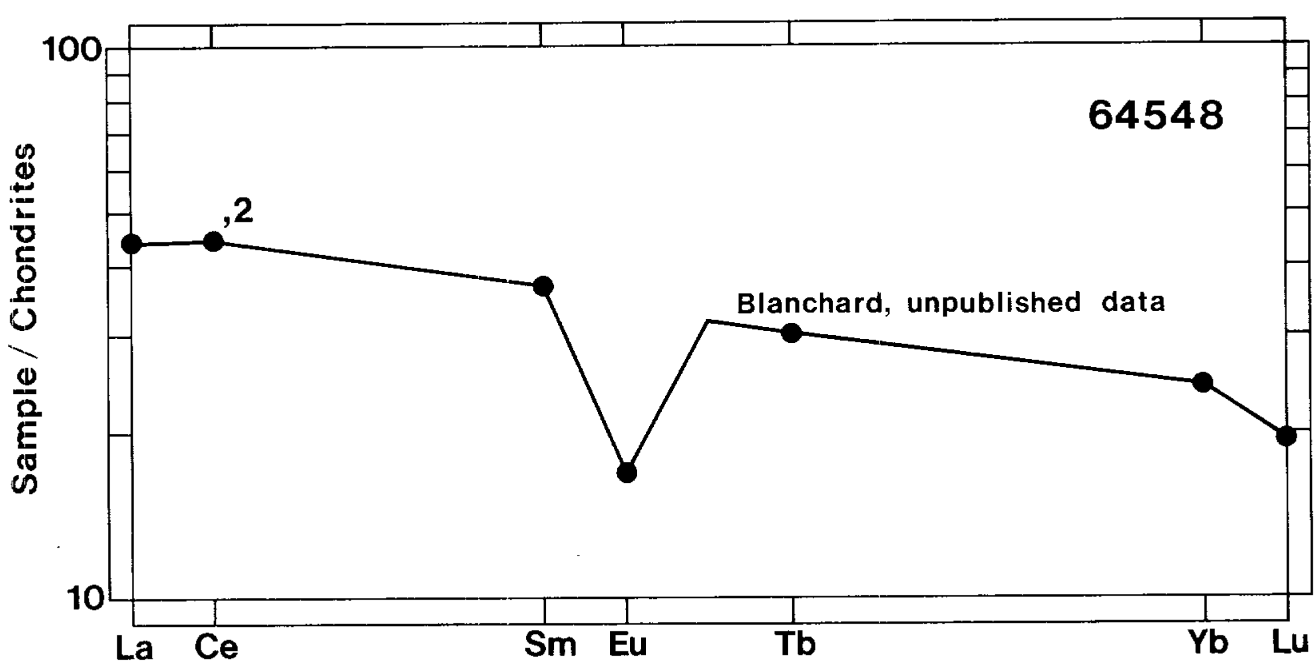



Figure 3.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64548. The very small saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.0043) indicates that virtually all of the ferromagnetic phases in this sample are multidomain particles. $Fe^o/Fe^{2+}$ is 0.113.

PROCESSING AND SUBDIVISIONS: In 1972 the rock was split into several pieces and one of these (,1) allocated to Phinney for thin sectioning and petrography. In 1975 a set of three small chips (,3) was allocated for chemistry; the analyses of Floran et al. (1976) and Blanchard (unpublished) are both of portions of this split. The magnetic studies were done on the potted butt of ,1. The remainder of the rock remains at JSC as ,0 (8.20 g).

# 64549 DILITHOLOGIC BRECCIA (?) 6.47 g

INTRODUCTION: 64549 is a moderately coherent, white breccia with a dark gray clast on one corner (Fig. 1). Macroscopically it appears to be an unrepresentative sample of the larger Station 4 dilithologic breccias (e.g., 64535-6-7), being completely dominated by the white material. It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits and patina are present.

Figure 1. S-72-42558.

## 64555 FRAGMENTAL DILITHOLOGIC(?) BRECCIA 5.29 g

INTRODUCTION: 64555 is a moderately coherent, very light gray breccia with rare dark clasts (Fig. 1). It is covered with patina making identification difficult, but it could be an unrepresentative sample of the larger Station 4 dilithologic breccias (e.g., 64535-6-7). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are rare or absent.

Figure 1. S-72-42558

## 64556 DILITHOLOGIC OR POLYMICT BRECCIA 5.15 g

INTRODUCTION: 64556 is composed of a coherent, medium gray material with white clasts and a moderately coherent, white material swirled together (Fig. 1). Clast/matrix relations between the two lithologies are unclear and 64556 may be related to the larger Station 4 dilithologic breccias (e.g., 64535-6-7). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are rare.

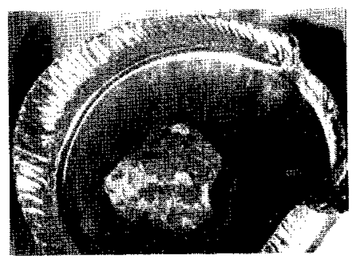


Figure 1. S-72-42558.

# 64557 POLYMICT MELT MATRIX(?) BRECCIA 4.79 g

INTRODUCTION: 64557 consists of many white, angular clasts in a dark matrix that is probably an impact melt (Fig. 1). In some places the clasts and matrix have been swirled together in a marbled texture. It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are rare or absent.

Figure 1. S-72-42557.

INTRODUCTION: 64558 is a coherent breccia apparently composed of only two lithologies: a white, anorthositic breccia and a gray, fine-grained impact melt (Fig. 1). It is a rake sample. Zap pits are rare.

PHYSICAL PROCESSES: Pearce and Simonds (1974) tabulate magnetic data for a sample listed as 64558, but Curatorial records indicate that 64558 has never been split or allocated.

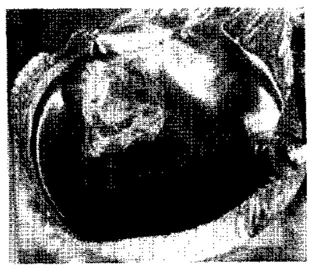


Figure 1. S-72-42557.

INTRODUCTION: 64559 is a coherent, medium gray, basaltic impact melt with several stringers and clasts of anorthosite (Fig. 1). It is a rake sample collected from the rim of a subdued doublet crater on Stone Mountain. Zap pits and vesicles are absent.

Figure 1. S-72-55352, mm scale.

PETROLOGY: Warner et al.(1973) include this rock in a general petrographic discussion of Apollo 16 rake samples. It is a fine-grained basaltic impact melt with abundant glassy mesostasis and many plagioclase clasts (Fig. 2). An electron microprobe analysis of the mesostasis is given by Warner et al.(1973) and reproduced here as Table 1. Some of the clasts have been smeared out to elongate veinlets. Accessory phases in the basalt include Fe-metal, associated troilite and schreibersite, and cohenite (Gooley et al., 1973). Compositions of Fe-metal and coexisting schreibersite are provided by Gooley et al. (1973) and reproduced here as Table 2.

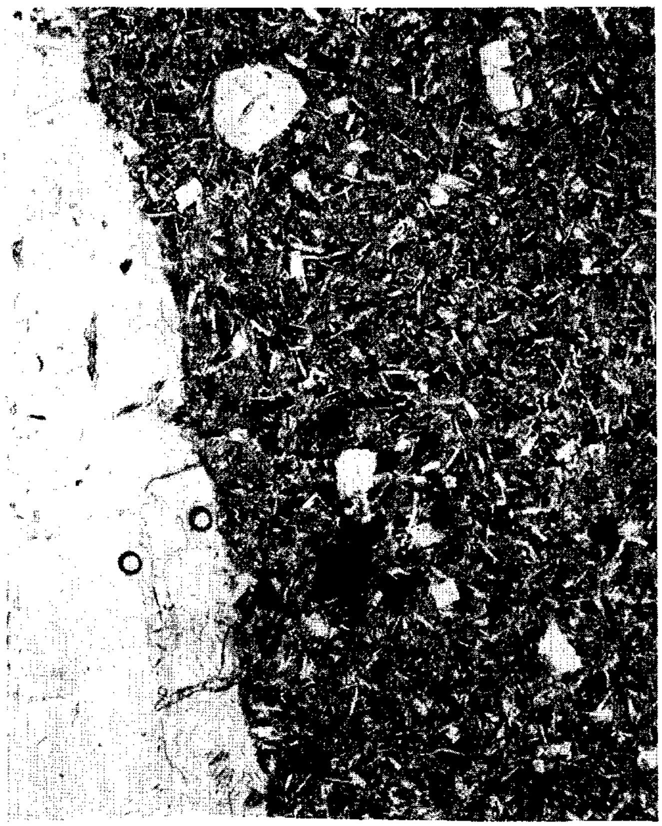


Figure 2. 64559,4, impact melt and anorthosite clast, ppl. width 1mm.

TABLE 1. Composition of mesostasis in 64559
(from Warner *et al.*, 1973)

| | |
|---|---|
| $SiO_2$ | 52.7 |
| $TiO_2$ | 0.4 |
| $Al_2O_3$ | 18.2 |
| $Cr_2O_3$ | 0.2 |
| FeO | 6.5 |
| MgO | 7.4 |
| CaO | 13.6 |
| $Na_2O$ | 0.1 |
| $K_2O$ | 0.4 |

TABLE 2. Composition of metal and schreibersite in 64559
(from Gooley *et al.*, 1973)

| | Ni | Co | Fe | P | S |
|---|---|---|---|---|---|
| Metal | 4.2 | 0.6 | 95.5 | 0.1 | - |
| Schreibersite | 13.9 | 0.6 | 71.6 | 15.5 | 0.1 |

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64559. The very small saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.0049) indicates that the ferromagnetic phases in this rock are dominantly >300 Å, multidomain particles. $Fe^0/Fe^{2+}$ is 0.242 and total $Fe^0$ is 1.08 wt % (Pearce and Simonds, 1974).

PROCESSING AND SUBDIVISIONS: In 1972 three chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography. The magnetic studies were made on the potted butt of ,1.

INTRODUCTION: 64565 is a coherent, dark gray, impact melt with several large vesicles (Fig. 1). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are absent.

Figure 1. S-72-55354, mm scale.

PETROLOGY: Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples and classify it as "spherulitic to dendritic devitrified glass". Abundant shocked to recrystallized clasts of plagioclase and anorthosite rest in a matrix of plagioclase needles and glassy mesostasis (Fig. 2). Accessory phases include Fe-metal and troilite.

Figure 2. 64565,4, general view, ppl. width 1mm.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64565. The saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.011) suggests that both single domain and multidomain particles are present. $Fe^o/Fe^{2+}$ is 0.122 and total $Fe^o$ is 0.34 wt% (Pearce and Simonds, 1974).

PROCESSING AND SUBDIVISIONS: In 1972 two small chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography. The magnetic studies were made on the potted butt of ,1.

## 64566 FINE-GRAINED IMPACT MELT 14.13 g

INTRODUCTION: 64566 is a coherent, dark gray, aphanitic impact melt with a few white clasts (Fig. 1). Portions of the rock may be glassy. It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits and patina are present on all surfaces.

Figure 1. S-72-42556.

INTRODUCTION: 64567 is a coherent, medium gray, poikilitic impact melt (Fig. 1) collected as a rake sample. Zap pits are abundant on one surface, rare on the other surfaces. The face that is heavily pitted also shows a concentration of rusted metal (Phinney and Lofgren, 1973).

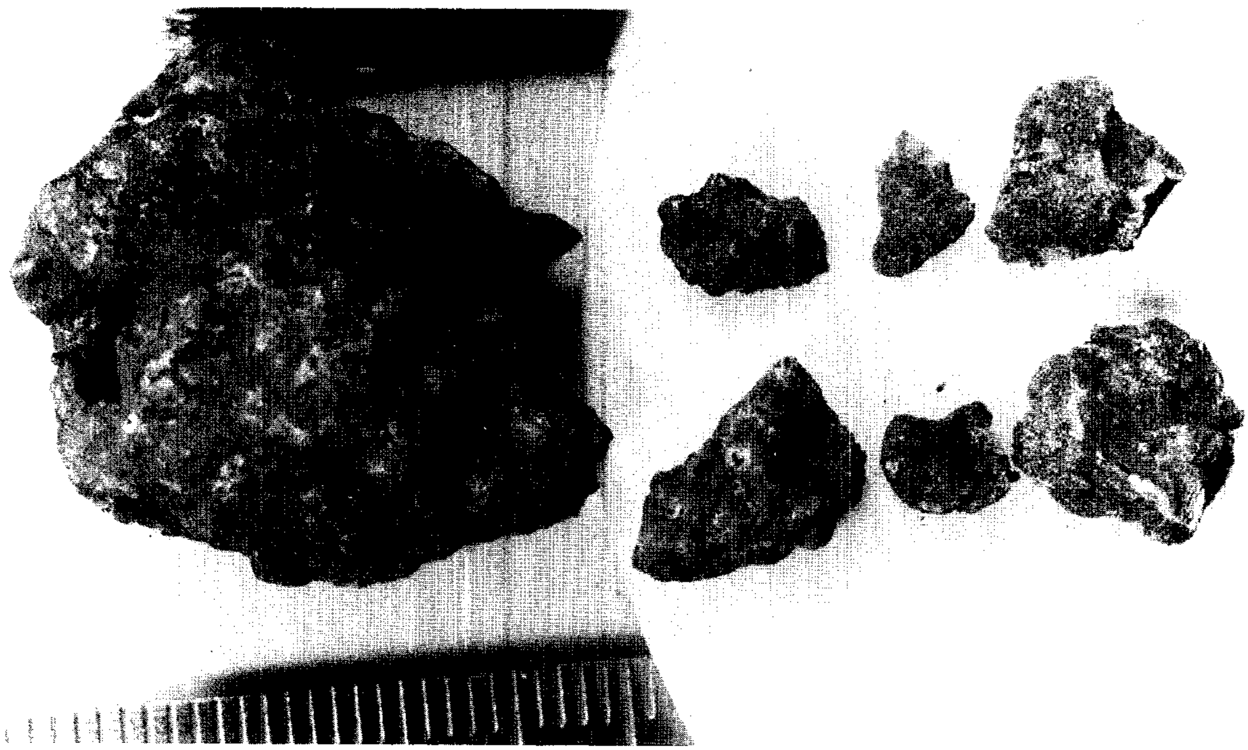


Figure 1. S-72-55373, mm scale.

PETROLOGY: A petrographic description is given by Simonds et al. (1973). 64567 differs from most other Apollo 16 poikilitic impact melts in having olivine as the sole oikocryst phase. Plagioclase laths (up to ~0.1 mm) are well developed and the texture approaches subophitic in places (Fig. 2). Simonds et al. (1973) give a mode of 69% plagioclase and mesostasis, 20% olivine, 10% pigeonite, and 1% opaques. Mineral compositions are shown in Figure 3. A single clast of "meta-breccia" is noted by Simonds et al. (1973). Compositions of Fe-metal and coexisting schreibersite are given by Gooley et al. (1973) and reproduced here as Table 1.

Figure 2. 64567,9, general view, ppl. width 1mm.

TABLE 1. Compositions of metal and coexisting schreibersite (wt %)

| | Ni | Co | Fe | P | S |
|---|---|---|---|---|---|
| metal (without schreibersite) | 4.1-6.1 | 0.5 | - | 0.0-0.5 | 0.02 |
| metal (with schreibersite) | 4.4 | 0.6 | 94.3 | 0.05 | 0.01 |
| schreibersite | 15.0 | 0.2 | 69.7 | 15.0 | 0.1 |

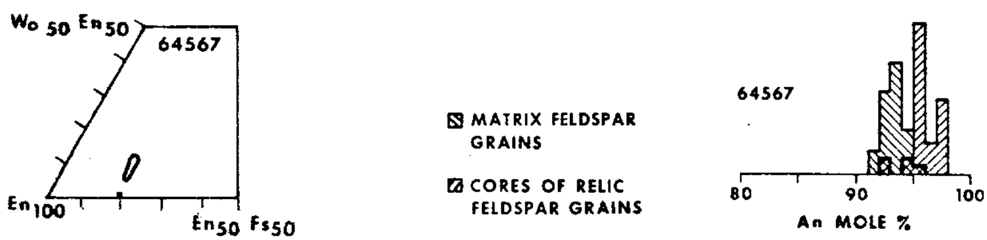



Figure 3. Mineral compositions, olivine plotted along base of pyroxene diagram, from Simonds et al. (1973).

CHEMISTRY: Major and trace element data are presented by Hubbard et al. (1973) and summarized here as Table 2 and Figure 4. Other chemical data are given by geochronologists (referenced below).

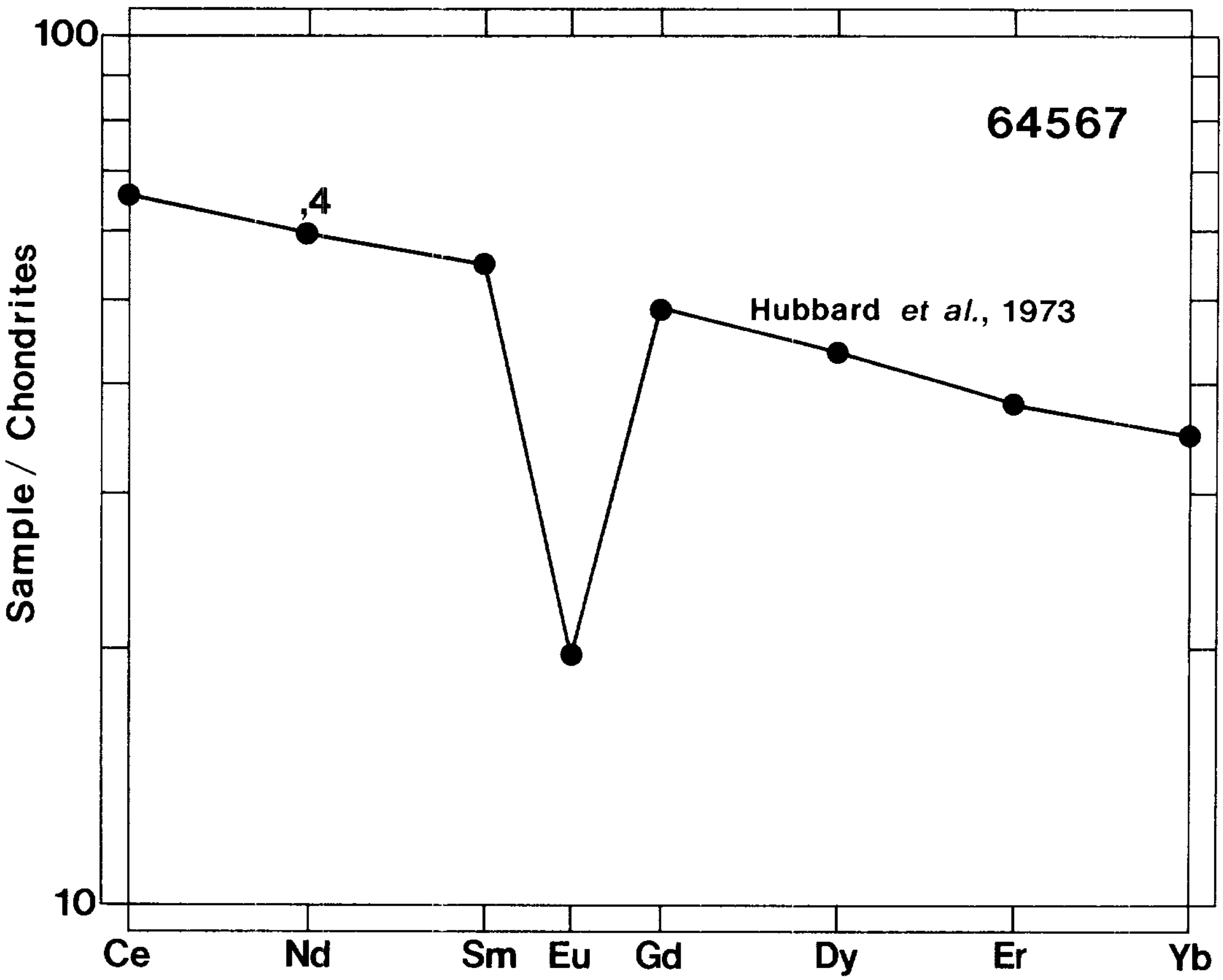



Figure 4. Rare earths.

RADIOGENIC ISOTOPES/GEOCHRONOLOGY: Nyquist et al. (1973) and Nyquist (1977) provide whole rock Rb-Sr data which are summarized here in Table 3. $^{87}Sr/^{86}Sr$ (at 4.6 b.y.) is corrected by Nyquist (1977) for interlaboratory bias.

TABLE 2. Summary chemistry of 64567

| | |
|---|---|
| $SiO_2$ | 45.7 |
| $TiO_2$ | 0.71 |
| $Al_2O_3$ | 21.3 |
| $Cr_2O_3$ | 0.149 |
| FeO | 7.2 |
| MnO | 0.07 |
| MgO | 11.5 |
| CaO | 12.8 |
| $Na_2O$ | 0.42 |
| $K_2O$ | 0.18 |
| $P_2O_5$ | 0.19 |
| Sr | 147 |
| La | |
| Lu | |
| Rb | 4.93 |
| Sc | |
| Ni | |
| Co | |
| Ir ppb | |
| Au ppb | |
| C | |
| N | |
| S | |
| Zn | |
| Cu | |

Oxides in wt%; others in ppm except as noted.

TABLE 3. Rb-Sr data for 64567

| $^{87}Rb/^{86}Sr$ | $^{87}Sr/^{86}Sr$ (measured) | $^{87}Sr/^{86}Sr$ (at 4.6 b.y.) | $T_{BABI}$ (b.y.) | $T_{LUNI}$ (b.y.) |
|---|---|---|---|---|
| 0.0968±8 | 0.70503±7 | 0.69952 | 4.28±0.07 | 4.34±0.07 |

Ar data are given by Turner and Cadogan (1975). The release pattern approaches a plateau (Fig. 5) and an age of 3.97±0.04 b.y. is favored by Turner and Cadogan (1975). The sample has lost a moderate amount (∿20%) of radiogenic Ar.

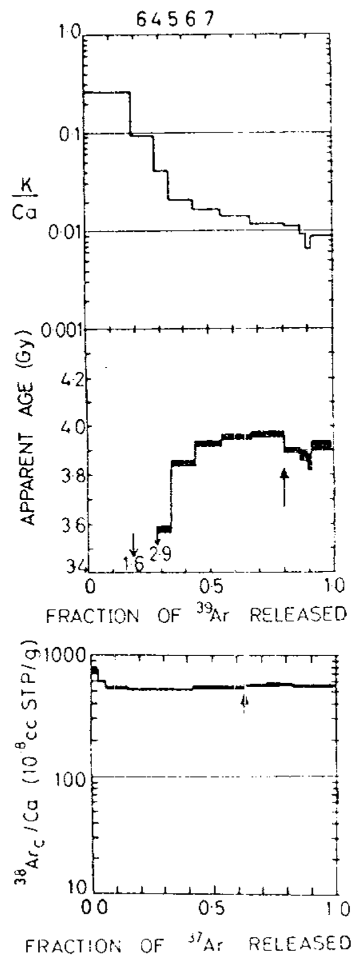



Figure 5. Ar releases, from Turner and Cadogan (1975)

RARE GASES/EXPOSURE AGES: Ar data are given by Turner and Cadogan (1975). These authors calculate a nominal exposure age of 370 m.y. based on the intermediate temperature release pattern.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64567. The saturation remanence to saturation magnetization ratio is very small ($J_{RS}/J_S$ = 0.0012) indicating that virtually all of the ferromagnetic phases in this rock are >300 Å, multidomain particles. Fe°/$Fe^{2+}$ is 0.053 and total Fe° is 0.28 wt% (Pearce and Simonds, 1974).

PROCESSING AND SUBDIVISIONS: In 1972 six small, homogeneous chips were removed. From these chips, allocations were made for thin sectioning and petrography (,3), chemistry and Rb-Sr isotopic analyses (,4) and Ar geochronology (,5).

INTRODUCTION: 64568 is a coherent, medium gray, poikilitic impact melt (Fig. 1). Small vugs (~0.5 mm) are apparently distributed along healed fractures (Phinney and Lofgren, 1973). This rock is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are abundant on all surfaces.

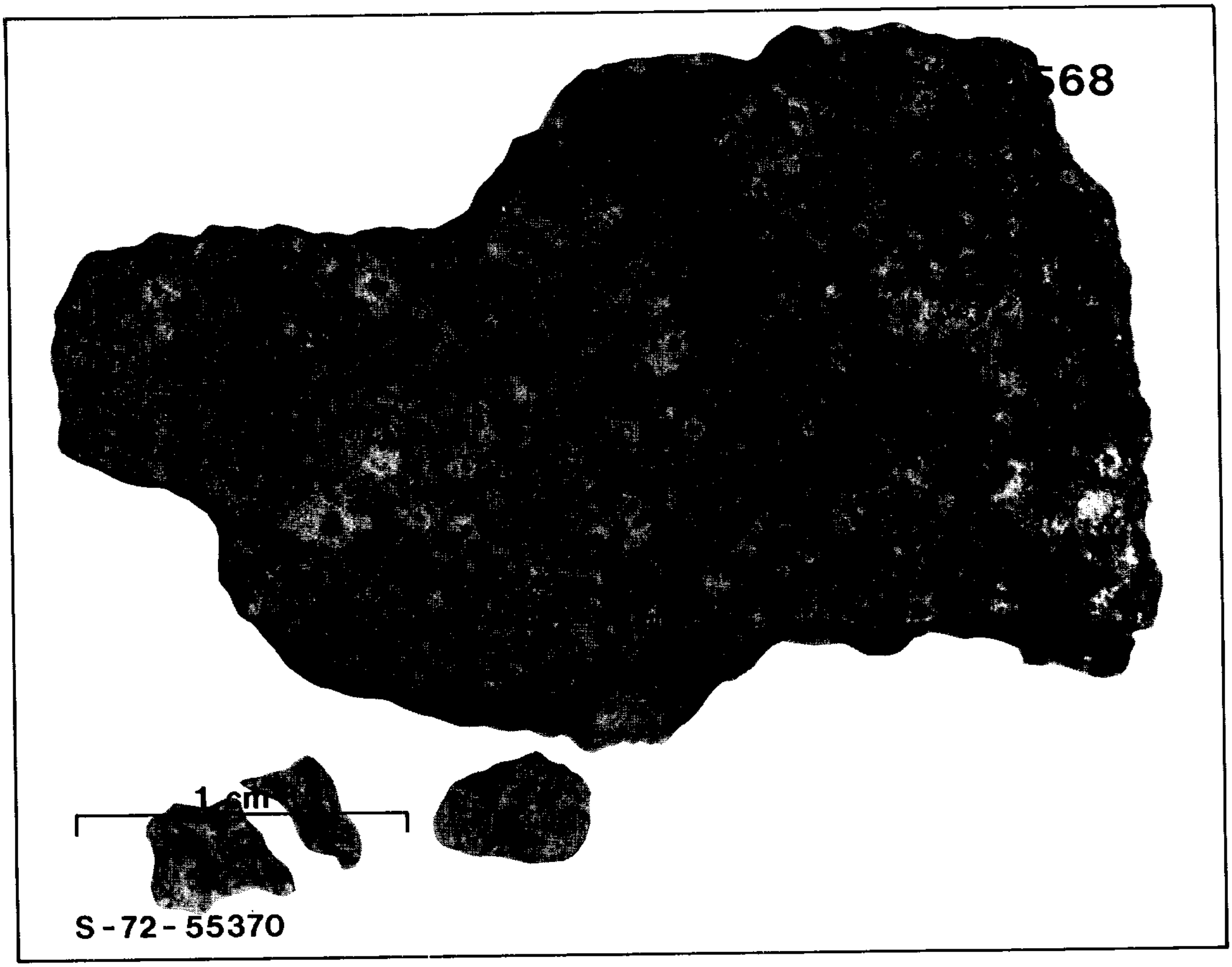



Figure 1.

PETROLOGY: A petrographic description and mineral compositions are given by Simonds et al. (1973). Pigeonite is the sole oikocryst phase (~0.5 mm), enclosing abundant laths of plagioclase (Fig. 2). Clasts of plagioclase and rare anorthosite and mafic minerals are concentrated in the interoikocryst regions. A mode by Simonds et al. (1973) is 56% plagioclase + mesostasis, 39% pigeonite, 2% olivine, 2% opaques (Fe-metal, troilite, ilmenite) and 1% augite. Mineral compositions are shown in Figure 3.

a b

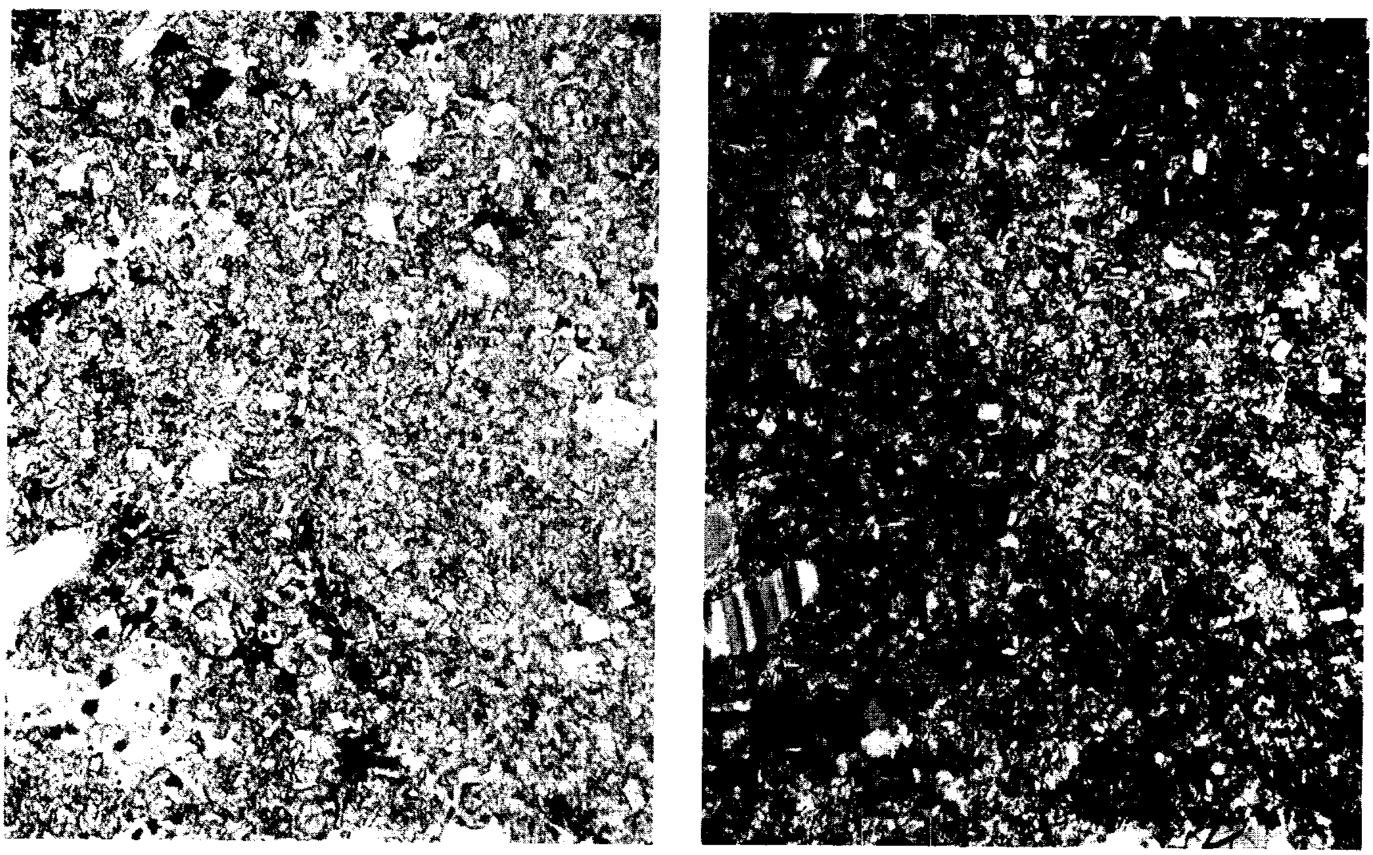


Figure 2. 64568,4, general view, width 1mm.
a) ppl. b) xpl.

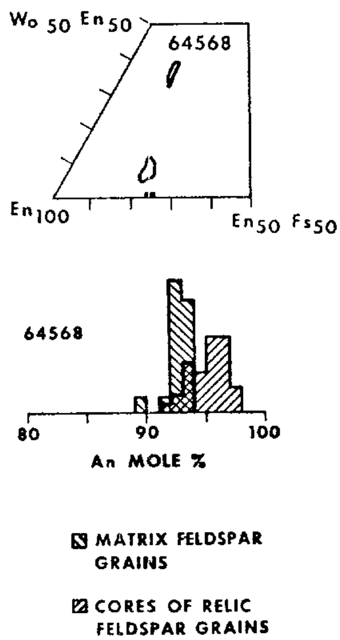



Figure 3. Mineral compositions, olivine plotted along base of pyroxene diagram, from Simonds et al. (1973).

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report a magnetically determined $Fe^0/Fe^{2+}$ of 0.61.

PROCESSING AND SUBDIVISIONS: In 1972 three small chips (,1) were removed and allocated to Phinney for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1.

INTRODUCTION: 64569 is a coherent, medium gray, poikilitic impact melt (Fig. 1) with high levels of incompatible elements. It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are absent.

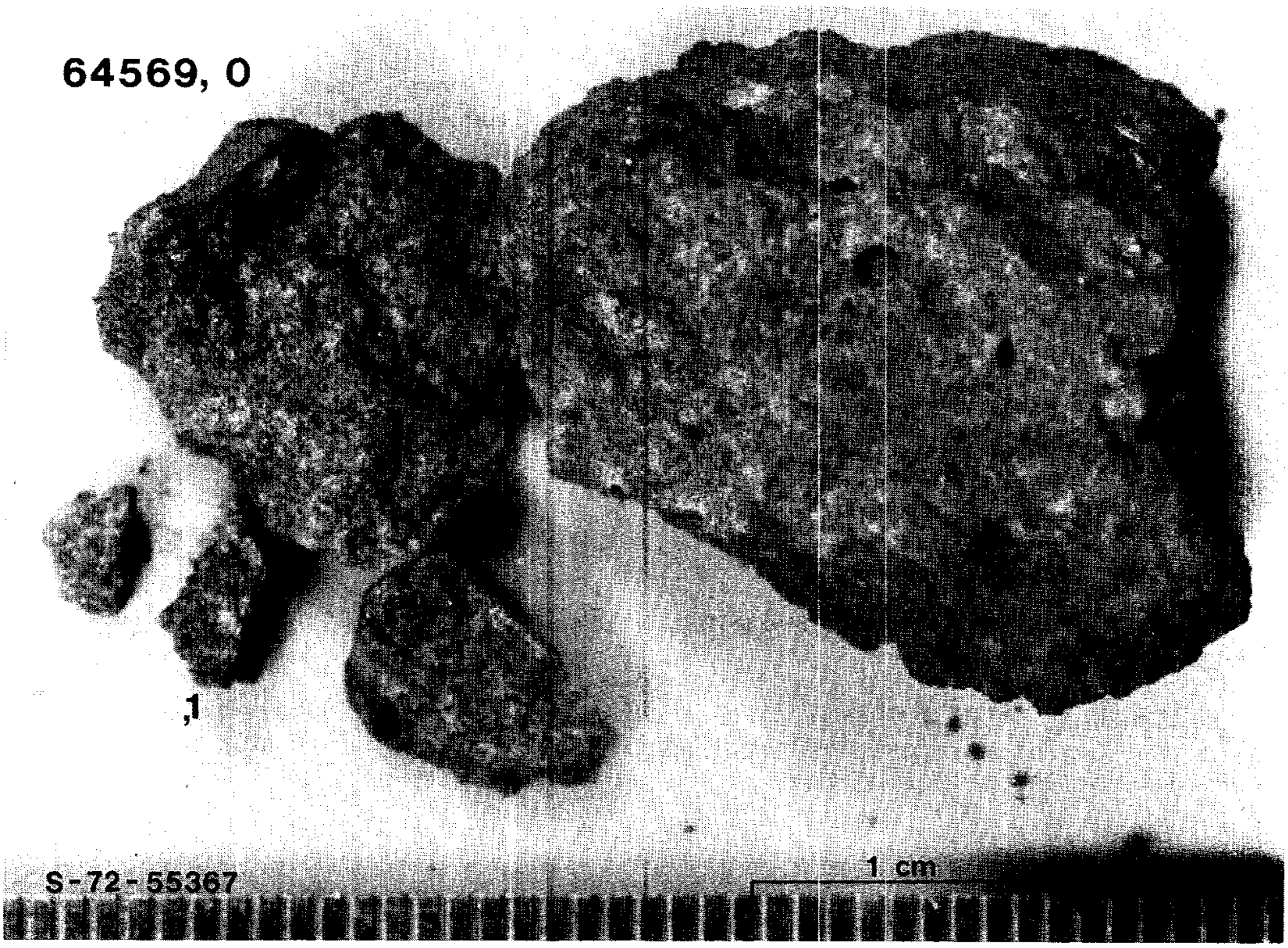



Figure 1.

PETROLOGY: A petrographic description is given by Simonds et al. (1973). Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples.

Pigeonite is the sole oikocryst phase (to ∿0.4 mm) and encloses abundant tabular chadacrysts of plagioclase (Fig. 2). Shocked clasts of plagioclase and olivine are also abundant. A mode by Simonds et al. (1973) is 57% plagioclase + mesostasis, 19% pigeonite, 21% olivine and 4% opaques. Silicate mineral compositions (Simonds et al., 1973) are shown in Figure 3. Metal compositions are presented by Gooley et al. (1973) and reproduced here as Table 1.

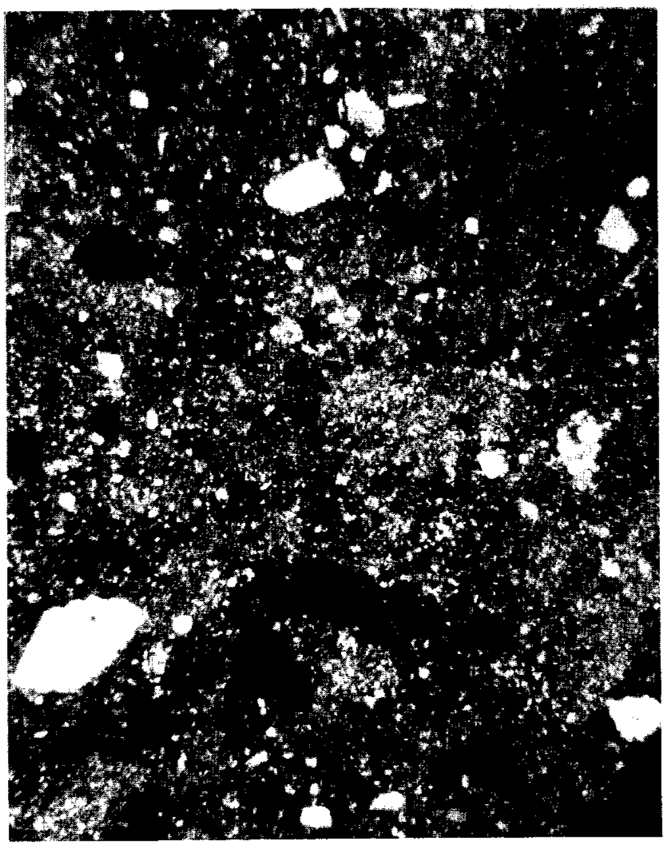


Figure 2. 64569,4, general view, xpl. width 2mm.

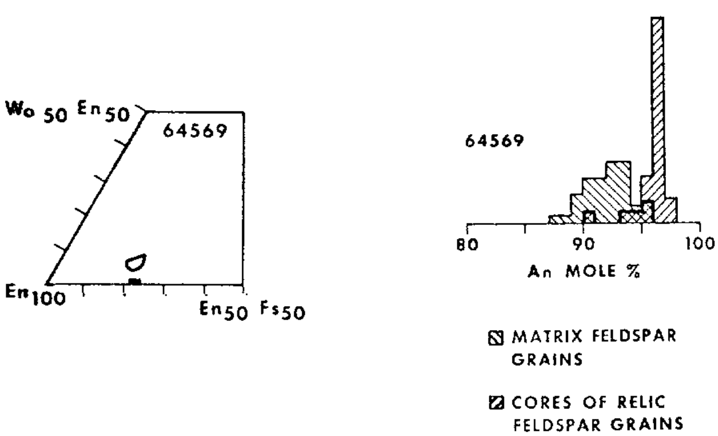



Figure 3. Mineral compositions, olivine plotted along base of pyroxene diagram, from Simonds et al. (1973).

TABLE 1. Metal composition (wt%) in 64569

| | Ni | Co | P | S |
|---|---|---|---|---|
| Metal | 4.1-6.1 | 0.5 | 0.0-0.5 | 0.02 |

CHEMISTRY: Wasson et al. (1977) present a major and trace element analysis. Floran et al. (1976) report major element data obtained by electron microprobe analysis of natural rock powder fused to a glass (except FeO and $Na_2O$ by instrumental neutron activation). Blanchard (unpublished data) provides a trace element analysis and the FeO and $Na_2O$ data quoted by Floran et al. (1976).

The different analyses are all in good agreement. The low $Al_2O_3$ and high levels of REEs (Table 2, Fig. 4) are typical of Apollo 16 poikilitic impact melts.

TABLE 2. Summary chemistry of 64569

| | |
|---|---|
| $SiO_2$ | 46.4 |
| $TiO_2$ | 0.99 |
| $Al_2O_3$ | 21.7 |
| $Cr_2O_3$ | 0.193 |
| FeO | 8.1 |
| MnO | 0.10 |
| MgO | 11.9 |
| CaO | 12.1 |
| $Na_2O$ | 0.514 |
| $K_2O$ | 0.21 |
| $P_2O_5$ | |
| Sr | |
| La | 26.3 |
| Lu | 1.22 |
| Rb | |
| Sc | 13.2 |
| Ni | ∿760 |
| Co | ∿45 |
| Ir ppb | 19 |
| Au ppb | 20 |
| C | |
| N | |
| S | |
| Zn | |
| Cu | |

Oxides in wt%; others in ppm except as noted.

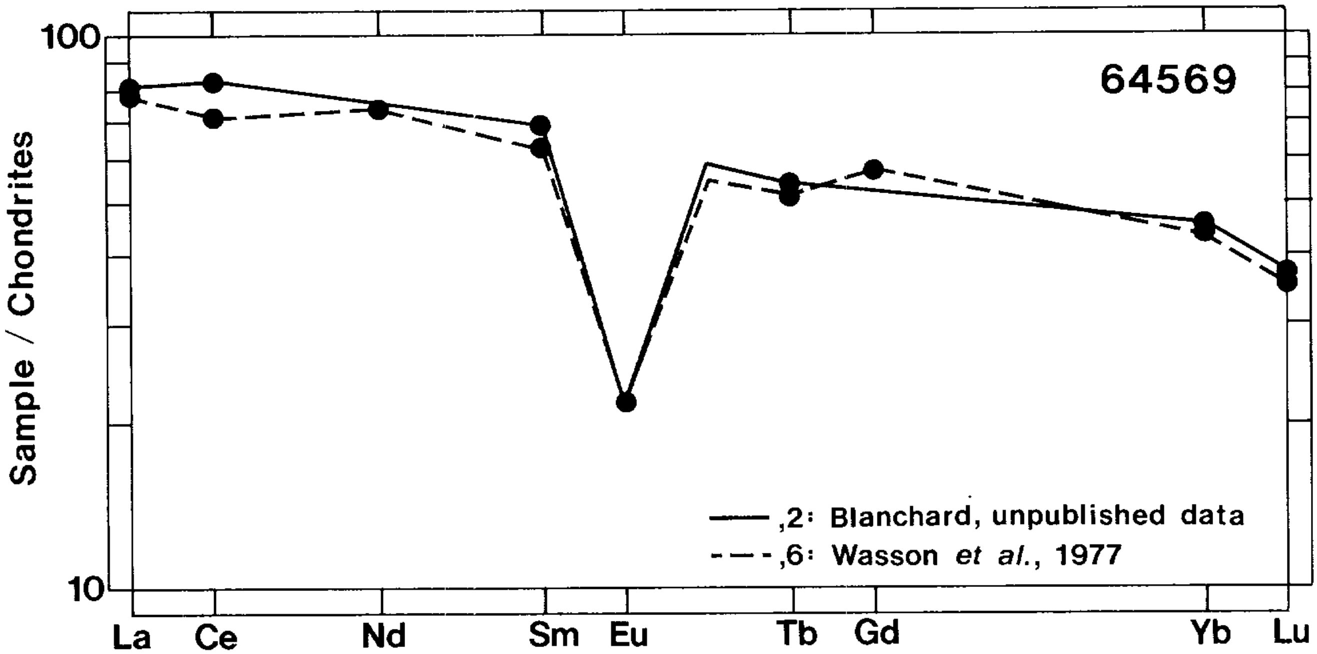



Figure 4. Rare earths.

PROCESSING AND SUBDIVISIONS: In 1972 four chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography. In 1975 a set of four small chips (,3) was allocated for chemistry; the analyses of Floran et al. (1976) and Blanchard (unpublished) are both portions of this split. In 1976 a small chip (,6) was allocated to Wasson for chemistry. The magnetic studies were done on the potted butt of ,1. The remainder of the rock remains at JSC as ,0 (13.85 g).

INTRODUCTION: 64575 is a coherent, medium gray, poikilitic impact melt (Fig. 1). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are rare on one surface, absent on other surfaces.

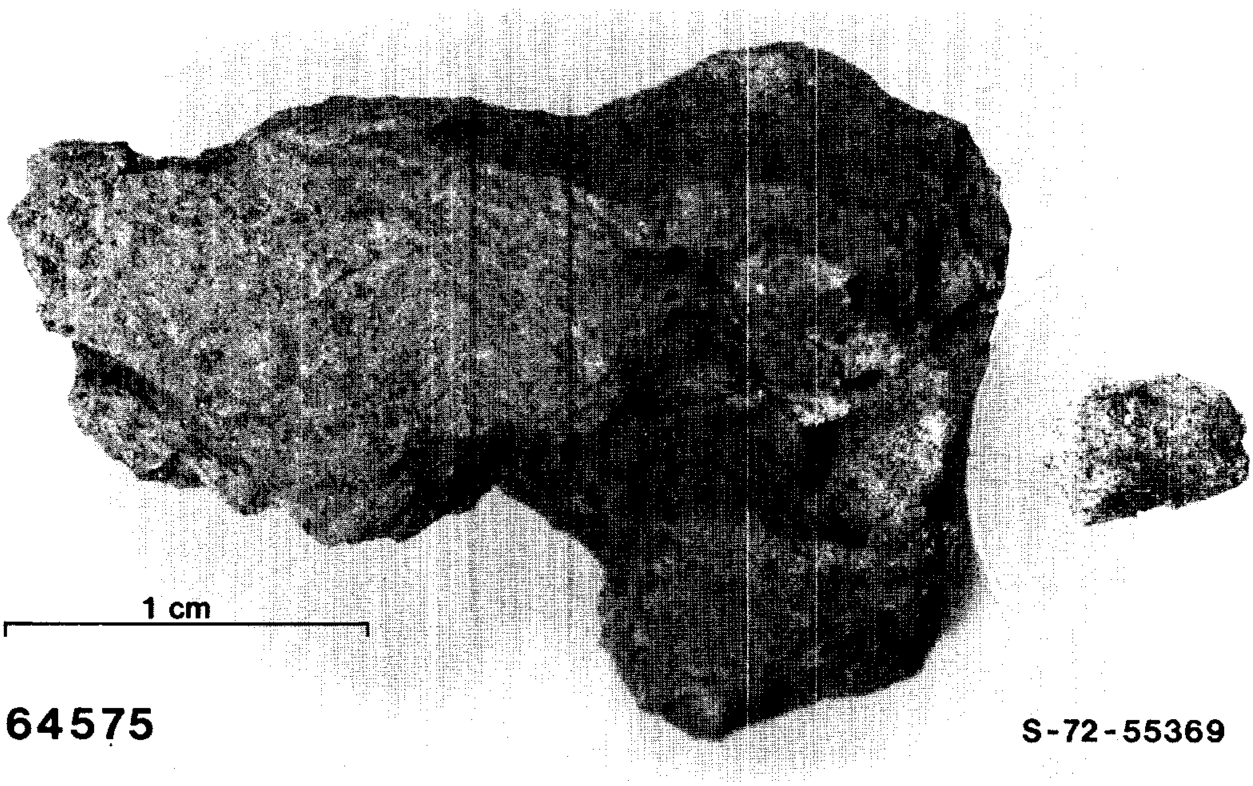



Figure 1.

PETROLOGY: A petrographic description and mineral compositions are given by Simonds et al. (1973). Orthopyroxene is the sole oikocryst phase (~0.2 mm). Plagioclase chadacrysts tend to be very equant; many have rounded corners indicating some recrystallization (Fig. 2). A mode by Simonds et al. (1973) is 47% plagioclase + mesostasis, 43% orthopyroxene, 6% augite, 3% olivine and 2% opaques (dominantly ilmenite, a small amount of troilite and very rare Fe-metal). Mineral compositions are shown in Figure 3. Metal compositions are given by Gooley et al. (1973) and reproduced here as Table 1.

TABLE 1. Compositions of metal (wt%) in 64575

| | Ni | Co | P | S |
|---|---|---|---|---|
| Metal | 4.1-6.1 | 0.5 | 0.0-0.5 | 0.02 |

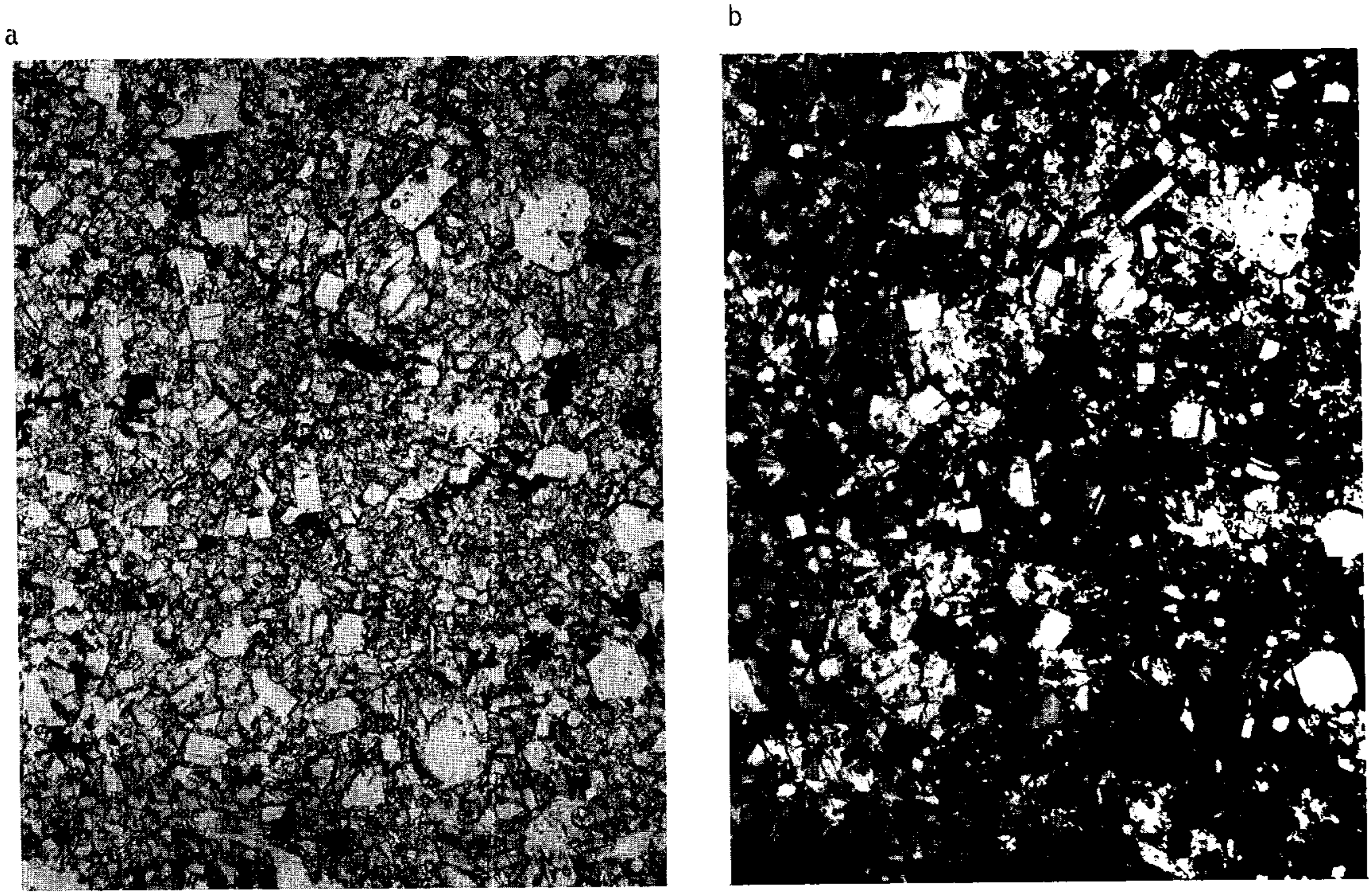



Figure 2. 64575,4, general view, width 1mm.
a) ppl. b) xpl.

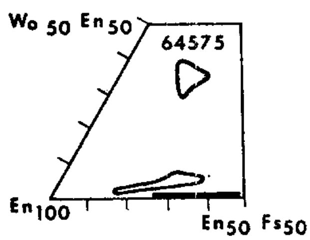



Figure 3. Mafic mineral compositions, olivine plotted along base, from Simonds et al. (1973).

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64575. The $Fe^o/Fe^{2+}$ is 0.126 and the total $Fe^o$ is 0.696 wt%.

PROCESSING AND SUBDIVISIONS: In 1972 a single chip (,1) was removed and allocated to Phinney for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1.

INTRODUCTION: 64576 is a coherent, light gray, basaltic impact melt (Fig. 1). It is a rake sample collected from the rim of a subdued doublet crater on Stone Mountain. Zap pits are absent.

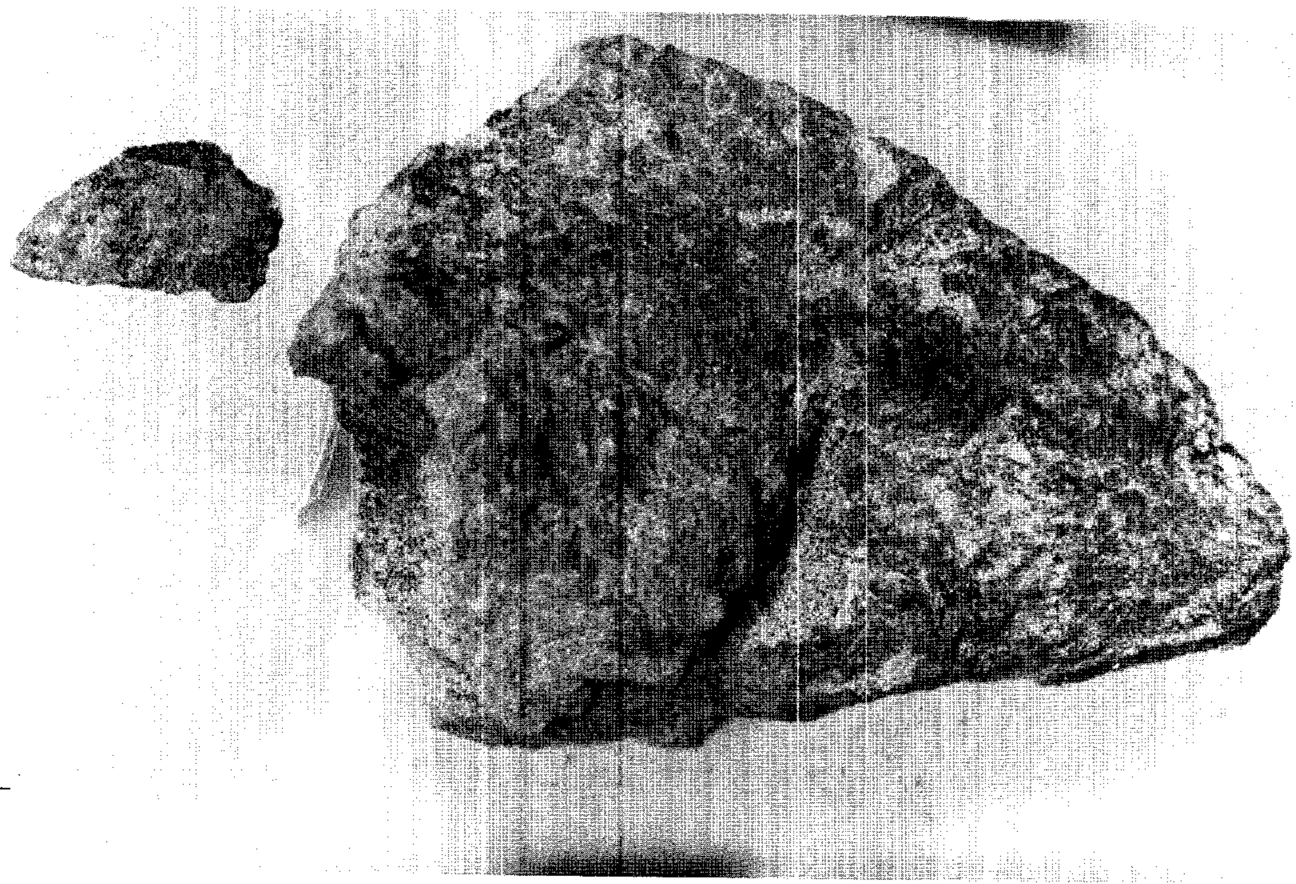


Figure 1. S-72-55363, mm scale.

PETROLOGY: Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples and give mineral compositions. Skeletal olivine phenocrysts rest in a matrix of plagioclase laths, interstitial olivine and pigeonite and abundant glassy mesostasis (Fig. 2). The texture is somewhat variable, ranging from intersertal to subophitic to variolitic. Clasts of plagioclase are common; one clast of fine-grained poikilitic impact melt was also observed. Metal and troilite are accessory phases. Mineral compositions are shown in Figure 3. Compositions of metal and coexisting schreibersite are given by Gooley et al. (1973) and are reproduced here as Table 1.

Figure 2. 64576,4, general view, ppl. width 1mm.

TABLE 1. Compositions of metal and coexisting schreibersite (wt%) in 64576 (from Gooley et al., 1973)

| | Ni | Co | Fe | P | S |
|---|---|---|---|---|---|
| Metal (without schreibersite) | 4.4-16.1 | 0.6-1.2 | - | 0.0-0.2 | 0.02 |
| Metal (with schreibersite) | 12.0 | 0.8 | 86.9 | 0.03 | 0.01 |
| Schreibersite | 24.6 | 0.1 | 59.8 | 15.1 | 0.3 |

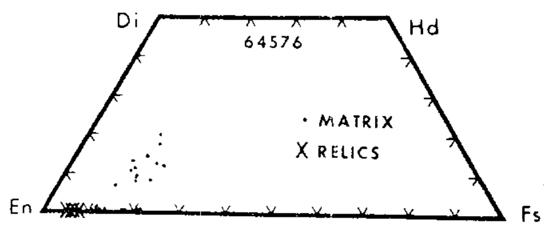



Figure 3. Mafic mineral compositions, olivine plotted along base, from Warner et al. (1973).

PROCESSING AND SUBDIVISIONS: In 1972 a single chip (,1) was removed and allocated to Phinney for thin sectioning and petrology.

INTRODUCTION: 64577 is a coherent, medium gray, glassy breccia (Fig. 1). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are abundant on all surfaces.

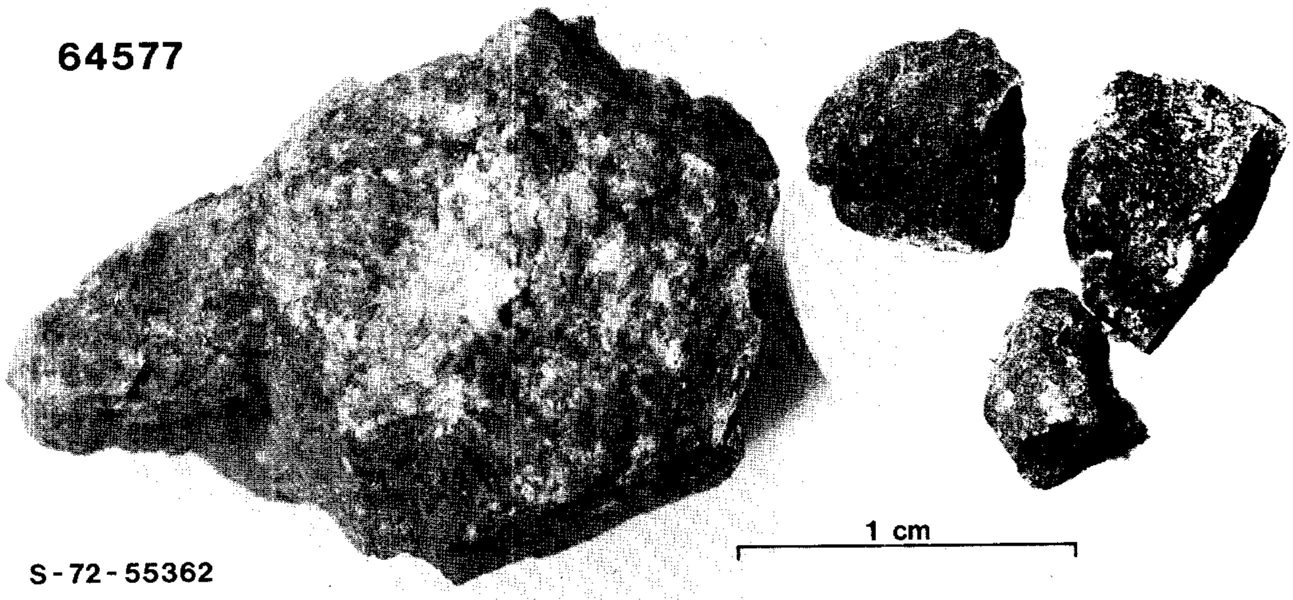



Figure 1.

Figure 2. 64577,4, general view, ppl. width 2mm.

PETROLOGY: Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples. Rare plagioclase clasts with diffuse boundaries rest in a heterogeneous matrix of small plagioclase laths and glassy mesostasis (Fig. 2). Portions of the matrix have crystallized to a faintly poikilitic texture.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64577. $Fe^{o}/Fe^{2+}$ is 0.0104 and total $Fe^{o}$ is 0.24 wt%.

PROCESSING AND SUBDIVISIONS: In 1972 three chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1.

## 64578 FINE-GRAINED IMPACT MELT 5.60 g

INTRODUCTION: 64578 is a coherent, medium gray, aphanitic impact melt with a few white clasts (Fig. 1). A small area of splash glass is present on one surface, and a few zap pits are present on all surfaces. It is a rake sample from the rim of a subdued doublet crater on Stone Mountain.

Figure 1. S-72-42556.

INTRODUCTION: 64579 is a coherent, dark gray, aphanitic impact melt (Fig. 1). It is somewhat vesicular with a few zap pits on some surfaces. It is a rake sample from the rim of a subdued doublet crater on Stone Mountain.

Figure 1. S-72-55368, mm scale.

PETROLOGY: Warner et al. (1973) include 64579 in a general petrographic discussion of Apollo 16 rake samples. It is an impact melt which has crystallized to a fine-grained intergrowth of radiating plagioclase crystals and glassy mesostasis. Clasts of plagioclase and cataclastic anorthosite are common and often act as nucleation sites for the matrix crystals (Fig. 2). Fe-metal occurs in association with eutectic metal-phosphide intergrowths. Compositions of the metallic phases are given by Gooley et al. (1973) and reproduced here as Table 1.

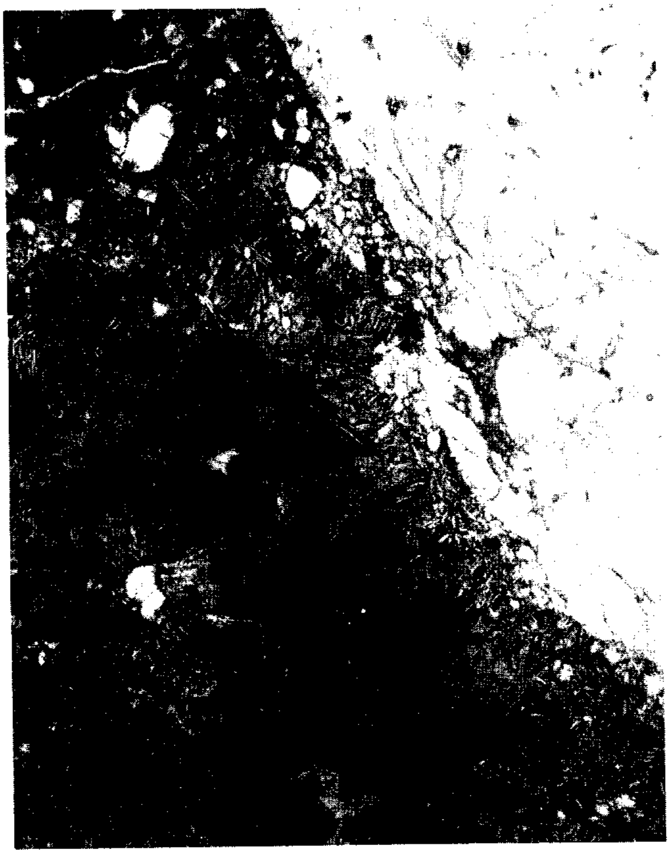


Figure 2. 64579,4, general view, ppl. width 2mm.

TABLE 1. Compositions of metal and metal-phosphide intergrowths (wt%) in 64579

| | Ni | Co | Fe | P | S |
|---|---|---|---|---|---|
| Metal | 18.6 | 0.9 | 78.9 | 1.1 | 0.02 |
| Eutectic Intergrowth | 21.8 | 0.8 | 65.0 | 12.0 | 0.7 |

PROCESSING AND SUBDIVISIONS: In 1972 two chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography.

INTRODUCTION: 64585 is a coherent, medium gray, fine-grained impact melt (Fig. 1). One large (5 mm) tabular glass clast is present (Phinney and Lofgren, 1973). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are rare on all surfaces.

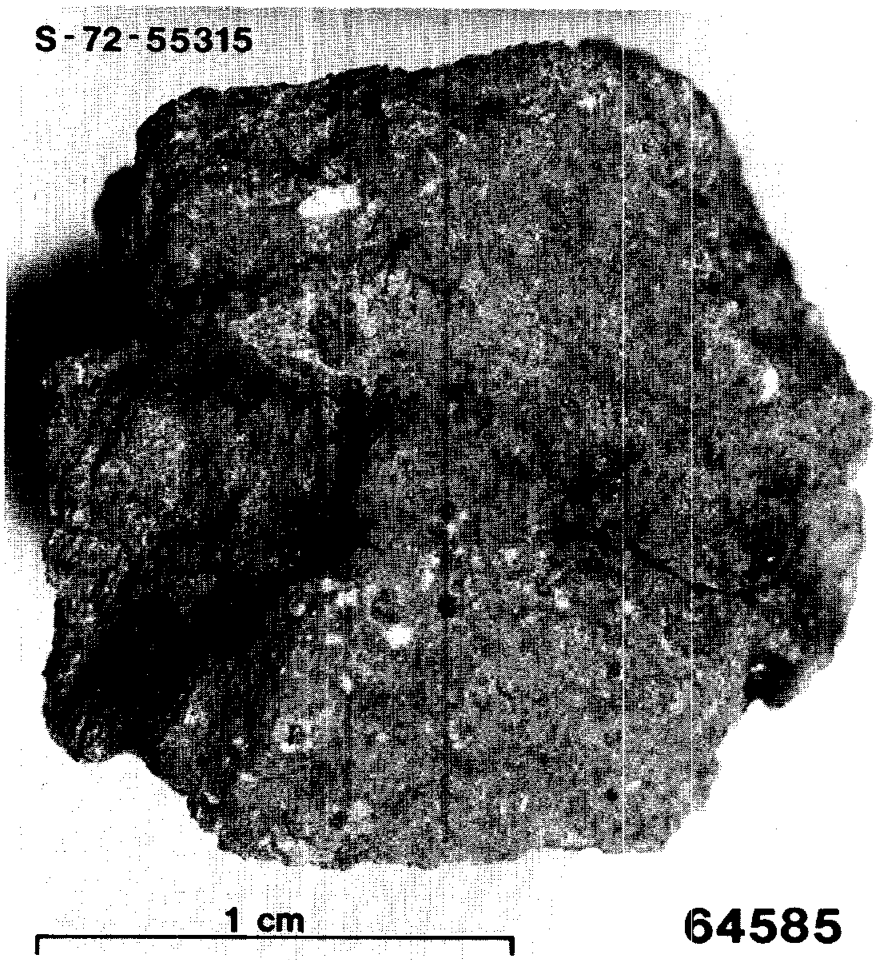



Figure 1.

PETROLOGY: Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples. It is a fine-grained impact melt with randomly oriented plagioclase laths and abundant glassy mesostasis. Texturally it grades from subophitic to ophitic or poikilitic with elongate oikocrysts (up to ~0.5 mm). Plagioclase relicts are scattered through the rock. An electron microprobe analysis of the mesostasis is given by Warner et al. (1973) and reproduced here as Table 1. Compositions of metal with and without coexisting schreibersite are presented by Gooley et al. (1973) and reproduced here as Table 2.

Figure 2. 64585,3, general view, ppl. width 1mm.

TABLE 1. Composition of mesostasis (wt%) in 64585
(from Warner *et al.*, 1973)

| | |
|---|---|
| $SiO_2$ | 54.5 |
| $TiO_2$ | 2.8 |
| $Al_2O_3$ | 14.5 |
| $Cr_2O_3$ | 0.2 |
| FeO | 7.0 |
| MgO | 7.3 |
| CaO | 13.5 |
| $Na_2$ | 0.2 |
| $K_2O$ | 0.2 |

TABLE 2. Compositions of metal and schreibersite (wt%) in 64585
(from Warner et al., 1973)

| | Ni | Co | Fe | P | S |
|---|---|---|---|---|---|
| Metal (without schreibersite) | 6.6-7.4 | 0.6 | - | 0.0-0.3 | 0.2 |
| Metal (with schreibersite) | 4.9 | 0.6 | 92.6 | 0.2 | 0.01 |
| Schreibersite | 9.4 | 0.4 | 75.1 | 15.7 | 0.1 |

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64585. The very low saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.0045) indicates that virtually all of the ferromagnetic phases in this rock are >300 Å, multidomain particles. $Fe^o/Fe^{2+}$ is 0.246 and total $Fe^o$ is 1.15 wt % (Pearce and Simonds, 1974).

PROCESSING AND SUBDIVISIONS: In 1972 a single chip (,1) was removed and allocated to Phinney for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1.

INTRODUCTION: 64586 is coherent, dark gray, aphanitic impact melt (Fig. 1). It lacks both vesicles and zap pits and is partially glass coated. It is a rake sample from the rim of a subdued doublet crater on Stone Mountain.

PETROLOGY: Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples. Abundant plagioclase clasts, often with diffuse boundaries, rest in a dark brown, glassy matrix that is faintly poikilitic (Fig. 2). Many tiny laths of plagioclase (<0.1 mm) are suspended in the matrix and often appear to be oriented due to flow. Spherules of Fe-metal are abundant and are often associated with schreibersite.

PROCESSING AND SUBDIVISIONS: In 1972 two chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography.

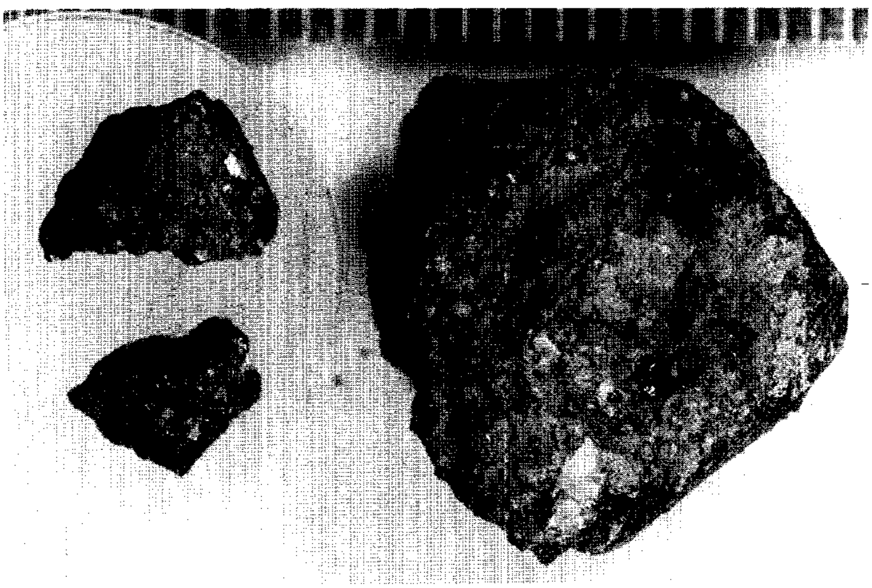


Figure 1. S-72-55339, mm scale.

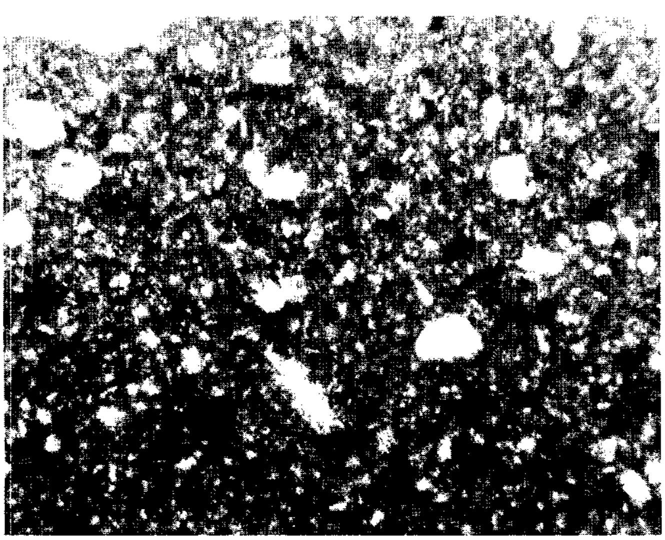


Figure 2. 64586,3, general view, ppl. width 1mm.

INTRODUCTION: 64587 is a moderately coherent, light gray, clastic breccia partially coated by greenish, vesicular glass (Fig. 1). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are absent.


Figure 1.

PETROLOGY: Phinney et al. (1976) studied the matrix characteristics of 64587 using SEM techniques. Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples.

64587 is dominated by mineral fragments, principally plagioclase, in a fine-grained matrix, ~20% of which is a discontinuous network of glass (Fig. 2). Fragments and beads of clear and light yellow glass are present. Lithic clasts are relatively rare and include fragments of cataclastic anorthosite, fine-grained poikilitic impact melt and basaltic impact melt.

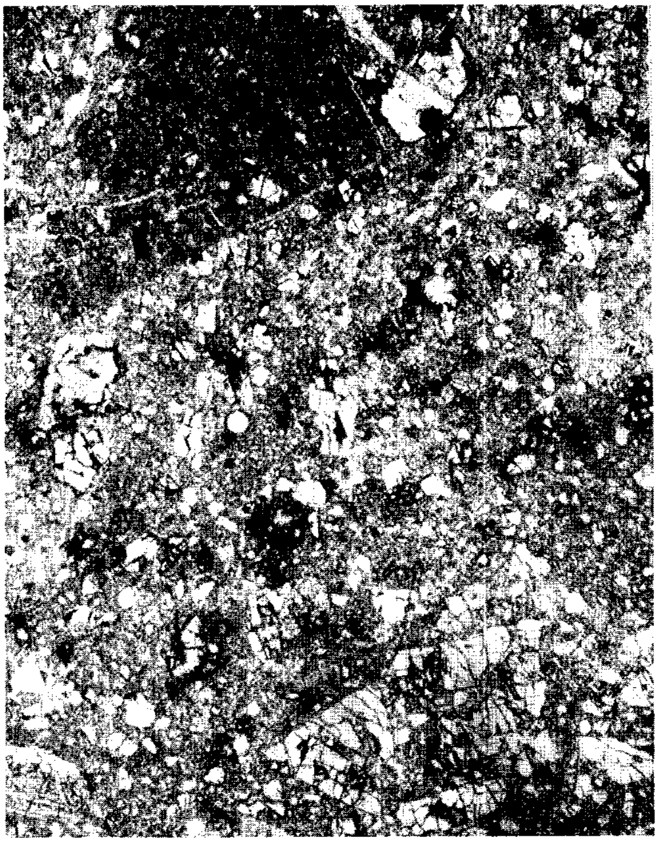


Figure 2. 64587,3, general view, ppl. width 1mm.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64587. The saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.025) indicates that ∿3-6% of the metal in this sample is single domain and the remainder is multidomain. The $Fe^o/Fe^{2+}$ is 0.0457.

PROCESSING AND SUBDIVISIONS: In 1972 this rock was broken into several pieces. One fragment of bulk rock (,1) was allocated to Phinney for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1.

INTRODUCTION: 64588 is a medium gray, friable, clastic breccia (Fig. 1). It is a rake sample from the rim of a subdued doublet crater on Stone Mountain. Zap pits are absent.

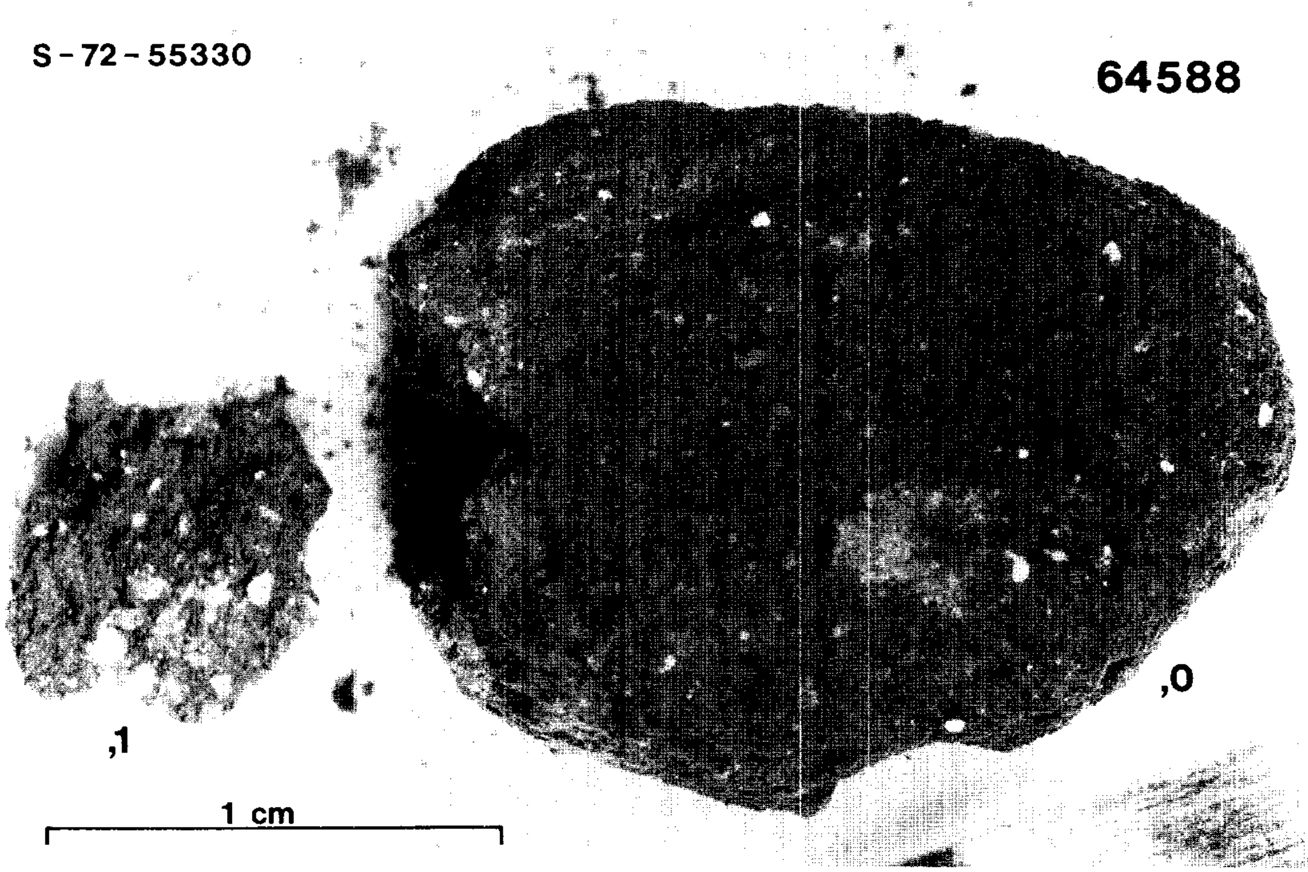



Figure 1.

PETROLOGY: Phinney et al. (1976) studied the matrix characteristics of 64588 using SEM techniques. Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples. Mineral and lithic clasts, and shards and beads of clear glass, rest in a porous matrix containing variable amounts of glass (Fig. 2). Phinney et al. (1976) estimate <1% glass in the matrix whereas the thin section shows some areas with considerable glass which lead Warner et al. (1973) to classify this rock as a "glassy breccia". Lithic clasts include basaltic impact melt, cataclastic anorthosite and granoblastic anorthosite.

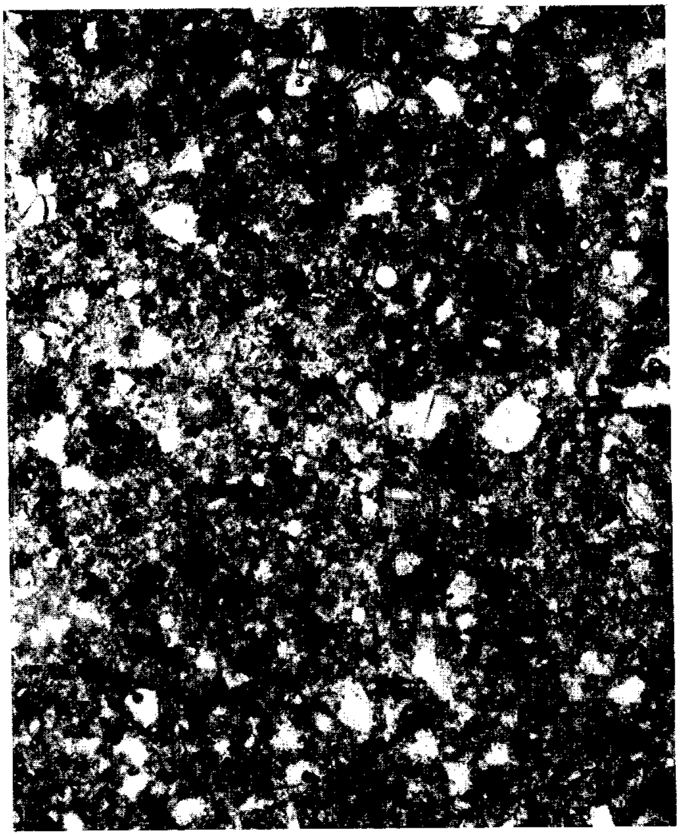


Figure 2. 64588,3, general view, ppl. width 1mm.

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 64588 (Fig. 3). The saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.027) indicates that 3-6% of the metal in this rock is single domain and the remainder is multi-domain. $Fe^0/Fe^{2+}$ is 0.0733.

PROCESSING AND SUBDIVISIONS: In 1972 a single chip (,1) was removed and allocated to Phinney for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1.

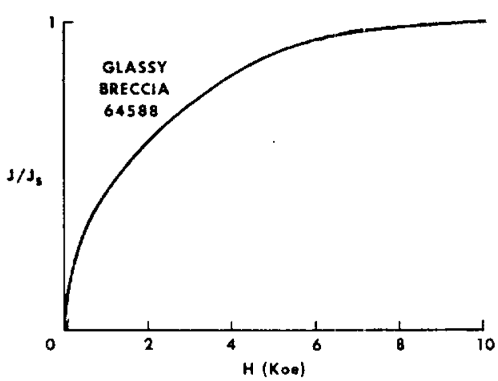



Figure 3. Ferromagnetic component of magnetization curves, from Pearce and Simonds (1974).

INTRODUCTION: 64589 is a moderately coherent, white anorthosite (Fig. 1) collected as a rake sample. Macroscopically, individual crystals appear to be several mm long. Zap pits are absent.

PROCESSING AND SUBDIVISIONS: In 1975 two small chips (,1 and ,2) were removed and allocated to Bell. In 1979 these chips were returned unopened to JSC.

Figure 1. S-73-17116, mm scale.

INTRODUCTION: 64815 is a poikilitic impact melt that has been subjected to low-grade thermal metamorphism. It was erroneously identified by LSPET (1973) and the Apollo 16 Lunar Sample Information Catalog (1972) as a "crushed ultramafic rock". Macroscopically 64815 is light olive gray in color, coherent and angular (Fig. 1). A few zap pits are present on one surface. This rock is a rake sample collected from the rim of a subdued crater on Stone Mountain.


Figure 1. S-72-55336, mm scale.

PETROLOGY: Simonds et al. (1973) include 64815 in a general discussion of poikilitic impact melts. Texturally 64815 is distinct from most other Apollo 16 poikilitic rocks in being coarser-grained, more clast-rich and apparently somewhat metamorphosed (Fig. 2). Simonds et al. (1973) give a mode of 55% plagioclase plus mesostasis, 34% orthopyroxene, 9% olivine and 2% opaques. Oikocrysts are irregular in shape, up to 0.5 mm, and contain abundant chadacrysts of rounded plagioclase and olivine. Low-Ca pyroxene ($Wo_4En_{72}$) is the dominant oikocryst-forming mineral although many plagioclase and olivine grains also contain abundant rounded inclusions. Olivine usually occurs as discrete, rounded grains ($Fo_{68-70}$, mostly 0.1-0.3 mm) both outside of, and included within, orthopyroxene oikocrysts. Angular, lightly shocked clasts of plagioclase (up to 0.5 mm) are very abundant. The grain boundaries of these clasts tend to be smooth, often forming triple junctions with other plagioclase and olivine grains (Fig. 2). Accessory minerals include metal, troilite, ilmenite, at least one other opaque oxide, and phosphate. Some of the phosphate grains also contain minute, rounded inclusions of plagioclase. Very small (<10 µm), irregularly shaped interstices are often filled by a homogeneous, poorly-reflecting phase which may be either K-feldspar or glass. No relict olivine or lithic clasts were observed (Simonds et al., 1973).

a b

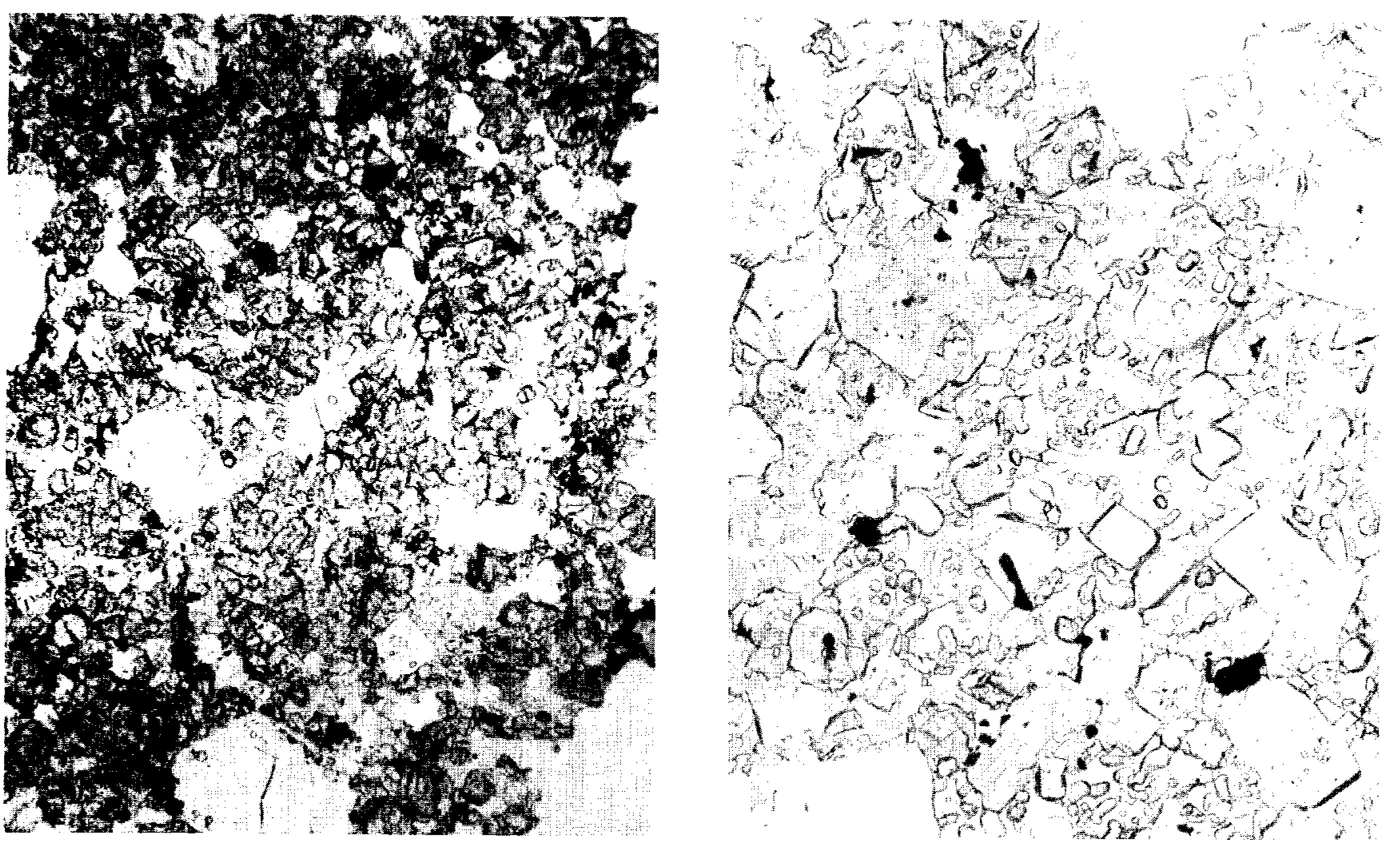


Figure 2. 64815,5 a) general view, ppl. width 2mm.
b) close-up, ppl. width 0.5mm.

CHEMISTRY: Major and trace element analyses of 64815 are provided by Hubbard et al. (1973), Wänke et al. (1976, 1977) and Wasson et al. (1977). The data are summarized in Table 1 and Figures 3 and 4. Chemically 64815 closely resembles other KREEP-rich Apollo 16 poikilitic rocks such as 60315 and 62235 although it has slightly lower incompatible element abundances. Its major element composition plots very near the olivine-plagioclase-spinel peritectic of the OL-AN-SI system (Fig. 3). 64815 is highly enriched in siderophile elements (Table 1), indicating a significant meteoritic component.

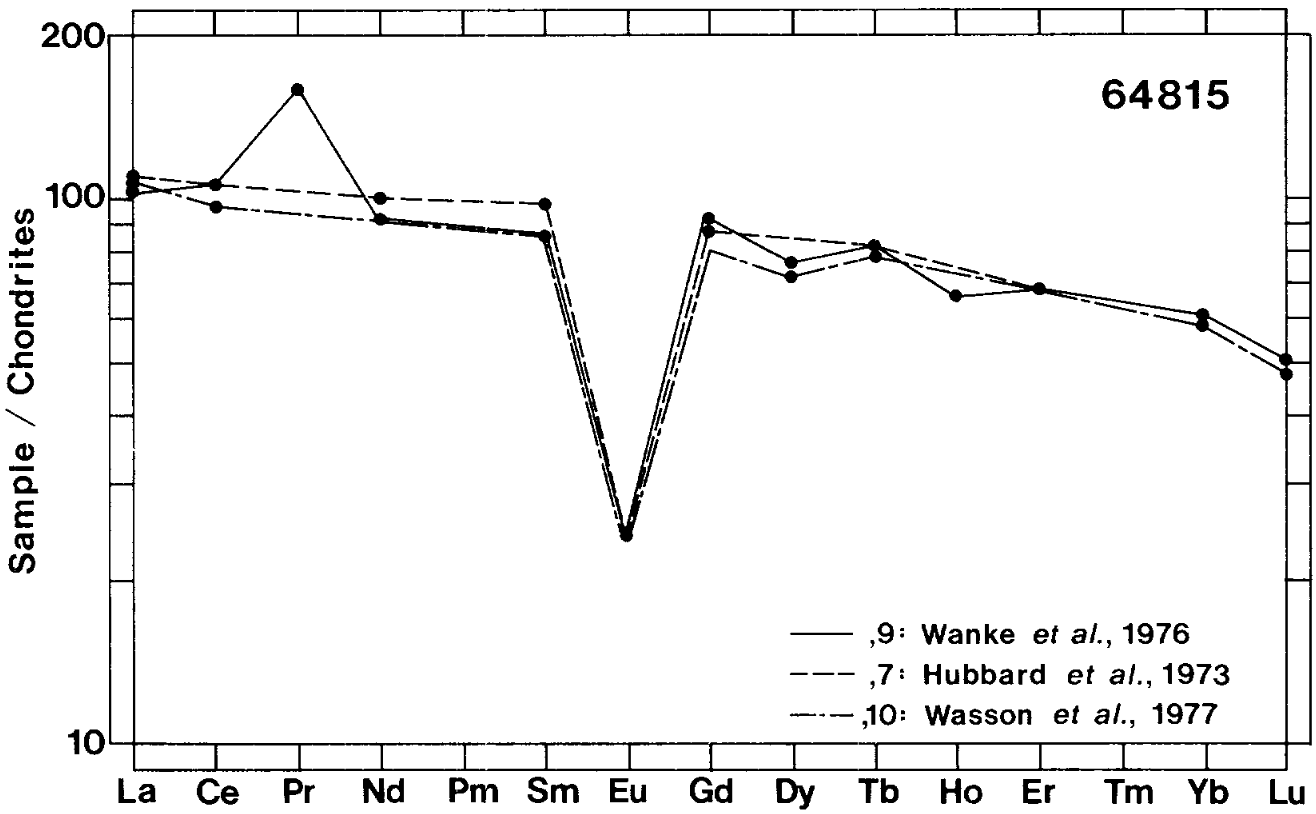



Figure 3. Rare earths.

TABLE 1. Summary chemistry of 64815.

| | |
|---|---|
| $SiO_2$ | 45.6 |
| $TiO_2$ | 1.64 |
| $Al_2O_3$ | 17.6 |
| $Cr_2O_3$ | 0.24 |
| FeO | 9.4 |
| MnO | 0.12 |
| MgO | 11.9 |
| CaO | 12.0 |
| $Na_2O$ | 0.50 |
| $K_2O$ | 0.27 |
| $P_2O_5$ | 0.30 |
| Sr | 138 |
| La | 34.8 |
| Lu | 1.7 |
| Rb | 6.7 |
| Sc | 22 |
| Ni | 460-830 |
| Co | ~45 |
| Ir ppb | 9-16 |
| Au ppb | 8-14 |
| C | |
| N | |
| S | 1140 |
| Zn | <5.8 |
| Cu | 14 |

Oxides in wt%; others in ppm except as noted.

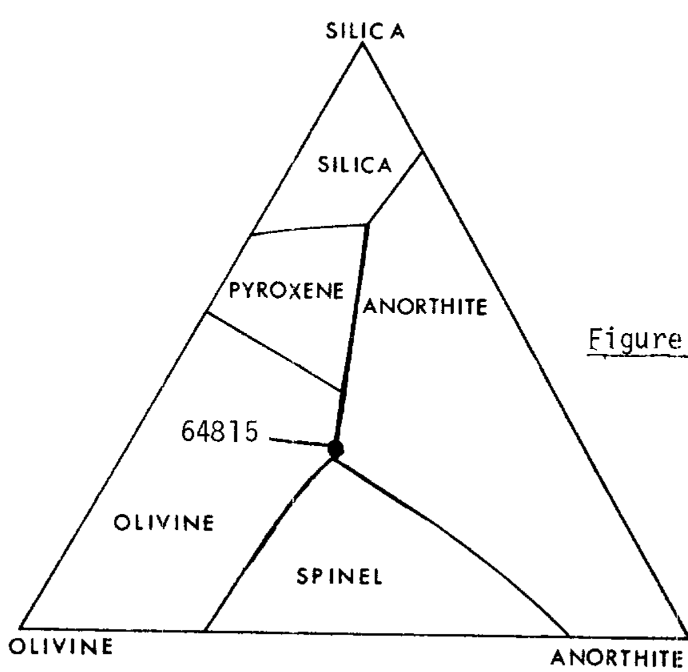



Figure 4. From Simonds et al. (1973).

RADIOGENIC ISOTOPES AND GEOCHRONOLOGY: Nyquist et al. (1973) report whole rock Rb-Sr data (Table 2). The high $^{87}Sr/^{86}Sr$ ratio is typical of KREEP-rich lunar rocks.

TABLE 2. Summary of Rb-Sr data for 64815

| Sample | $^{87}Rb/^{86}Sr$ | $^{87}Sr/^{86}Sr$ measured | $^{87}Sr/^{86}Sr$ at 4.6 b.y.* | $T_{BABI}$(b.y.) | $T_{LUNI}$ (b.y.) |
|---|---|---|---|---|---|
| 64815,2 | 0.142 | 0.70808± 8 | 0.70008 | 4.43±.07 | 4.47± 0.07 |

*Corrected for interlaboratory bias by Nyquist (1977)

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report magnetic parameters determined on a potted butt. $Fe^{0}/Fe^{2+}$ is 0.0245 and total $Fe^{0}$ is 1.8 wt%.

PROCESSING AND SUBDIVISIONS: 64815 has never been sawn. Allocations have been filled by taking small chips from the rock. The largest single piece remaining (,0) weighs 18.9 g.

INTRODUCTION: 64816 is a coherent, medium gray, poikilitic impact melt (Fig. 1). It is a rake sample from a small subdued crater on Stone Mountain. Zap pits are absent.

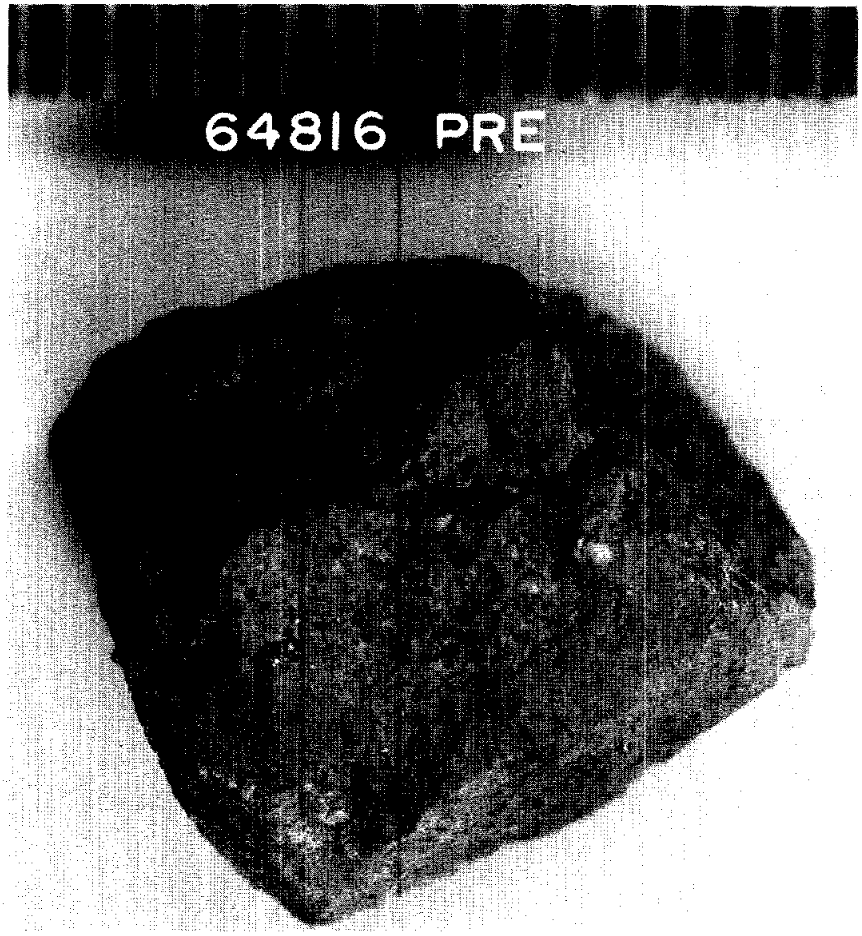



Figure 1. S-72-55328, mm scale.

PETROLOGY: A petrographic description and mineral compositions are given by Simonds et al. (1973). Pigeonite is the sole oikocryst phase and tends to occur as elongate crystals (up to ~0.5 mm long). Interoikocryst regions contain patches with a subophitic texture, a "K-rich phase" with up to 9% $K_2O$ and as little as 7% CaO, and abundant plagioclase clasts (Simonds et al., 1973). Lathy ilmenite often outlines the oikocrysts (Fig. 2). A mode given by Simonds et al. (1973) is 59% plagioclase + mesostasis, 34% pigeonite, 4% olivine and 2% opaques. Mineral compositions are shown in Figure 3. Fe-metal with rare schreibersite inclusions are accessory minerals. Metal compositions are reported by Gooley et al. (1973) and reproduced here as Table 1.

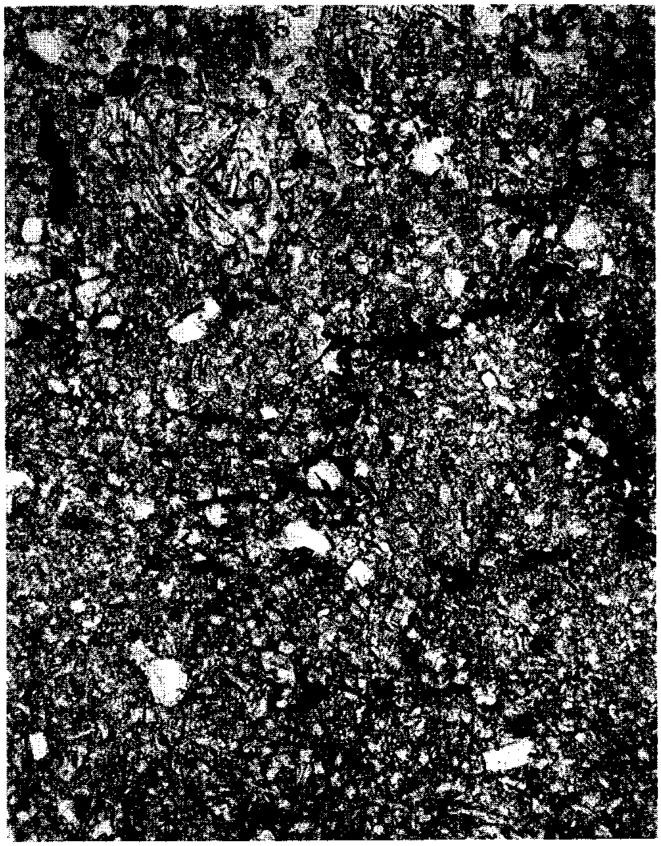


Figure 2. 64816,3, general view, ppl. width 1mm.

TABLE 1. Metal compositions (wt%)

| | Ni | Co | P | S |
|---|---|---|---|---|
| Metal (without schreibersite) | 4.1-6.1 | 0.5 | 0.0-0.5 | 0.02 |

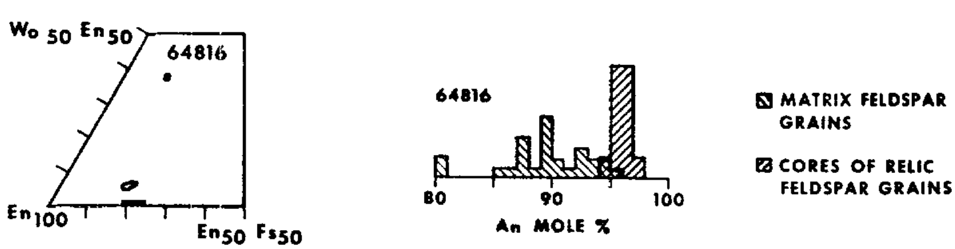



Figure 3. Mineral compositions, olivine plotted along base of pyroxene diagram, from Simonds et al. (1973).

PHYSICAL PROPERTIES: Pearce and Simonds (1974) report the results of a room temperature hysteresis curve determination on 68416. The very small saturation remanence to saturation magnetization ratio ($J_{RS}/J_S$ = 0.0012) indicates that virtually all of the ferromagnetic phases in this sample are multidomain particles. $Fe^0/Fe^{2+}$ is 0.222 and total $Fe^0$ is 1.15 wt%.

PROCESSING AND SUBDIVISIONS: In 1972 two chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography. The magnetic studies were done on the potted butt of ,1.

# 64817 BASALTIC IMPACT MELT 8.98 g

INTRODUCTION: 64817 is a coherent, medium gray, basaltic impact melt (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits and vesicles are rare.

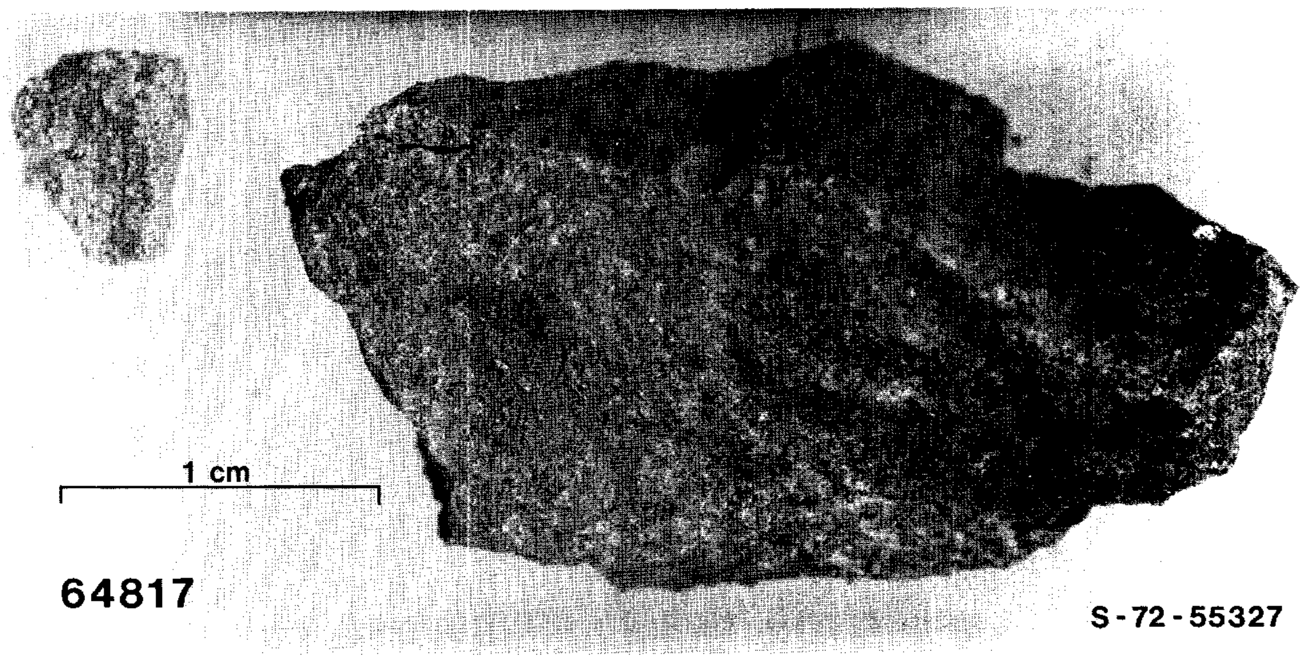



Figure 1.

PETROLOGY: Warner et al. (1973) include 64817 in a general petrographic discussion of Apollo 16 rake samples and provide mineral compositions. Anhedral pyroxene and, more rarely, glassy mesostasis fills interstices between narrow plagioclase laths (up to ∿0.4 mm long, Fig. 2). Blocky plagioclase phenocrysts and shocked, irregularly shaped plagioclase clasts are occasionally present. Mineral compositions are shown in Figure 3.

PROCESSING AND SUBDIVISIONS: In 1972 a single chip (,1) was removed and allocated to Phinney for thin sectioning and petrography.

Figure 2. 64817,3, general view, ppl. width 1mm.

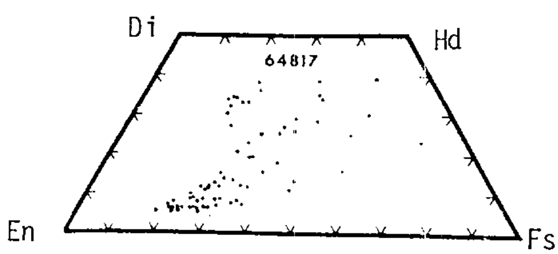



Figure 3. Pyroxene compositions, from Warner et al. (1973).

INTRODUCTION: 64818 is a coherent breccia (Fig. 1) composed of two lithologies: a dark, clast-laden, glassy breccia and a lighter colored, recrystallized anorthositic breccia. It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are abundant on some surfaces, absent from others.

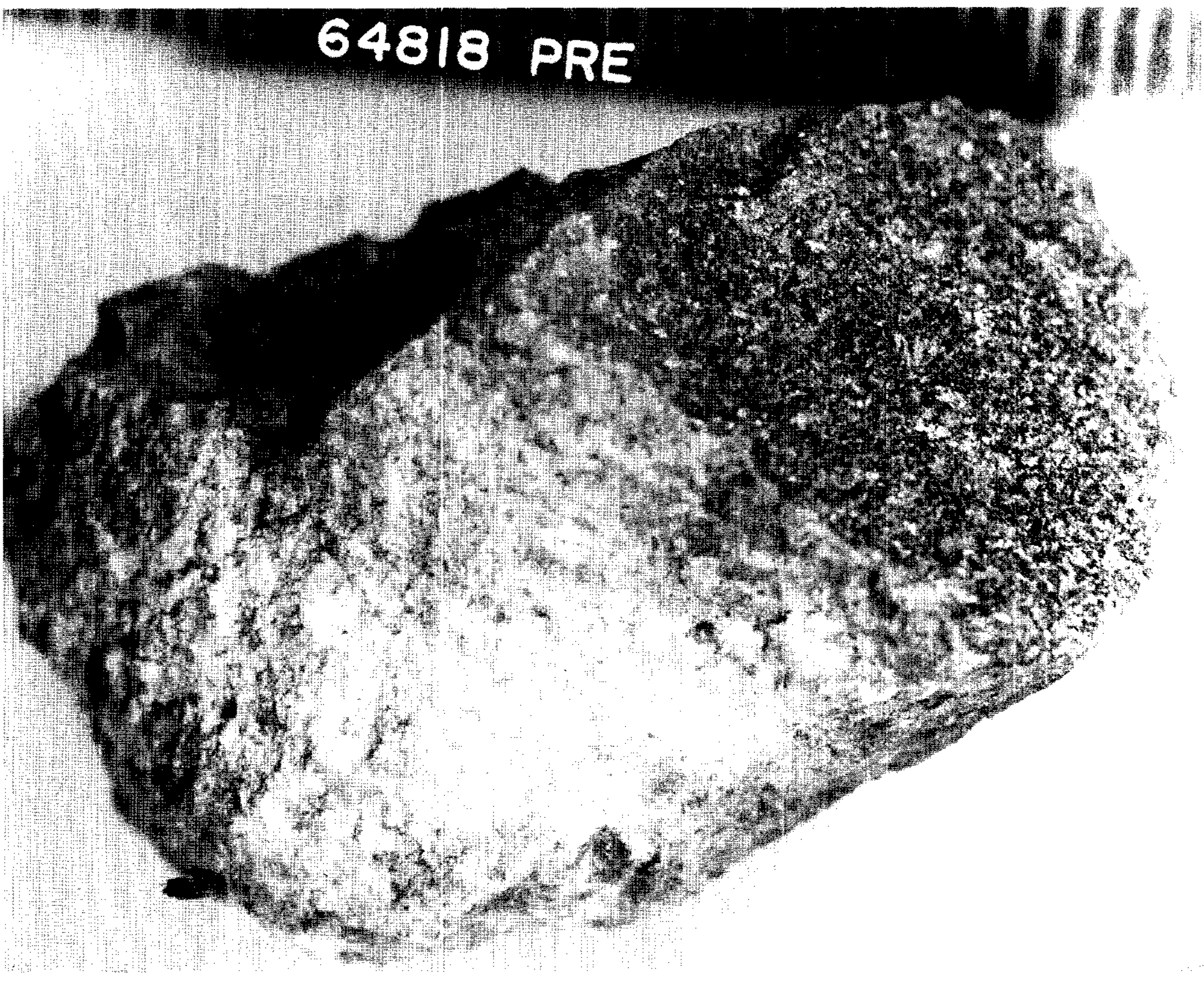



Figure 1. S-72-55338, mm scale.

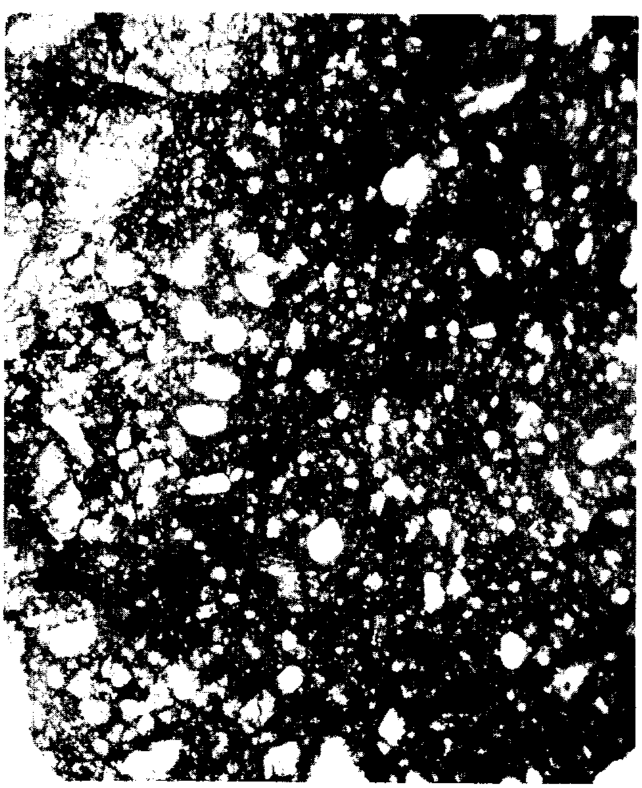
PETROLOGY: 64818 is composed of two distinct lithologies: a glassy breccia and a recrystallized, anorthositic breccia. Warner et al. (1973) include this rock in a general petrographic discussion of Apollo 16 rake samples and classify it as a "meta-norite".

The glassy breccia appears to coat and intrude the anorthositic lithology. It contains abundant clasts of plagioclase and, less commonly, mafic minerals in a continuous glassy matrix (Fig. 2). A single ~3 mm clast of cataclastic anorthosite was observed. The clasts have diffuse boundaries and show a poorly developed foliation.

The anorthositic breccia is an extremely cataclasized anorthosite, the finer portions of which have been recrystallized to a microgranular intergrowth of plagioclase and orthopyroxene (Fig. 2). Many of the larger fragments show severe shock effects. Phinney et al. (1976) studied this lithology using SEM techniques and found it to have a very low porosity with virtually no glass in the matrix.

PROCESSING AND SUBDIVISIONS: In 1972 a single chip (,1) of glassy matrix was removed and allocated to Phinney for thin sectioning and petrography. In 1975 the rock was broken into several pieces to fill further allocations, revealing the nature of the interior of the rock. A single chip of the anorthositic breccia (,6) was allocated for thin sections in 1975.

a



b

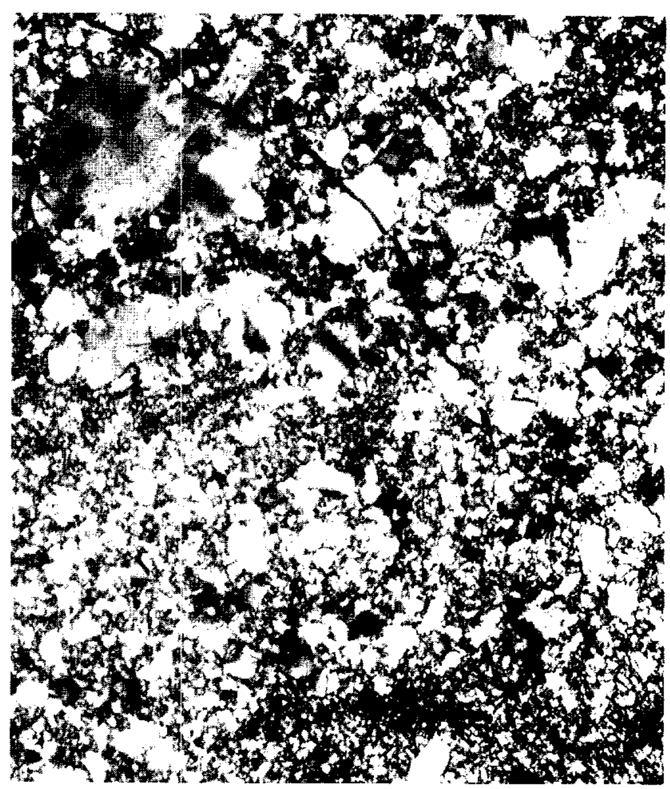


Figure 2. a) 64818,3, glassy breccia, ppl. width 2mm.
b) 64818,9, anorthositic breccia, xpl. width 1mm.

INTRODUCTION: 64819 is a coherent, white, cataclastic anorthosite partially coated and veined by a clast-laden, glassy impact melt (Fig. 1). The anorthosite is chemically pristine. This rock is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

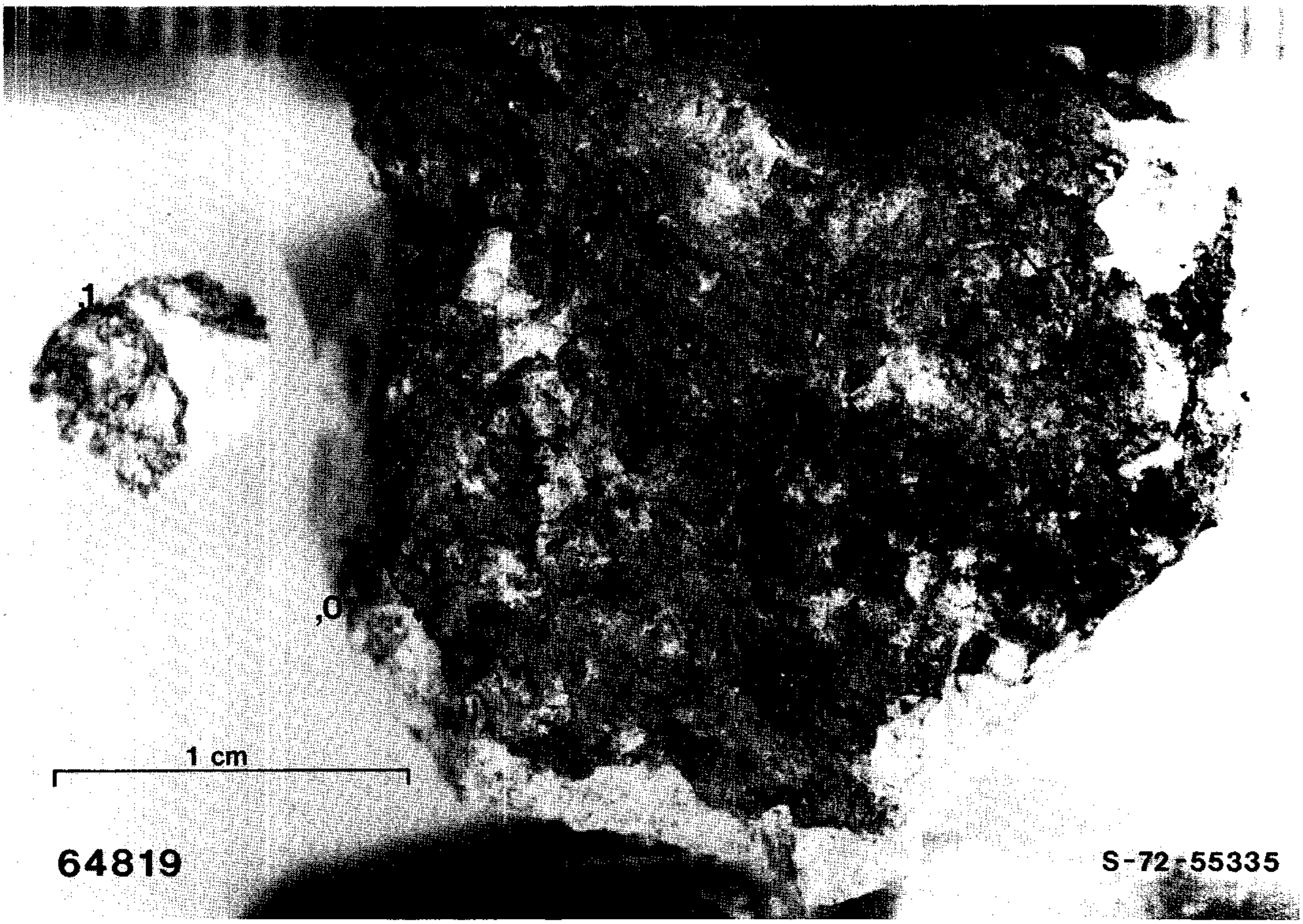



Figure 1.

PETROLOGY: A petrographic description is given by Dixon and Papike (1975). 64819 is a cataclastic anorthosite with original grain size >5 mm (Fig. 2). Rare pyroxenes with small exsolution lamellae occur as interstitial grains and are of composition $Wo_3En_{65}$ and $Wo_{44}En_{44}$; plagioclase is $An_{96-97}$ (Dixon and Papike, 1975). Small amounts of Fe-metal and troilite are also present. A mode by Dixon and Papike (1975) shows 72% feldspar, 1.0% orthopyroxene, 0.1% clinopyroxene, 0.1% opaques and 27% brown glass as veins or a coating. The glassy material is compositionally identical to feldspar.

Figure 2. 64819,7, general view, partly xpl. width 4mm.

CHEMISTRY: Floran et al. (1976) present major element data obtained by electron microprobe analysis of natural rock powder fused to a glass (except FeO and $Na_2O$ by instrumental neutron activation). Blanchard (unpublished data) provides a trace element analysis and the FeO and $Na_2O$ data quoted by Floran et al. (1976).

These data show that 64819 is nearly pure plagioclase with the low levels of siderophile and lithophile elements typical of pristine lunar anorthosites (Table 1, Fig. 3).

PROCESSING AND SUBDIVISIONS: In 1972 a single chip (,1) was removed and allocated for thin sectioning. In 1975 a set of several chips of clean anorthosite (,4) was allocated for chemistry; the analysis of Floran et al. (1976) and Blanchard (unpublished) are both of portions of this split.

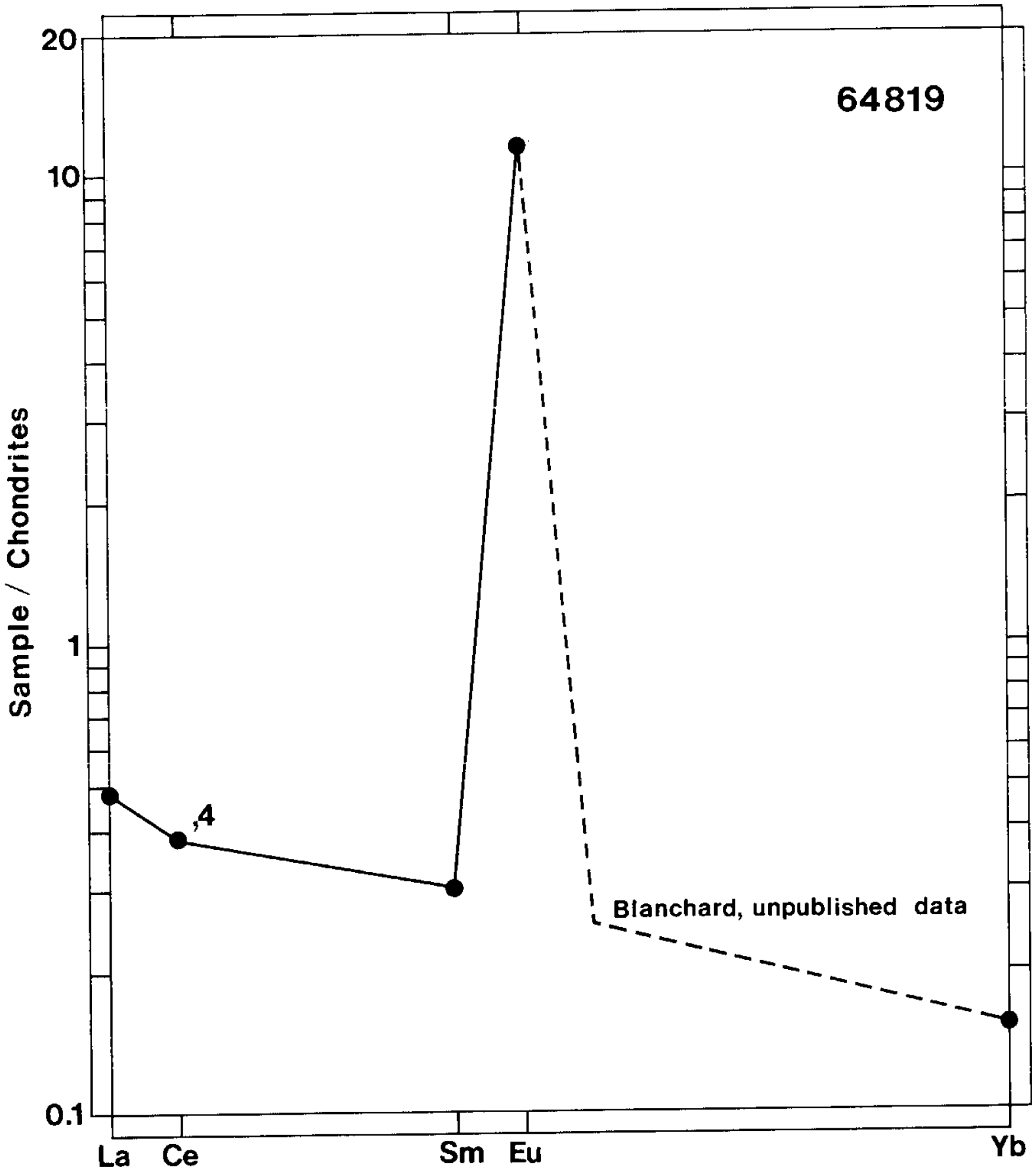



Figure 4. Rare earths.

TABLE 1. Summary chemistry of 64819

| | |
|---|---|
| $SiO_2$ | 44.3 |
| $TiO_2$ | 0.01 |
| $Al_2O_3$ | 34.6 |
| $Cr_2O_3$ | 0.005 |
| FeO | 0.46 |
| MnO | |
| MgO | 0.37 |
| CaO | 19.3 |
| $Na_2O$ | 0.371 |
| $K_2O$ | 0.04 |
| $P_2O_5$ | |
| Sr | |
| La | 0.16 |
| Lu | <0.0062 |
| Rb | |
| Sc | 0.65 |
| Ni | <5 |
| Co | 0.95 |
| Ir ppb | |
| Au ppb | |
| C | |
| N | |
| S | |
| Zn | |
| Cu | |

Oxides in wt%; others in ppm except as noted

INTRODUCTION: 64825 is a medium gray, friable, clastic breccia (Fig. 1) with a diverse clast population, including at least one clast of green glass. This rock is a rake sample from the rim of a small, subdued crater on Stone Mountain. A few zap pits are present on one surface.

Figure 1. S-72-42077.

INTRODUCTION: 64826 is a friable, medium gray, clastic breccia (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.


Figure 1.

PETROLOGY: Warner et al. (1973) include 64826 in a general petrographic discussion of Apollo 16 rake samples and classify it as a "glassy breccia." Phinney et al. (1976) studied the characteristics of the matrix using SEM techniques and found <1% glass.

Abundant mineral and lithic clasts and bead fragments of clear to pale yellow glass rest in a porous, unequilibrated matrix (Fig. 2). Mineral fragments are dominantly plagioclase with lesser amounts of mafic silicates, metal, troilite and ilmenite. Lithic clasts include basaltic impact melt, fine-grained poikilitic impact melt, recrystallized breccia and granoblastic anorthosite.

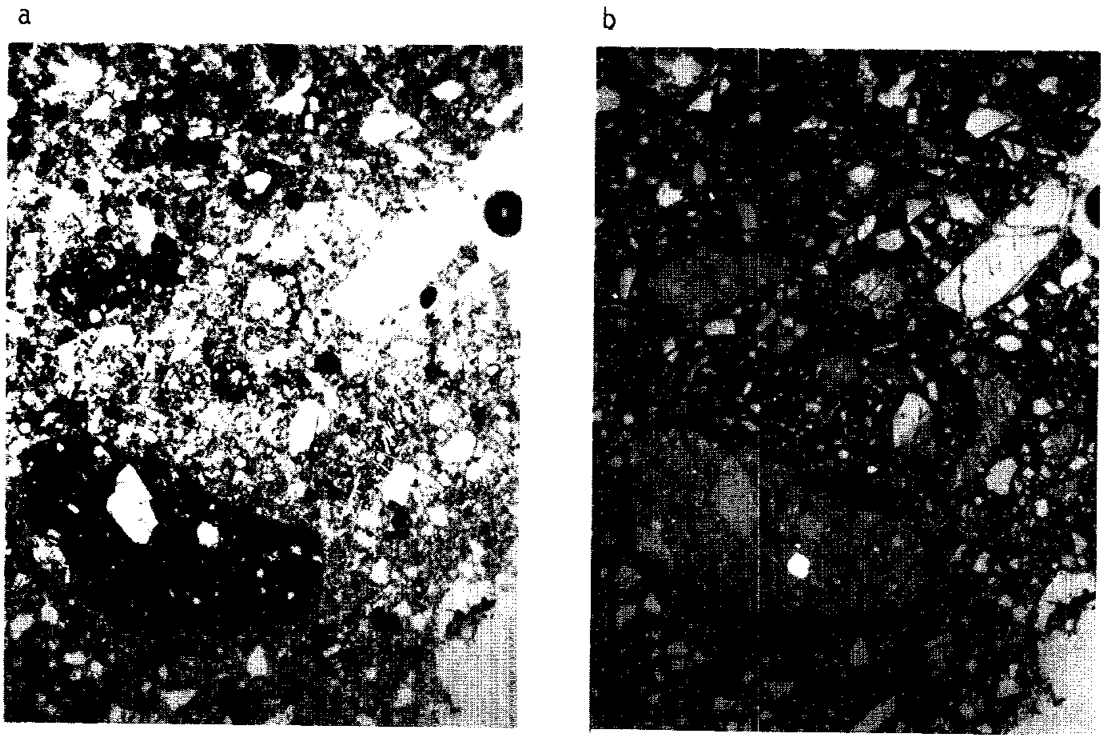



Figure 2. 64826,3, general view, width 2mm.
a) ppl. b) rfl.

CHEMISTRY: Floran et al. (1976) report major element data obtained by electron microprobe analysis of natural rock powder fused to a glass (except FeO and $Na_2O$ by instrumental neutron activation). Blanchard (unpublished data) provides a trace element analysis and the FeO and $Na_2O$ data quoted by Floran et al. (1976).

These data show that 64826 is very similar to the local mature soils in both major and trace element composition (Table 1, Fig. 3).

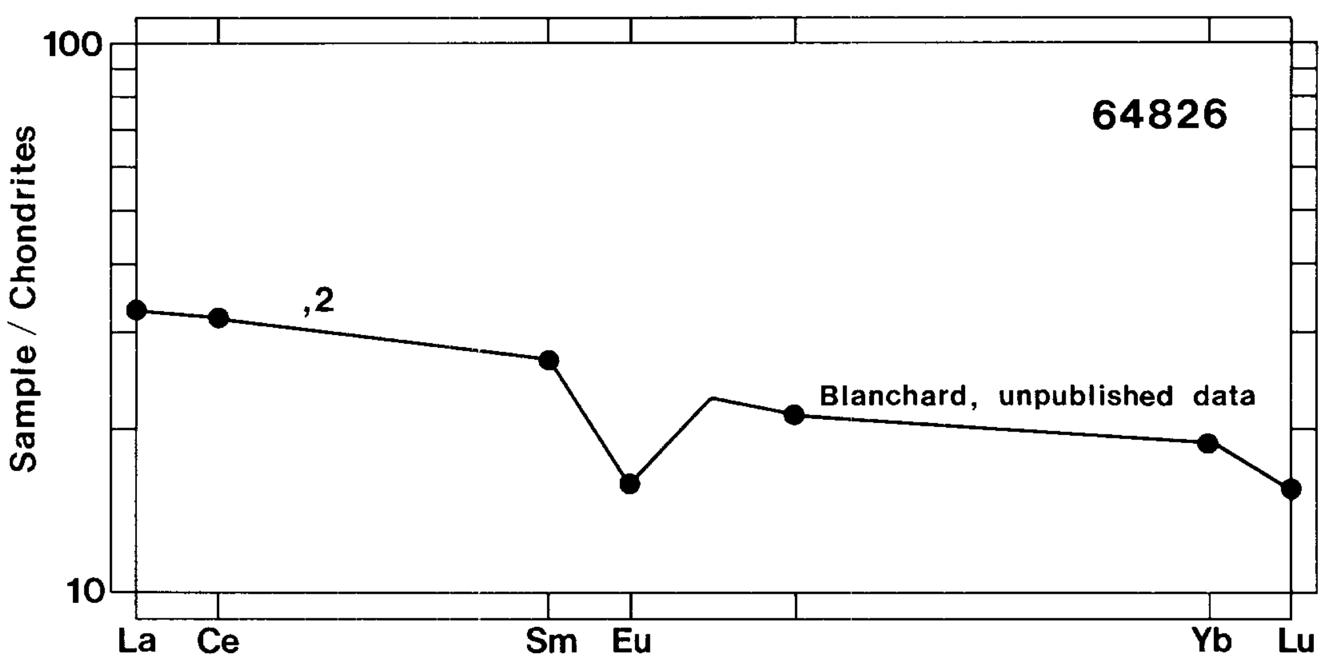
PROCESSING AND SUBDIVISIONS: In 1972 four small chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography. In 1975 a set of seven chips (,2) was allocated for chemistry; the analyses of Floran et al. (1976) and Blanchard (unpublished) are both of portions of this split. The remainder of the rock remains at JSC as ,0 (10.51 g).

TABLE 1. Summary chemistry of 64826

| | |
|---|---|
| $SiO_2$ | 45.30 |
| $TiO_2$ | 0.45 |
| $Al_2O_3$ | 28.10 |
| $Cr_2O_3$ | 0.099 |
| FeO | 4.43 |
| MnO | |
| MgO | 4.59 |
| CaO | 16.22 |
| $Na_2O$ | 0.479 |
| $K_2O$ | 0.13 |
| $P_2O_5$ | |
| Sr | |
| La | 10.8 |
| Lu | 0.527 |
| Rb | |
| Sc | 8.04 |
| Ni | 260 |
| Co | 19.4 |
| Ir ppb | |
| Au ppb | |
| C | |
| N | |
| S | |
| Zn | |
| Cu | |

Oxides in wt%; others in ppm except as noted

Figure 3.
Rare earths.



INTRODUCTION: 64827 is an extremely friable, medium gray, clastic breccia (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

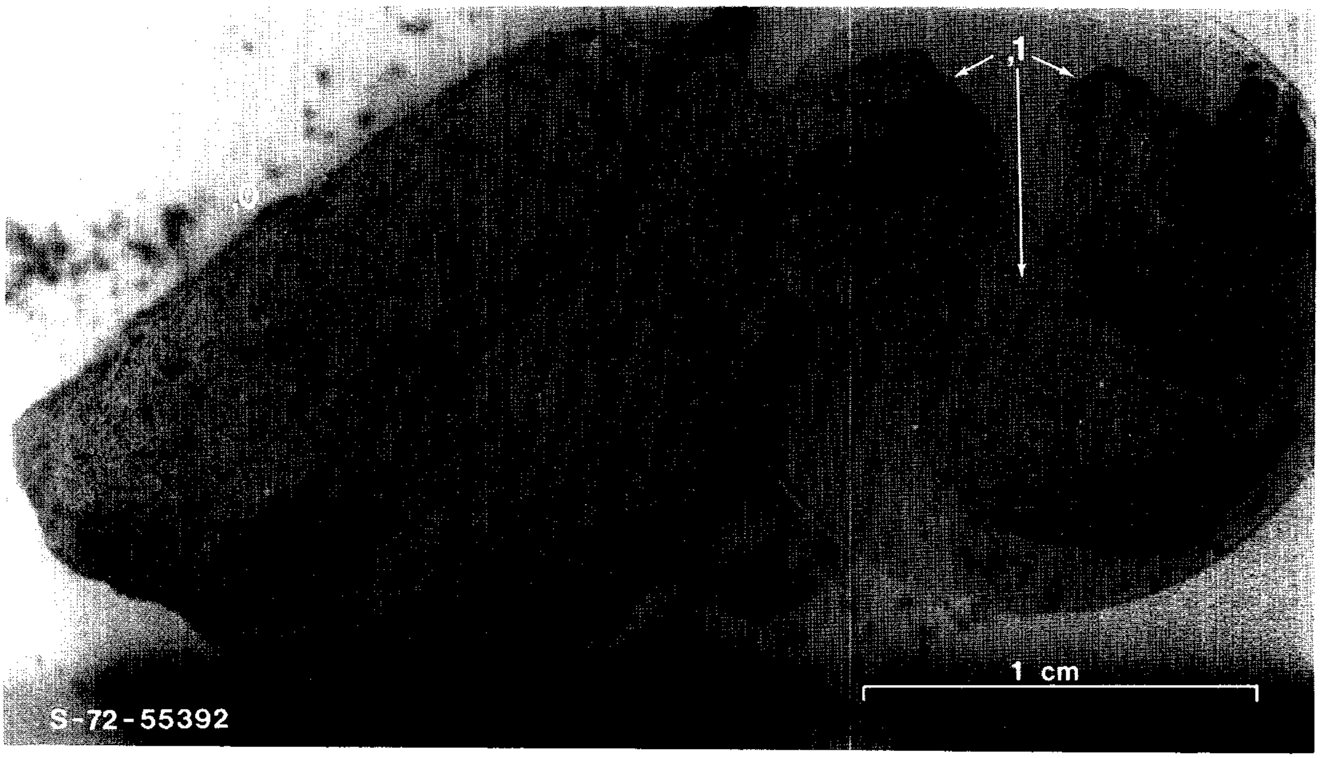



Figure 1.

PETROLOGY: Warner et al. (1973) include 64827 in a general petrographic discussion of Apollo 16 rake samples and classify it as a "glassy breccia". Phinney et al. (1976) studied the characteristics of the matrix using SEM techniques and found <1% glass.

Abundant mineral and lithic clasts and beads and fragments of pale orange glass rest in a porous, unequilibrated matrix (Fig. 2). Mineral fragments are dominantly plagioclase with lesser amounts of mafic silicates, metal, troilite, and ilmenite. Lithic clasts include coarse-grained, annealed, and recrystallized breccias, poikilitic impact melts, and granoblastic impactites. Trace amounts of agglutinates are reported by Phinney et al. (1976).

Figure 2. 64827,3, general view, ppl. width 2mm.

PROCESSING AND SUBDIVISIONS: In 1972 three chips were removed and one of these (,1) allocated to Phinney for thin sectioning and petrography.

INTRODUCTION: 64828 is an extremely friable, light gray, clastic breccia with several white to dark gray clasts (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

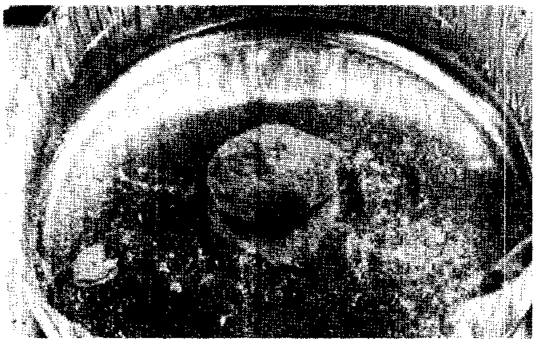


Figure 1. S-72-42077.

## 64829 FRAGMENTAL POLYMICT BRECCIA 2.20 g

INTRODUCTION: 64829 is an extremely friable, light gray, clastic breccia with several white to dark gray clasts (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

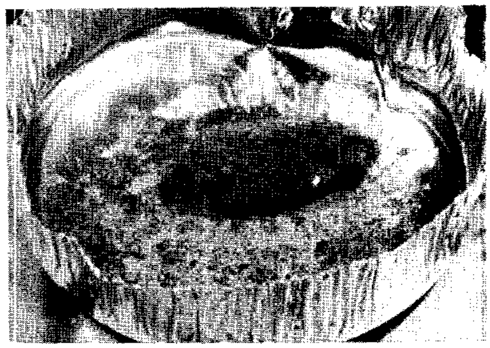


Figure 1. S-72-42077.

## 64835 FRAGMENTAL POLYMICT BRECCIA 2.32 g

INTRODUCTION: 64835 is an extremely friable, light gray, clastic breccia with several white to dark gray clasts (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

Figure 1. S-72-42070.

INTRODUCTION: 64836 is a friable, medium gray, clastic breccia with several small white clasts (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

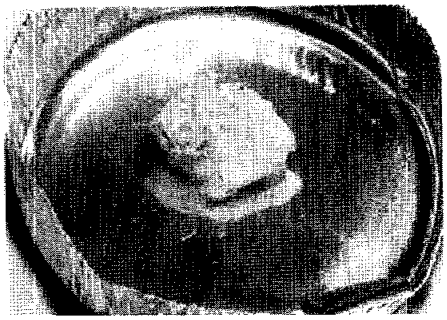


Figure 1. S-72-42070.

64837 FRAGMENTAL POLYMICT BRECCIA 2.18 g

INTRODUCTION: 64837 is a friable, medium gray, clastic breccia with a partial coat of dark glass (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

Figure 1. S-72-42070.

INTRODUCTION: 65015 is a clast-rich poikilitic impact melt that contains high abundances of incompatible elements and clasts of ancient, isotopically unequilibrated plagioclase. Macroscopically it is angular, homogeneous and very coherent (Fig. 1).

This sample was collected from the lower slope of Stone Mountain but the exact lunar orientation is unknown. An obvious soil line encircles the sample (Fig. 1). Zap pits are abundant above this ring and absent below it indicating a relatively simple exposure history.

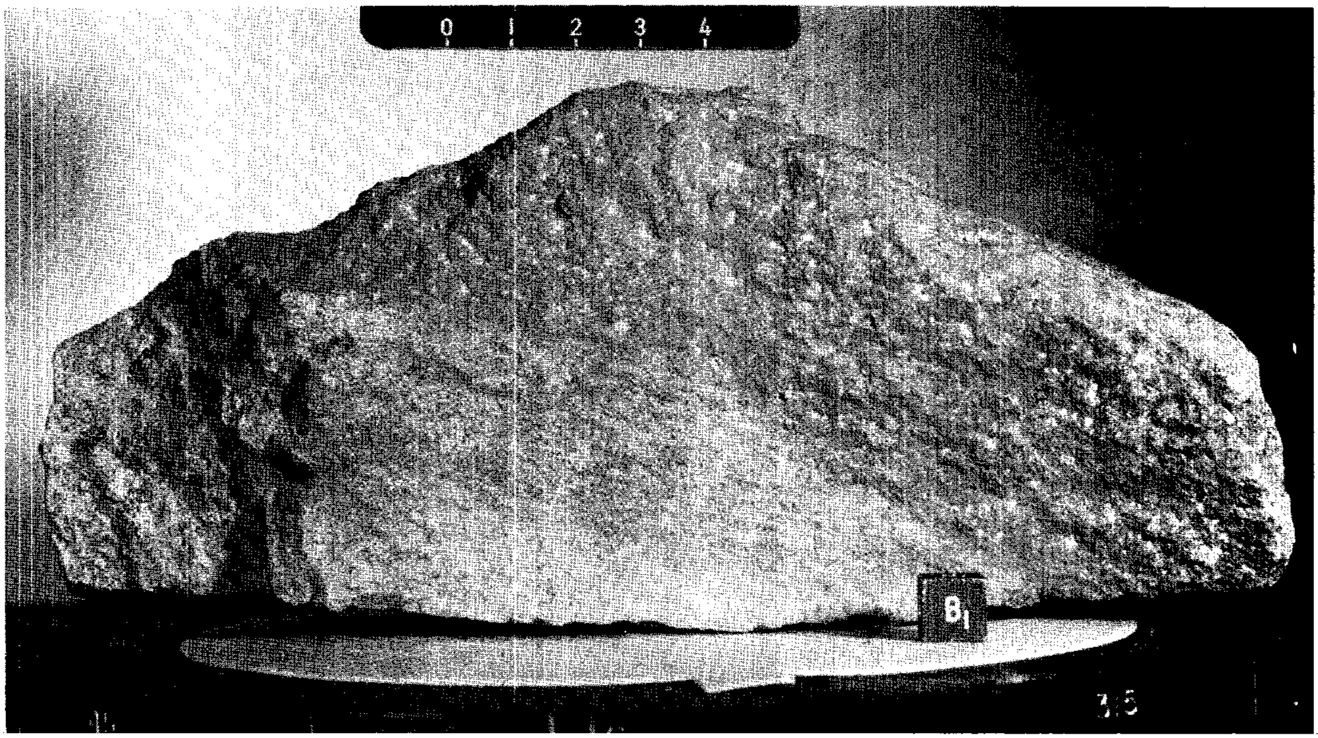



FIGURE 1. S-72-39211. Scale in cm.

PETROLOGY: Petrographic descriptions are given by Albee et al. (1973), Simonds et al. (1973), McGee et al. (1979) and Vaniman and Papike (1981). 65015 is an impact melt characterized by a well developed poikilitic texture in which oikocrysts of pyroxene (low Ca >> high Ca) enclose abundant clasts (>100 μm) and chadacrysts (<100 μm) (Fig. 2). Modes are given in Table 1.

The groundmass comprises abundant small (<100 μm) chadacrysts of plagioclase, olivine, high-Ca pyroxene, metal, and troilite enclosed by somewhat larger (up to ~1 mm) oikocrysts of pyroxene. X-ray crystallographic data on an augite-pigeonite crystal are given by Takeda (1973). Interoikocryst areas are K-rich and contain abundant accessory minerals such as whitlockite, ilmenite, metal and troilite. The larger clasts also tend to be concentrated in the interoikocryst regions.

a b

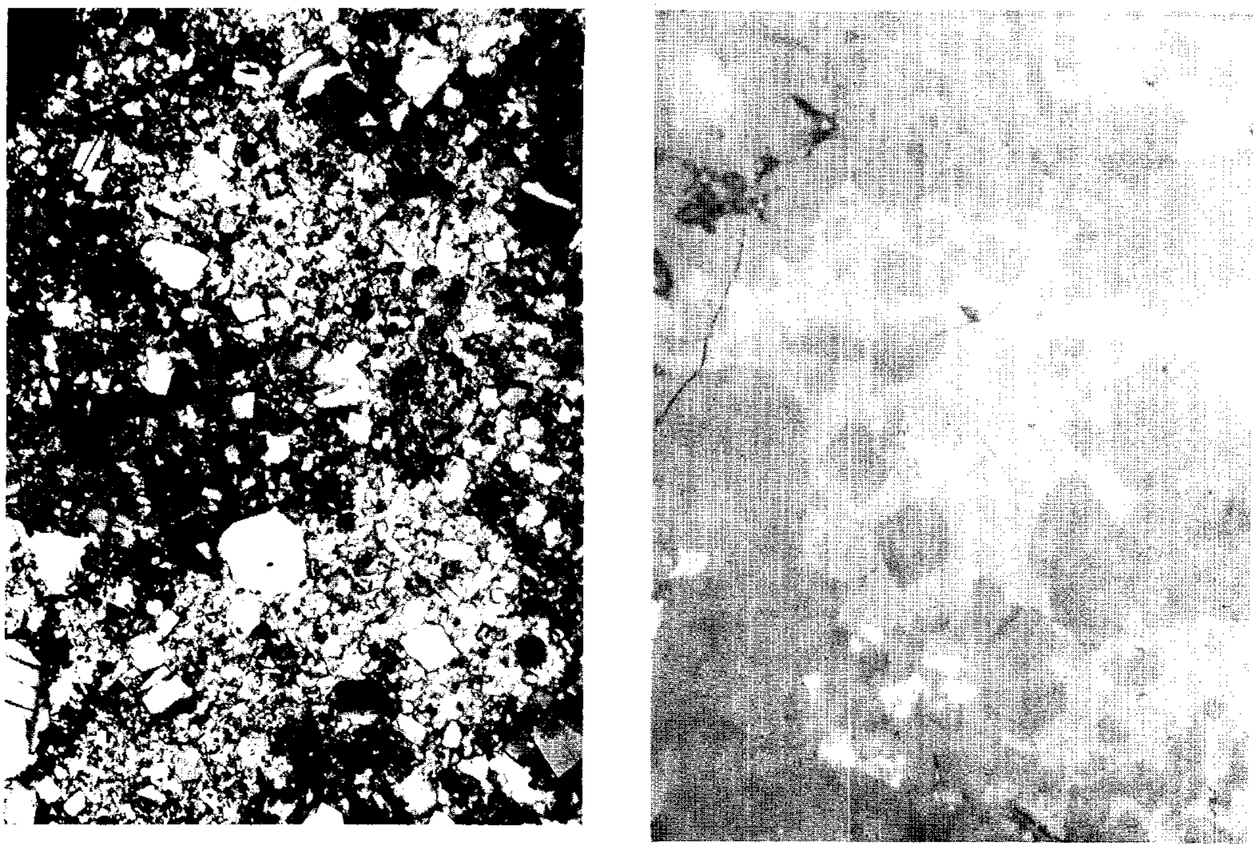


FIGURE 2. 65015,13. a) general view, xpl. width 1mm. b) rfl. width 0.2mm.

The clasts are predominantly angular fragments of plagioclase (up to ~0.5 mm) with subordinate amounts of olivine, high-Ca pyroxene, metal, granoblastic anorthosite, basaltic impact melt, noritic anorthosite, and devitrified maskelynite. Many of the plagioclase clasts are discontinuously rimmed by more sodic and more Fe-rich compositions (Figs. 3 and 4). Most of the olivine and high-Ca pyroxene clasts are embayed. From trace elements in the plagioclase clasts and chadacrysts, Meyer et al. (1974) and Meyer (1979) conclude that the clasts could not be in equilibrium with the bulk of the rock (Fig. 5 and Table 2). Metal occurs both as rounded clasts and as interoikocryst crystals, and is very homogeneous in composition (Fig. 6) (Albee et al., 1973; El Goresy et al., 1973a; Misra and Taylor, 1975).

This rock has been somewhat annealed but not as extensively as, for example, 64815. Clasts in 65015 tend to be quite angular and plagioclase chadacrysts, though somewhat rounded, clearly retain their euhedral shape (Fig. 2).

TABLE 1. Modes of 65015 (vol %)

| | ,83 (Albee et al., 1973) | (Simonds et al.,1973) |
|---|---|---|
| Plagioclase | 57.1 | 61 (includes mesostasis) |
| Low-Ca pyroxene | 28.9 | 29 |
| High-Ca pyroxene | 6.4 | 6 |
| Olivine | 1.1 | 1 |
| Opaques | 1.7 | 3 |
| Ilmenite | 1.2 | |
| Fe-metal | 0.4 | |
| Troilite | 0.1 | |
| K-rich interstitial material | 3.6 | |
| Whitlockite | 0.7 | |

TABLE 2. Minor elements in plagioclase determined by ion microprobe (Meyer et al., 1974; Meyer, 1979)

| | $Na_2O$ (%) | Li | Mg | K | Ti | Sr | Ba |
|---|---|---|---|---|---|---|---|
| Xenocrysts (12 analyses) | 0.45 | 6 | 570 | 320 | 87 | 161 | 7 |
| Xenocrysts (7 analyses) | | 4.2-8.6 avg.6.2 | 400-800 avg.610 | | | | |
| Chadacrysts (6 analyses) | 0.43 | 5 | 380 | 400 | 78 | 170 | 35 |
| Chadacrysts (1 analysis) | 1.36 | 20 | 600 | 1000 | 360 | 450 | 183 |

All elements ppm except as noted.

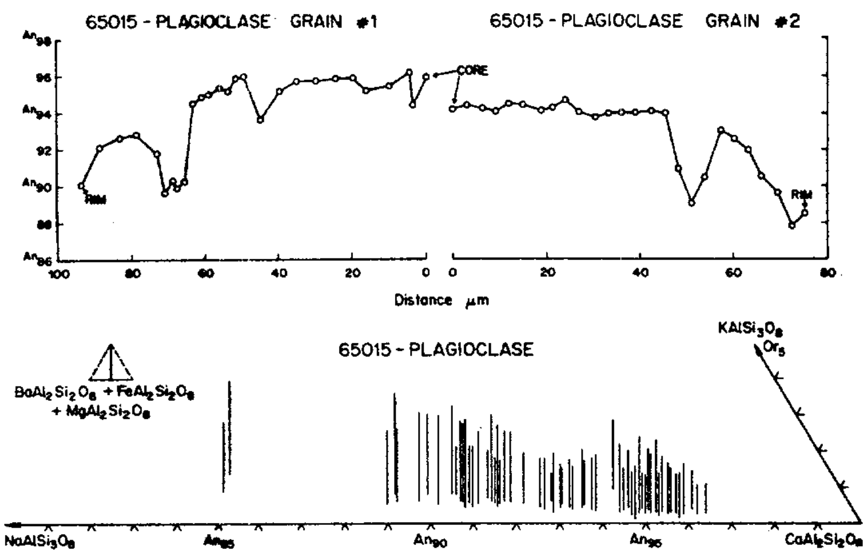



FIGURE 3a. Plagioclase compositions; from Albee et al.(1973).

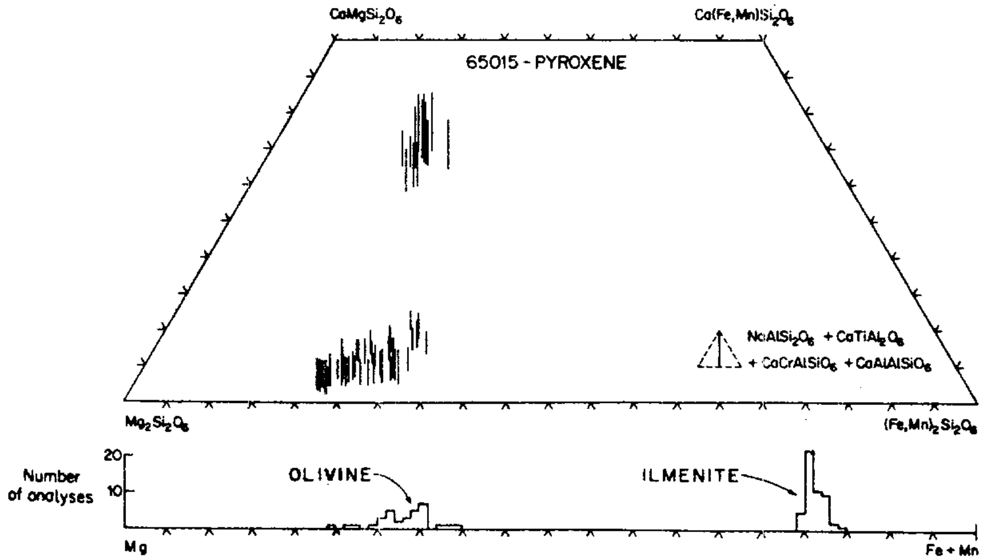



FIGURE 3b. Mafic mineral compositions; from Albee et al. (1973).

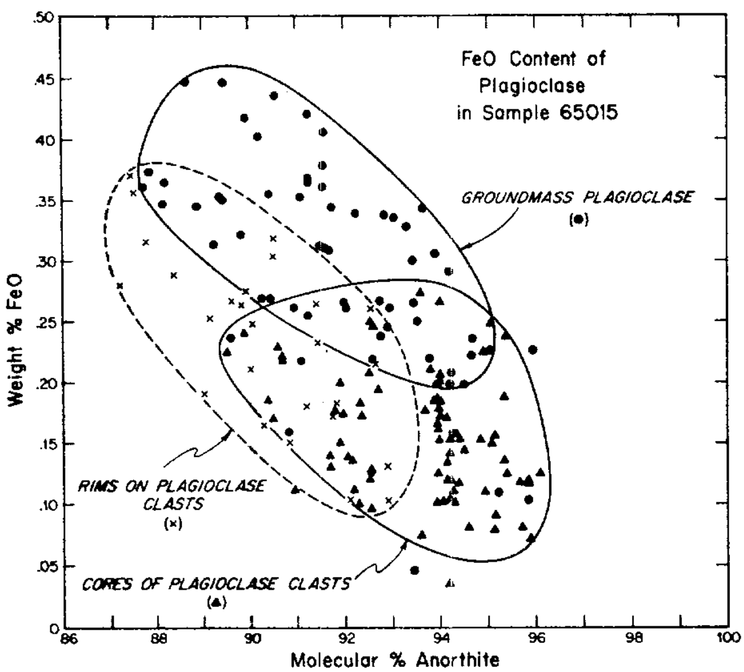



FIGURE 4. FeO in plagioclase; from Albee et al. (1975).

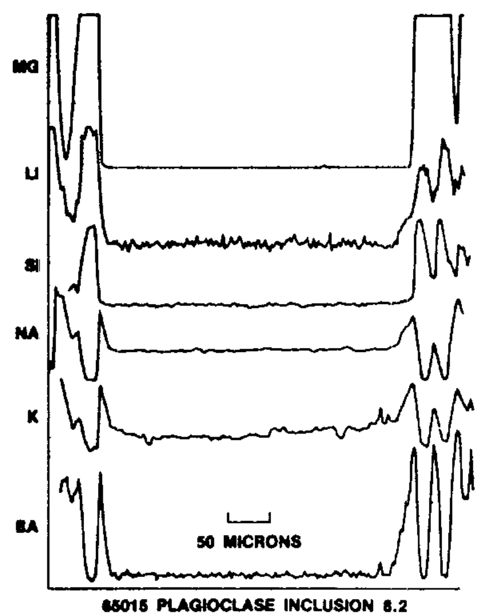



FIGURE 5. Minor elements in plagioclase inclusion; from Meyer (1979).

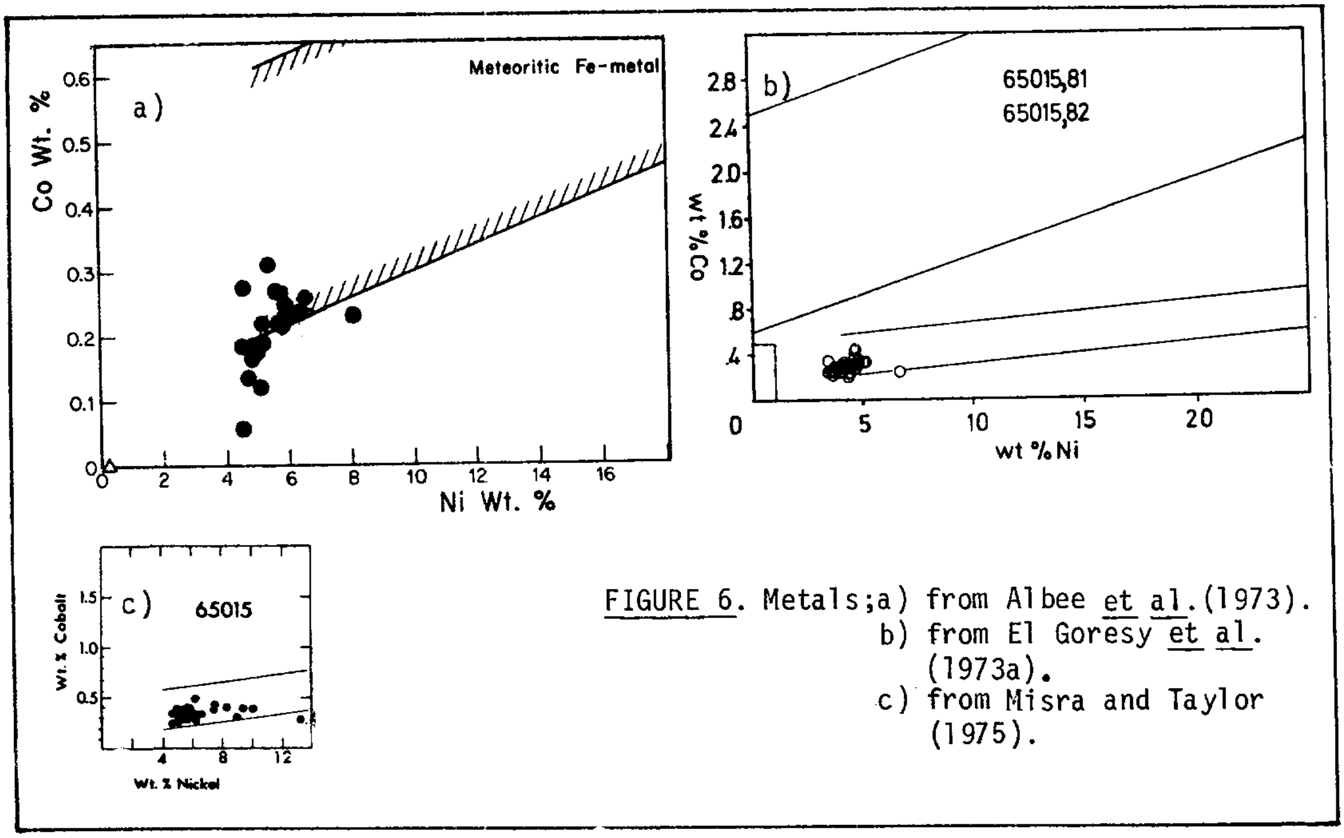



FIGURE 6. Metals;a) from Albee et al.(1973).
b) from El Goresy et al. (1973a).
c) from Misra and Taylor (1975).

EXPERIMENTAL PETROLOGY: Taylor et al. (1976) performed subsolidus annealing experiments on 65015 to determine the change in composition and morphology of metal grains with time. Such annealing had little or no effect on the metal in this rock (Fig. 7) indicating that the metal was already largely equilibrated.

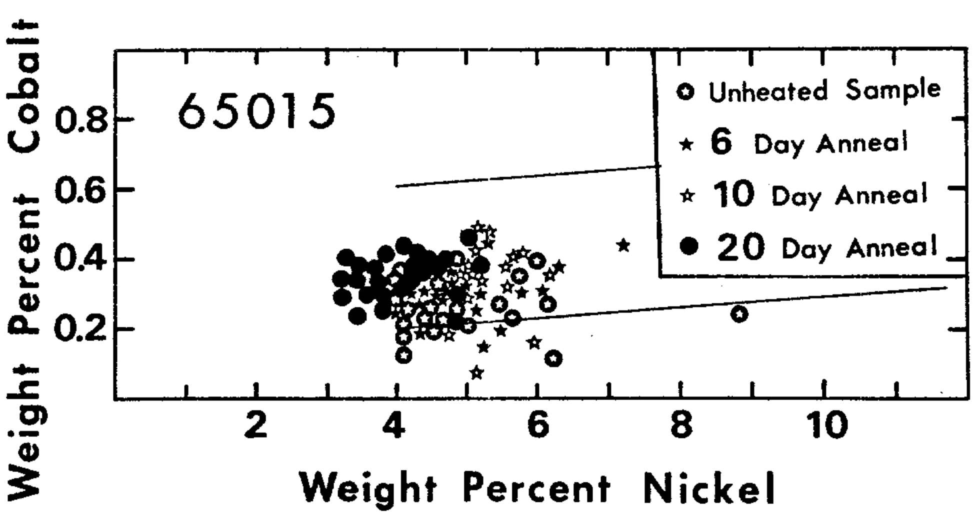



FIGURE 7. from L.A. Taylor et al. (1976).

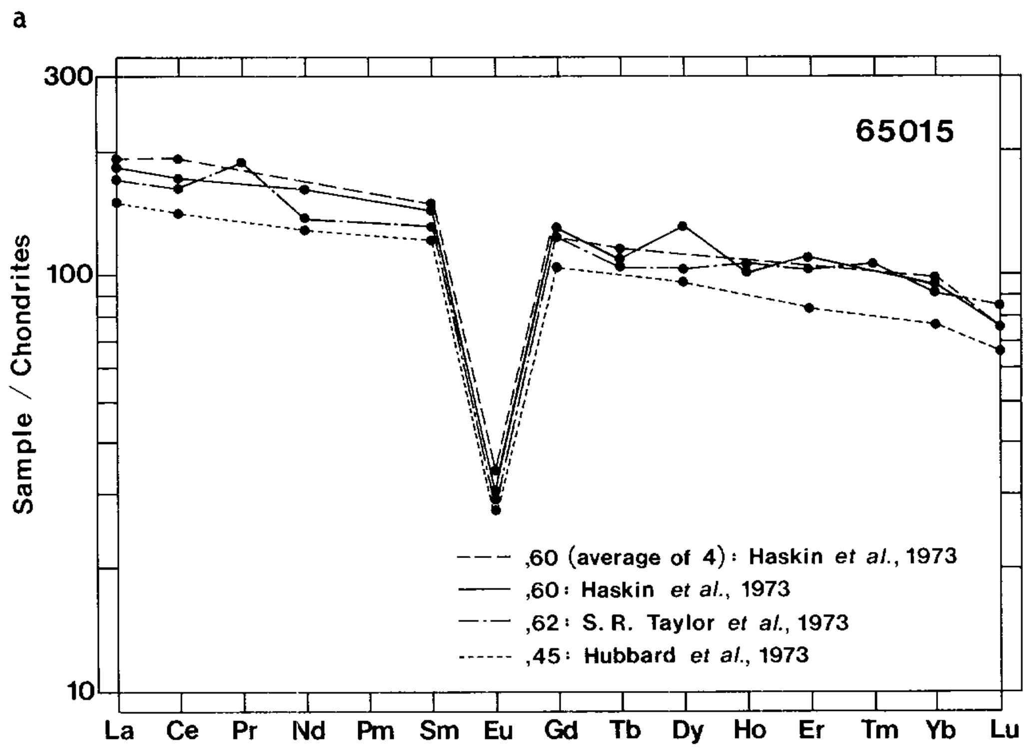
TABLE 3. Chemical work on 65015 whole rock

| Reference | Split # | Elements Analyzed |
|---|---|---|
| Janghorbani et al. (1973) | ,54 | Majors |
| Haskin et al. (1973) | ,60 | Majors, trace incl. rare earths |
| Hubbard et al. (1973) | ,45 | Majors, trace incl. rare earths |
| S.R. Taylor et al. (1973) | ,62 | Majors, trace incl. rare earths |
| Duncan et al. (1973) | ,57 | Majors, some trace |
| Baedecker et al. (1974 a,b) | ,63 | Fe, Sc, other trace incl. rare earths |
| Miller et al. (1974) | ,54 | Fe, Co, Sc, Cr, Eu, La |
| Ehmann and Chyi (1974) | ,54 | Zr, Hf |
| Boynton et al. (1975) | ,63 | Some majors and trace |
| Wasson et al. (1975) | ,63 | Trace, incl. siderophiles and rare earths |
| Wänke et al. ( 1976) | ,133 | Majors, trace (∿40 elements) |
| Wänke et al. (1977) | ,133 | V |
| Wasson et al. (1977) | ,63 | Majors, trace incl. rare earth and Co |
| Krähenbühl et al. (1973) | ,51 | Meteoritic siderophiles and volatiles |
| Hughes et al. (1973) | ,44 | Meteoritic siderophiles and volatiles |
| Jovanovic and Reed (1973) | ,32 | U, Li, Cl, Br, I, Hf |
| Jovanovic and Reed (1976a) | ,32 | Ru, Os |
| Jovanovic and Reed (1976b) | ,32 | Cl, P, F, U |
| Jovanovic and Reed (1977) | ,32 | Hg |
| Reed et al. (1977) | ,32 | Volatilized Tl, Zn |
| Kerridge et al. (1975b) | ,64 | C, S |
| Des Marais (1978) | ,174 | C, N, S |
| Nyquist et al. (1973) | ,45 | Rb, Sr |
| Kirsten et al. (1973) | ,61 | Ca, K |
| Nunes et al. (1973) | ,52 | U, Th, Pb |
| Jessberger et al. (1974) | ,56 | Ca, K |
| Tera et al. (1973,1974) | ,56 | K, U, Th, Pb |
| Papanastassiou and Wasserburg (1972b) | ,56 | Rb, Sr |

TABLE 4. Summary chemistry of 65015

| | Bulk rock | Metal spherule |
|---|---|---|
| $SiO_2$ | 47.5 | |
| $TiO_2$ | 1.18 | |
| $Al_2O_3$ | 20.0 | |
| $Cr_2O_3$ | 0.20 | |
| FeO | 8.4 | |
| MnO | 0.12 | |
| MgO | 9.8 | |
| CaO | 12.0 | |
| $Na_2O$ | 0.56 | |
| $K_2O$ | 0.350 | |
| $P_2O_5$ | 0.40 | |
| Sr | 158 | |
| La | 56.9 | |
| Lu | 2.64 | |
| Rb | 9.0 | |
| Sc | 14.8 | |
| Ni | 185-730 | 56,700 |
| Co | ∿35 | |
| Ir ppb | 12.6 | 990 |
| Au ppb | 10.3 | 1,070 |
| C | 10(?) | |
| N | 0.7 | |
| S | ∿975 | |
| Zn | 0.9 | 3.2 |
| Cu | 4.5 | |

Oxides in wt%; others in ppm except as noted.



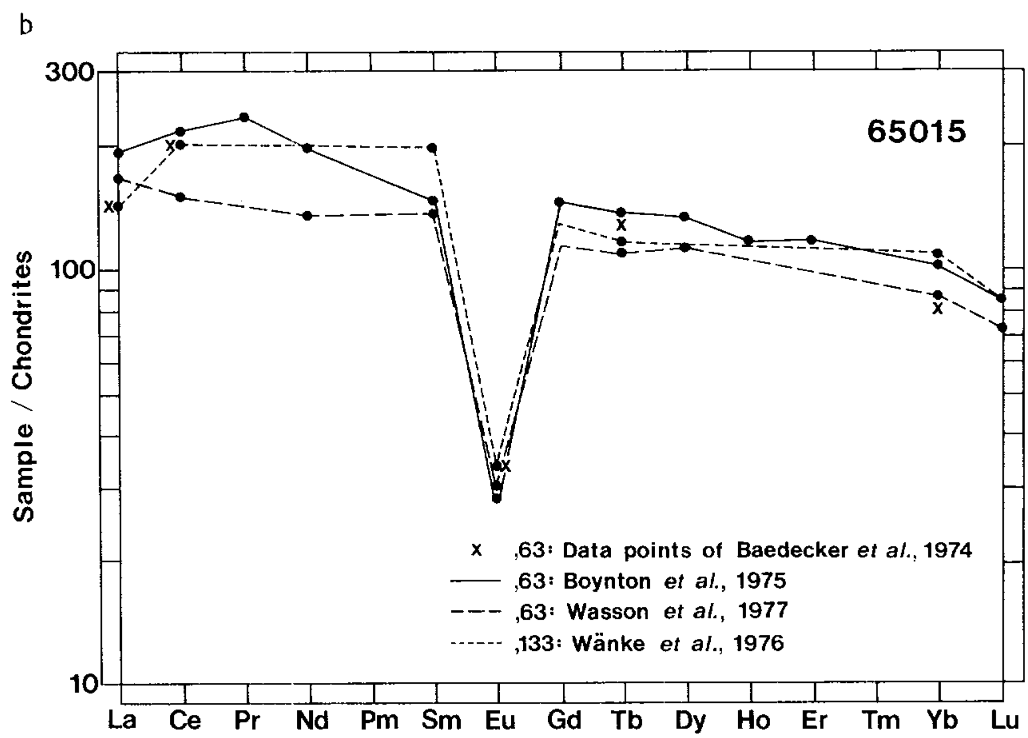




FIGURE 8. Rare earth elements.

CHEMISTRY: Abundant chemical data have been published for 65015, referenced in Table 3. Trace element abundances in accessory mineral phases are given by Lovering and Wark (1974), and Wasson et al. (1975) also report an analysis of a metal spherule taken from the rock.

Chemically, 65015 is similar to other KREEP-rich Apollo 16 impact melts, except that it is somewhat more aluminous than most (Table 4). Rare earth elements in 65015 are among the highest of any Apollo 16 rocks (Table 4, Fig. 8) and are only slightly less abundant than in Apollo 15 KREEP basalts 15382 and 15386. The high Zr and Hf abundances and the high Zr/Hf ratio are also typical of KREEP (Ehmann and Chyi, 1974; Garg and Ehmann, 1976). The high abundances of siderophile elements in 65015 (Table 4) indicate meteoritic contamination. Hertogen et al. (1977) assign 65015 to ancient meteoritic group 1H, a group largely restricted to the Apollo 16 site. Wasson et al. (1975) note that siderophile ratios of the bulk rock differ from those in a separated metal spherule (Table 4), implying incomplete equilibration between the metal and the rock. 65015 is depleted in volatiles, both in absolute abundances and relative to involatile elements (e.g. Tl/Cs) (Krähenbühl et al., 1973; Jovanovic and Reed, 1973 and others).

Sato (1976) measured the oxygen fugacity of 65015 directly using the solid-electrolyte oxygen cell method. Self-reduction by as much as 1.5 log $fO_2$ units was observed during the first heating cycle. The values after the shift (Table 5) were reproducible in subsequent cycles.

TABLE 5

Average oxygen fugacity values of 65015

| T ($^{o}$C) | -log $fO_2$ (atm) |
|---|---|
| 1000 | 17.0 |
| 1050 | 16.3 |
| 1100 | 15.6 |
| 1150 | 14.9 |
| 1200 | 14.1 |

STABLE ISOTOPES: Kerridge et al. (1975b) provide whole rock C and S isotopic data, Taylor and Epstein (1973) report O and Si isotope data for the whole rock and mineral separates and Clayton et al. (1973) give O isotope data for mineral separates (Table 6).

From the lack of $\delta O^{18}$ enrichment commonly found in lunar soils, Taylor and Epstein (1973) conclude that 65015 must have formed from material without a significant surface exposure history. Clayton et al. (1973) calculate a temperature of equilibration of 1020$^{o}$C from the isotopic fractionation between plagioclase and ilmenite.

TABLE 6. Stable isotope abundances in 65015 (all values $^{o}/oo$)

| Sample | $\delta C^{13}$ | $\delta S^{34}$ | $\delta O^{18}$ | $\delta Si^{30}$ |
|---|---|---|---|---|
| whole rock | -16.7 | +1.8 | +5.94 | -0.02 |
| high-Ca pyroxene | | | +5.71 | -0.22 |
| low-Ca pyroxene | | | +5.63 | -0.13 |
| plagioclase | | | +6.04 | -0.04 |
| | | | +5.76 | |
| ilmenite | | | +3.8 | |

RADIOGENIC ISOTOPES AND GEOCHRONOLOGY: Extensive geochronological work has been performed on 65015. All of the systems indicate a major disturbance 3.9-4.0 b.y. ago, which is most simply interpreted as the age of the crystallization of 65015 from an impact melt. Rb-Sr and Ar systematics indicate incomplete equilibration between some plagioclase clasts and the matrix, consistent with ion microprobe data (Meyer et al., 1974).

Rb-Sr data have been determined on whole rock and mineral separates by Papanastassiou and Wasserburg (1972b) and Tera et al. (1973) and on a whole rock sample by Nyquist et al. (1973) (Table 7). These data reveal the presence of ancient, isotopically unequilibrated clasts of plagioclase (Papanastassiou and Wasserburg, 1972b). Three separates of xenocrystic plagioclase fall distinctly below a 3.93±0.02 b.y. isochron defined by whole rock and "quintessence" separates, and on a mixing line with BABI (Fig. 9). If 65015 remained a closed system during the 3.9-4.0 b.y. disturbance, then an isochron connecting the most primitive clasts with the whole rock separates yields the time of crystallization of the rock. Such an isochron gives an age of 4.42±0.04 b.y. with I = 0.69917±8. However it seems likelv that the 3.93 b.y. age obtained from the whole rock and "quintessence" splits actually dates the time of crystallization of 65015 from an impact melt and the requirement for a closed system probably cannot be met. Thus the 4.42 b.y. "primary" age probably has no real geochronological significance.

Sm-Nd data on a whole rock chip are reported by Lugmair and Carlson (1978) (Table 8). No large plagioclase xenocrysts were present in this chip so the sample is considered representative of the fine-grained matrix. The Sm-Nd isotopic systematics of 65015 are very similar to those of the KREEP-rich samples from other landing sites (Fig. 10). The light REE enrichment characteristic of 65015 (and other KREEP-rich samples) was established well before the 3.9-4.0 b.y. disturbance and could not have been produced by partial melting at this time (Lugmair and Carlson, 1978).

TABLE 7. Rb-Sr isotopic data for 65015

| Sample | $^{87}Rb/^{86}Sr$ | $^{87}Sr/^{86}Sr$ measured | $T_{BABI}$ (b.y.) | Reference |
|---|---|---|---|---|
| whole rock A | 0.1629±7 | 0.70945±5 | 4.48±0.03 | Papanastassiou and Wasserburg (1972b) |
| whole rock B | 0.1504±6 | 0.70874±8 | 4.52±0.04 | |
| Plagioclase A | 0.02574±10 | 0.70080±6 | | |
| Plagioclase B | 0.0900±4 | 0.70520±6 | | |
| Plagioclase C | 0.0972±6 | 0.70561±5 | | |
| Quintessence | 0.981±4 | 0.75542±10 | 4.02±0.02 | |
| Plagioclase M | 0.00242 | 0.69920±7 | | Tera et al. (1973) |
| Plagioclase | 0.02919 | 0.70110±12 | | |
| Pyroxene L | 0.03555 | 0.70240±10 | | |
| "Phosphates"A | 0.05703 | 0.70348±5 | | |
| Ilmenite | 0.2019 | 0.71163±7 | | |
| Quintessence | 0.998 | 0.75607±11 | | |
| whole rock | 0.1606±12 | 0.70935±6 | 4.45±0.06 | Nyquist et al. (1973) |

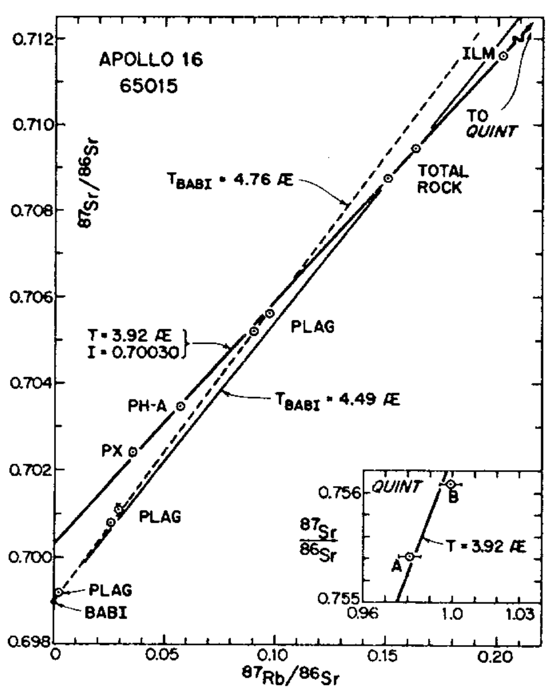



FIGURE 9. Rb-Sr; from Tera et al. (1973).

TABLE 8. Sm-Nd isotopic data for 65015 (Lugmair and Carlson, 1978)

| Sample | Sm (ppm) | Nd (ppm) | $^{147}Sm/^{144}Nd$ | $^{143}Nd/^{144}Nd$ | $T_{ICE}$ (b.y.) | $T_{JUV}$ (b.y.) |
|---|---|---|---|---|---|---|
| 65015,31 | 27.96 | 101.0 | 0.1673 | 0.511883±19 | 4.32±0.12 | 4.60±0.02 |

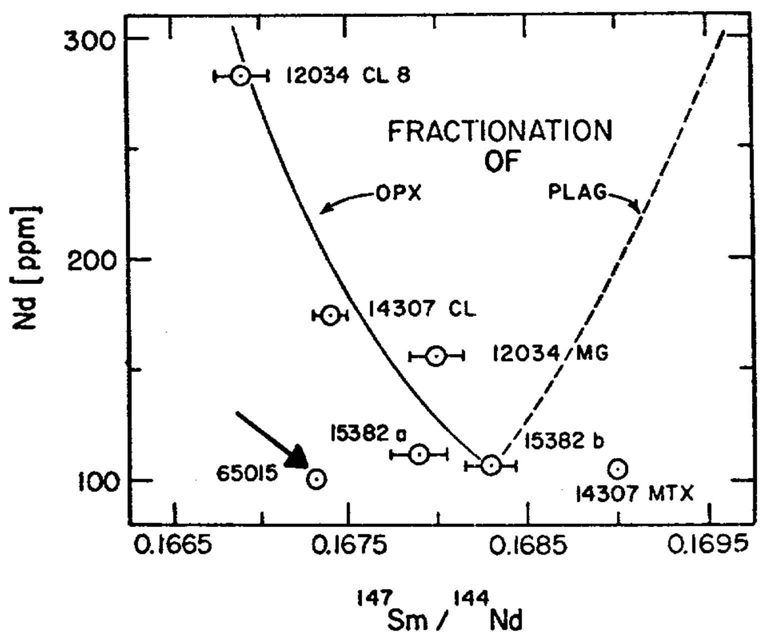



FIGURE 10. Sm-Nd; from Lugmair and Carlson (1978).

Ar-Ar data on whole rock splits yield a plateau age of 3.92±0.04 b.y. (Kirsten et al., 1973) (Fig. 11) and total Ar ages of 3.81±0.06 b.y. (Kirsten et al., 1973) and 3.852±0.005 b.y. (Jessberger et al., 1974). Jessberger et al. (1974) also report Ar isotopic data on separates (of varying purity) of plagioclase, pyroxene, and "phosphates", some of which have also been analyzed for Rb-Sr (Papanastassiou and Wasserburg, 1972b). Ar data on the purest plagioclase separate give a well defined, intermediate temperature plateau age of 3.98 b.y. At higher temperatures the apparent age of this separate rises to 4.47 b.y., confirming the presence of ancient, isotopically unequilibrated clasts (Figs. 12 and 13). The pyroxene and "phosphate" separates and the whole rock split did not show such evidence for ancient clasts but did show anomalous decreases in apparent age at high temperatures (Figs. 13, 14, and 15). Huneke and Smith (1976) interpret these anomalous release patterns as resulting from the recoil transfer of significant $^{39}Ar$ from K-rich areas of the rock to surrounding mafic minerals.

Schaeffer et al. (1979) report total K-Ar laser ages of the matrix of 3.87±0.01 and 3.82±0.01 b.y. and laser ages of 3.73-3.94 b.y. for plagioclase clasts. These authors also discuss blank problems which cast some doubt on their earlier results (Schaeffer et al., 1978) which seemed to indicate the presence of plagioclase clasts with ages up to 4.5 b.y.

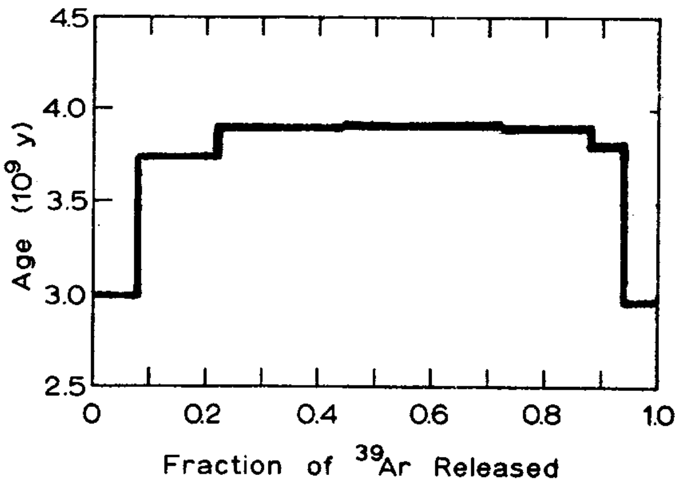



FIGURE 11. Ar-Ar release, whole rock; from Kirsten et al.(1973).

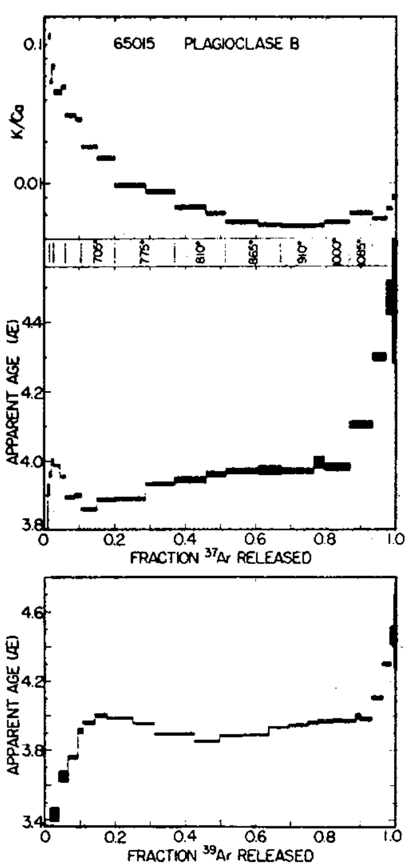



FIGURE 12. Ar-Ar release, plagioclase; from Jessberger et al.(1974).

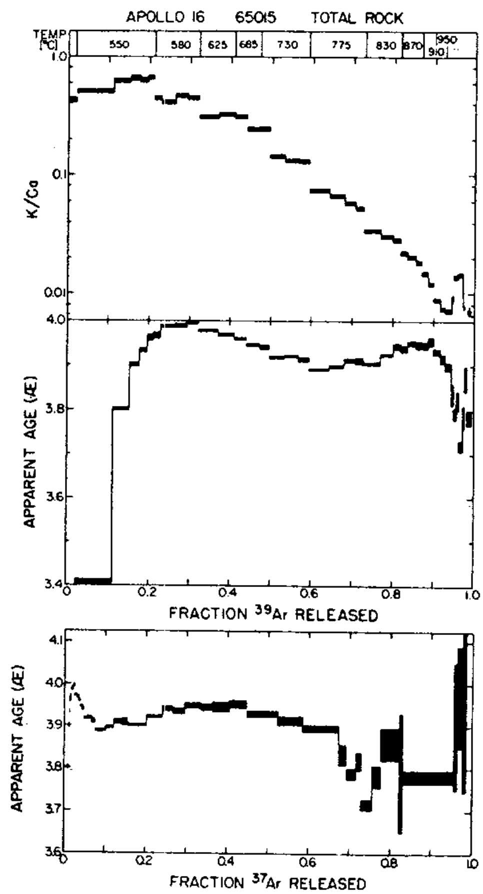



FIGURE 13. Ar-Ar release, whole rock; from Jessberger et al.(1974).

U-Th-Pb isotopic data are given by Tera et al. (1973,1974) for whole rock and plagioclase separates and by Nunes et al. (1973) for a whole rock sample. 65015 is very rich in U and Th and its Pb is very radiogenic. Both whole rock analyses are concordant at 3.99 b.y. (Fig. 16).

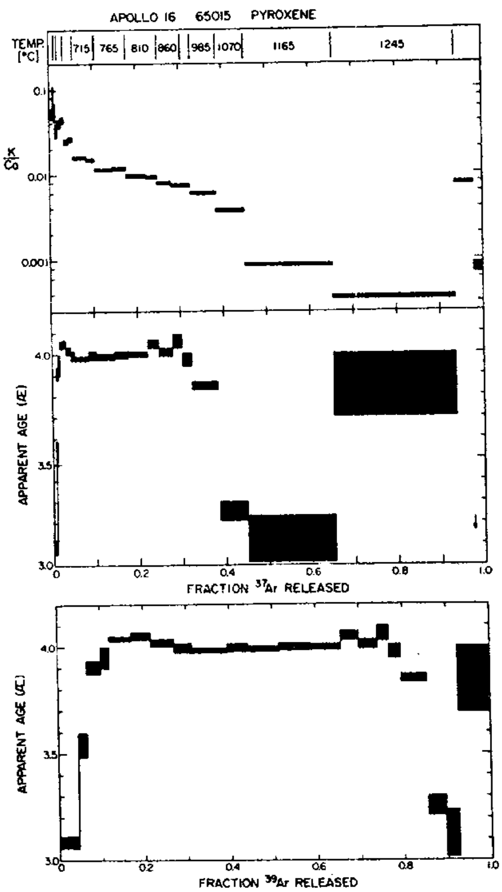



FIGURE 14. Ar-Ar release, pyroxene; from Jessberger et al.(1974).

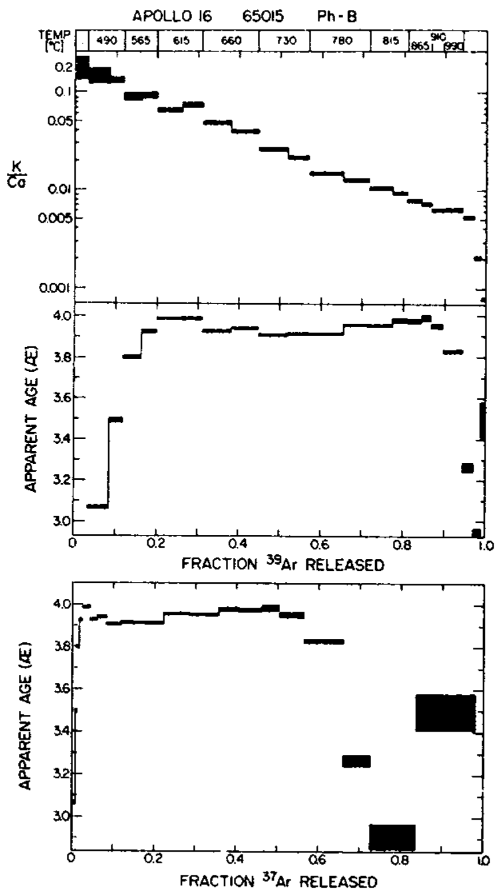



FIGURE 15. Ar-Ar release, mixed phases; from Jessberger et al. (1974).

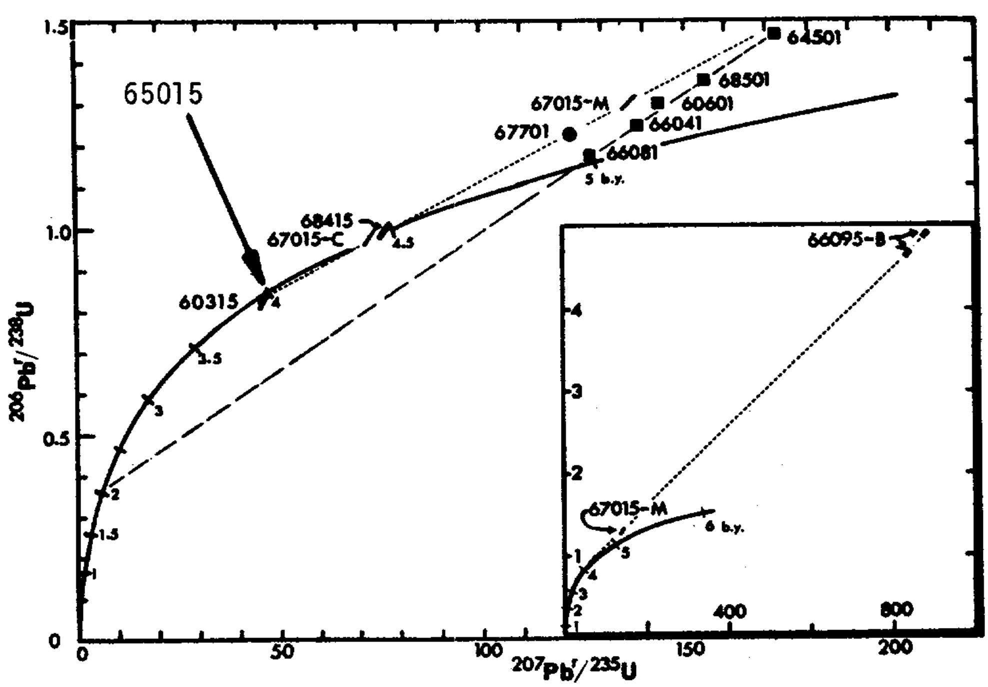
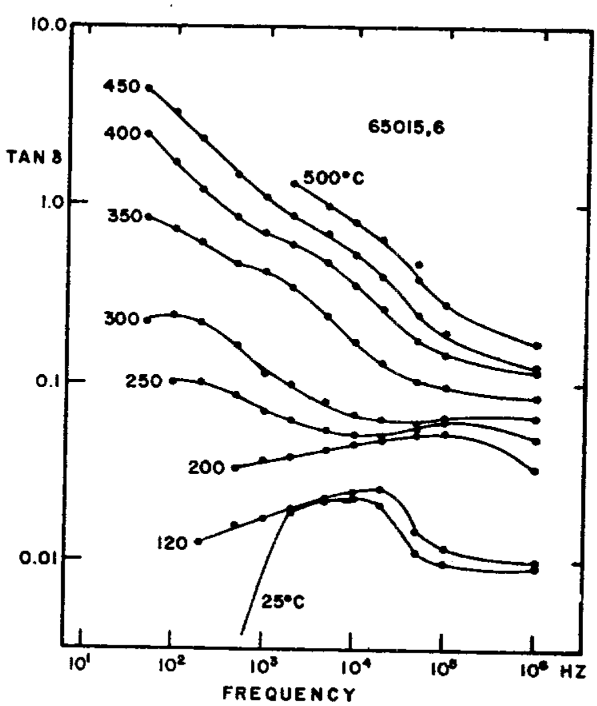


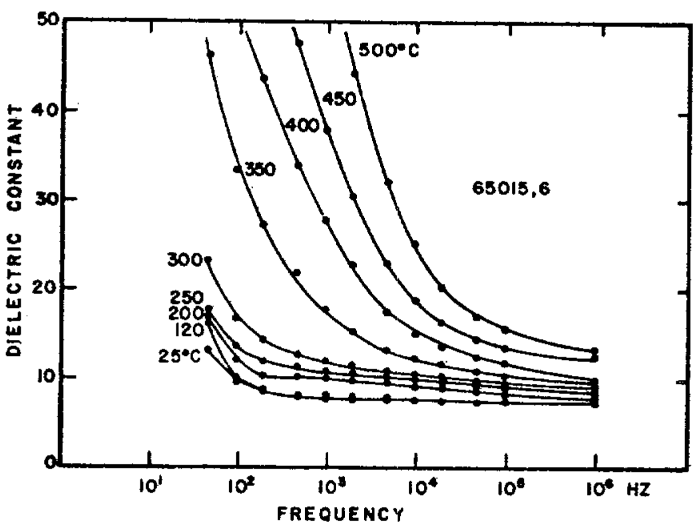

FIGURE 16. U-Pb concordia; from Nunes et al.(1973).

RARE GAS/EXPOSURE AGE: From track profiles Bhandari et al. (1973) determined that 65015 spent 1.2 m.y. at the lunar surface and 50 m.y. within the upper 10 cm of the regolith. This contrasts with $^{38}Ar$ exposure ages of 365 m.y. calculated by Kirsten et al. (1973) and 460-490 m.y. calculated by Jessberger et al. (1974) for the whole rock and mineral separates.

PHYSICAL PROPERTIES: Brecher (1977) finds that the directional magnetic properties of 65015 are correlated with one of two major planes of observed fractures. Other room temperature magnetic data are given by Stephenson et al. (1977).

Elastic properties at confining pressures up to 5 kb are provided by Todd et al. (1973). Electrical parameters (Fig. 17) are reported by Olhoeft et al. (1973) and Alvarez (1977). Todd et al. (1973) also compare the calculated and measured values of the mean volume thermal expansion coefficient of 65015. The calculated values are less than those measured due to cracks and fractures in the rock into which mineral grains can expand.



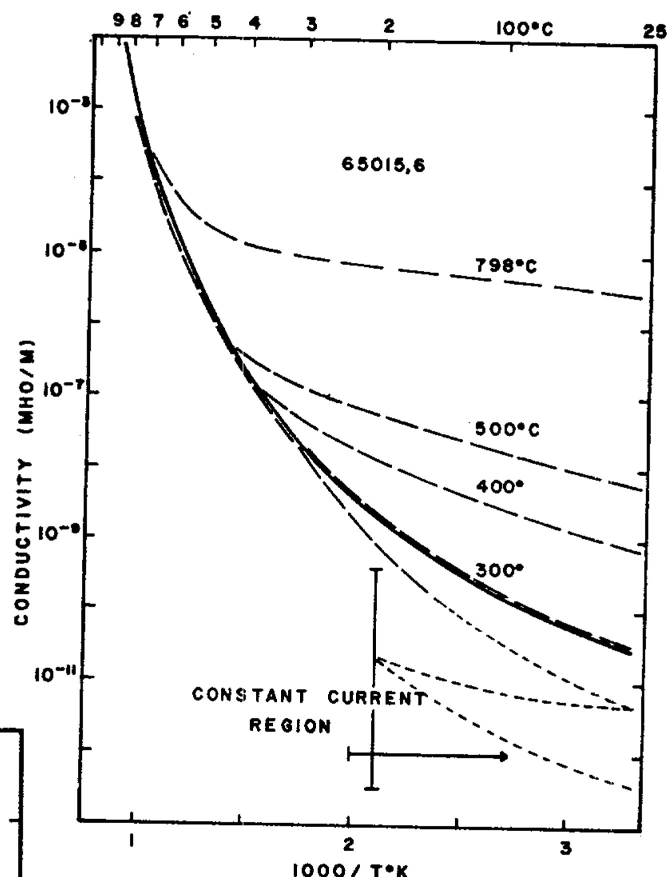




FIGURE 17. Electrical characteristics; from Olhoeft et al.(1973).

On the basis of electron spin resonance (ESR) studies, Tsay and Live (1974) conclude that 65015 has been annealed at ~1000°C (Fig. 18).

Hapke et al. (1978) provide ultraviolet reflectance spectra for a split of 65015 ground to <74 μm, but list the sample as 65016.

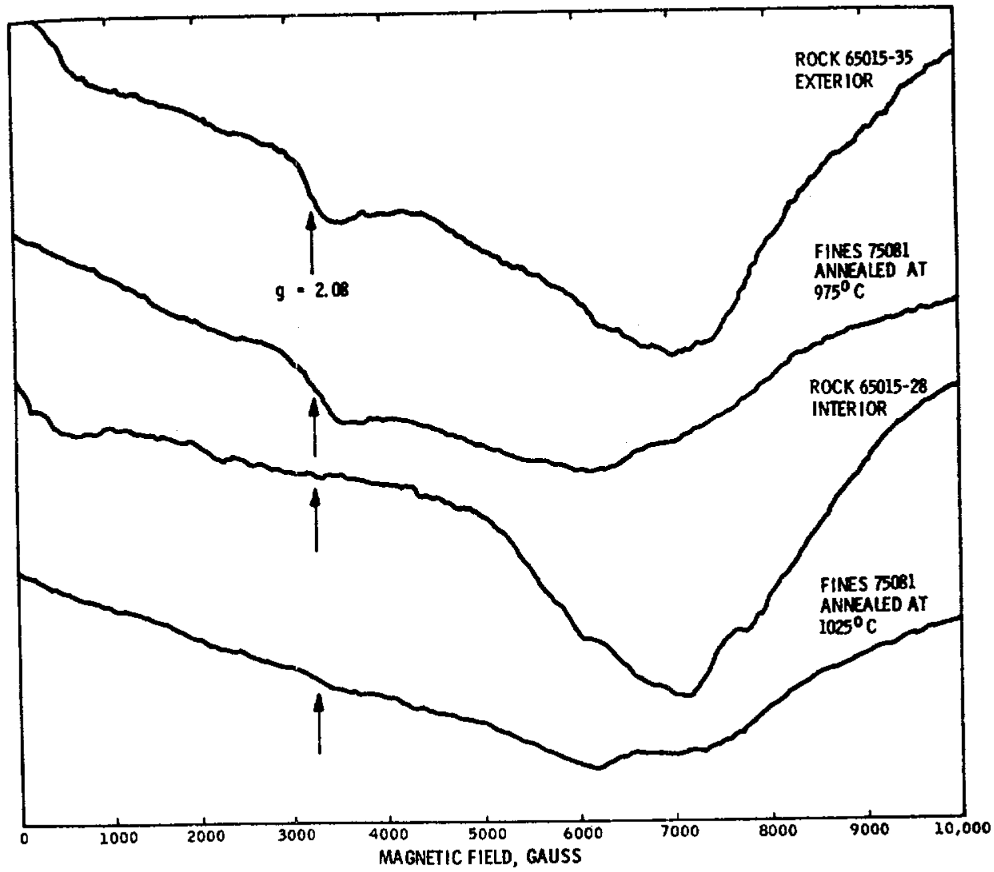



FIGURE 18. Electron spin resonance; from Tsay and Live (1974).

PROCESSING AND SUBDIVISIONS: 65015 has been extensively split and widely allocated. In 1972 it was cut into three main pieces including a slab (Figs. 19, 20). The slab and the W butt end were subdivided for allocations. Many documented and undocumented pieces of all sizes exist. The largest single pieces in existence are ,25 (1322.3 g) and ,73 (215.2 g).

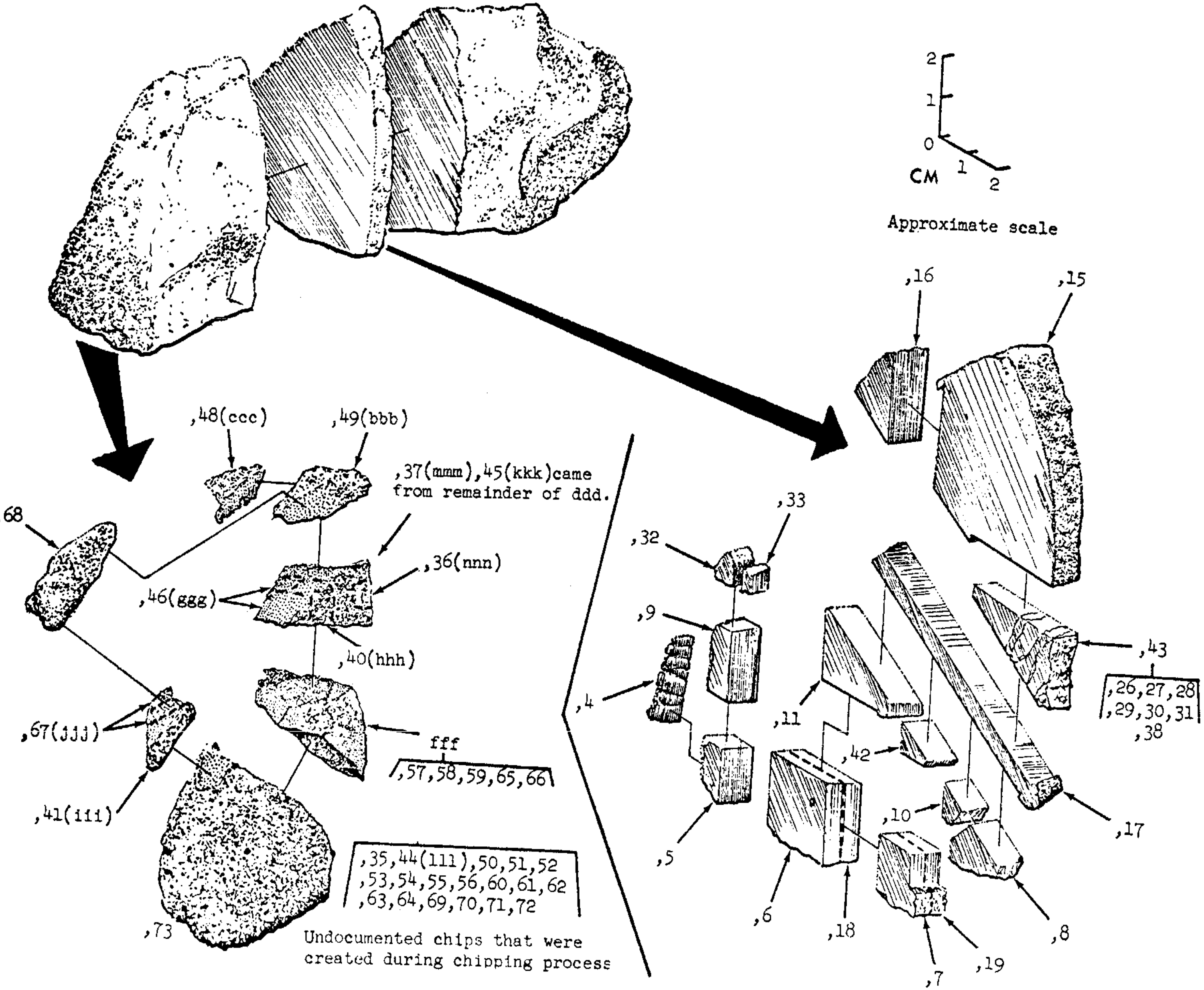



FIGURE 19. Cutting diagram.

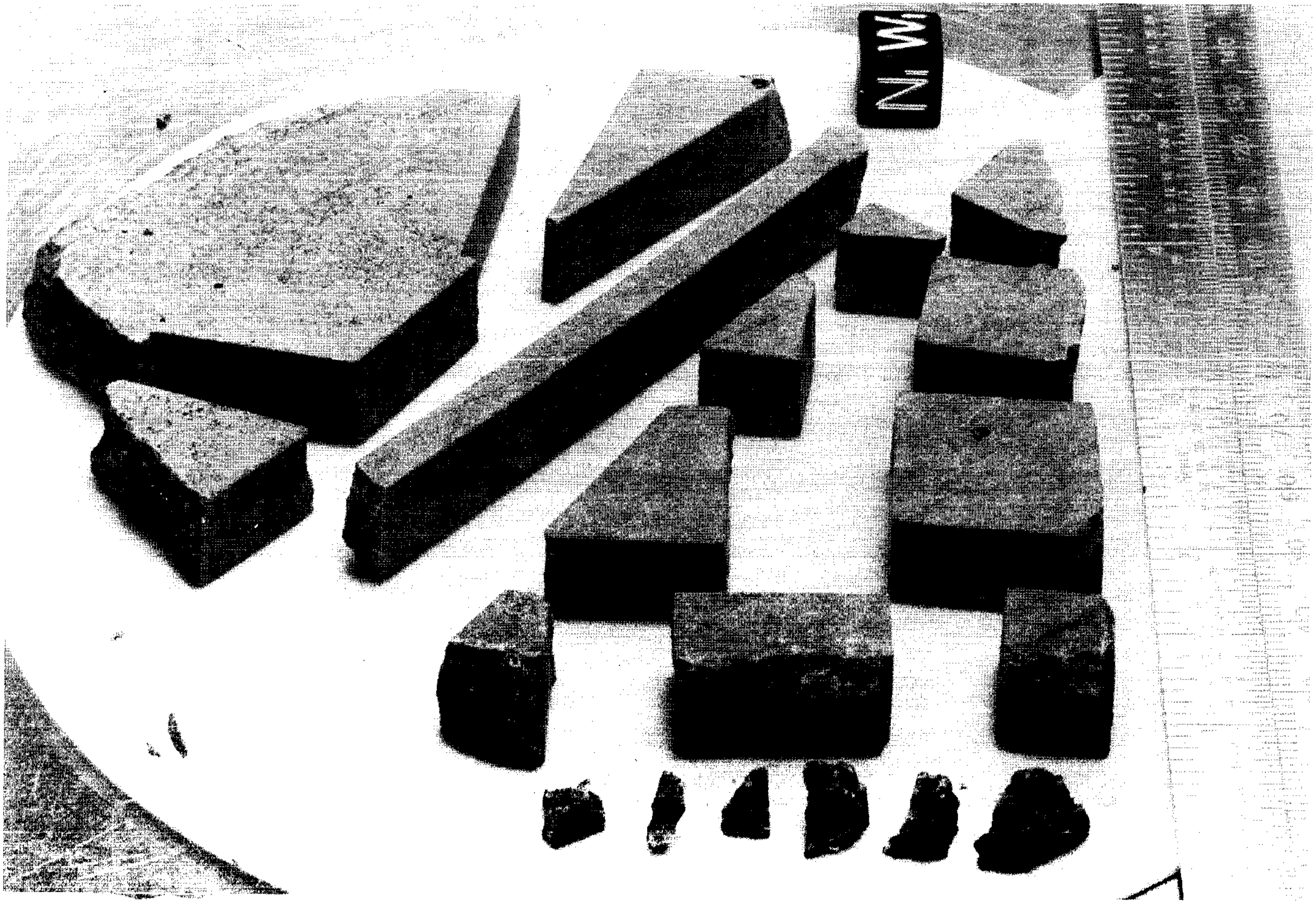


FIGURE 20. Slab subdivision. Cube has 1 cm. sides. S-72-47359.

INTRODUCTION: 65016 is a hollow hemisphere of green impact glass (Fig. 1). Its smooth surfaces and spheroidal shape indicates that it cooled during free flight. Vesicles and bubbles are abundant. Most of the vesicles are filled with soil. 65016 was collected near the rim of a subdued 20 m crater; its lunar orientation is unknown. Zap pits are absent.

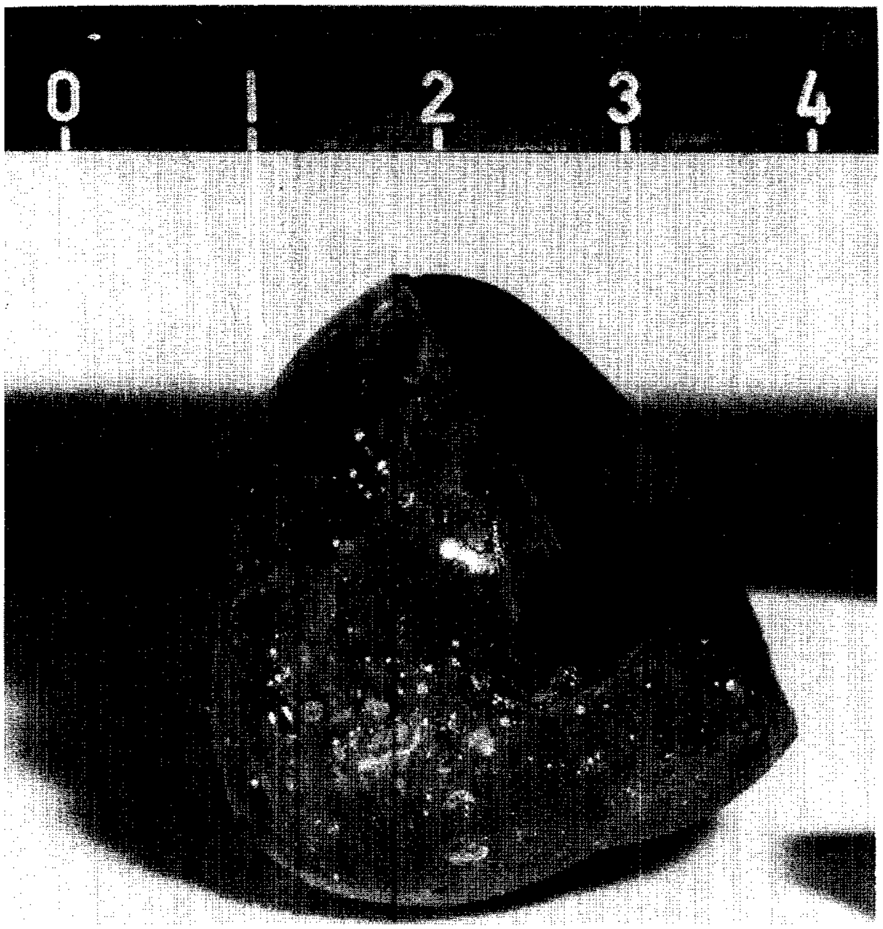



FIGURE 1. Scale in cm. S-72 39403.

PETROLOGY: 65016 is nearly holohyaline. A few clasts of cataclastic anorthosite are present which act as nucleation sites for quench crystals (Fig. 2). Spherules of Fe-metal, sometimes intergrown with schreibersite, are uncommon. Schaal et al. (1979) provide a brief petrographic description and tabulate various physical parameters, such as vesicularity.

FIGURE 2. 65016,17. devitrified (bottom) and clear (top) glass, ppl. width 2mm.

CHEMISTRY: A major element analysis by electron microprobe is presented by Uhlmann et al. (1977). Ganapathy et al. (1974) report meteoritic siderophile and volatile element abundances. These data are summarized in Table 1.

65016 is compositionally very similar to the local mature soils. Hertogen et al. (1977) tentatively assign 65016 to meteoritic group 5H, note that this is the same group as in glass sample 60095 and the glass coat of 64455, and conclude that all of these glasses probably represent impact melt produced by the South Ray Crater event.

PHYSICAL PROPERTIES: Uhlmann et al. (1974, 1977, 1978) and Klein and Uhlmann (1976) provide an analysis of the kinetics of the glass forming process and the crystallization behavior of a synthetic analog and a natural sample of 65016 (Figs. 3, 4). Close agreement between the natural and the synthetic samples was obtained. A cooling rate of $2 \times 10^3$ °C/min was estimated (Uhlmann et al., 1977). The liquidus temperature of 65016 is ∿1360°C.

TABLE 1. Summary chemistry of 65016

| | | |
|---|---|---|
| $SiO_2$ | | 44.2 |
| $TiO_2$ | | 0.6 |
| $Al_2O_3$ | | 26.5 |
| $Cr_2O_3$ | | |
| FeO | | 5.5 |
| MnO | | |
| MgO | | 7.3 |
| CaO | | 15.3 |
| $Na_2O$ | | 0.4 |
| $K_2O$ | | 0.1 |
| $P_2O_5$ | | |
| Sr | | |
| La | | |
| Lu | | |
| Rb | | 1.44 |
| Sc | | |
| Ni | | 532 |
| Co | | |
| Ir | ppb | 26.3 |
| Au | ppb | 7.19 |
| C | | |
| N | | |
| S | | |
| Zn | | 0.52 |
| Cu | | |

Oxides in wt%; others in ppm except as noted.

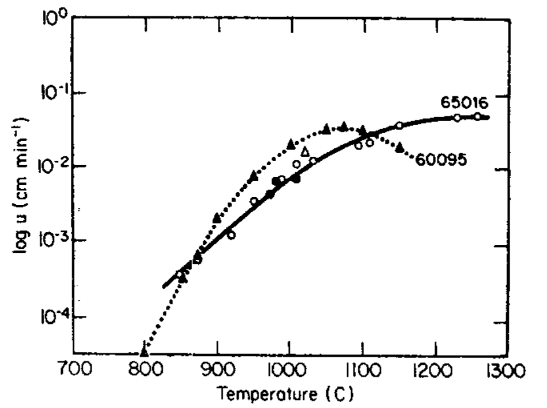



FIGURE 3. Growth rate v. temperature for synthetic compositions; from Klein and Uhlmann (1976).

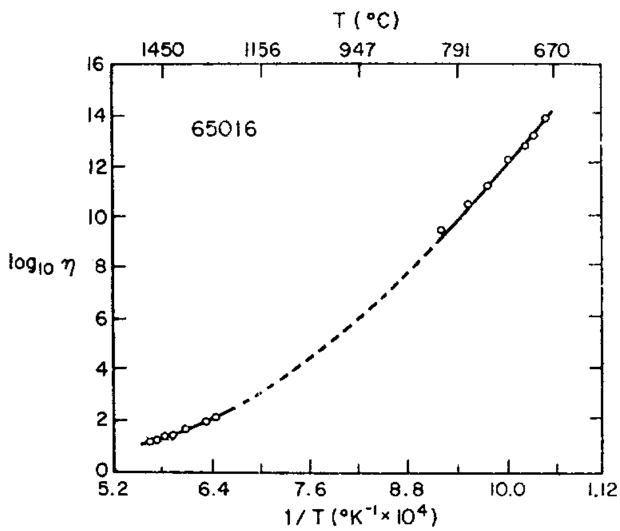



FIGURE 4. Viscosity v. temperature for synthetic composition; from Uhlmann et al. (1974).

Hapke et al. (1978) present ultra-violet reflectance spectra for a sample listed as 65016, but the data are actually for 65015.

PROCESSING AND SUBDIVISIONS: Several chips have been broken off for allocation and for stock at JSC.

INTRODUCTION: The interior of 65035 is a cataclastic ferroan anorthosite with a glass coat which fractured during its emplacement (Figs. 1a,1b). Gray clast-like areas within the anorthosite macroscopically appear continuous with the glass coat but the current evidence is not entirely conclusive.

65035 was collected from the south interior wall of a 20 m crater, near the rim of a superposed 2 m crater. Its orientation is known. The glass coat gives the sample, which is coherent, a generally rounded outline. Patina and zap pits are common on the broken, dominantly white side (Fig. 1a) whereas the opposite, smooth glassy side is devoid of zap pits--this latter side, however, was the lunar "up" showing that the rock must have been flipped over a short time prior to collection.

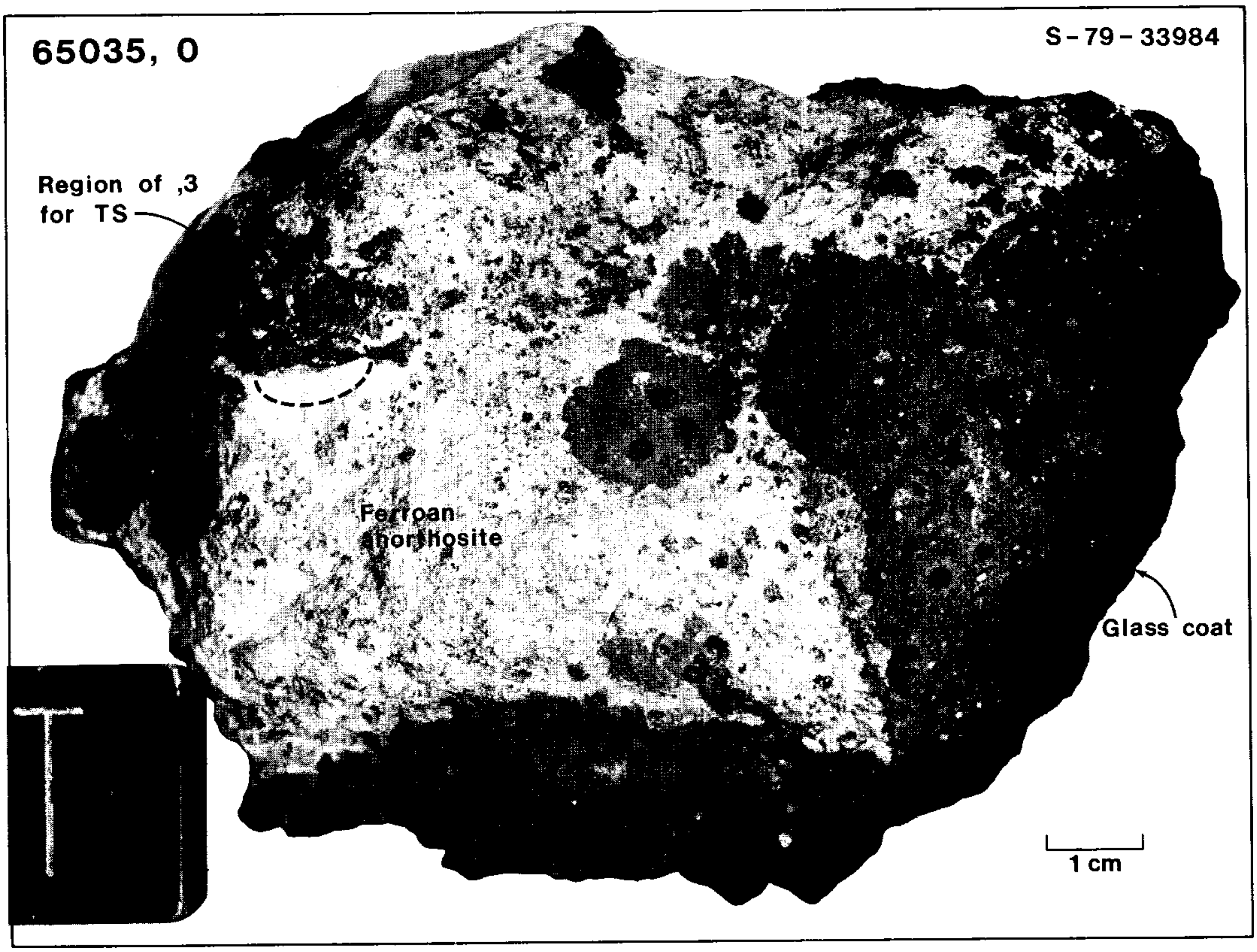



FIGURE 1a.

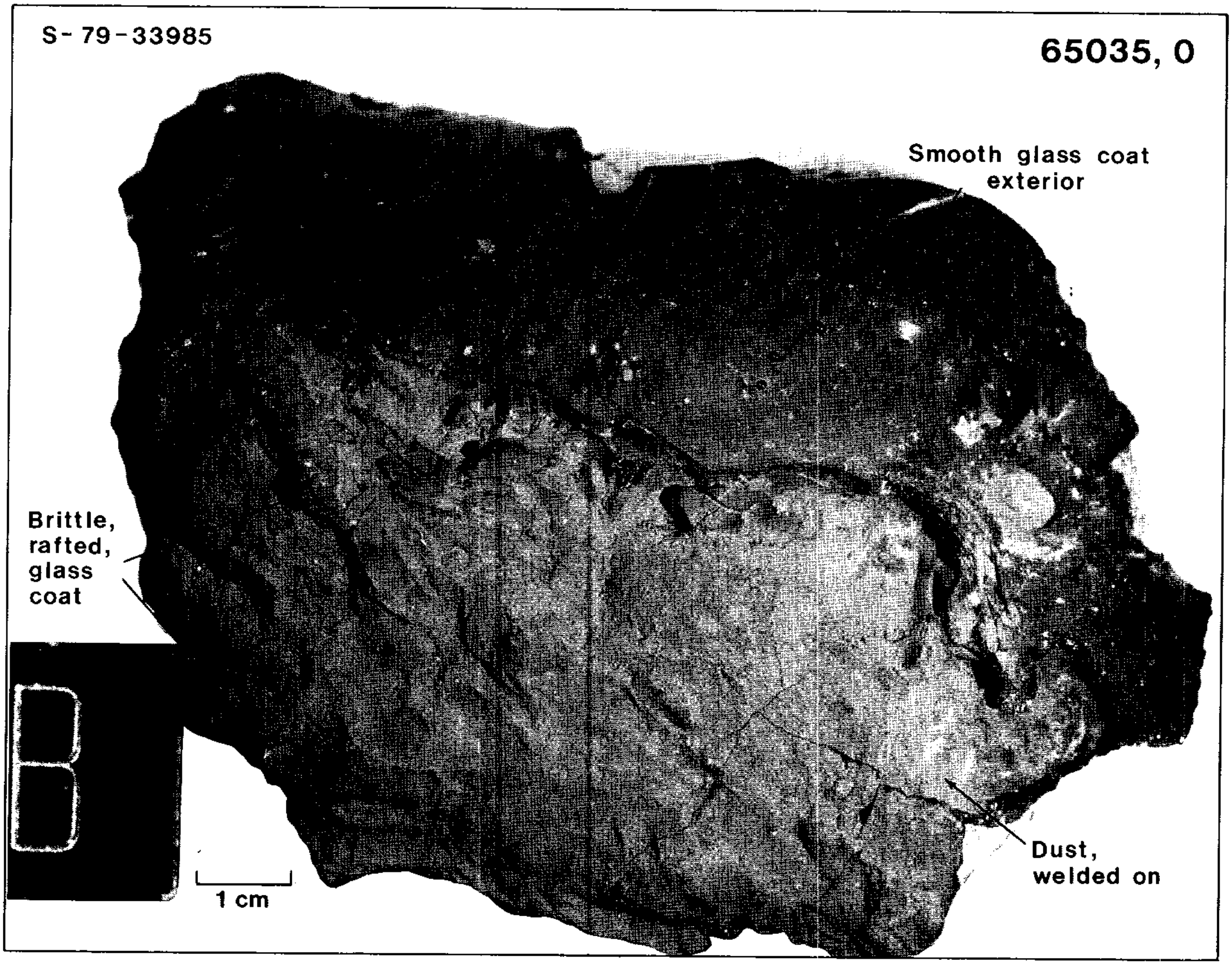



FIGURE 1b.

PETROLOGY: Schaal et al. (1979) briefly describe the textures of the glass coat and the anorthosite.

The interior cataclastic anorthosite (Fig. 2) consists of more than 99% plagioclase, with grains up to 3 mm present. The mafic grains are smaller than 20 μm. Microprobe analyses (Schaal, pers. comm.) show plagioclase $An_{96-97}$ and a single analyzed pyroxene was $En_{63}Wo_2$. Higher birefringences in some grains show that olivine or augite is also present. Sulfide is more common than very rare specks of Fe-metal, and oxide phases are rare.

The gray clast-rich areas are fine-grained mesostasis-rich basalt (Fig. 2) containing plagioclase clasts ($\sim An_{97}$, Schaal, pers. comm.) and abundant Fe-metal/troilite/schreibersite blebs. Plagioclase laths and olivine crystals are less than 20 μm, and scattered pale-green pleonaste spinels are of similar size. In the thin section area (Fig. 1a) the basalt is finer-grained towards the cataclastic anorthosite (Fig. 2). A thin brown to colorless vein runs along the contact in places but elsewhere cuts both phases. Its composition varies from pure anorthosite (36% $Al_2O_3$) to 30% $Al_2O_3$ (Schaal, pers. comm.). It is unknown whether this vein is an extension of the glass coat.

a

b

c

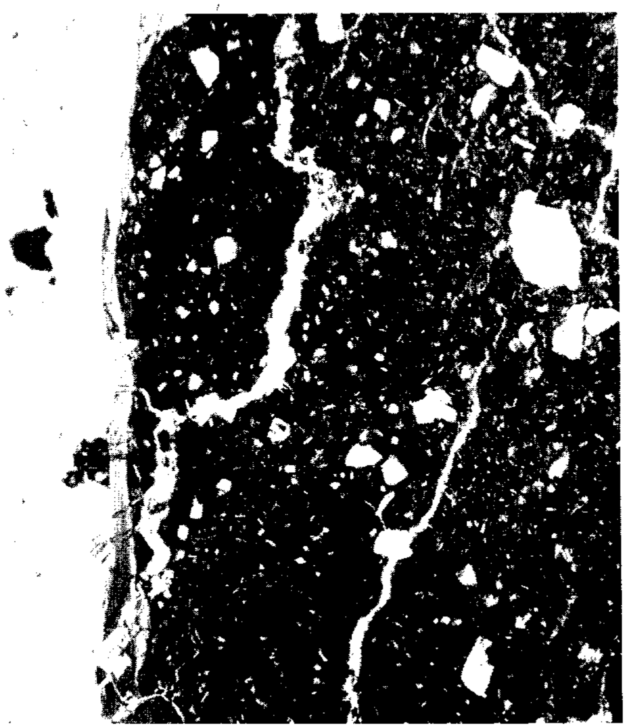


FIGURE 2. a) 65035,8. cataclastic anorthosite, xpl. width 2mm.
b) 65035,5. basaltic impact melt, ppl. width 0.5mm
c) 65035,6. basalt/anorthosite contact, with glass vein, ppl. width 2mm.

Macroscopically, the coat is glassiest on the exterior, and the contact with the anorthosite is variable from sharp to gradational. In places the obvious glass coat appears to grade into the gray clast-like areas, in others that contact is sharp. The coat was molten or plastic on the inside while the exterior was solid and brittle, and pieces of the exterior were torn off or rafted into the still-molten material (Fig. 1b) either in flight or on landing. Soil adhered to the freshly exposed molten material while the latter was still hot and cannot now be dusted off.

CHEMISTRY: Rancitelli et al. (1973b) report bulk rock K (0.09%), Th (1.65 ppm), and U (0.43 ppm) abundances derived from γ-ray spectroscopy.

EXPOSURE AGE: Rancitelli et al. (1973a) report $^{22}$Na and $^{26}$Al data from γ-ray spectroscopy. The sample is saturated in $^{26}$Al (Yokoyama et al., 1974).

PROCESSING AND SUBDIVISIONS: 65035 remains essentially intact as ,0 (440 g). One loose chip of anorthosite (,4) was made into thin sections and a second chip (,3) of gray clast-like material (glass coat?) and anorthosite (Fig. 1) was also made into thin sections.

INTRODUCTION: 65055 is an aluminous, basaltic impact melt. Macroscopically it is homogeneous, angular in shape,and very coherent (Fig. 1). This rock was collected from the lower northeast slope of Stone Mountain. It must have been disturbed shortly before collection as zap pits are absent from the "lunar top" but abundant on adjacent sides.

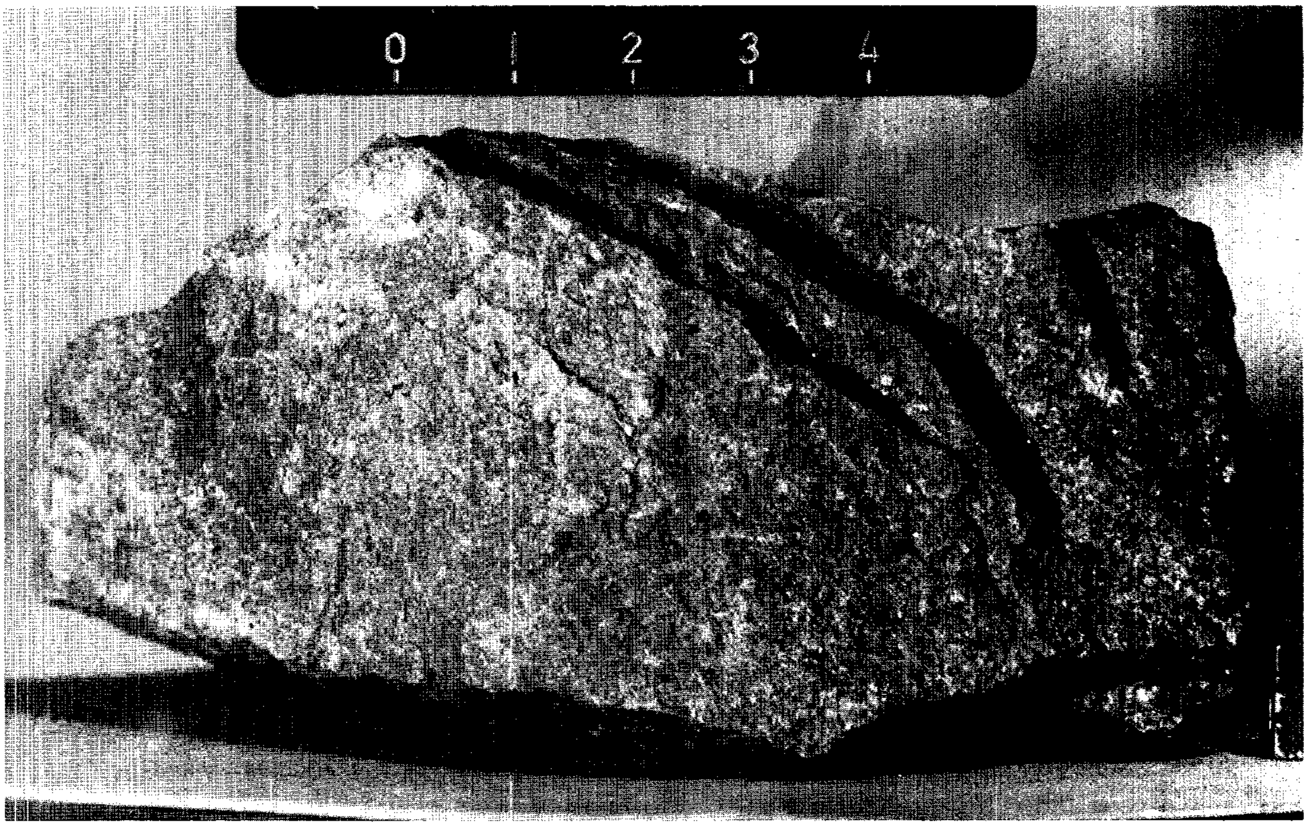
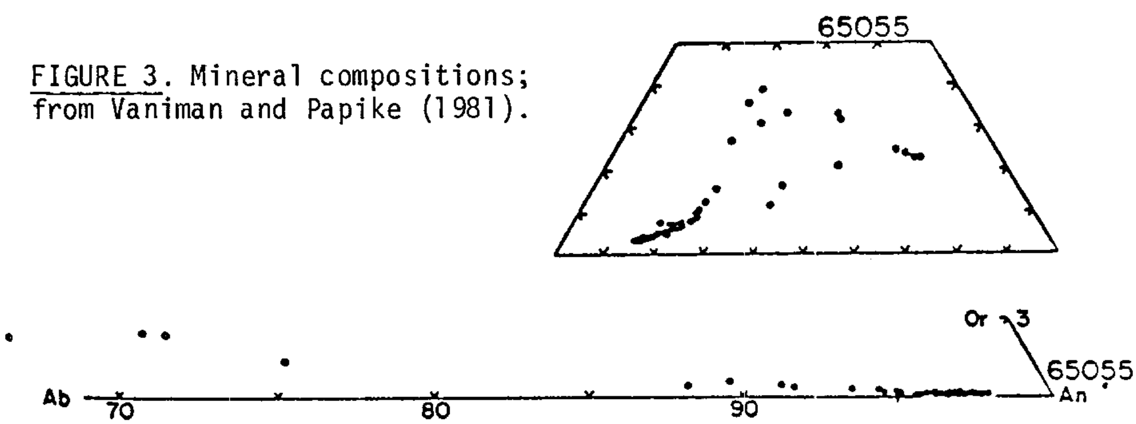



FIGURE 1. Scale in cm. S-72-43861.

PETROLOGY: 65055 is described by Vaniman and Papike (1981), who provide microprobe data. It is characterized by an intergranular, subophitic texture with euhedral to subhedral laths of plagioclase (up to 1.5 mm) enclosing anhedral pyroxene (Fig. 2). According to Vaniman and Papike (1981), olivine is absent, and the silicate minerals are extensively zoned (Fig. 3). Metal, troilite, ilmenite and a cryptocrystalline mesostasis are interstitial, accessory phases. Many of the laths are lightly shocked, showing a slight undulose extinction. Rare relict clasts of plagioclase are anhedral, irregular in shape,and tend to be more heavily shocked than the laths.

FIGURE 2. 65055,15. general view, ppl with reflector in. width 3mm.

FIGURE 3. Mineral compositions; from Vaniman and Papike (1981).




CHEMISTRY: Analyses of major elements, lithophiles, siderophiles and volatiles in 65055 are presented by Boynton et al. (1976), Christian et al. (1976) and Wasson et al. (1977). Clark and Keith (1973) report natural and cosmogenic radionuclide abundances as determined by gamma-ray spectroscopy.

65055 is more aluminous and has lower abundances of rare-earths than the average local soil and most of the Apollo 16 basaltic impact melts (Table 1, Fig. 4). Overall it is very similar to the Station 11 soils, which tend to be somewhat more aluminous and less KREEPy than soils from other stations.

TABLE 1. Summary chemistry of 65055

| | | | |
|---|---|---|---|
| $SiO_2$ | 45.4 | Sr | 140 |
| $TiO_2$ | 0.38 | La | 6.8 |
| $Al_2O_3$ | 28.5 | Lu | 0.33 |
| $Cr_2O_3$ | 0.10 | Rb | 1.0 |
| FeO | 4.3 | Sc | 7.6 |
| MnO | 0.06 | Ni | 235 |
| MgO | 4.5 | Co | 21 |
| CaO | 16.1 | Ir ppb | 10.1 |
| $Na_2O$ | 0.46 | Au ppb | 4.0 |
| $K_2O$ | 0.073 | C | |
| $P_2O_5$ | 0.13 | N | |
| | | S | |
| | | Zn | 0.6 |
| | | Cu | |

Oxides in wt%; others in ppm except as noted.

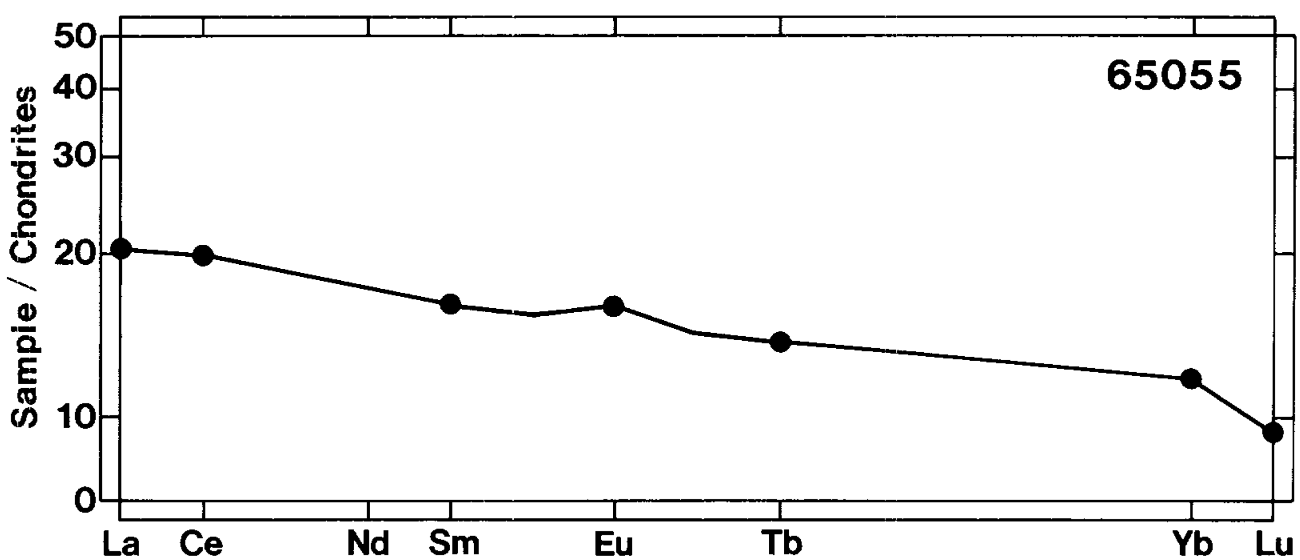



FIGURE 4. Rare earths; from Boynton et al. (1976).

GEOCHRONOLOGY: Jessberger et al. (1977) report total K-Ar ages of 3.94±0.01 b.y. and $^{39}Ar$-$^{40}Ar$ plateau ages of 3.96±0.02 and 3.95±0.02 b.y. for two splits of basalt.

EXPOSURE AGES: Clark and Keith (1973) give natural and short-lived cosmogenic radionuclide abundances. Jessberger et al. (1977) determined $^{38}Ar$ exposure ages of 2.4±1.1 and 2.2±0.5 m.y. for two splits of basalt, consistent with the excavation of 65055 by the South Ray Crater event.

PROCESSING AND SUBDIVISIONS: In 1975, 65055 was cut into three main pieces, including a slab (Fig. 5). Allocations to investigators were made from subdivisions of the slab. Thin sections have been made from splits of the slab and other exterior documented chips.

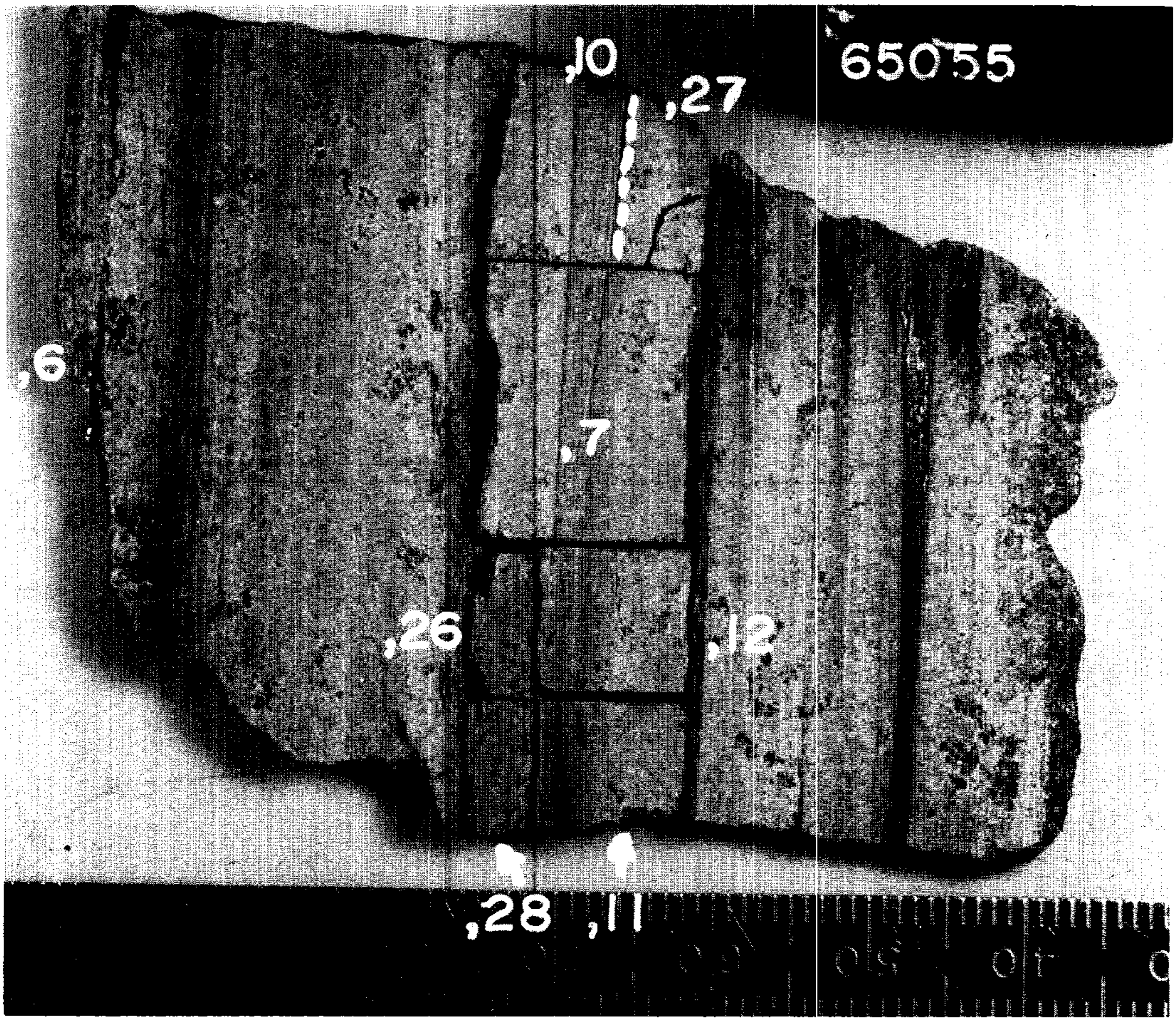



FIGURE 5. Slab subdivision. Scale in mm. S-75-22694.

INTRODUCTION: 65056 is a coherent, dark gray, glassy impact melt with abundant vesicles and a few large white clasts (Fig. 1). The exterior surfaces of this rock are smooth suggesting that it represents a complete cooling unit.

65056 was collected from the interior wall of a subdued 20 m crater, ~30 cm from 65055. Although its lunar location is precisely known, its orientation could not be determined in the laboratory due to breakage. Zap pits are absent.

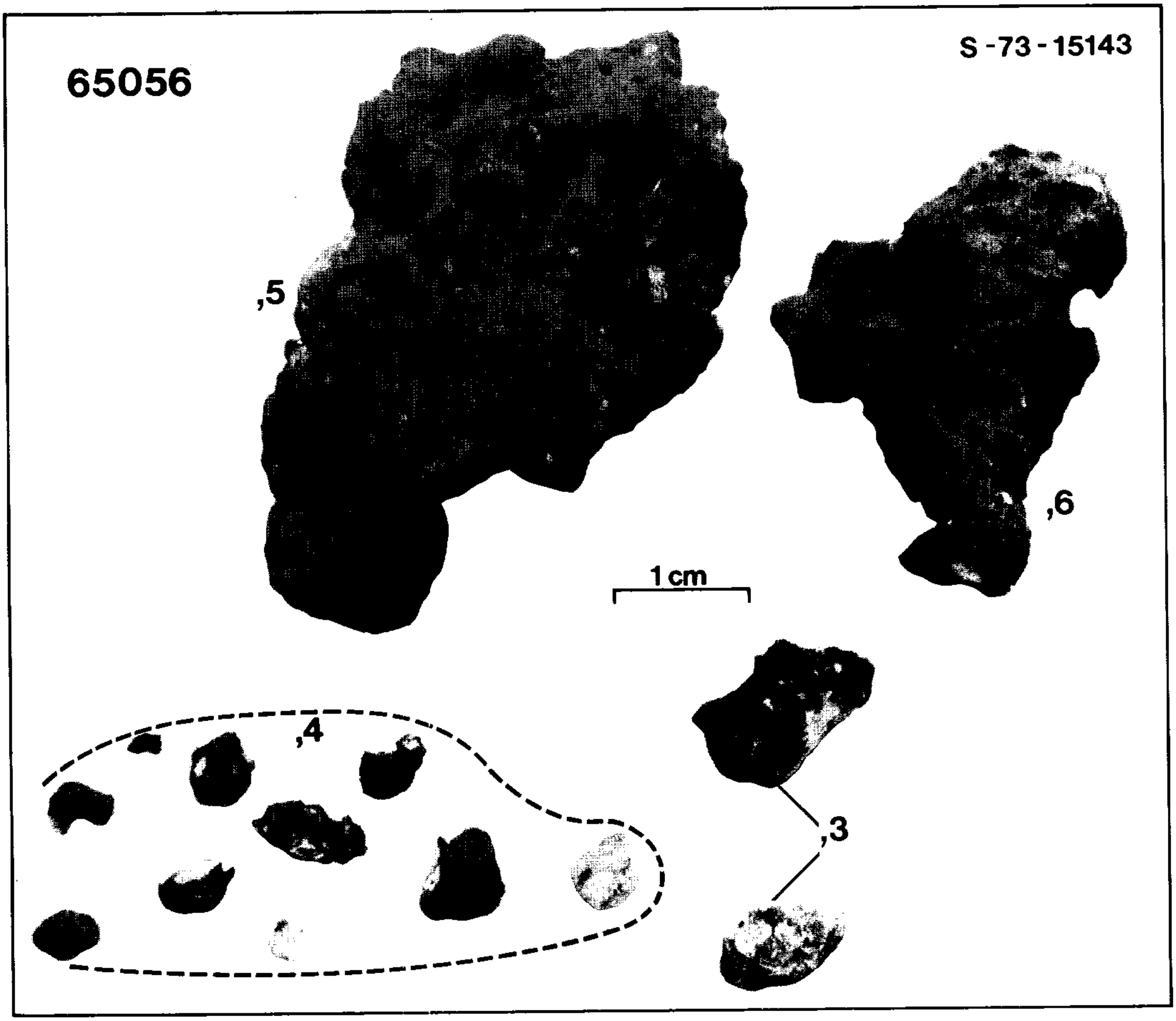



FIGURE 1.

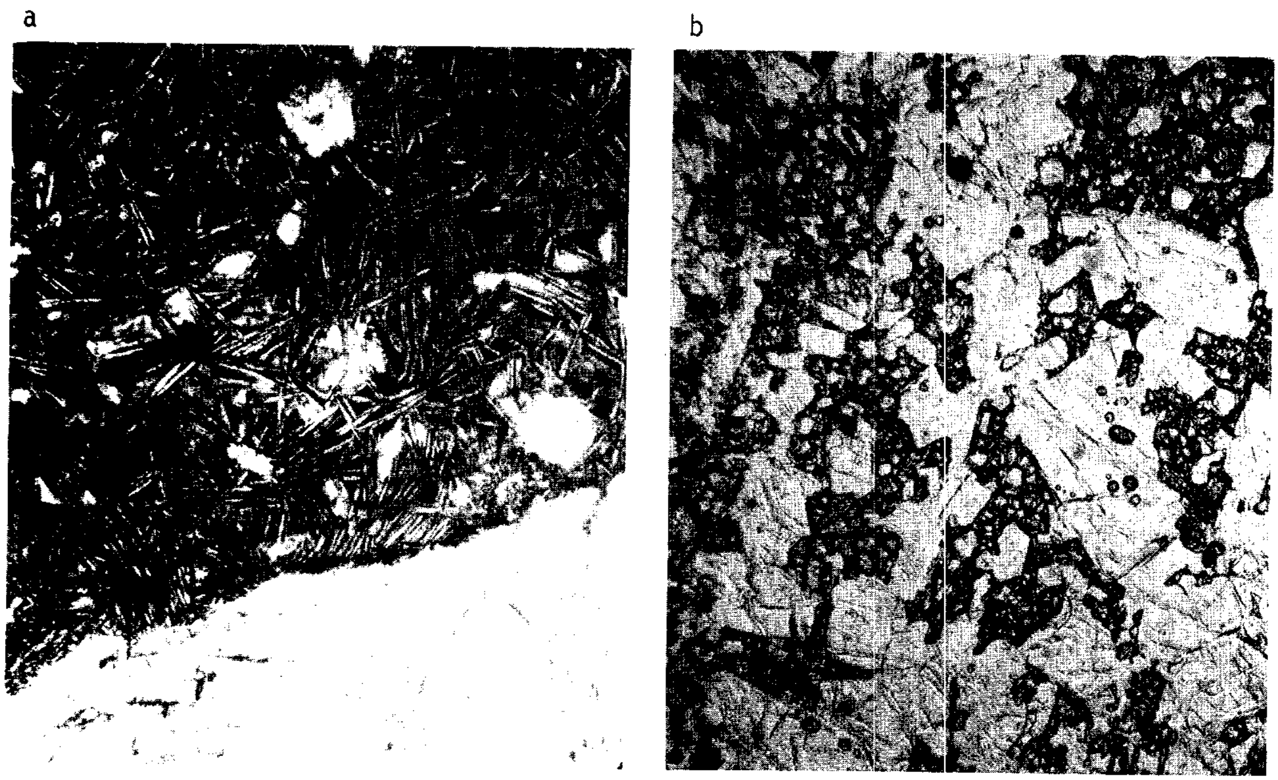


FIGURE 2. 65056,13. a) spherulitic melt, ppl. width 2mm. b) poikiloblastic clast, ppl. width 2mm.

PETROLOGY: The matrix of 65056 is a mesostasis-rich impact melt with thin laths of plagioclase in sheaves, "bow-tie" structures, and radiating clusters (Fig. 2). Interstices are generally cryptocrystalline, not glassy. Some Fe-metal spherules are present.

One clast of coarse-grained cataclastic anorthosite (plagioclases up to 4 mm) and one clast of mafic-rich, recrystallized breccia are sampled by the thin sections (Fig. 2). Ilmenite, troilite and metal (some rusty) are accessory phases in the mafic-rich clast. Both clasts are ~1 cm long.

CHEMISTRY: Rancitelli et al. (1973b) provide whole rock K ($K_2O$ = 0.13%), U (0.41 ppm) and Th (1.55 ppm) abundances by gamma-ray spectroscopy.

EXPOSURE AGE: Rancitelli et al. (1973a) provide whole rock $^{26}Al$ and $^{22}Na$ abundance data. From these data Yokoyama et al. (1974) conclude that 65056 is saturated in $^{26}Al$ activity.

PROCESSING AND SUBDIVISIONS: 65056 was removed from its documented bag as two pieces that fit together. In 1972 several small chips of matrix and clasts were removed as ,3 and ,4 (Fig. 1). ,3 was made into a potted butt from which thin sections ,13 and ,14 were cut. The two large pieces were numbered ,5 and ,6 (Fig. 1).

INTRODUCTION: 65075 consists of crystalline, clast-bearing material coated with black glass (Fig. 1). Although Grieve and Plant (1973) interpret the crystalline material as consisting of clasts of subophitic basalt in a recrystallized plagioclase-rich matrix, the textures are compatible with most of the sample being a basaltic impact melt of extremely variable texture. The hot emplacement of the glass coat caused partial melting to take place on the adjacent crystalline rock.

65075 was taken from the interior southwest wall of a 20 m crater on Stone Mountain and was probably about half buried. Although photographed prior to sampling, it was returned as 4 separate pieces, hence its orientation was not established. The sample is friable and the pieces are angular. Zap pits are present on only a few surfaces because of the breakages.

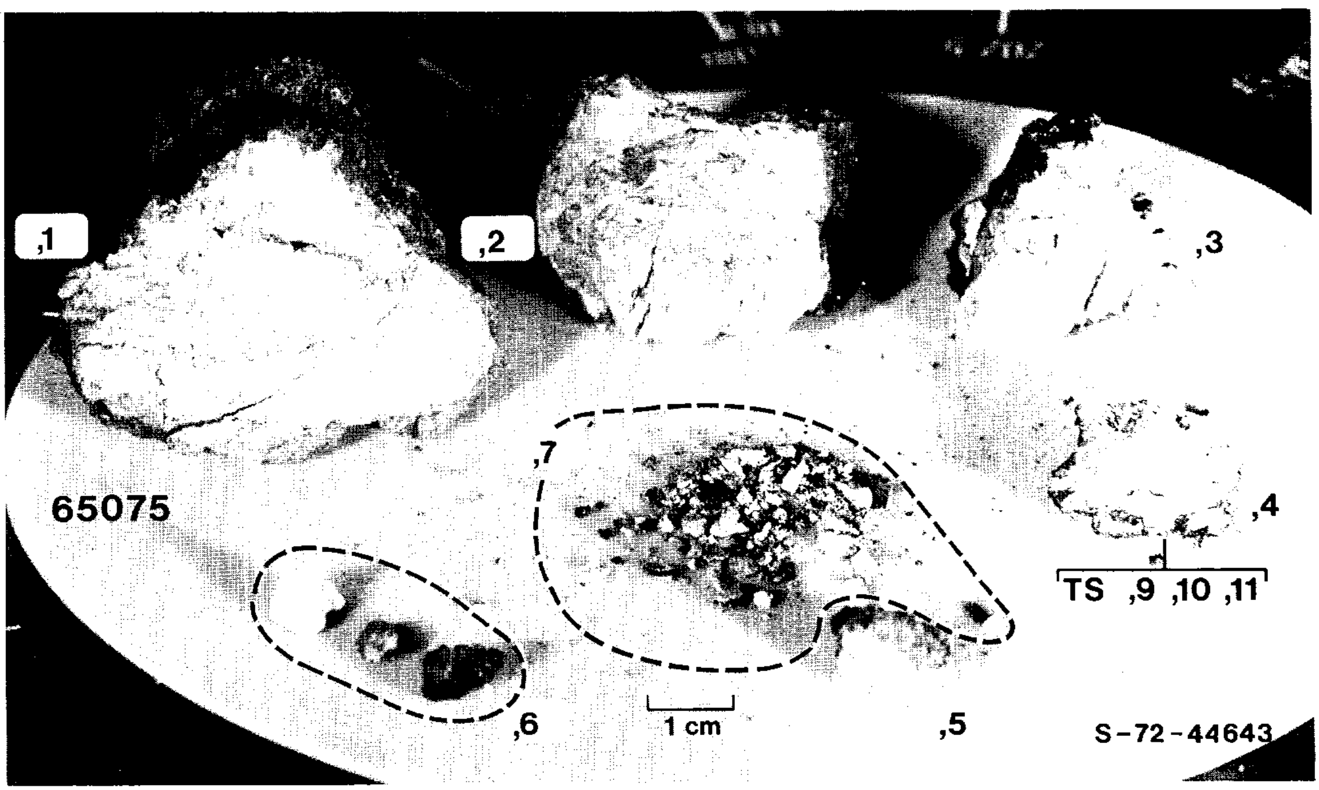



FIGURE 1.

PETROLOGY: Grieve and Plant (1973) provide a petrographic description with microprobe data, particularly of bulk compositions of discrete lithic and glass types, with some mineralogical data.

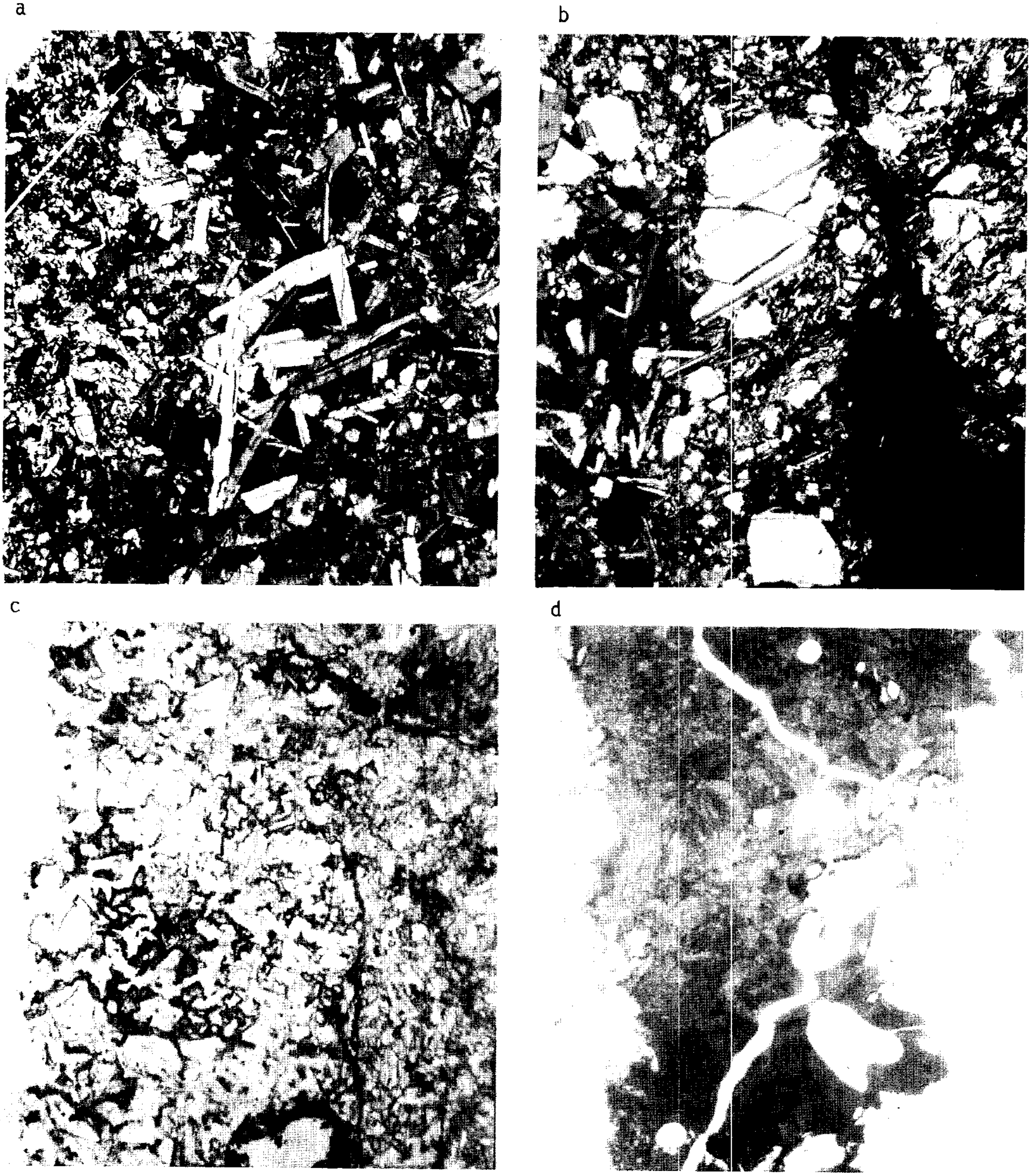



FIGURE 2. a) 65075,11. general heterogeneous melt, xpl. width 2mm.
b) 65075,11. plagioclase-rich melt (right), xpl. width 2mm.
c) 65075,11. interstitial melt, ppl. width 2mm.
d) 65075,10. glass coat, ppl. width 2mm.

The thin sections show that the crystalline material dominantly consists of ophitic and subophitic impact melt (Fig. 2), with some poikilitic melt areas. Distinct areas of fine-grained and more plagioclase-rich melts are present (Fig. 2). Grieve and Plant (1973) refer to the sample as a light matrix-light clast breccia and interpret the crystalline material (anorthositic gabbro breccia) as consisting of clasts of subophitic basalt in a recrystallized matrix. Its bulk composition has ~24% $Al_2O_3$, 0.31% $K_2O$ and 0.72% $TiO_2$. Olivine ($Fo_{75}$) ophitically encloses plagioclase ($An_{95}$) and metal grains contain 1.4-4.9% Ni. Pigeonite, minor augite, ilmenite, and rare pleonaste spinels are also present. Fragmental plagioclases are extremely strained and cataclasized. The "anorthositic microbreccia" clasts (Grieve and Plant, 1973) consist of plagioclase laths with interstitial olivine and pyroxene; they contain shocked plagioclase clasts. Pleonaste spinel is present. This lithology is much more feldspathic (30% $Al_2O_3$) than the general crystalline material. In a few places, laths of plagioclase are optically continuous from these clasts into the general crystalline material. Because the entire breccia is crystalline and "clast" boundaries indistinct, it seems possible that most of the crystalline area is a single impact melt with extremely variable texture.

The crystalline material, including the feldspathic clasts, contain areas of partial melt (Fig. 2) described in detail by Grieve and Plant (1973). They are usually devitrified. These partial melts are variable in composition but in general have ~18% $Al_2O_3$ and are similar in composition to KREEP (low and medium-K Fra Mauro). The partial melt results from the heat introduced by the emplacement of the surface splash glass, which probably had a temperature >1350°C.

The glass coat consists of an outer glass (0.75 mm maximum) which is devitrified to a mosaic of plates, and an inner zone up to 1.7 mm wide which is coarsely devitrified into acicular plagioclase (Fig. 2) (Grieve and Plant, 1973). The two areas have similar compositions with 25% $Al_2O_3$, and differ from the crystalline material in lower $K_2O$ (0.06%) and $TiO_2$ (0.33%) abundances. Metal grains with ~20% Ni are present. The coat is not a melt of an older surface of the rock but is splashed on.

CHEMISTRY: Rancitelli et al. (1973b) report bulk rock K (0.161%), Th (2.89 ppm) and U (0.84 ppm) abundances from $\gamma$-ray spectroscopy, without comment.

EXPOSURE: Rancitelli et al. (1973a) report cosmogenic radionuclide ($^{22}Na$ and $^{26}Al$) data from $\gamma$-ray spectroscopy without comment. Yokoyama et al. (1974) list the sample as saturated with $^{26}Al$.

PROCESSING AND SUBDIVISIONS: The sample, received as four main pieces, is divided as shown in Figure 1.

INTRODUCTION: 65095 is composed of abundant gray clasts in a friable white matrix (Fig. 1). It is partially coated with dark glass.

65095 was collected from the lower slope of Stone Mountain. Lunar orientation is known. It must have been disturbed shortly before collection as zap pits are absent from the "lunar top" but abundant on the opposite surfaces.

FIGURE 1. 65095,21, about half of the sample. Smallest scale divisions in mm.

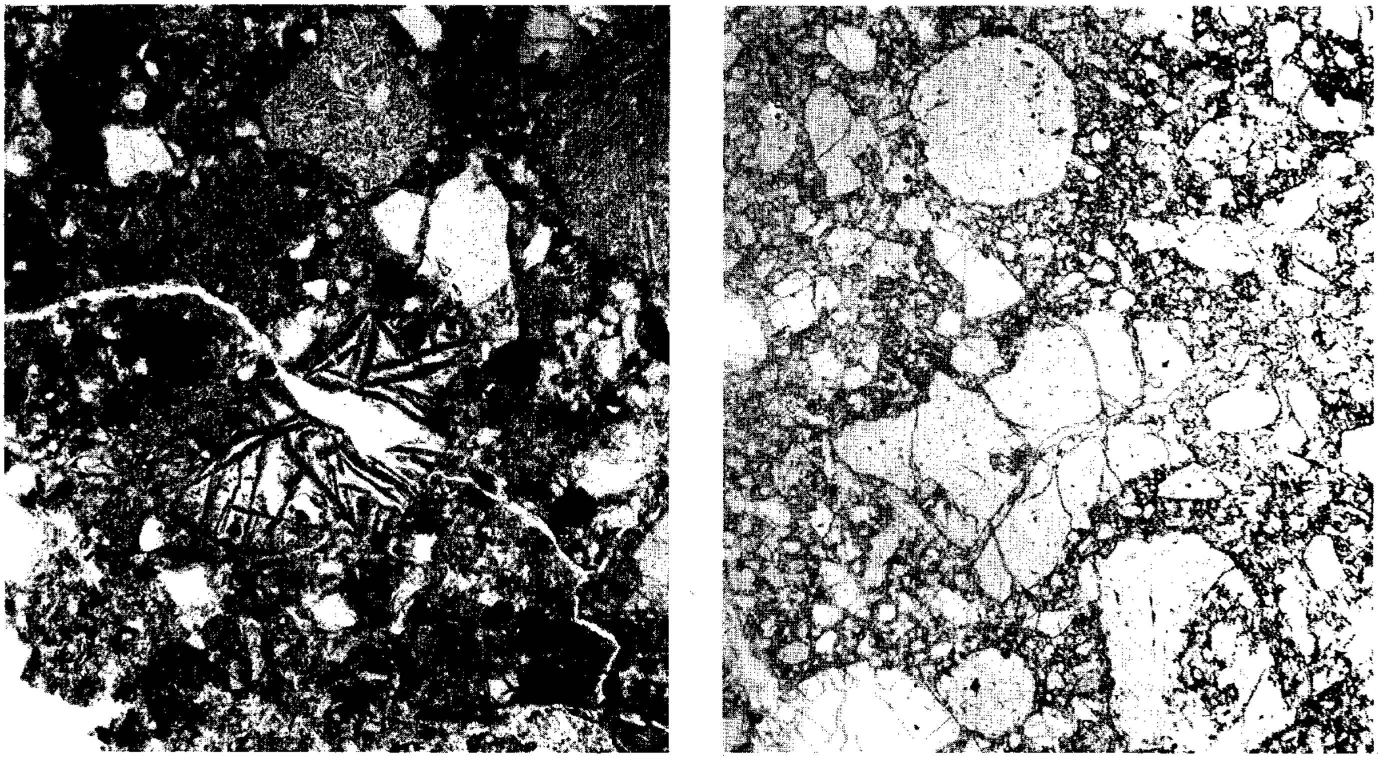
PETROLOGY: 65095 is a clastic breccia with an abundant and diverse clast population in a fragmental matrix (Fig. 2). Clasts include grains of plagioclase, mafic minerals, Fe-metal (some rusty), troilite, ilmenite, and spinel, and fragments of poikilitic and basaltic impact melt, vitric matrix breccia, cataclastic and granoblastic anorthosite, feldspathic granulite (some with a relict basaltic texture), and rare mafic vitrophyres (Fig. 2). Beads and fragments of glass and vitrophyric impact melt are abundant and suggest the presence of a regolith component. One fragment of shocked and partially recrystallized cataclastic anorthosite has a grain size >1 cm and small grains of interstitial pyroxene. Bickel and Warner (1978) refer to the pyroxene in this clast as ferroan and unequilibrated but provide no specific data.

Portions of the white matrix (TS ,13-,15) are nearly monomict cataclastic anorthosite. The Apollo 16 Lunar Sample Information Catalog (1972) describes one of these areas.

Metal compositional data for the bulk rock are given by Misra and Taylor (1975) (Fig. 3).

a

b



c

FIGURE 2. a) 65095,49. general matrix with olivine vitrophyre clast (lower center),ppl. width 1 mm.
b) 65095,54. general matrix, rfl. width 2mm.
c) 65095,49. cataclastic anorthosite clast, xpl. width 2mm.

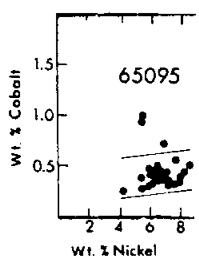



FIGURE 3. Metals; from Misra and Taylor (1975).

CHEMISTRY: Krähenbühl et al. (1973) analyzed a representative interior split and found high levels of both siderophile and volatile elements (Table 1). The high volatile to involatile ratios (e.g. Tl/U) are interpreted as indicating a fumarolic component. Hertogen et al. (1977) assign 65095 to meteoritic group 1H, a group largely restricted to Apollo 16.

Eldridge et al. (1973) and Rancitelli et al. (1973a,b) provide whole rock data for K, U, Th, and cosmogenic radionuclides. These data indicate that the levels of incompatible elements in 65095 are roughly similar to those in the local soils.

EXPOSURE AGES: From the cosmogenic radionuclide data of Eldridge et al. (1973) and Rancitelli et al. (1973a), Yokoyama et al. (1974) conclude that 65095 is saturated in $^{26}Al$ activity.

PHYSICAL PROPERTIES: Hargraves and Dorety (1975) and Cisowski et al. (1975, 1976) provide magnetic data. Cisowski et al. (1975, 1976) note that a field of at least a few tenths of an oersted is implied by the magnetization of this rock. Sugiura et al. (1978) investigated the effects of heating under a controlled oxygen fugacity on the magnetic properties of 65095 (Fig. 4). The prominent peak in pTRM is probably due to the formation of magnetite from the natural rust in the rock.

TABLE 1. Summary chemistry of 65095

| | | |
|---|---|---|
| $K_2O$ | wt% | 0.098 |
| Rb | ppm | 1.1 |
| Ni | ppm | 235 |
| Ir | ppb | 6.43 |
| Au | ppb | 5.45 |
| Zn | ppm | 8.65 |

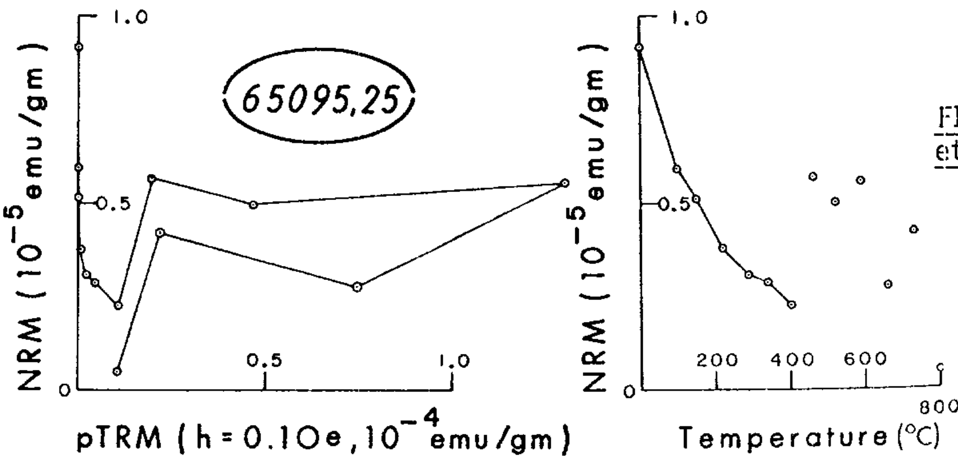



FIGURE 4. from Sugiura et al. (1978).

PROCESSING AND SUBDIVISIONS: In 1972 two small chips (,1) of nearly pure white matrix were made into thin sections ,13-,15. In 1973 the rock was broken along existing fractures into two main pieces (,21 and ,22) and the smaller of these (,22) extensively subdivided. The largest single piece remaining is ,21 (361.5 g). ,22 (129.15 g) is stored at the Brooks Remote Vault.

INTRODUCTION: 65315 is a monomict, cataclastic, ferroan anorthosite that is chemically pristine. Macroscopically it is bluish white in color, and somewhat rounded (Fig. 1).A partial glass coating is in sharp contact with the anorthosite. The coating was once more extensive but was eroded away on the Moon.

This rock was collected on the lower slope of Stone Mountain; lunar orientation is not known. Zap pits are rare on the N surface, absent from other surfaces.

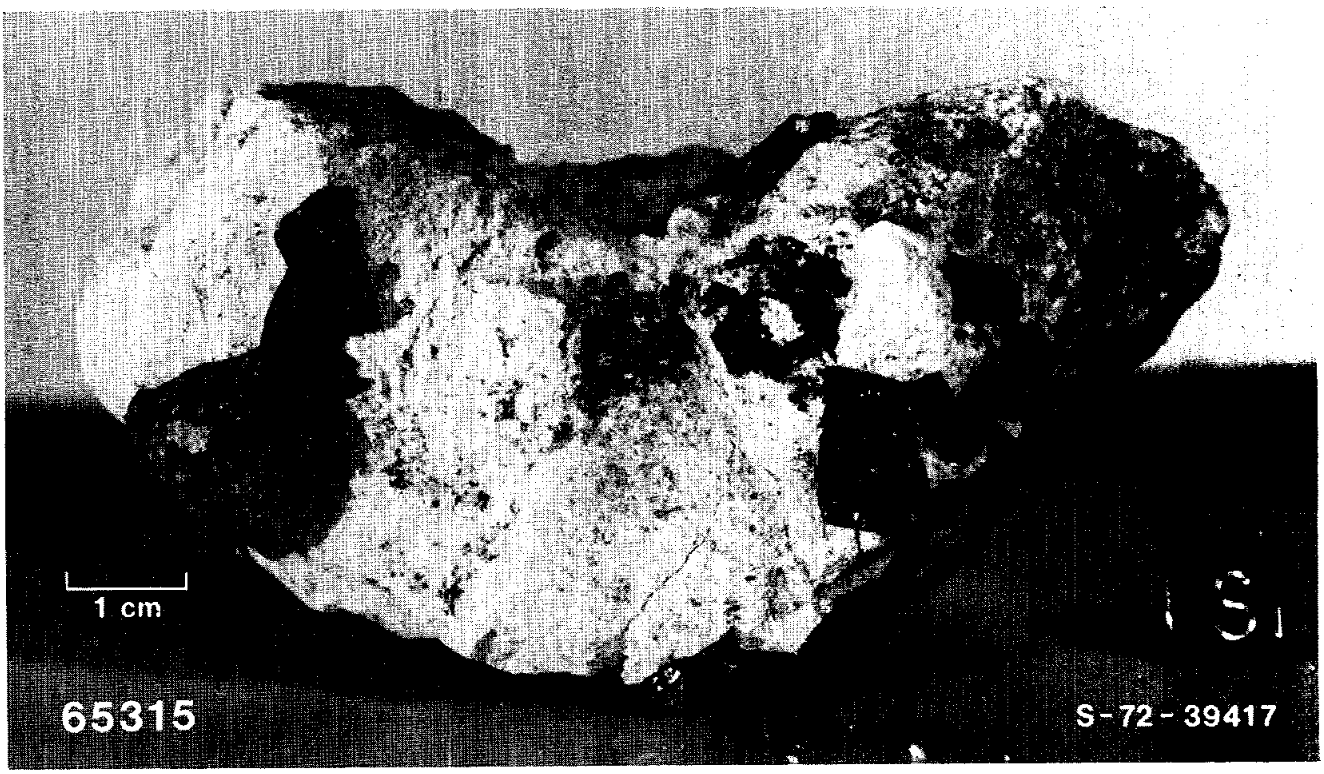



FIGURE 1.

PETROLOGY: Dixon and Papike (1975) and the Apollo 16 Lunar Sample Information Catalog (1972) provide petrographic information. 65315 is a crushed, ferroan anorthosite with relict plagioclase grains ($An_{97}$) up to 4 mm long (Fig. 2). Pyroxene is the only mafic silicate present and is concentrated as small, discrete grains interstitial to the larger plagioclases. A few original plagio-clase-pyroxene grain boundaries remain. The original pyroxene was apparently a pigeonite which has subsequently exsolved (Fig. 3). All grains exhibit undulose extinction. No shock melting or recrystallization was observed.

Mehta and Goldstein (1980) report the compositions of metal grains from the glass coat (Fig. 4).

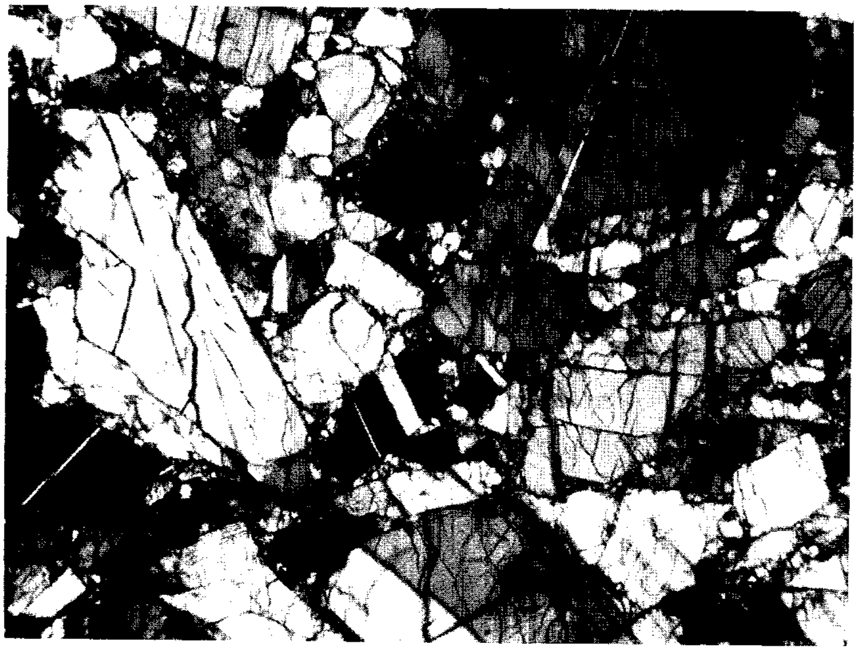


FIGURE 2. 65315,4. general view, xpl. width 2mm.

Meyer (1979) reports minor elements in plagioclase as determined by ion microprobe (Table 1).

TABLE 1. Minor elements in plagioclase (ppm)(Meyer, 1979)

| | Li | Mg | Ti | Sr | Ba |
|---|---|---|---|---|---|
| a) | 2 | 600 | | | 10 |
| b) | 1.8 | 616 | 150 | 208 | 8 |

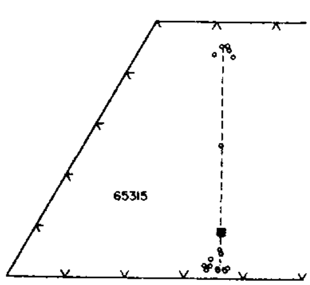



FIGURE 3. Pyroxene compositions; from Dixon and Papike (1975).

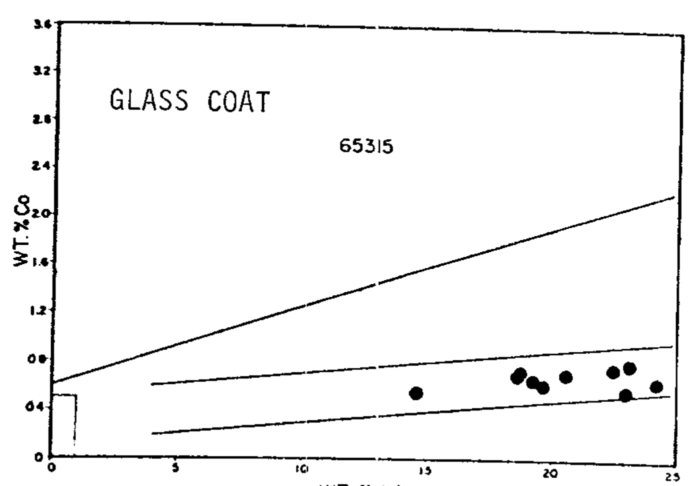



FIGURE 4. Metals; from Mehta and Goldstein (1980).

CHEMISTRY: Major, lithophile, siderophile, volatile and other trace element abundances are presented by Wänke et al. (1974). With nearly 35% $Al_2O_3$ (Table 2), 65315 is virtually pure plagioclase. Rare earth (Fig. 5) and siderophile (Table 2) elements are very low in abundance, indicating that 65315 is chemically pristine. Zn is unusually high at 93 ppm, but other volatiles are not similary enriched (see data of Wänke et al., 1974).

TABLE 2

Summary chemistry of anorthosite 65315

| | | | |
|---|---|---|---|
| $SiO_2$ | 44.3 | Sr | 167 |
| $TiO_2$ | 0.012 | La | 0.12 |
| $Al_2O_3$ | 34.87 | Lu | 0.004 |
| $Cr_2O_3$ | 0.003 | Rb | 0.17 |
| FeO | 0.31 | Sc | 0.39 |
| MnO | 0.006 | Ni | 1.4 |
| MgO | 0.25 | Co | 0.58 |
| CaO | 19.07 | Ir ppb | |
| $Na_2O$ | 0.304 | Au ppb | 1.0 |
| $K_2O$ | 0.007 | C | $\leqslant$12 |
| $P_2O_5$ | 0.001 | N | |
| | | S | |
| | | Zn | 93 |
| | | Cu | 2.1 |

Oxides in wt%; others in ppm except as noted.

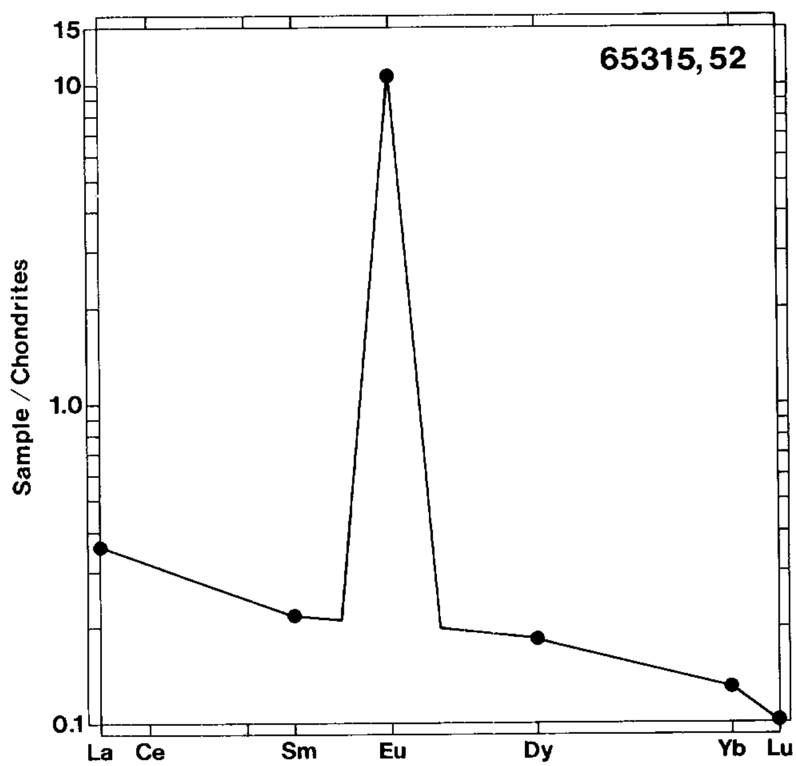



FIGURE 5. Rare earths; from Wänke et al. (1974).

GEOCHRONOLOGY: Stettler et al. (1974) did not obtain a good K-Ar plateau (Fig.6). The low temperature releases point to a disturbance ∿ 2 b.y. ago whereas the higher temperature release may indicate a metamorphic event 3-4 b.y. ago and the presence of ancient (4.30± 0.26 b.y.), incompletely outgassed,plagioclase in the rock (Stettler et al., 1974).

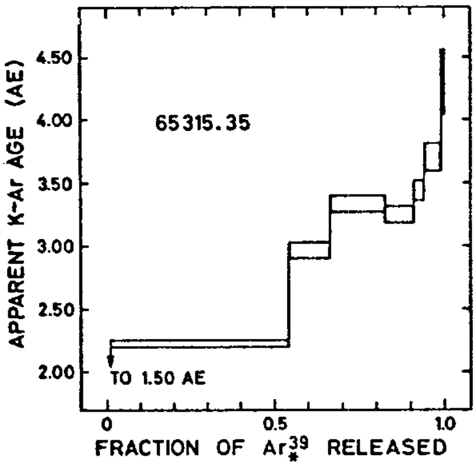



FIGURE 6. Ar release; from Stettler et al.(1974).

RARE GAS/EXPOSURE AGES: Various rare gas exposure ages cluster about 1.5-1.8 m.y., consistent with the excavation of 65315 by the South Ray cratering event (Table 3).

Kr and Xe isotopic data are provided by Eberhardt et al. (1975) and Eugster et al. (1975), respectively. The isotopic composition of the > 600°C fraction of Xe is consistent with a mixture of terrestrial atmospheric contamination and spallation Xe.

TABLE 3. Exposure ages of 65315

| System | Exposure Age (m.y.) | Reference |
|---|---|---|
| Ar | 1.8 | Stettler et al.(1974) |
| $^{38}Ar$-$^{37}Ar$ | 1.6 | Eberhardt et al.(1975) |
| $^{81}Kr$ - Kr | 1.5±0.7 | Eberhardt et al.(1975) |
| $^{21}Ne$ | 1.5 | Gopalan and Rao (1976) |
| Solar Cosmic Ray | 7 | Gopalan and Rao (1976) |

MICROCRATERS AND SURFACES: Nagel et al. (1976) and Hartung et al. (1978) studied the glass linings of zap pits on 65315. Compositional gradients in some linings indicate a mixture of meteoritic material with melted target (Fig.7).

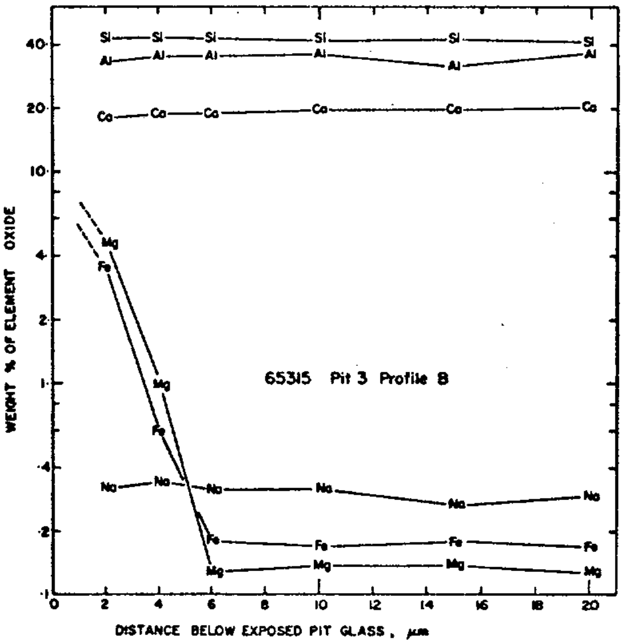



FIGURE 7. Compositional data for impact crater; from Hartung et al. (1978).

Fluorine data on an exterior and an interior surface are provided by Leich et al. (1974). Significant fluorine present on the exterior surface is most likely terrestrial contamination.

Filleux et al. (1977) find no solar wind-implanted carbon on the surface of a fresh interior chip.

PROCESSING AND SUBDIVISIONS: In 1972, several chips of anorthosite and glass were taken from various surfaces for allocation. In 1973, 65315 was slabbed and the slab and the W butt end further subdivided (Fig. 8). The largest single piece remaining is ,46 (167.14 g).

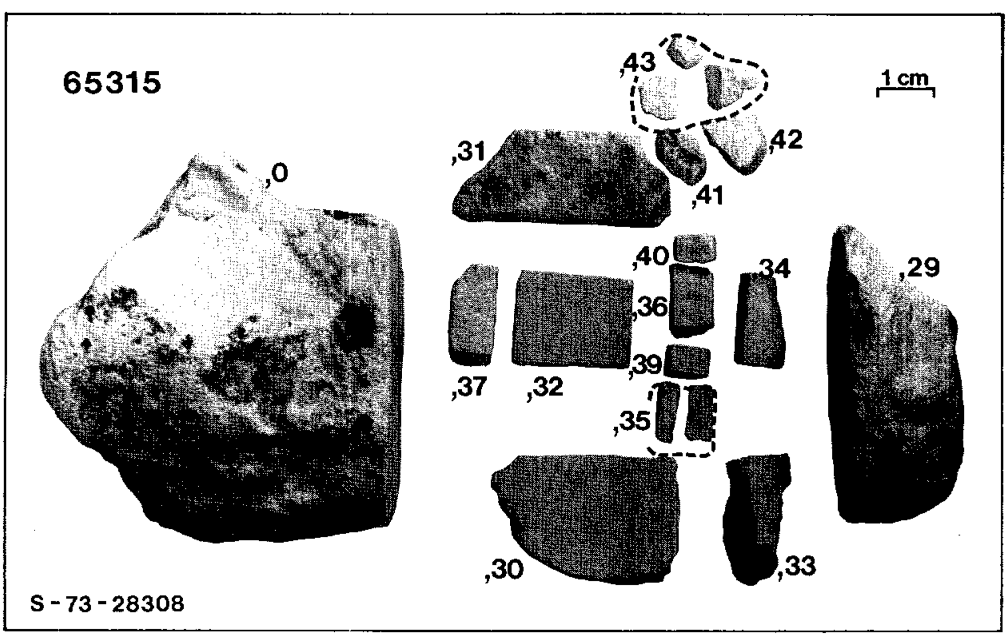



FIGURE 8. Sawing subdivisions.

INTRODUCTION: 65325 is a friable, cataclastic, ferroan anorthosite which is chemically pristine. An irregular crust of dark brown glass partially coats one surface (Fig. 1). This rock was collected as a rake sample from the lower slope of Stone Mountain; lunar orientation is unknown. A few glass-lined zap pits are present.

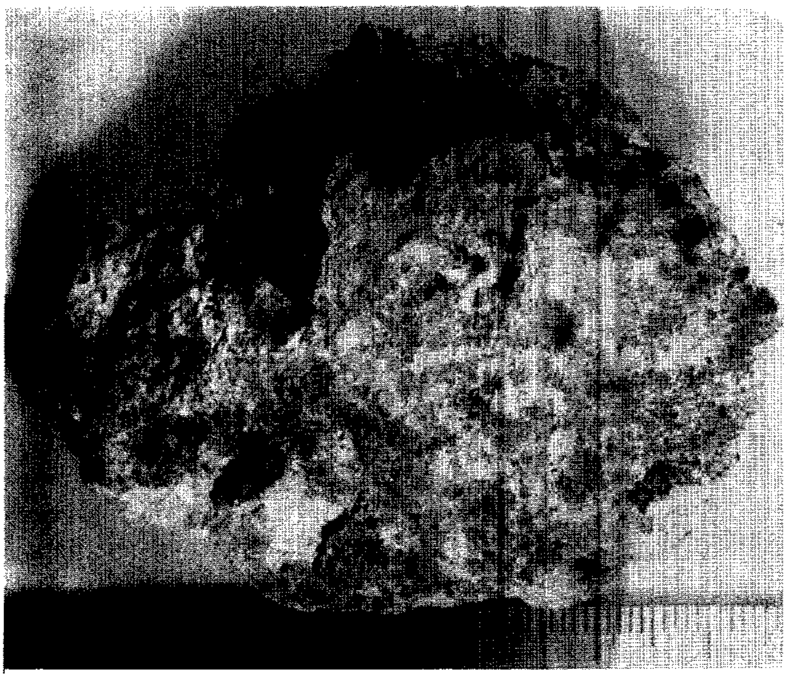


FIGURE 1. Smallest scale division in mm.

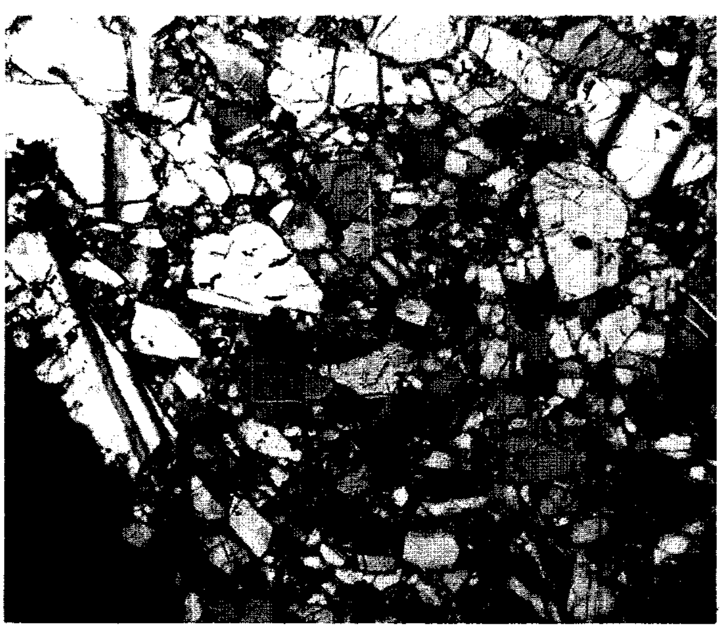


FIGURE 2. 65325,6. general view, xpl. width 2mm.

PETROLOGY: Warren and Wasson (1978) provide a petrographic description. Plagioclase ($An_{96-97}$) accounts for ∿ 99% of the rock with the remainder principally low-Ca pyroxene ($Wo_2En_{63}$). Traces of ilmenite and rusty metal are also present. The rock has been severely crushed; few grains are more than 1 mm long with most less than ∿ 0.1 mm (Fig.2).

CHEMISTRY: Warren and Wasson (1978) give a bulk analysis of the anorthosite, summarized here as Table 1. The analysis shows 65325 to be nearly pure plagioclase with levels of rare-earth and siderophile elements typical of pristine anorthosites.

TABLE 1. Summary chemistry of 65325

| | |
|---|---|
| $SiO_2$ | 44.08 |
| $TiO_2$ | |
| $Al_2O_3$ | 35.15 |
| $Cr_2O_3$ | 0.004 |
| FeO | 0.28 |
| MnO | 0.008 |
| MgO | 0.23 |
| CaO | 19.60 |
| $Na_2O$ | 0.340 |
| $K_2O$ | |
| $P_2O_5$ | |
| Sr | |
| La | 0.12 |
| Lu | |
| Rb | |
| Sc | 0.43 |
| Ni | 0.68 |
| Co | 1.0 |
| Ir ppb | 0.06 |
| Au ppb | 0.04 |
| C | |
| N | |
| S | |
| Zn | 22 |
| Cu | |

Oxides in wt%; others in ppm except as noted.

PROCESSING AND SUBDIVISIONS: A few small chips of the anorthosite have been allocated for chemical analyses and for thin sections. Kirsten was allocated chips of a zap pit, and Housley was allocated chips of the glass coat and exterior anorthosite. Otherwise the sample remains nearly intact.

INTRODUCTION: 65326 is a light gray, moderately coherent, cataclastic anorthosite (Fig. 1). A few areas with a sheared appearance are present. Streaks of rust and veins of unaltered metal are common on some faces. It is a rake sample. Zap pits are rare.

PETROLOGY: Petrographic descriptions are provided by Dowty et al. (1974a) and Warner et al. (1976b). Texturally 65326 is a typical cataclastic anorthosite, with angular clasts of plagioclase in a fine-grained matrix of plagioclase. Some heterogeneity is present with some coarser, clast-rich areas separated by regions of predominantly fine-grained, granulated material (Fig. 2). Pyroxene is the only mafic phase present and is very rare. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Ilmenite is an accessory phase.

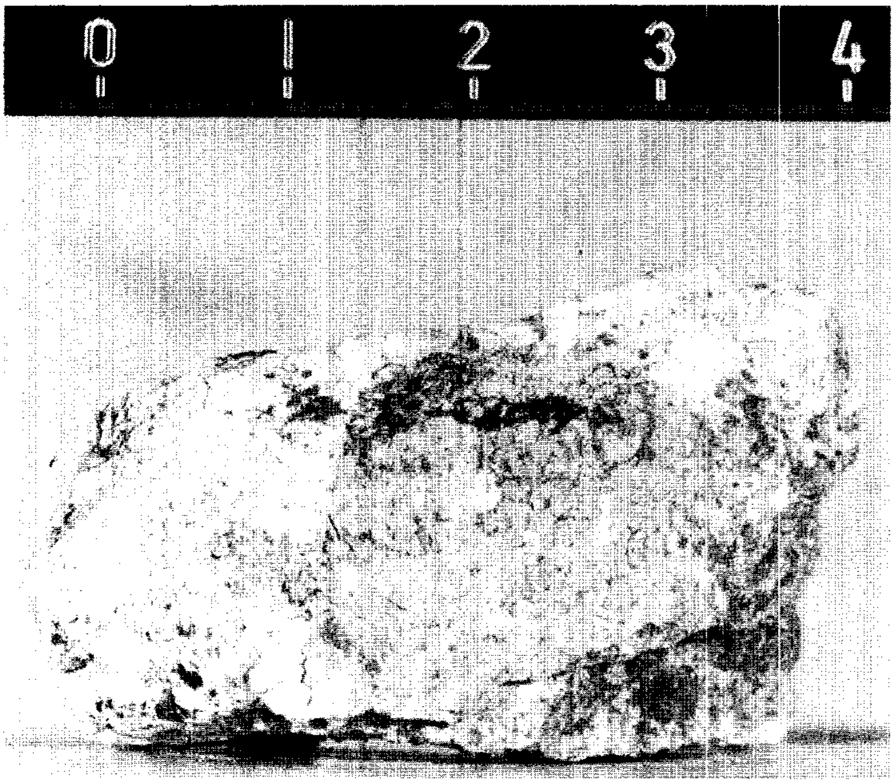



FIGURE 1. Scale in cm. S-72-43410.

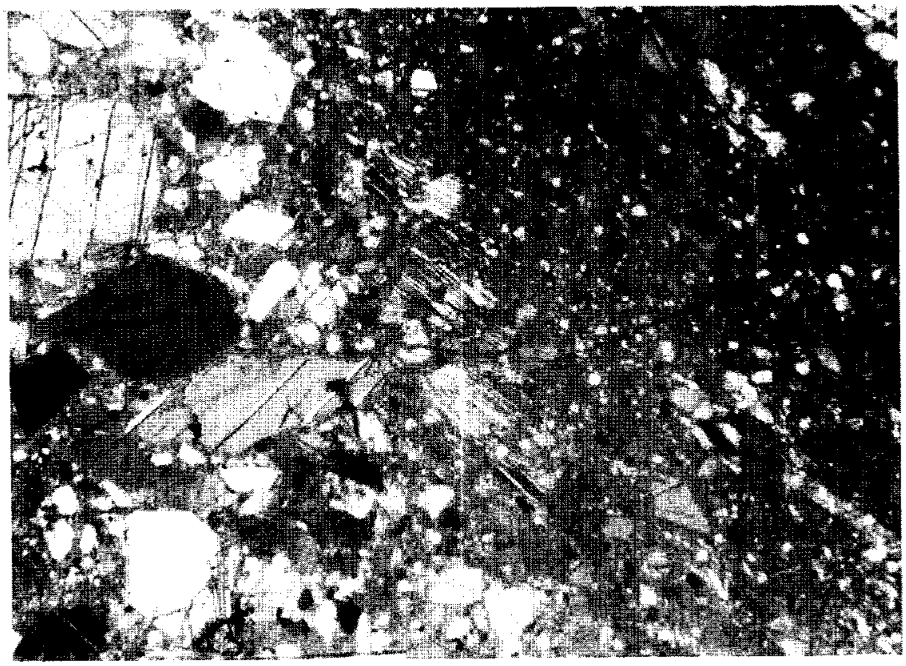


FIGURE 2. 65326,3. general view, partly xpl. width 3mm.

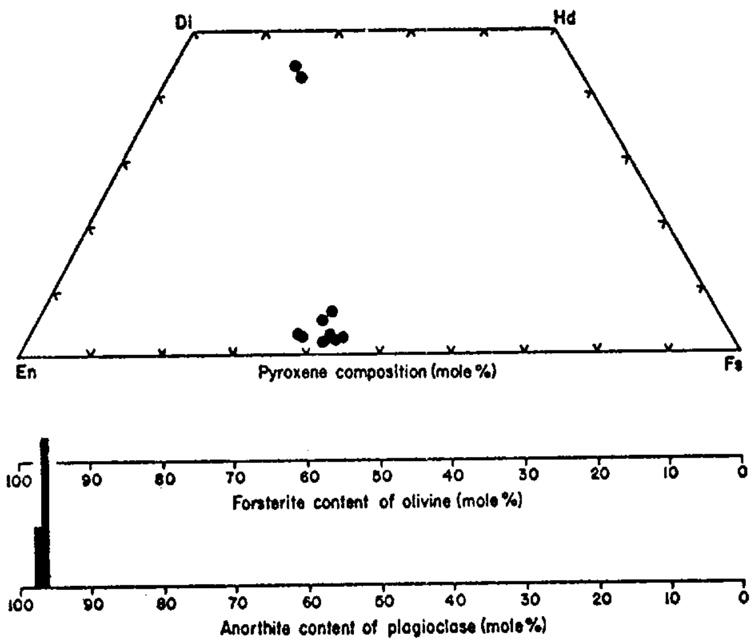



FIGURE 3. Mineral compositions; from R. Warner *et al.*(1976b).

TABLE 1. Chemistry of 65326 (DBA, normalized to 100%)

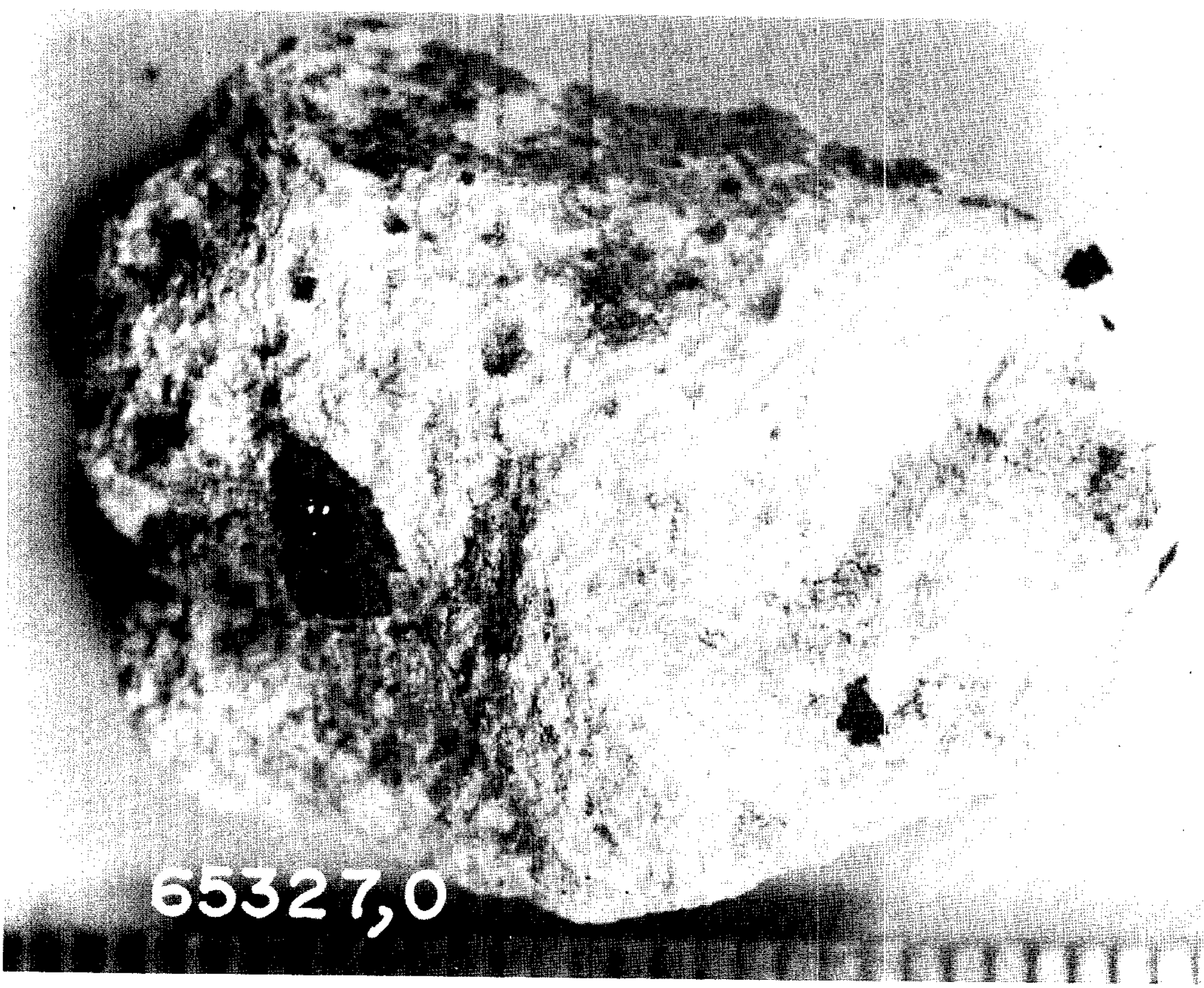
| | |
|---|---|
| $SiO_2$ | 44.5 |
| $Al_2O_3$ | 35.6 |
| FeO | 0.23 |
| MgO | 0.07 |
| CaO | 19.1 |
| $Na_2O$ | 0.45 |
| $K_2O$ | 0.06 |
| $P_2O_5$ | 0.03 |

CHEMISTRY: A defocussed electron beam analysis (DBA) is presented by Dowty *et al.* (1974a) and reproduced by Warner *et al.* (1976b) and here as Table 1. The analysis indicates that 65326 is virtually pure plagioclase.

PROCESSING AND SUBDIVISIONS: In 1973 two small chips and some fines (,1) were allocated to Keil for petrography.

<u>INTRODUCTION</u>: 65327 is a white, cataclastic anorthosite of variable coherence that was collected as a rake sample (Fig. 1). It is chemically pristine. Small areas of glassy crust and a few zap pits are present.

<u>PETROLOGY</u>: Warren and Wasson (1978) provide a brief petrographic description and mineral compositions. Plagioclase ($An_{97}$, up to 1.5 mm long) composes ~99% of the rock, with the remainder low-Ca pyroxene ($Wo_2$ $En_{62-67}$). Rare grains of metal were observed macroscopically (Keil <u>et al</u>., 1972). No signs of recrystallization are present (Fig. 2).




<u>FIGURE 1</u>. Small scale division in mm. S-72-47678.

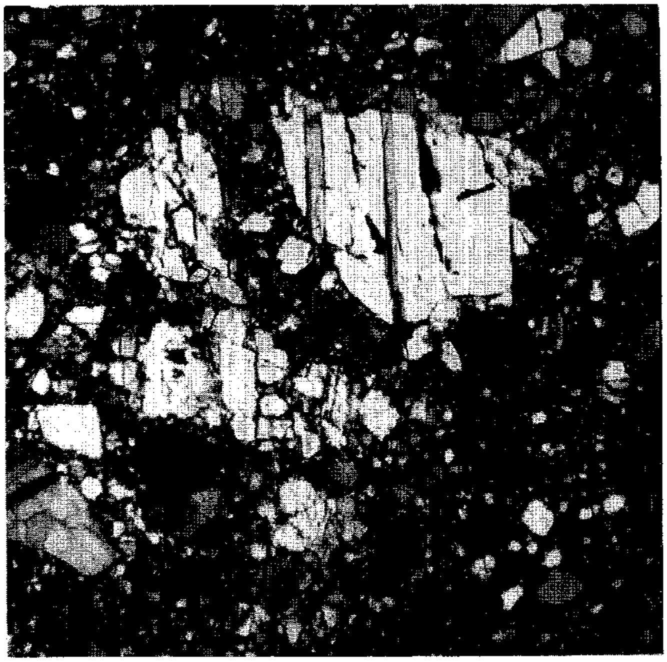


FIGURE 2. 65327,5. general view, xpl. width 2mm.

TABLE 1. Summary chemistry of 65327

| | | | |
|---|---|---|---|
| $SiO_2$ | 44.5 | Sr | |
| $TiO_2$ | | La | 0.08 |
| $Al_2O_3$ | 34.4 | Lu | |
| $Cr_2O_3$ | 0.003 | Rb | |
| FeO | 0.34 | Sc | 0.40 |
| MnO | 0.009 | Ni | <0.9 |
| MgO | 0.33 | Co | 0.96 |
| CaO | 19.7 | Ir ppb | 0.010 |
| $Na_2O$ | 0.297 | Au ppb | 0.012 |
| $K_2O$ | | C | |
| $P_2O_5$ | | N | |
| | | S | |
| | | Zn | 22.0 |
| | | Cu | |

Oxides in wt%; others in ppm except as noted.

CHEMISTRY: Major and trace element data given by Warren and Wasson (1978) show 65327 to be nearly pure plagioclase with the low levels of incompatible and siderophile elements typical of pristine Apollo 16 anorthosites (Table 1). Zn is considerably enriched for a pristine anorthosite.

PROCESSING AND SUBDIVISIONS: In 1977, the rock was split into several chips (,1-,7) for allocation for chemistry (,1) and thin sections (,2 → thin sections ,4 and ,5).

INTRODUCTION: 65328 is a white, friable anorthosite (Fig. 1). It is subrounded with a granulated appearance. Grain size of the plagioclase ranges up to ~2 mm. Tiny dark specks (<0.05 mm) and a few metallic grains are present. A dark glass crust is present on one face. This rock is a rake sample, and has very few zap pits.

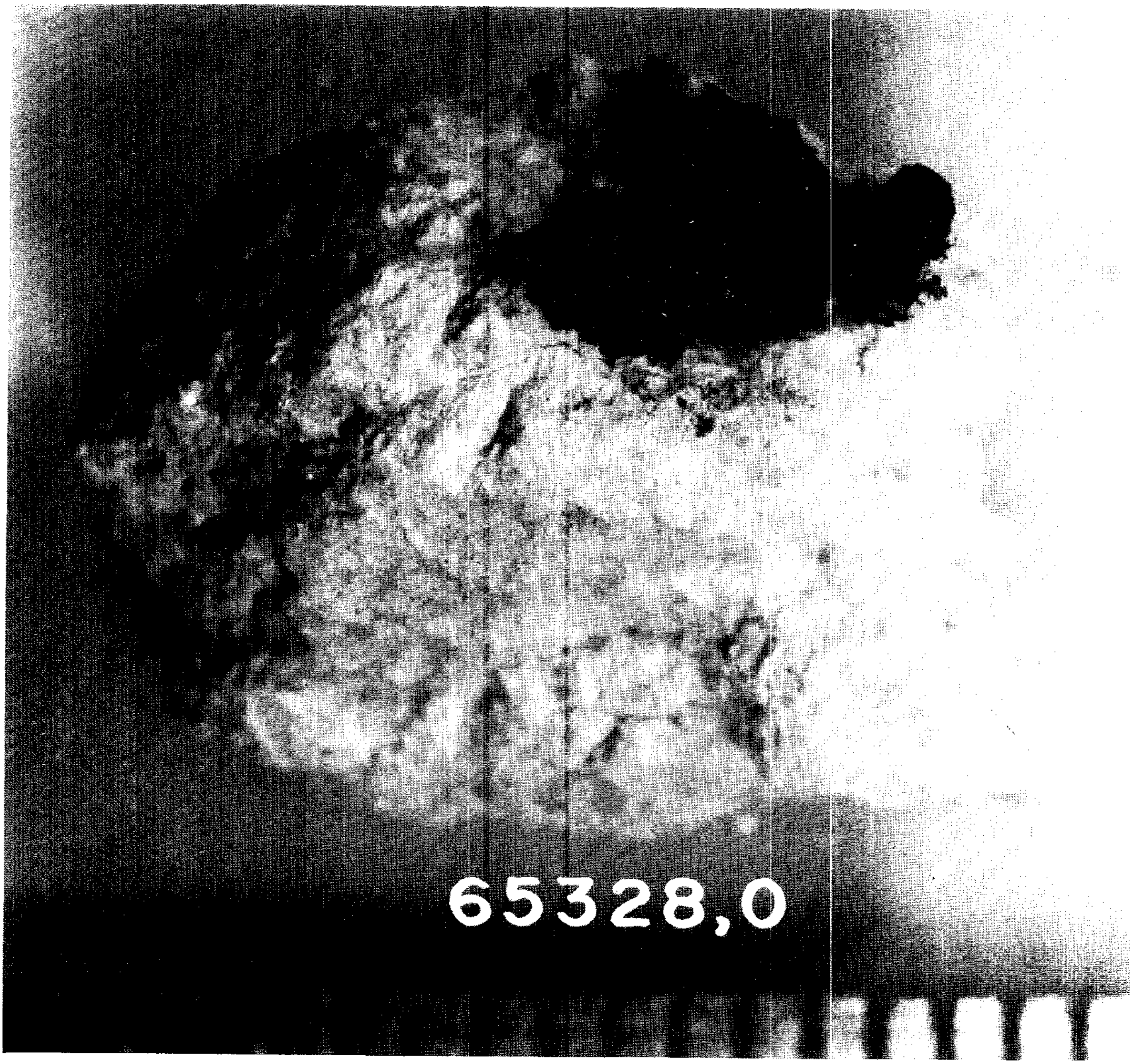



FIGURE 1. Scale division in mm. S-72-47665.

## 65329 CATACLASTIC ANORTHOSITE 1.92 g

INTRODUCTION: 65329 is a white, friable anorthosite collected as a rake sample (Fig. 1). It is subangular and has a granulated appearance. Plagioclase crystals up to 2 mm long are present. Tiny (<0.05 mm) dark flecks are scattered through the rock. Zap pits are rare.

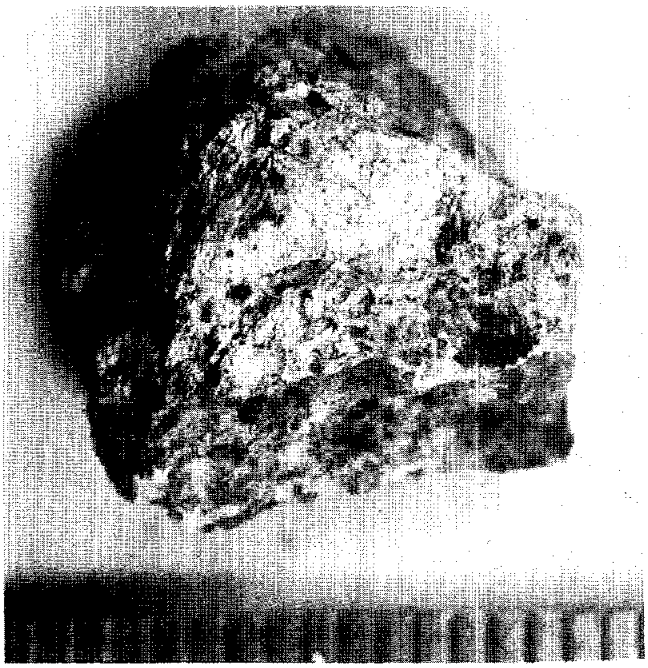


FIGURE 1. Scale division in mm.

## 65335 CATACLASTIC ANORTHOSITE 1.63 g

INTRODUCTION: 65335 is a white to light gray, friable anorthosite collected as a rake sample (Fig. 1). It is rounded and has a granular texture. Surfaces are abraded and covered with patina. Zap pits are rare.

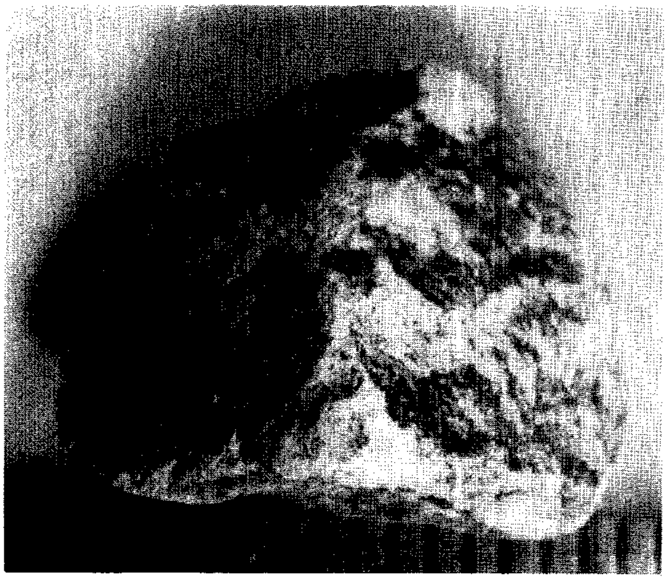


FIGURE 1. Scale division in mm.

## 65336 CATACLASTIC ANORTHOSITE 0.60 g

INTRODUCTION: 65336 is a white, friable anorthosite collected as a rake sample (Fig. 1). It is subangular and has a granular texture. Dark glass coats a portion of one surface. Zap pits are rare.

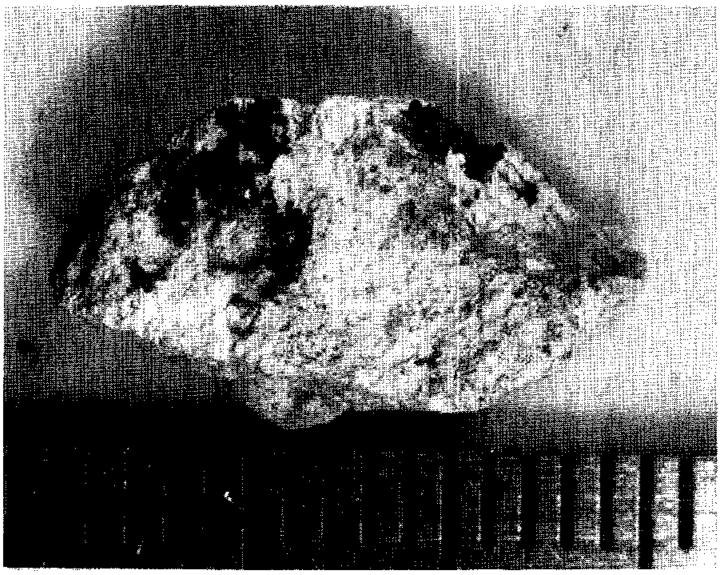


FIGURE 1. Scale division in mm.

INTRODUCTION: 65337 is a light gray, friable, clastic breccia with a diverse clast population (Fig. 1). It is a rake sample. Zap pits are very rare.

FIGURE 1. Small scale division in mm.

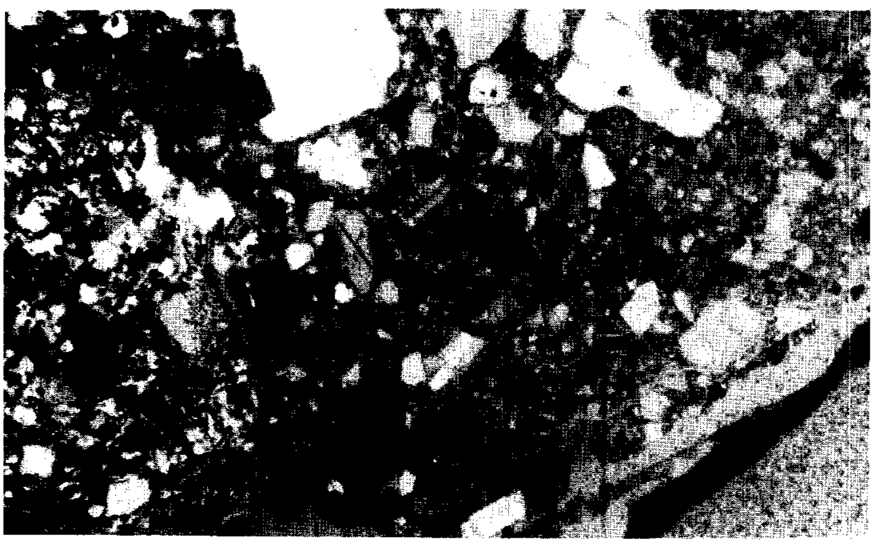


FIGURE 2. 65337,4. general view, partly xpl. width 3mm.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description. 65337 is a fragmental breccia composed of mineral, lithic and glass fragments with a small amount of interstitial glass (Fig.2). Lithic clasts include a large, partially recrystallized, troctolite fragment, granoblastic and cataclastic anorthosites, poikilitic rock fragments, various breccias and several small "chondrules."

PROCESSING AND SUBDIVISIONS: In 1973 several chips were allocated to Wasserburg for geochronology (,1 3.08 g) and to Keil for petrography (,2 0.10 g).

INTRODUCTION: 65338 is a light gray, friable breccia (Fig. 1). Macroscopically it appears to be predominantly a clastic rock although abundant vesicles are present in some areas. A 1.5 mm patch of metal and a similar area of dark glass are also present. This is a rake sample. Zap pits are rare.

PETROLOGY: A thin section of 65338 examined by Warner et al. (1976b) shows a coherent, recrystallized breccia, rather than the fragmental, clastic breccia expected from macroscopic examination (Fig. 2). The coherent breccia, presumed to be a clast by Warner et al. (1976b), has a poikilitic to granular texture with abundant mineral and lithic clasts. Lithic clasts are mostly recrystallized anorthositic fragments. Mineral compositions within the coherent breccia are shown in Figure 3 and tabulated by Dowty et al. (1976). Minor phases include ilmenite, armalcolite, rutile, Fe-metal (1.8-8.6% Ni, 0.3-0.5% Co) and baddelyeite (Warner et al., 1976b).

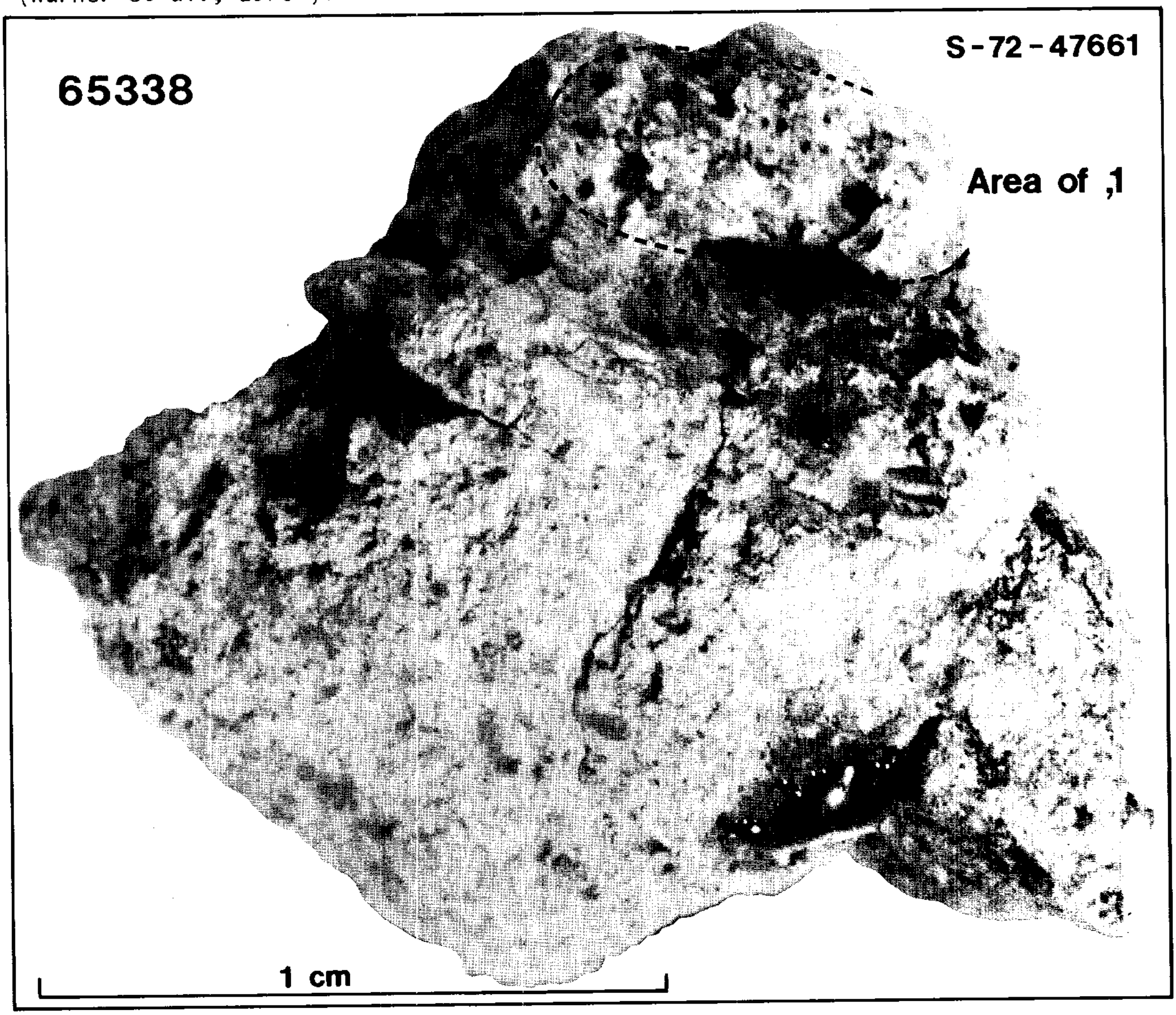



FIGURE 1.

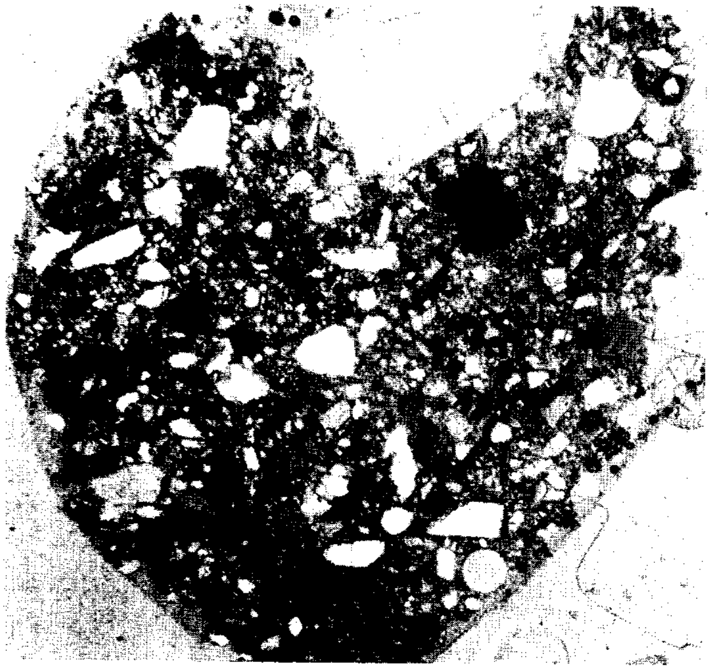


FIGURE 2. 65338,2. general view, partly xpl. width 2mm.

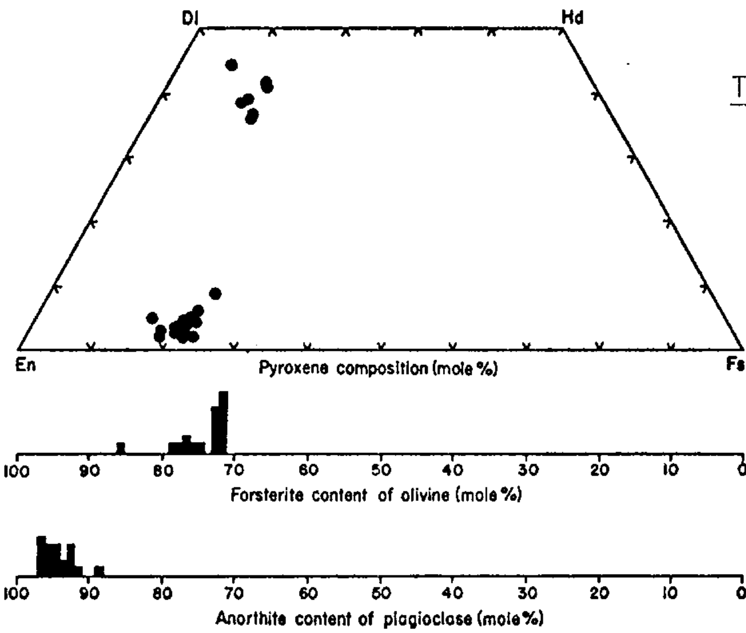



FIGURE 3. Mineral compositions; from R. Warner *et al.* (1976b).

TABLE 1. Chemistry of 65338 (clast?) (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 44.8 |
| $TiO_2$ | 0.54 |
| $Al_2O_3$ | 26.1 |
| $Cr_2O_3$ | 0.07 |
| FeO | 5.1 |
| MnO | 0.04 |
| MgO | 7.6 |
| CaO | 14.9 |
| $Na_2O$ | 0.52 |
| $K_2O$ | 0.10 |
| $P_2O_5$ | 0.20 |

CHEMISTRY: A defocussed electron beam analysis (DBA) of the coherent breccia (clast?) is given by Warner *et al.* (1976b) and reproduced here as Table 1.

PROCESSING AND SUBDIVISIONS: In 1973, a single chip (,1) was taken for thin sections (Fig. 1). Photodocumentation neither precludes nor necessitates the conclusion that the chip was a clast.

## 65339 FRAGMENTAL POLYMICT BRECCIA — 1.62 g

INTRODUCTION: 65339 is a light gray, friable breccia collected as a rake sample (Fig. 1). Clasts include white anorthositic fragments (~1 mm), gray aphanitic material (~1 mm) and a few yellow crystals (<0.1 mm). Zap pits are rare.

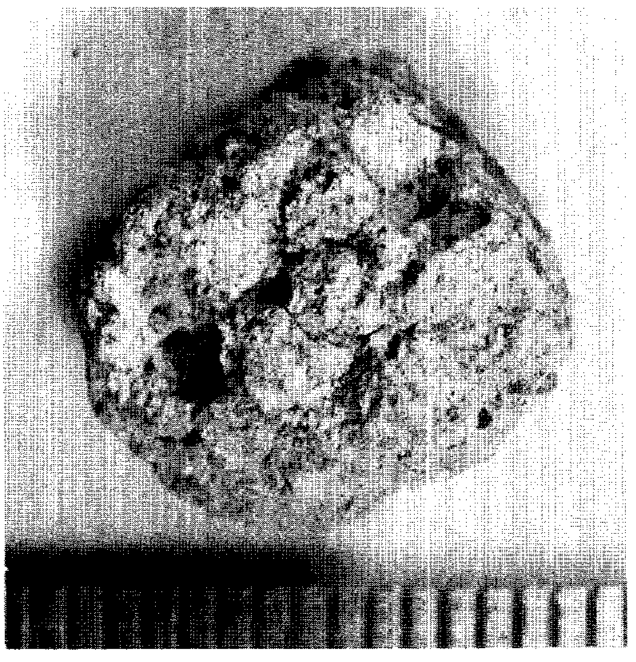


FIGURE 1. Scale division in mm.

## 65345 FRAGMENTAL POLYMICT BRECCIA 0.86 g

INTRODUCTION: 65345 is a light gray, friable, clastic breccia (Fig. 1). It is a rake sample. Zap pits are very rare.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description. 65345 is a clastic breccia with high porosity (Fig. 2). Lithic fragments include fine-grained poikilitic rock, an anorthositic clast with a single large pyroxene crystal, and several types of breccia.

PROCESSING AND SUBDIVISIONS: In 1973 a small set of chips and fines (,1) were allocated to Keil for petrography.

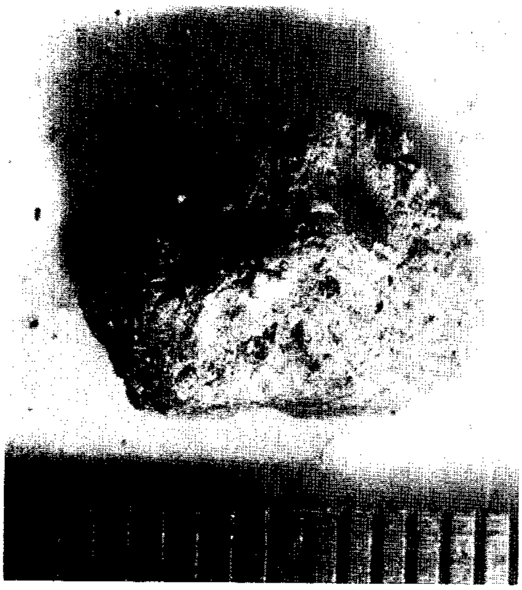


FIGURE 1. Scale division in mm.

FIGURE 2. 65345,3. general view, partly xpl. width 3mm.

## 65346 FRAGMENTAL POLYMICT BRECCIA 0.80 g

INTRODUCTION: 65346 is a light gray, friable breccia collected as a rake sample (Fig. 1). Clasts include white anorthositic material (∿0.5 mm), gray aphanitic fragments (∿0.7 mm), possibly some glass spherules and rare metal. It is subrounded with rare zap pits.

PROCESSING AND SUBDIVISIONS: During initial processing in 1972, 65346 broke into three subequal pieces (Fig. 1).

FIGURE 1. Scale division in mm.

INTRODUCTION: 65347 is a light gray, friable breccia collected as a rake sample (Fig. 1). Clasts include several gray crystalline fragments (up to 2 mm) and white anorthositic material (up to 1.5 mm). Zap pits are very rare.

FIGURE 1. Scale division in mm.

INTRODUCTION: 65348 is a dark gray, coherent glass or glassy breccia containing several large white clasts (Fig. 1). Most of the rock is hollow: a large vesicle or cavity occupies the center of the sample. This rock is a rake sample. Zap pits are rare.

PETROLOGY: A brief petrographic description of the dark matrix is provided by Warner et al. (1976b). Abundant mineral and lithic clasts reside in a glassy but fragmental matrix (Fig. 2). Clasts are generally smaller than in fragmental breccias.

PROCESSING AND SUBDIVISIONS: In 1973, a split (,1) consisting of a chip of dark matrix and a chip of white clast was taken for thin sections (Fig. 1).

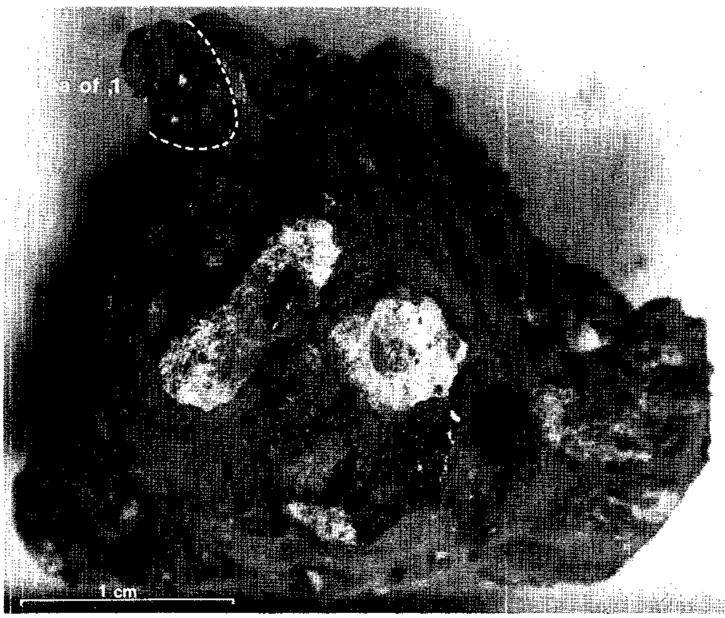



FIGURE 1.

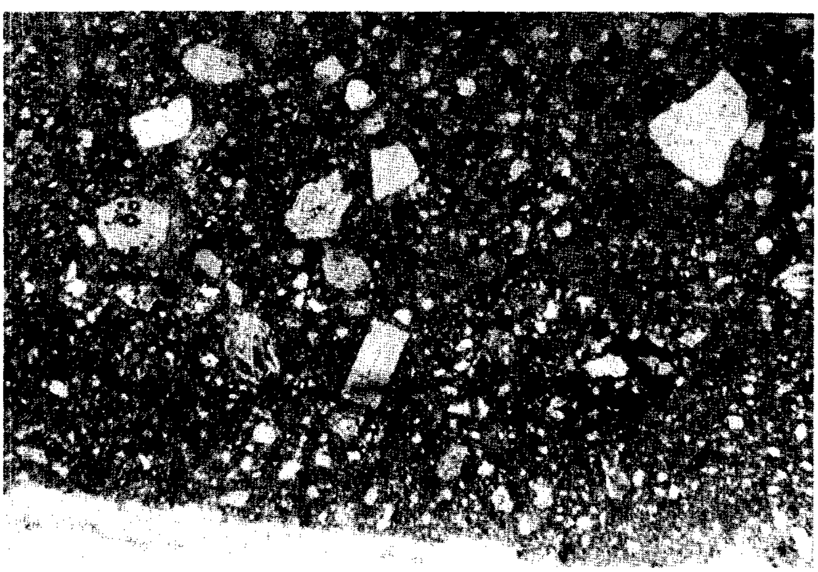


FIGURE 2. 63548,2. general view, partly xpl. width 3mm.

INTRODUCTION: 65349 is a medium gray, coherent, glassy impact melt collected as a rake sample (Fig. 1). It is somewhat vesicular with interlocking plagioclase laths common on the vesicle walls. Clasts and zap pits are rare.

FIGURE 1. Sample is about 2 cm. across.

INTRODUCTION: 65355 is a medium gray, coherent, glassy impact melt collected as a rake sample (Fig. 1). It is subrounded and somewhat vesicular. Clasts and zap pits are rare.

FIGURE 1. Scale division in mm.

65356 GLASSY IMPACT MELT 2.53 g

INTRODUCTION: 65356 is a medium gray, coherent, glassy impact melt collected as a rake sample (Fig. 1). It is angular and somewhat vesicular. A few white clasts (up to 1.5 mm) are present. Zap pits are rare.

FIGURE 1. Scale division in mm.

INTRODUCTION: 65357 is a light gray, coherent, poikilitic impact melt collected as a rake sample (Fig.1). It is subrounded with several zap pits.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description and mineral compositions. 65357 is relatively coarse-grained with oikocrysts up to 1 mm long (Fig.2). Clasts are predominantly plagioclase and are widely scattered through the rock. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Accessory phases include ilmenite, Fe-metal (4.3-9.1% Ni, 0.3-0.5% Co), baddeleyite and a "K-rich phase" (12.2-13.5% $K_2O$).

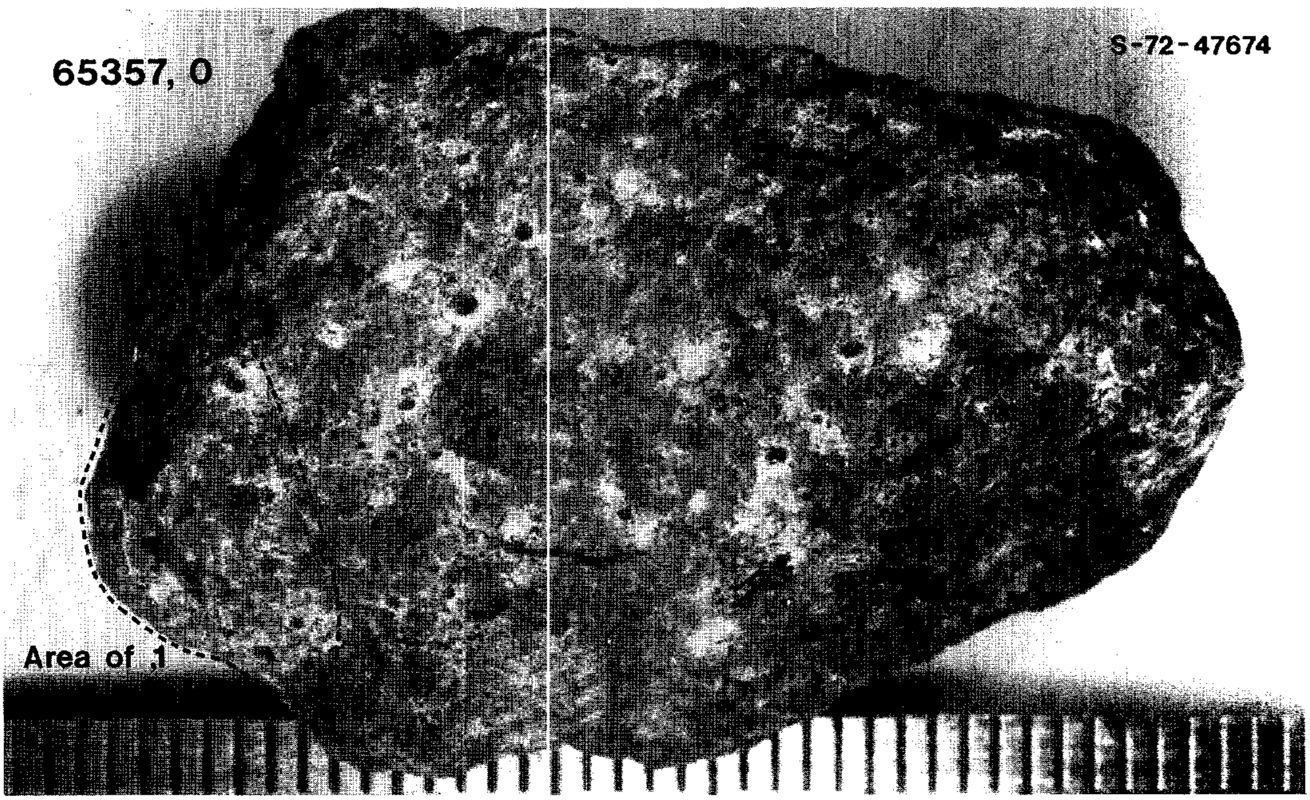



FIGURE 1.

CHEMISTRY: A defocussed electron beam analysis (DBA) is given by Warner et al. (1976b) and reproduced here as Table 1. The $TiO_2$ value is substantially higher than normal for an Apollo 16 poikilitic rock.

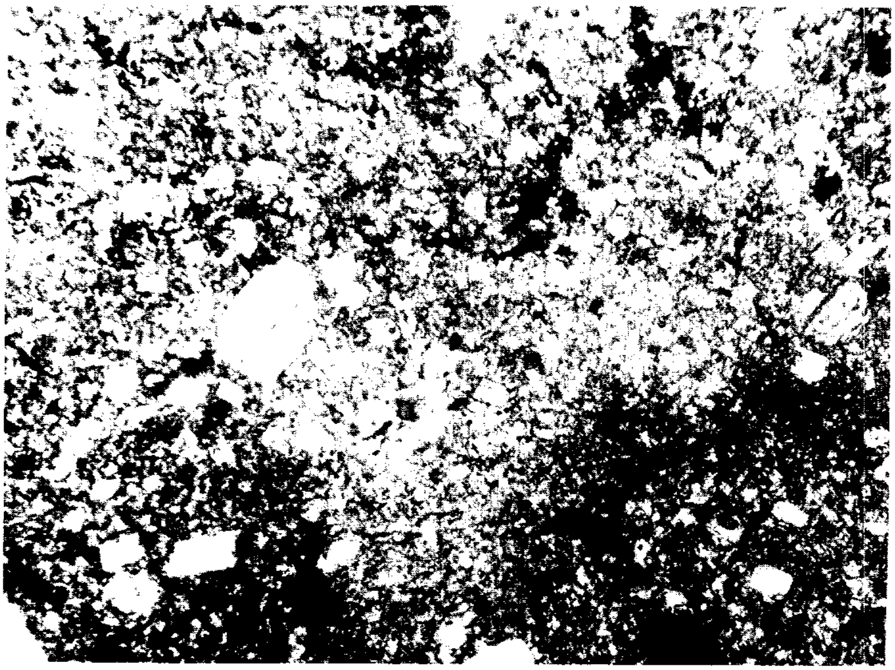


FIGURE 2. 65357,2. general view, partly xpl. width 3mm.

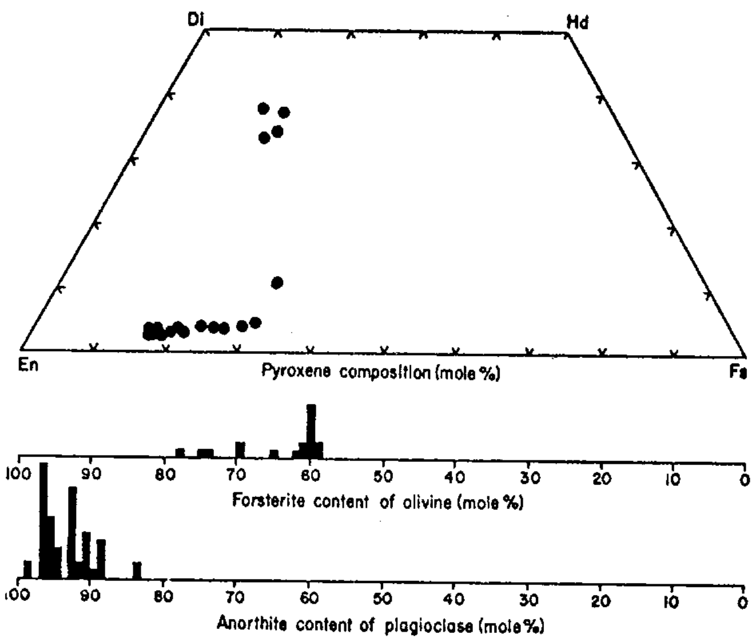



FIGURE 3. Mineral compositions; from R.Warner et al. (1976b).

TABLE 1. Chemistry of 65357 (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 46.4 |
| $TiO_2$ | 2.59 |
| $Al_2O_3$ | 20.5 |
| $Cr_2O_3$ | 0.12 |
| FeO | 7.3 |
| MnO | 0.08 |
| MgO | 9.0 |
| CaO | 12.4 |
| $Na_2O$ | 0.64 |
| $K_2O$ | 0.43 |
| $P_2O_5$ | 0.40 |

PROCESSING AND SUBDIVISIONS: In 1973 a single chip (,1) was allocated to Keil for petrography.

INTRODUCTION: 65358 is a light gray, coherent, poikilitic impact melt collected as a rake sample (Fig.1). Macroscopically half of the rock is very white and the other half more gray with a very smooth contact between the two areas. The differences do not appear to be due entirely to adhering surface material. It is angular in shape with rare vugs and zap pits.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description and mineral compositions. Oikocrysts (0.2-0.3 mm) of dominantly low-Ca pyroxene surround euhedral, subequant plagioclase chadacrysts and abundant clasts, most of which are also plagioclase (Fig.2). Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Minor phases include ilmenite, Fe-metal (1.7-7.3% Ni, 0.3-0.5% Co) and a"K-rich phase" (10.4-11.5% $K_2O$).

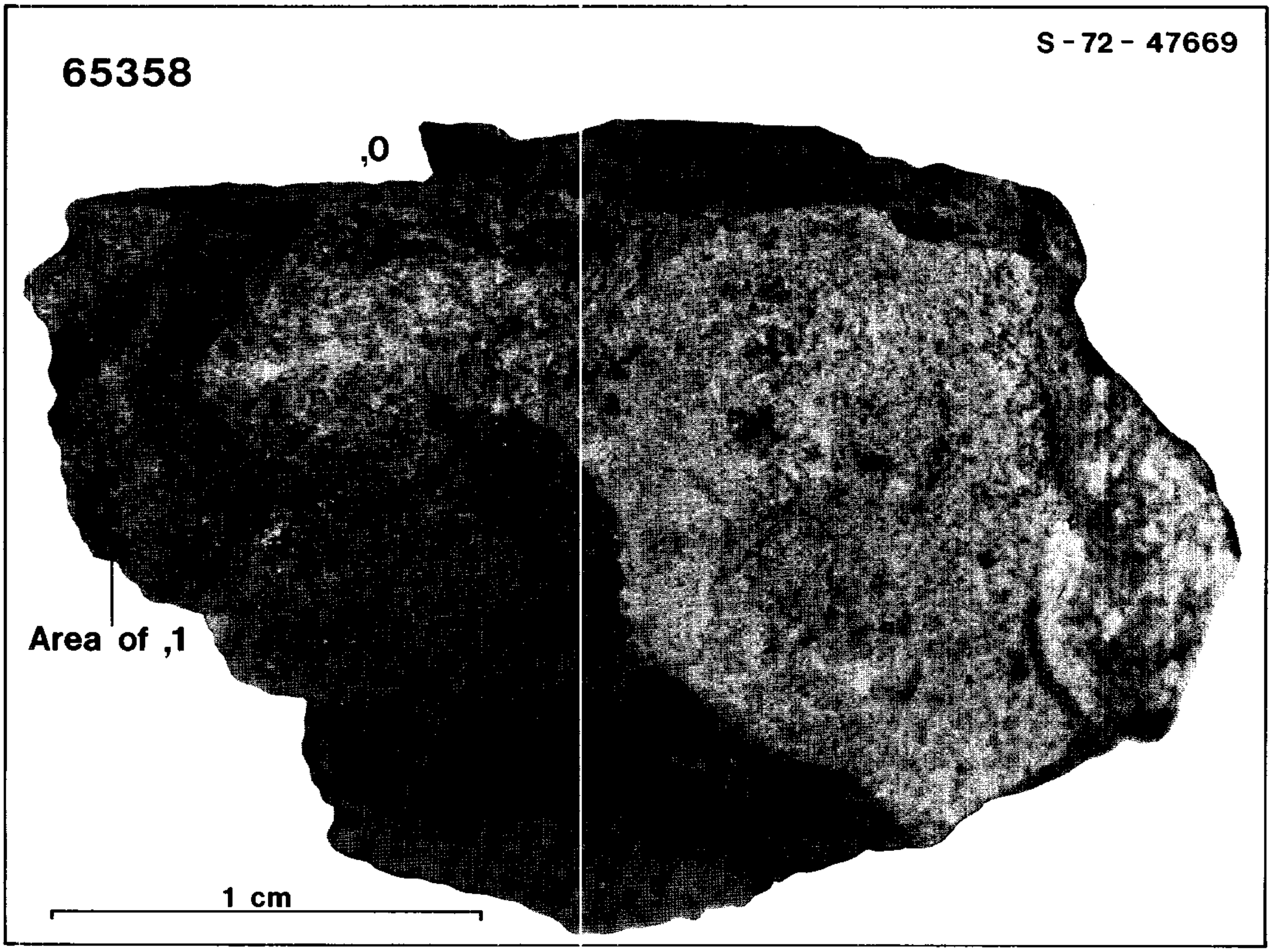



FIGURE 1.

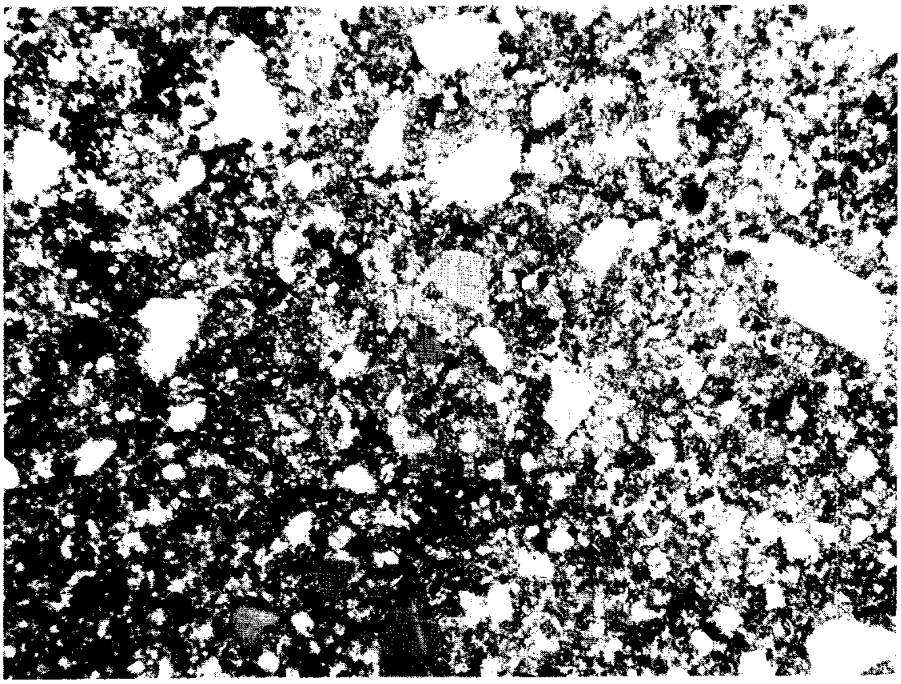


FIGURE 2. 65358,2. general view, partly xpl. width 3mm.

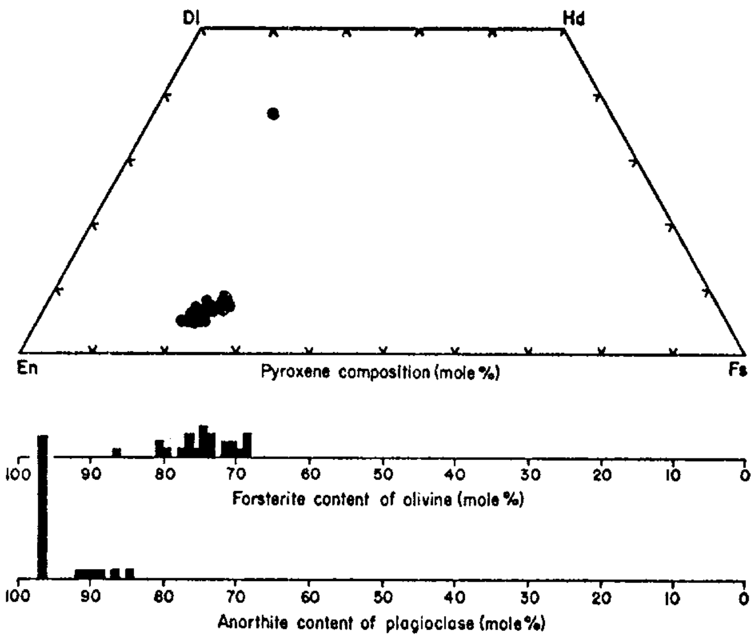



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

TABLE 1. Chemistry of 65358 (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 47.0 |
| $TiO_2$ | 0.86 |
| $Al_2O_3$ | 22.4 |
| $Cr_2O_3$ | 0.13 |
| FeO | 5.4 |
| MnO | 0.07 |
| MgO | 8.7 |
| CaO | 13.3 |
| $Na_2O$ | 0.53 |
| $K_2O$ | 0.27 |
| $P_2O_5$ | 0.24 |

CHEMISTRY: A defocussed electron beam analysis (DBA) is presented by Warner et al. (1976b) and reproduced here as Table 1.

PROCESSING AND SUBDIVISIONS: In 1973 a single chip (,1) was allocated to Keil for petrography (Fig.1).

INTRODUCTION: 65359 is a heterogeneous rock composed of white, friable breccia and dark, coherent impact melt (Fig. 1). Dark, bubbly glass coats one surface. Several veins of rusty material are present. 65359 is a rake sample; zap pits are very rare.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description and mineral compositions. Approximately half of the thin section examined by Warner et al. consists of a fine-grained, clast laden impact melt with a subophitic to poikilitic texture (Fig.2). The remainder of the section is a breccia composed of ∿ 80% plagioclase clasts (up to 2 mm long) and the remainder a fine-grained, melt matrix with a subophitic texture. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al.(1976). Minor phases from unspecified portions of the rock include Fe-metal (2.3-3.3% Ni, 0.4-0.6% Co) and schreibersite.

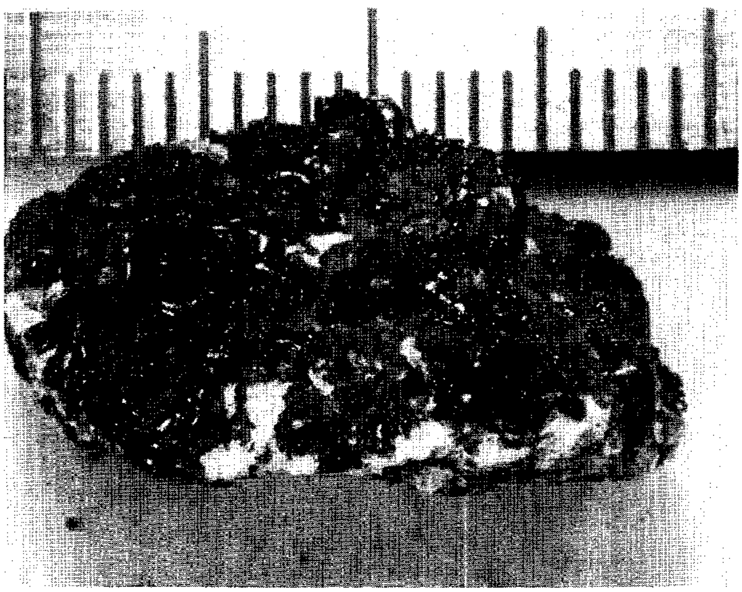


FIGURE 1. Small scale divisions in mm.

TABLE 1. Chemistry of 65359 (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 46.7 |
| $TiO_2$ | 0.47 |
| $Al_2O_3$ | 28.2 |
| $Cr_2O_3$ | 0.04 |
| FeO | 3.3 |
| MnO | 0.03 |
| MgO | 4.3 |
| CaO | 15.8 |
| $Na_2O$ | 0.66 |
| $K_2O$ | 0.30 |
| $P_2O_5$ | 0.23 |

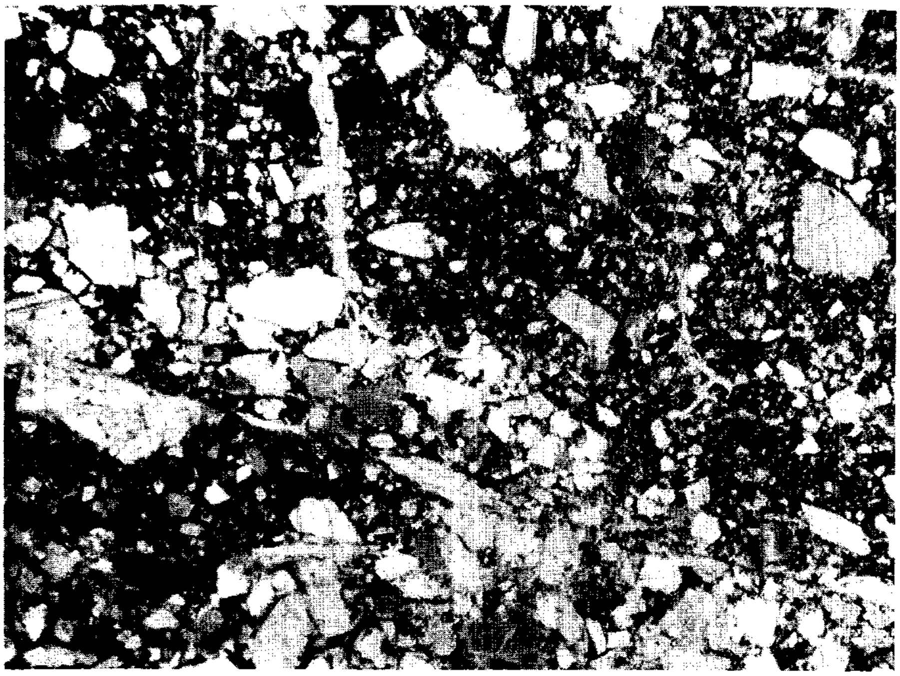


FIGURE 2. 65359,3. general view, partly xpl. width 3mm.

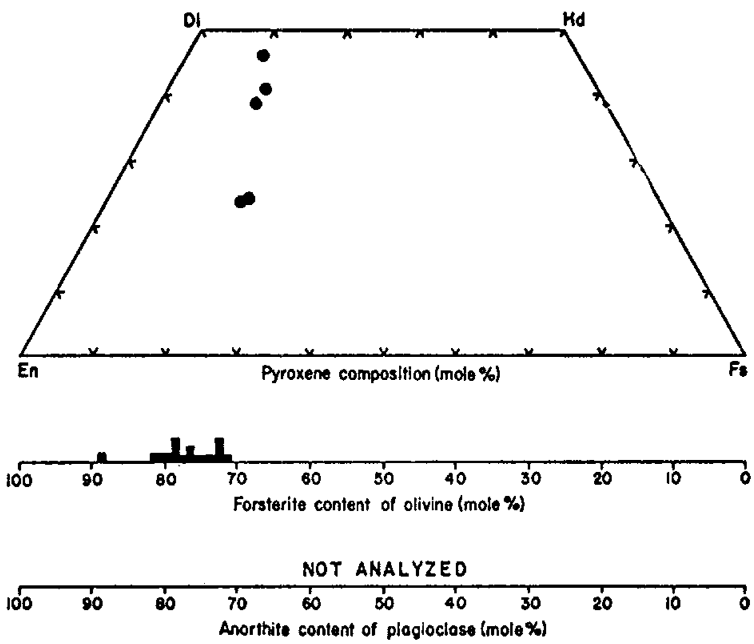



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

CHEMISTRY: A defocussed electron beam analysis (DBA) of the entire thin section is given by Warner et al. (1976b) and reproduced here as Table 1.

PROCESSING AND SUBDIVISIONS: In 1973 several small chips were removed as ,1 and allocated to Keil for petrography.

INTRODUCTION: 65365 is a light gray, friable, poikilitic impact melt collected as a rake sample (Fig.1). It is subangular and cut by fractures and glassy veins. Zap pits are rare.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description and mineral compositions. Irregularly shaped oikocrysts enclose euhedral plagioclase chadacrysts and relatively rare mineral clasts (Fig.2). Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Minor phases include ilmenite, armalcolite and metal (3.3-8.2% Ni, 0.3-3.5% Co).

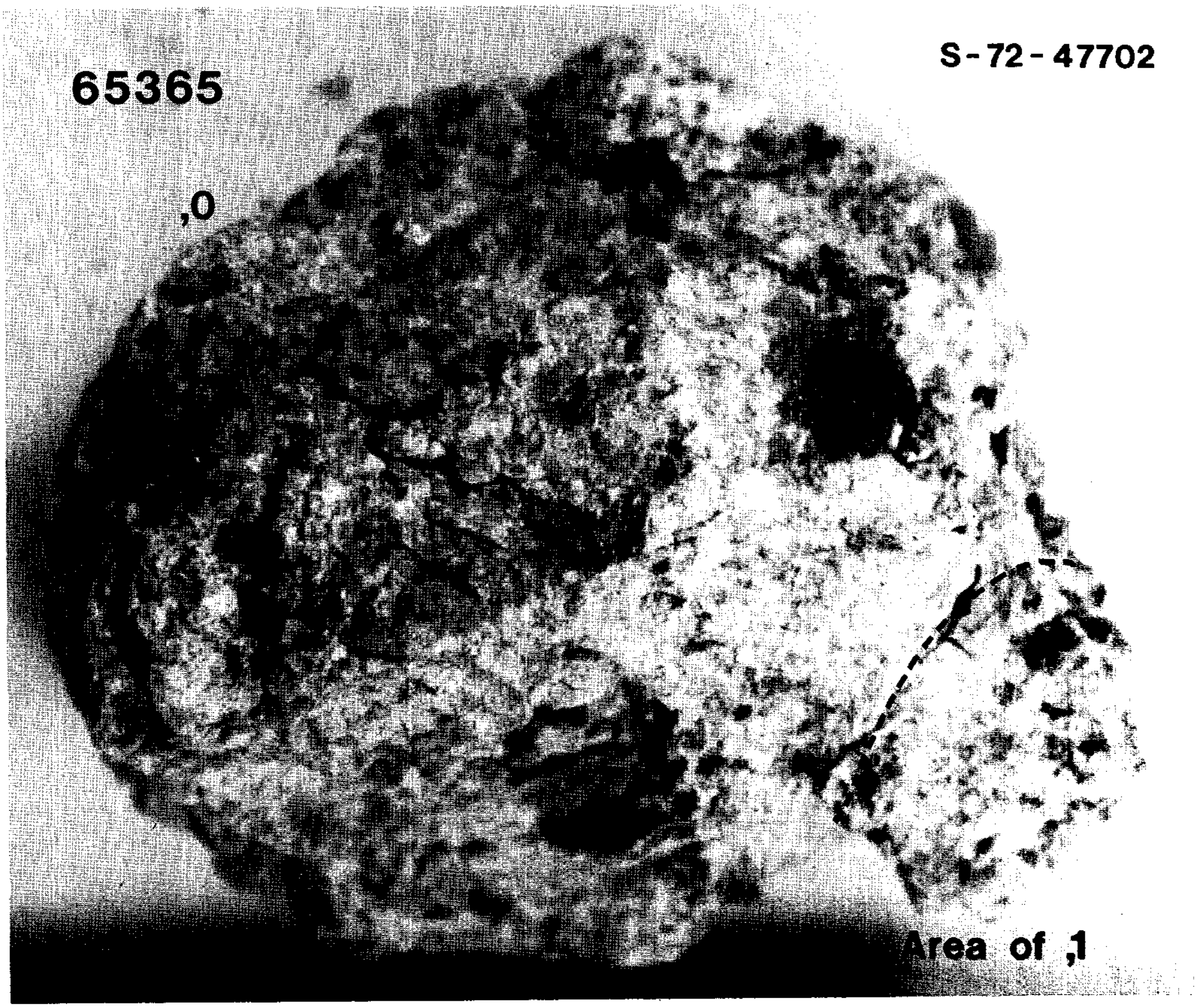



FIGURE 1.

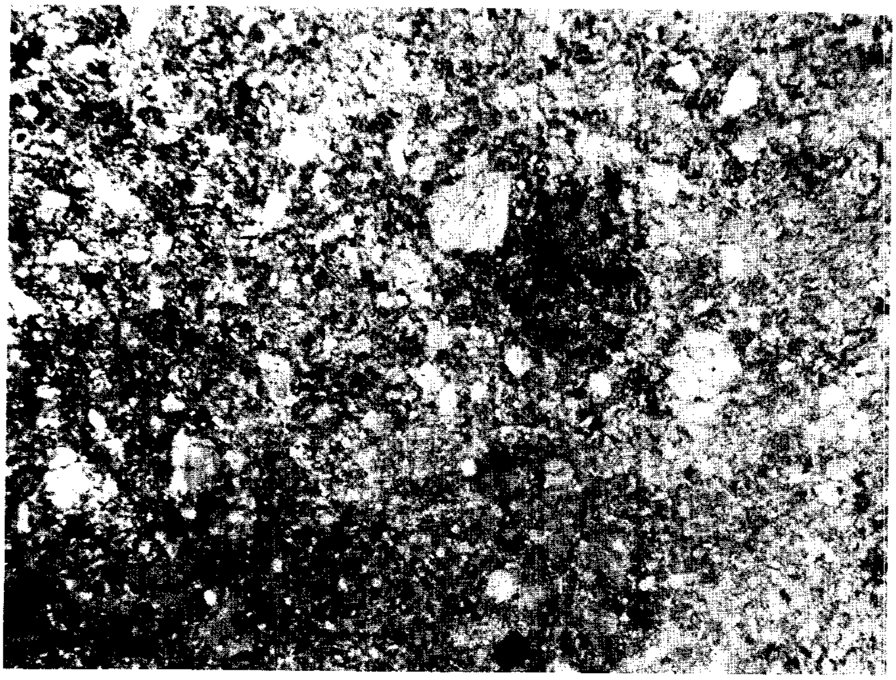


FIGURE 2. 65365,3. general view, partly xpl. width 3mm.

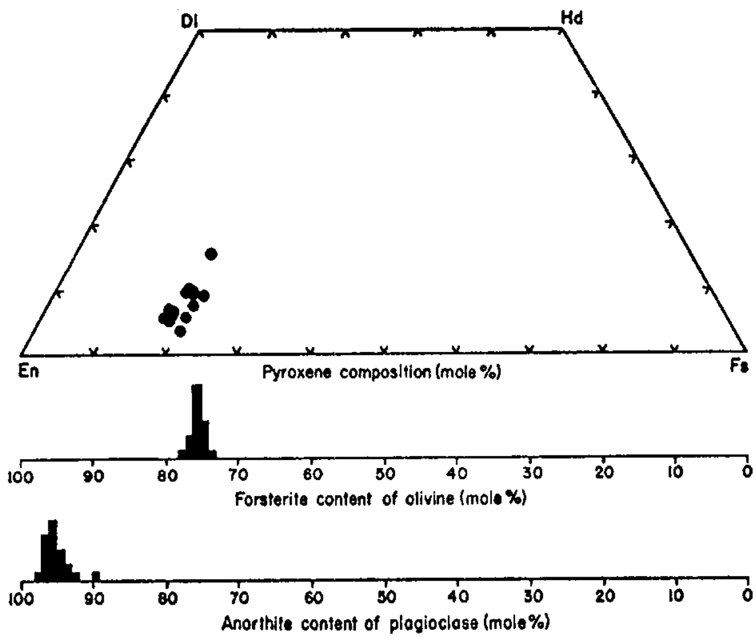



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

TABLE 1. Chemistry of 65365 (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 45.2 |
| $TiO_2$ | 0.63 |
| $Al_2O_3$ | 23.0 |
| $Cr_2O_3$ | 0.12 |
| FeO | 6.8 |
| MnO | 0.06 |
| MgO | 9.6 |
| CaO | 13.6 |
| $Na_2O$ | 0.52 |
| $K_2O$ | 0.19 |
| $P_2O_5$ | 0.19 |

CHEMISTRY: A defocussed electron beam analysis (DBA) is presented by Warner et al. (1976b) and reproduced here as Table 1.

PROCESSING AND SUBDIVISIONS: In 1973 a single chip (,1) was allocated to Keil for petrography (Fig.1).

INTRODUCTION: 65366 is a collection of several flat, angular fragments of glass, usually ∿ 1-2 mm thick (Fig.1). Most of these fragments have anorthositic material adhering to one of their surfaces indicating that they were once probably portions of glass coats on anorthositic rocks. Vesicles are not abundant. Zap pits are rare on all of the pieces. These fragments are rake samples.

PETROLOGY: Warner et al.(1976b) provide a brief petrographic description of one of the fragments, confirming that it is clear, flow-banded glass (Fig.2). Some cataclastic anorthosite debris adheres to one surface and a few partially assimilated clasts of breccia are suspended within the glass. Quench crystals surround the clasts and occur along the contact with the adhering anorthosite.

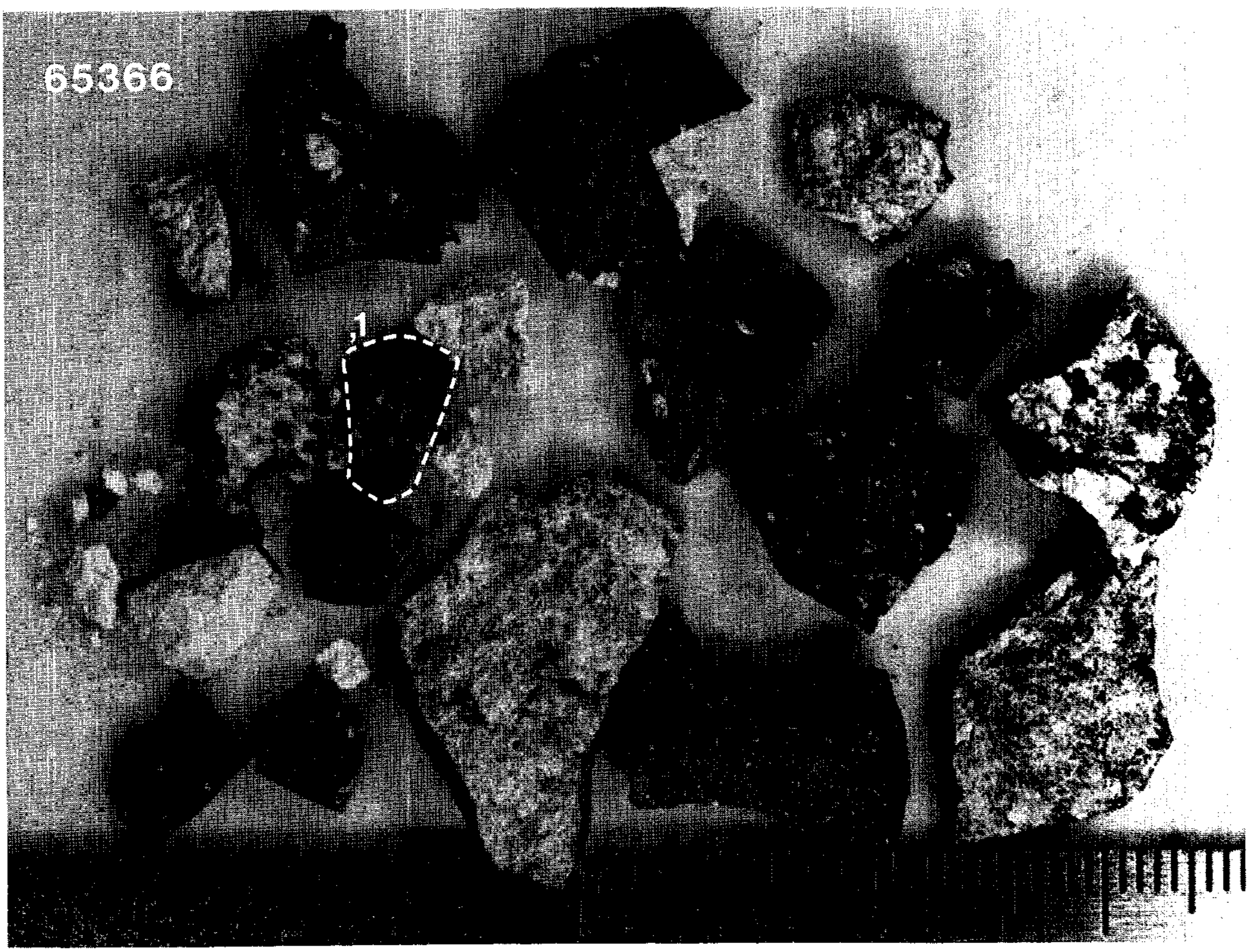



FIGURE 1.

FIGURE 2. 65366,3. general view, partly xpl. width 2mm.

TABLE 1. Chemistry of 65366 fragment (DBA)

| | |
|---|---|
| $SiO_2$ | 44.4 |
| $TiO_2$ | 0.38 |
| $Al_2O_3$ | 24.6 |
| $Cr_2O_3$ | 0.11 |
| FeO | 6.5 |
| MnO | 0.07 |
| MgO | 8.6 |
| CaO | 14.6 |
| $Na_2O$ | 0.39 |
| $K_2O$ | 0.08 |
| $P_2O_5$ | 0.08 |

CHEMISTRY: A defocussed electron beam analysis (DBA) is given by Warner et al. (1976b) and reproduced here as Table 1. The fragment is chemically similar to local soils.

PROCESSING AND SUBDIVISIONS: In 1973 one of the fragments (,1) was allocated to Keil for petrography (Fig.1)

65515 VERY FRIABLE, POLYMICT BRECCIA 50.25 g

INTRODUCTION: 65515 is a pale brown, extremely friable breccia probably composed of weakly lithified soil (Fig. 1). One very friable, white inclusion (~6 mm) is present. It was collected as a rake sample. It is rounded and zap pits are absent.

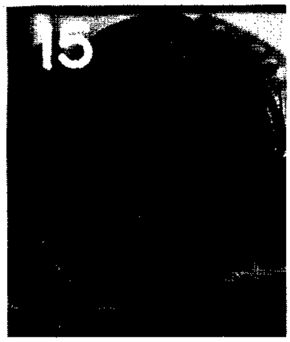



FIGURE 1. Sample is about 4 cm. across. S-72-43351.

## 65516 VERY FRIABLE, POLYMICT BRECCIA 10.49 g

INTRODUCTION: 65516 is a pale brown, extremely friable breccia probably composed of weakly lithified soil (Fig. 1). A few metal grains and plagioclase crystals can be seen macroscopically. It is a rake sample, rounded in shape and devoid of zap pits.

FIGURE 1. Sample is about 3 cm. across. S-72 43351.

65517 VERY FRIABLE (DISAGGREGATED?) POLYMICT BRECCIA 11.85 g

INTRODUCTION: 65517 is an extremely friable rake sample (Fig. 1) that has apparently disintegrated to loose soil (Keil *et al.*, 1972). It is very fine grained and pale brown in color.

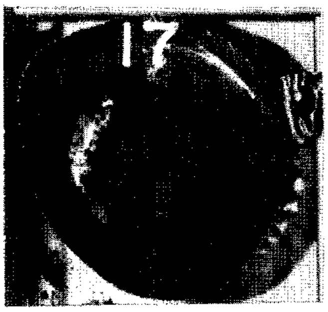



FIGURE 1. Sample is about 2.5 cm. across. S-72-43351.

65518 VERY FRIABLE, POLYMICT BRECCIA 9.48 g

INTRODUCTION: 65518 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is round and is probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 2 cm. across. S-72-43351.

## 65519 VERY FRIABLE, POLYMICT BRECCIA 10.58 g

INTRODUCTION: 65519 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 2 cm. across. S-72-43351.

65525 VERY FRIABLE, POLYMICT BRECCIA 7.48 g

INTRODUCTION: 65525 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 2 cm. across. S-72-43351.

65526 VERY FRIABLE, POLYMICT BRECCIA 3.55 g

INTRODUCTION: 65526 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

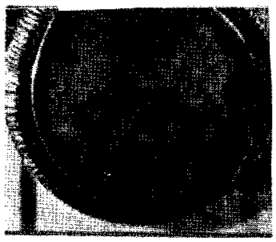


FIGURE 1. Sample is about 2 cm. across. S-72-43351.

## 65527 VERY FRIABLE, POLYMICT BRECCIA 2.89 g

INTRODUCTION: 65527 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 2 cm. across. S-72-43351.

## 65528 VERY FRIABLE, POLYMICT BRECCIA 3.08 g

INTRODUCTION: 65528 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

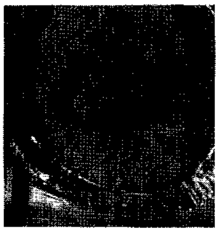


FIGURE 1. Sample is about 1.5 cm. across. S-72-43351.

INTRODUCTION: 65529 is a pale brown, very friable soil clod with several small glass beads and one glass spherule ~4 mm in diameter (Fig. 1). This rock is a rake sample. Zap pits are absent.

PETROLOGY: The large glass spherule was extracted and found to be a teardrop shaped bead. Warner et al. (1976b) examined a thin section of this bead and found a few vesicles (Fig. 2).

PROCESSING AND SUBDIVISIONS: In 1973 the rock was split and the large glass bead extracted as ,1 (0.03 g) for a thin section.

FIGURE 1. Larger piece is about 1.5 cm. across. S-72-43351.

FIGURE 2. general view, ppl. width about 2mm.

65535 VERY FRIABLE, POLYMICT BRECCIA 2.66 g

INTRODUCTION: 65535 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

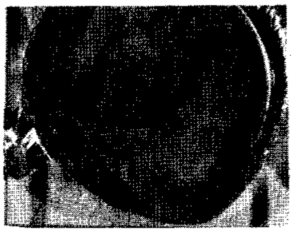


FIGURE 1. Sample is about 1.5 cm. across. S-72-43351.

65536 VERY FRIABLE, POLYMICT BRECCIA 1.58 g

INTRODUCTION: 65536 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. A fragment of green glass (0.5 mm) is exposed on the surface. Zap pits are absent.

FIGURE 1. sample is about 1.5 cm. across. S-72 43351.

## 65537 VERY FRIABLE, POLYMICT BRECCIA 2.43 g

INTRODUCTION: 65537 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

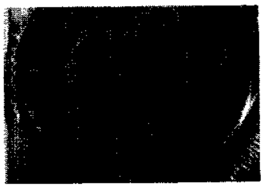


FIGURE 1. Sample is about 1.5 cm. across. S-72-43351.

## 65538 VERY FRIABLE, POLYMICT BRECCIA — 2.34 g

INTRODUCTION: 65538 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

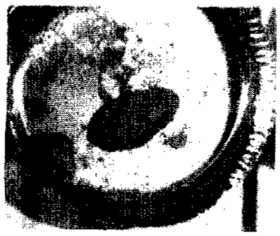


FIGURE 1. Sample is about 1.5 cm. across. S-72-43351.

## 65539 VERY FRIABLE, POLYMICT BRECCIA 2.18 g

INTRODUCTION: 65539 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

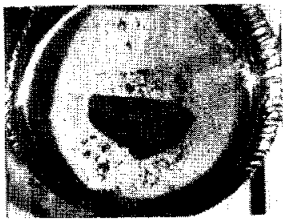


FIGURE 1. Sample is about 1.5 cm. across. S-72-43351.

## 65545 VERY FRIABLE, POLYMICT BRECCIA 1.80 g

INTRODUCTION: 65545 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 1 cm. across. S-72-43551.

## 65546 VERY FRIABLE, POLYMICT BRECCIA 1.35 g

INTRODUCTION: 65546 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

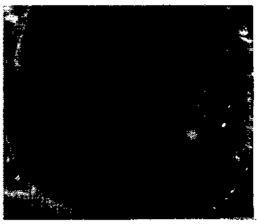


FIGURE 1. Sample is about 1 cm. across. S-72-43351.

## 65547 VERY FRIABLE, POLYMICT BRECCIA 1.59 g

INTRODUCTION: 65547 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 1 cm. across. S-72-43351.

## 65548 VERY FRIABLE, POLYMICT BRECCIA 3.02 g

INTRODUCTION: 65548 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 1 cm. across. S-72-43351.

65549 VERY FRIABLE, POLYMICT BRECCIA 2.09 g

INTRODUCTION: 65549 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Sample is about 1 cm. across. S-72-43351.

## 65555 VERY FRIABLE, POLYMICT BRECCIA 2.20 g

INTRODUCTION: 65555 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.


FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65556 VERY FRIABLE, POLYMICT BRECCIA 1.17 g

INTRODUCTION: 65556 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Dish has 5 cm diameter. S-72-43352.

## 65557 VERY FRIABLE, DISAGGREGATED, POLYMICT BRECCIA 1.11 g

INTRODUCTION: 65557 is a pale brown, extremely friable rake sample (Fig. 1) that has apparently disintegrated to loose soil (Keil *et al.*, 1972).


FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

65558 VERY FRIABLE, POLYMICT BRECCIA 1.70 g

INTRODUCTION: 65558 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

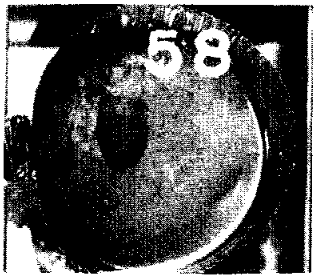



FIGURE 1. Dish has 5 cm. diameter. S-72-43341.

## 65559 VERY FRIABLE, POLYMICT BRECCIA 1.53 g

INTRODUCTION: 65559 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

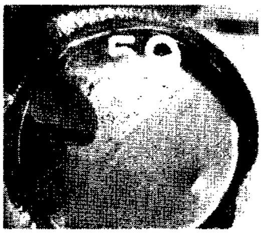


FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65565 VERY FRIABLE, POLYMICT BRECCIA 0.85 g

INTRODUCTION: 65565 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65566 VERY FRIABLE, POLYMICT BRECCIA 2.00 g

INTRODUCTION: 65566 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

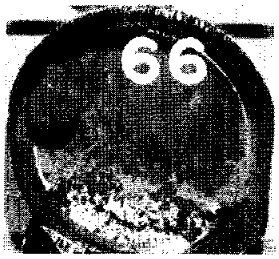



FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65567 VERY FRIABLE, POLYMICT BRECCIA 1.29 g

INTRODUCTION: 65567 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.

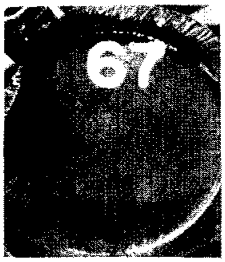



FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

65568 VERY FRIABLE, POLYMICT BRECCIA 0.81 g

INTRODUCTION: 65568 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.


FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65569 VERY FRIABLE, POLYMICT BRECCIA 0.87 g

INTRODUCTION: 65569 is a pale brown, extremely friable breccia collected as a rake sample (Fig. 1). It is rounded and probably composed of weakly lithified soil. Zap pits are absent.


FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65575 SOIL CLOD, CLAST OF POIKILITIC ROCK — 0.91 g

INTRODUCTION: 65575 is a pale brown, very friable soil clod collected as a rake sample (Fig. 1). One large clast of poikilitic impact melt was extracted and examined petrographically. Several yellow and white crystalline clasts were observed macroscopically (Keil et al., 1972). The rock is somewhat angular and lacks zap pits.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description and mineral analyses of a clast of poikilitic impact melt. Oikocrysts in this clast are up to 1 mm long and surround plagioclase and minor olivine chadacrysts (Fig. 2). Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Minor phases include ilmenite, Fe-metal (6.1-9.9% Ni, 0.4-0.5% Co) and a "K-rich phase" (10.3-12.6% $K_2O$).

CHEMISTRY: A defocussed electron beam analysis (DBA) of the poikilitic clast is given by Warner et al. (1976b) and reproduced here as Table 1. No analysis of the matrix is available.

PROCESSING AND SUBDIVISIONS: In 1973 a dark, coherent clast (,1) and a few small matrix chips (,2) were allocated to Keil for petrography.

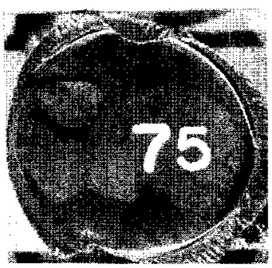



FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

FIGURE 2. 65575,4. general view of poikilitic clast, partly xpl. width 2mm.

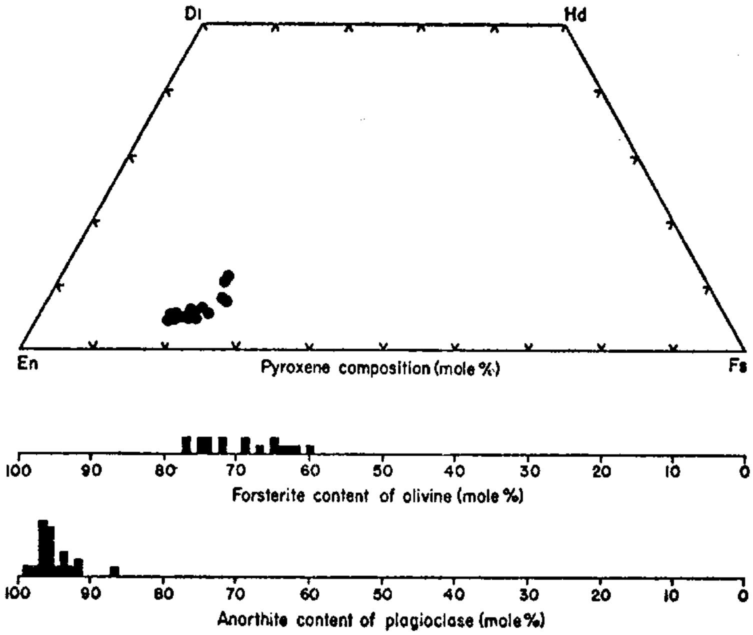



FIGURE 3. Mineral compositions of poikilitic clast; from R. Warner et al. (1976b).

TABLE 1

Chemistry of 65575 poikilitic clast (DBA)

| | |
|---|---|
| $SiO_2$ | 47.0 |
| $TiO_2$ | 0.85 |
| $Al_2O_3$ | 24.1 |
| $Cr_3O_3$ | 0.12 |
| FeO | 5.8 |
| MnO | 0.07 |
| MgO | 7.4 |
| CaO | 14.1 |
| $Na_2O$ | 0.56 |
| $K_2O$ | 0.37 |
| $P_2O_5$ | 0.26 |

## 65576 VERY FRIABLE, DISAGGREGATED, POLYMICT BRECCIA 0.91 g

INTRODUCTION: 65576 is a pale brown, extremely friable rake sample that has disintegrated to fine soil plus a few larger clods (Fig. 1).

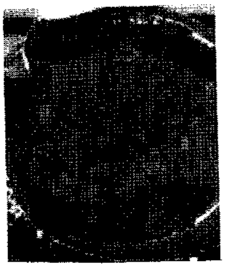


FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65577 VERY FRIABLE, DISAGGREGATED, POLYMICT BRECCIA 0.71 g

INTRODUCTION: 65577 is a pale brown, extremely friable rake sample (Fig. 1) that has apparently disintegrated to fine-grained soil (Keil *et al.*, 1972).

FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65578 VERY FRIABLE, DISAGGREGATED, POLYMICT BRECCIA 0.32 g

INTRODUCTION: 65578 is a pale brown, extremely friable rake sample (Fig. 1) that has disintegrated to a fine-grained soil (Keil *et al*., 1972).

FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

## 65579 VERY FRIABLE, DISAGGREGATED, POLYMICT BRECCIA 0.61 g

INTRODUCTION: 65579 is an extremely friable rake sample that has disintegrated to fine soil plus a few large pieces (Fig. 1). It is pale brown in color. A fragment of dark glass was observed macroscopically in one clod (Keil et al., 1972).

FIGURE 1. Dish has 5 cm. diameter. S-72-43352.

INTRODUCTION: 65585 is a yellow-green, coherent glass with large, inhomogeneously distributed vesicles (Fig. 1). It is a rake sample.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description. This fragment of highly vesicular, flow-banded glass contains several small mineral and lithic clasts (Fig. 2). One adhering fragment of clastic breccia is noted by Warner et al. (1976b).

PROCESSING AND SUBDIVISIONS: In 1973 the sample was split into two large, subequal pieces and three small chips. The three small chips (,1) were allocated to Keil for petrography. The two larger pieces remain as ,0.

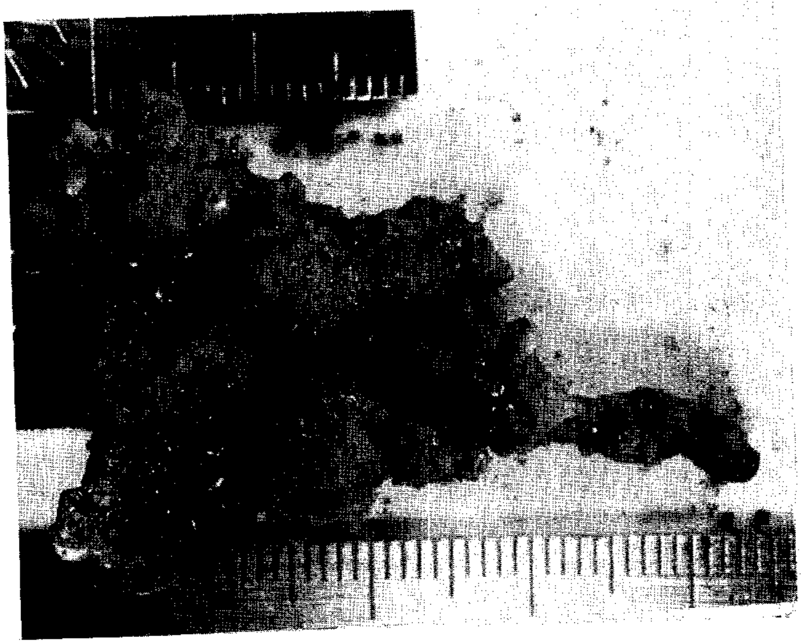


FIGURE 1. Smallest scale division is in mm.

FIGURE 2. 65585,3. general view, partly xpl. width 3 mm.

## 65586 FRAGMENTAL POLYMICT BRECCIA (REGOLITH BRECCIA?), GLASS COATED 6.76 g

INTRODUCTION: 65586 is a dark friable breccia thinly coated by coherent, vesicular glass (Fig. 1). Considerable soil adheres to the exterior surfaces of the glass and fills many vesicles. On fresh surfaces the glass is yellow green in color with streaks of white. It is a rake sample. Zap pits are absent.

FIGURE 1. Smallest scale division is in mm.

## 65587 FRAGMENTAL POLYMICT BRECCIA (REGOLITH BRECCIA), GLASS COATED 2.14 g

INTRODUCTION: 65587 is an irregular mixture of friable breccia and coherent, vesicular glass collected as a rake sample (Fig. 1). The glass appears to coat a soil clod and soil fills many vesicles in the glass. On fresh surfaces the soil is yellow green with streaks of white.

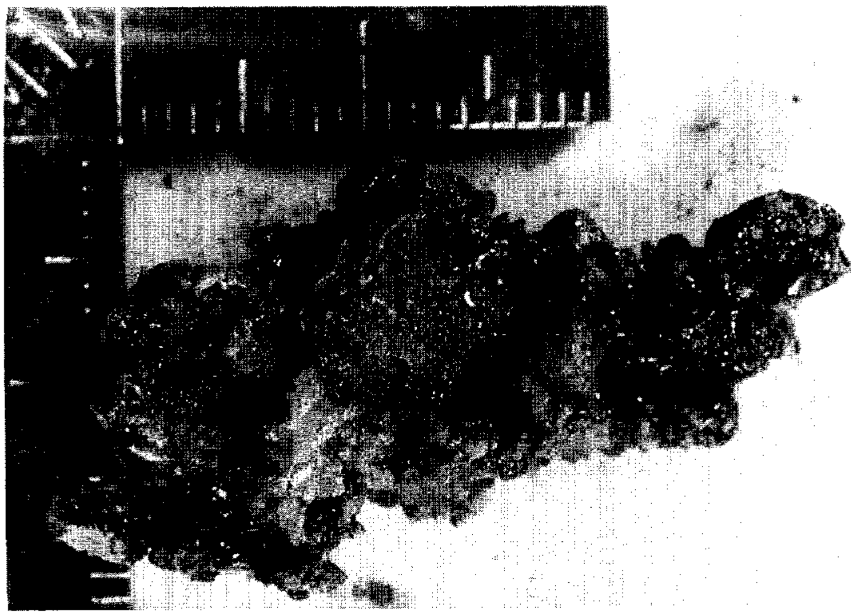


FIGURE 1. Smallest scale division is in mm.

65588 FRIABLE POLYMICT BRECCIA 9.63 g

INTRODUCTION: 65588 is a pale brown, friable breccia collected as a rake sample (Fig. 1). It is subangular and devoid of zap pits.

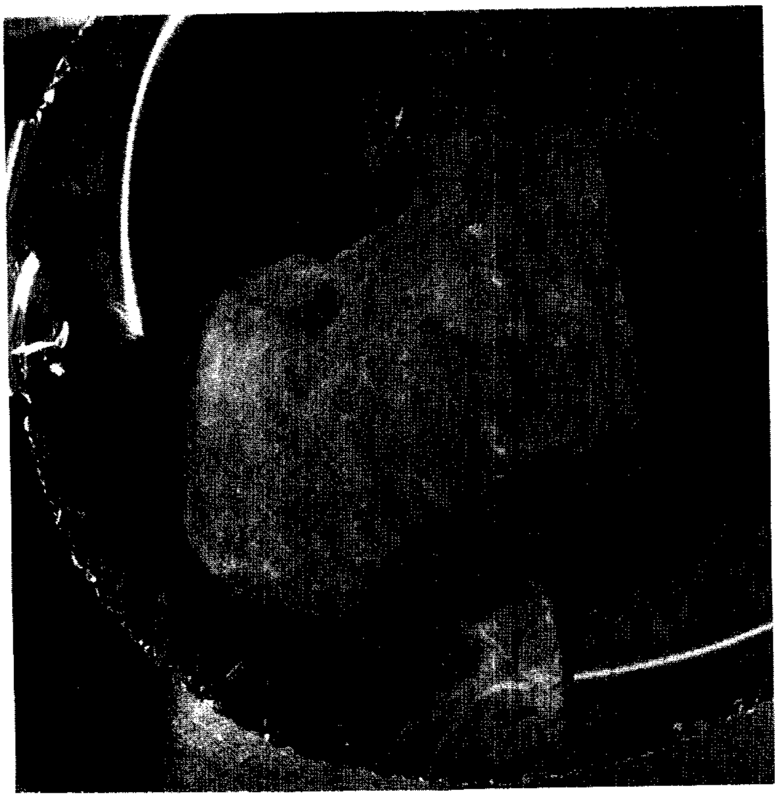


FIGURE 1. Sample is about 3 cm. long. S-72-43353.

INTRODUCTION: 65715 is a friable, light gray, clastic breccia with a diverse clast population (Fig. 1). It is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are rare or absent.

PETROLOGY: 65715 is a polymict, clastic breccia with many different clast types in a porous matrix of finely comminuted mineral and glass fragments (Fig. 2). Lithic clasts include cataclastic and granoblastic anorthosite, basaltic impact melt, coarse-grained and fine-grained poikilitic impact melt, glassy breccia and annealed, granoblastic breccia (Fig. 2). Plagioclase dominates the mineral clast population with lesser amounts of mafic silicates, Fe-metal and ilmenite.

PROCESSING AND SUBDIVISIONS: In 1979 a bulk rock chip (,1) and several separated clasts (,2) were made into thin sections.

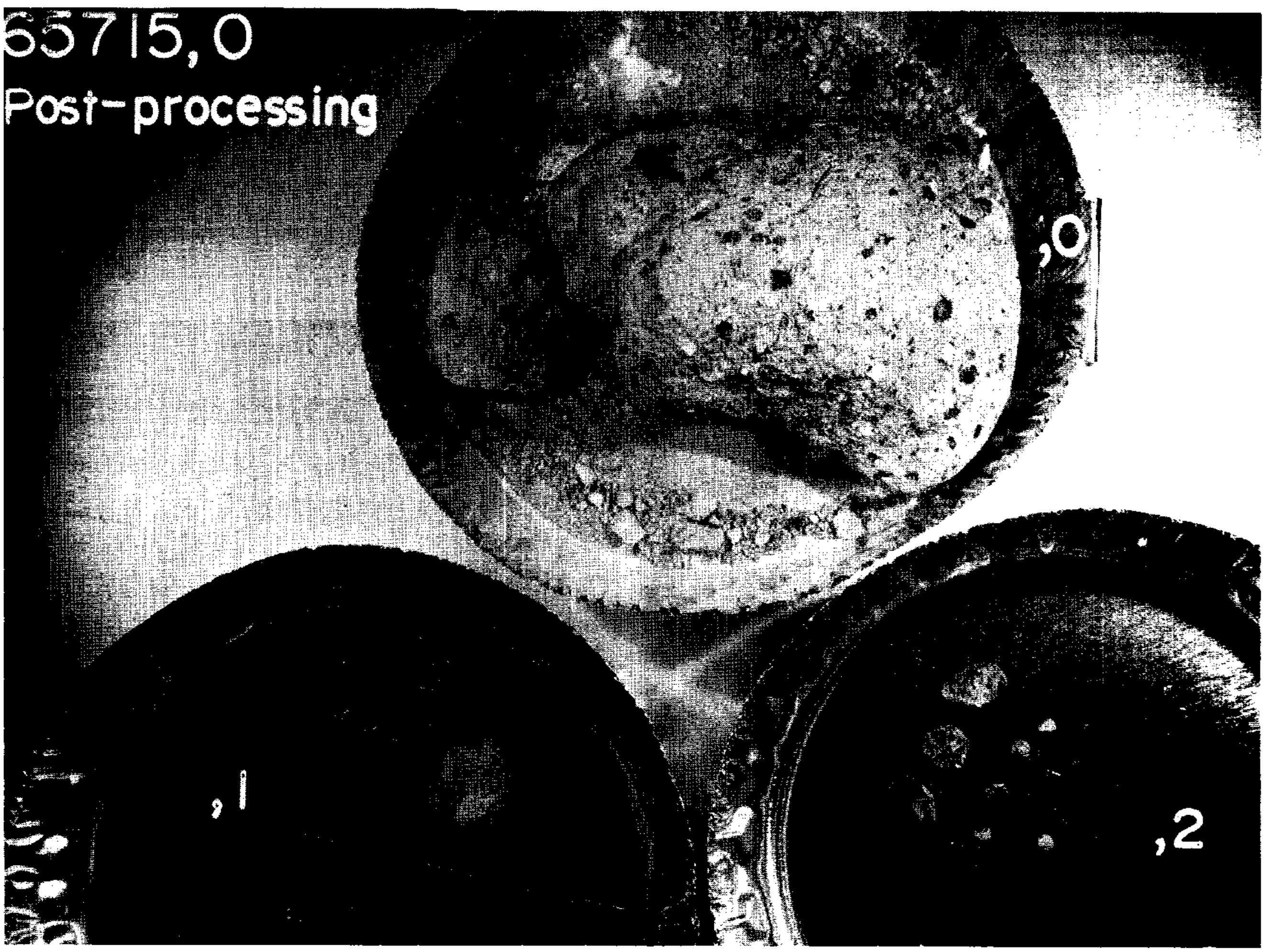



FIGURE 1. S-79-40517.

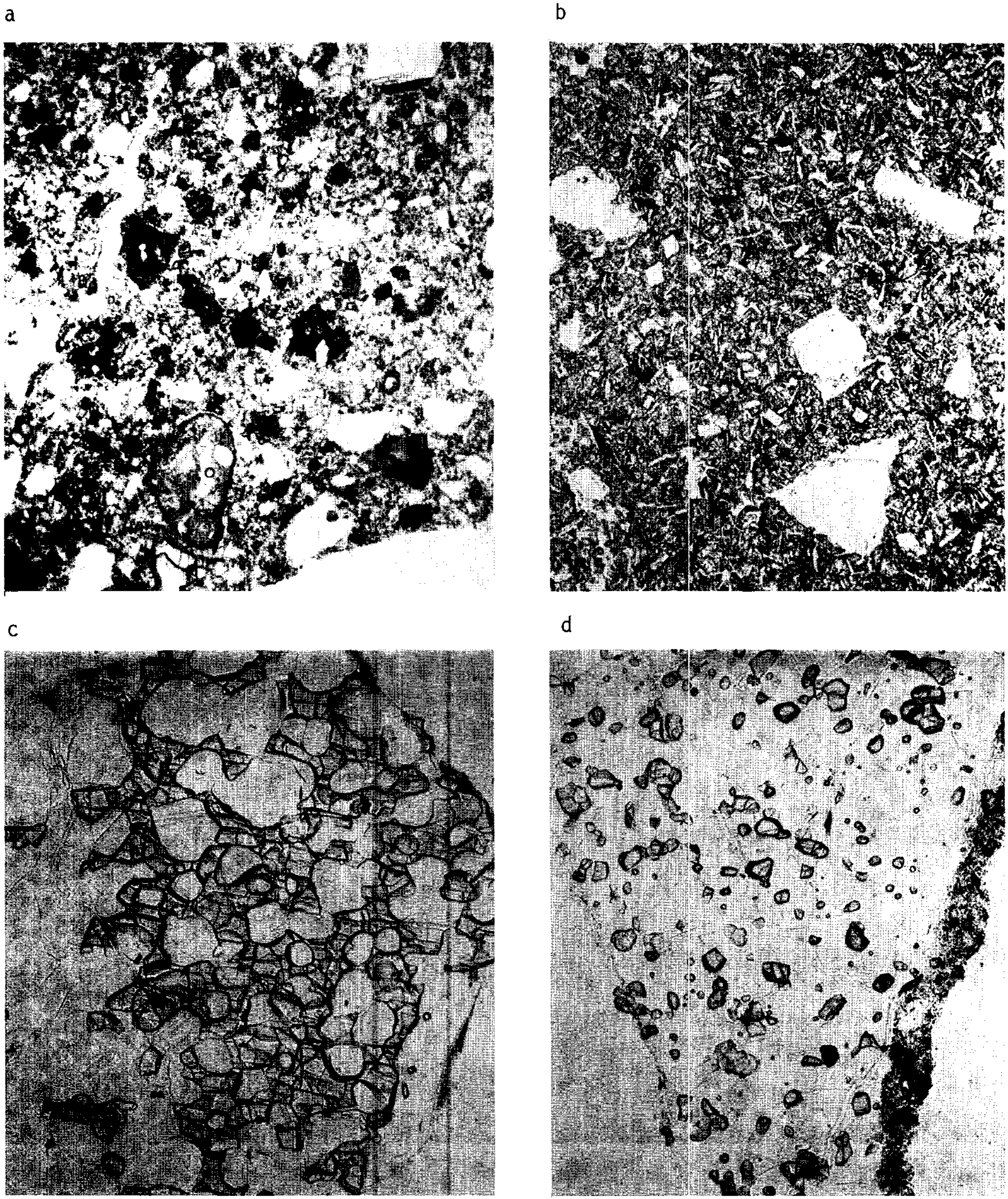


FIGURE 2. a) 65715,5. general matrix, ppl. width 2mm.
b) 65715,7. basaltic impact melt clast, ppl. width 1mm.
c) 65715,6. poikiloblastic clast, ppl. width 1mm.
d) 65715,6. granoblastic clast, ppl. width 1mm.

INTRODUCTION: 65716 is a light gray, friable breccia collected as a rake sample (Fig. 1). Clasts include white, anorthositic material (∿1 mm), light gray, crystalline fragments (∿0.5 mm) and dark gray, glassy fragments (∿0.5 mm) in approximately equal amounts. It is rounded with few zap pits.

FIGURE 1. Small scale division in mm.

PROCESSING AND SUBDIVISIONS: This rock consists of a large piece shown in Figure 1 and two smaller pieces ∿ 0.8 cm in diameter which were grouped together as 65716,0 during initial processing in 1972.

INTRODUCTION: 65717 is a light gray, friable breccia collected as a rake sample (Fig. 1). It is covered with adhering dust making macroscopic identification difficult. Color photos show one large lithic fragment (~8 mm) possibly with a considerable amount of a yellow mafic(?) mineral; smaller gray clasts and white clasts (~1 mm) are abundant. The rock is subrounded with rare zap pits.

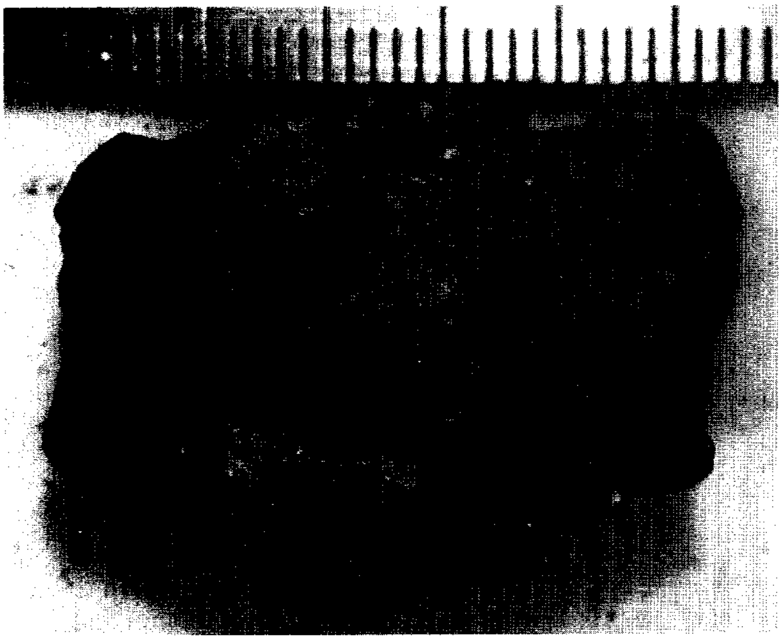


FIGURE 1. Small scale division in mm.

INTRODUCTION: 65718 is a light gray, friable breccia collected as a rake sample (Fig. 1). White, anorthositic clasts and gray, crystalline fragments are present. It is subrounded with rare zap pits.

FIGURE 1. Small scale division in mm.

INTRODUCTION: 65719 is a light gray, friable breccia collected as a rake sample (Fig. 1). Gray, crystalline clasts (∿2 mm), white, anorthositic fragments and rare yellow grains (∿0.5 mm) are present. It is subrounded with rare zap pits.

FIGURE 1. Small scale division in mm.

INTRODUCTION: 65725 is a light gray, friable breccia collected as a rake sample (Fig. 1). Gray, crystalline clasts (up to 5 mm) and a subordinate amount of white, anorthositic fragments are abundant. It is subangular with rare zap pits.

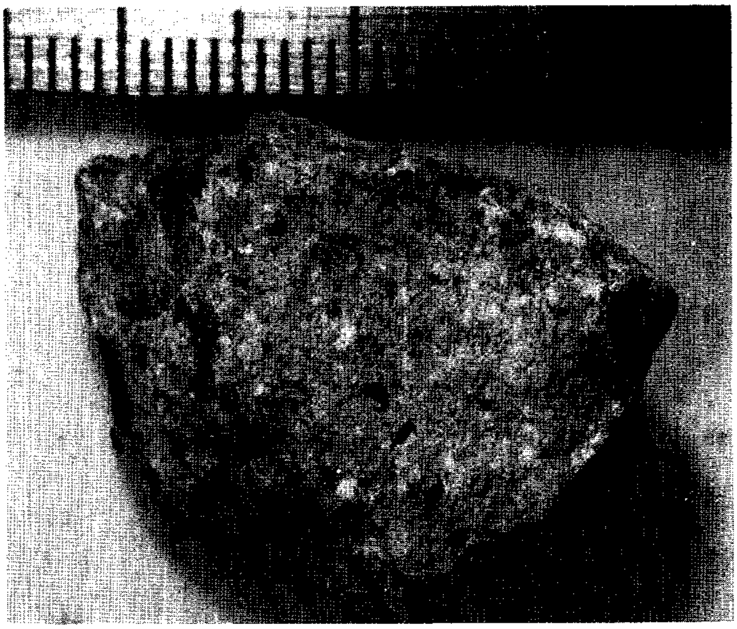


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65726 is a light gray, friable breccia collected as a rake sample (Fig. 1). Medium and dark gray crystalline clasts (up to ~5 mm) and a subordinate amount of white, anorthositic clasts are abundant. It is subrounded with a few zap pits.

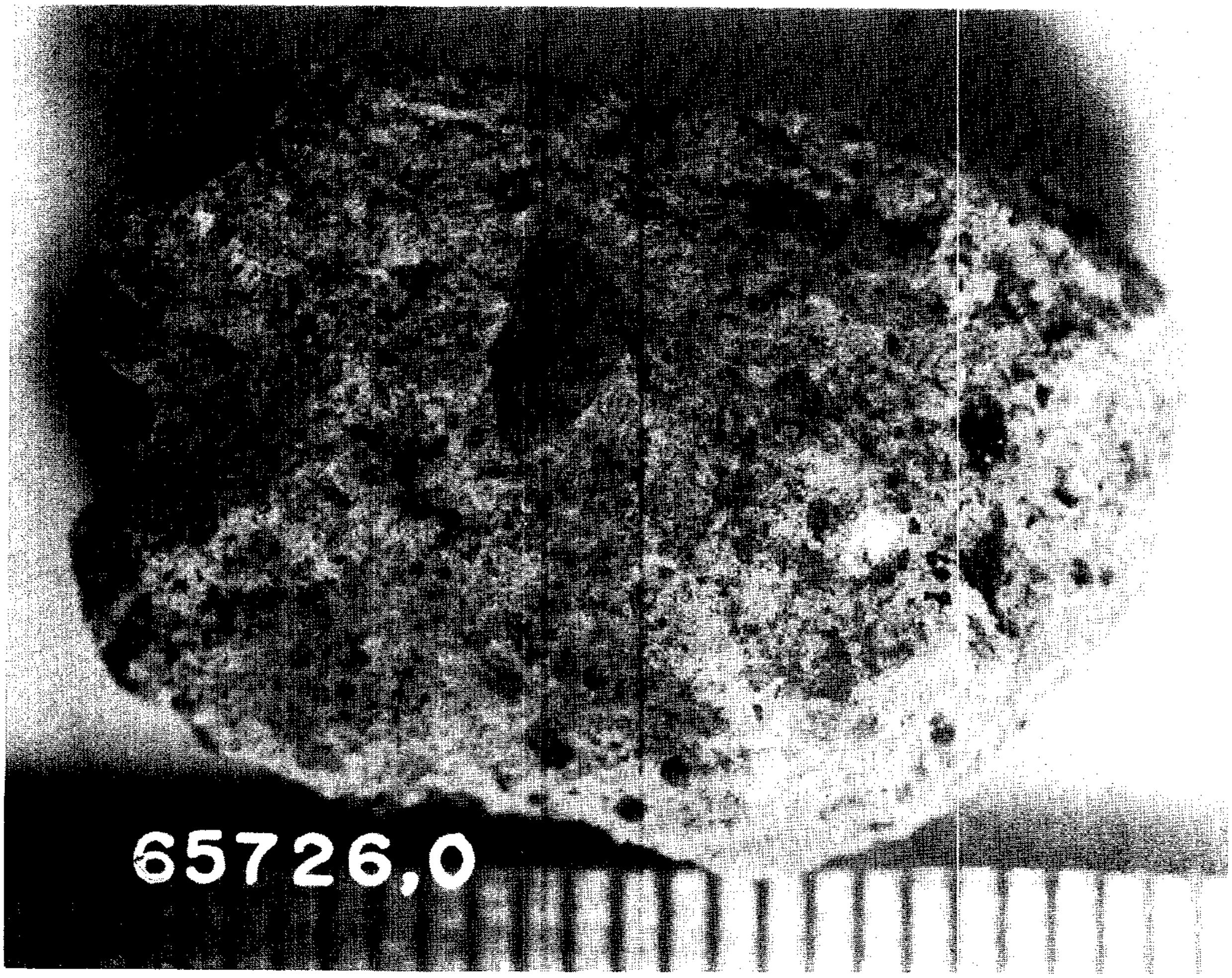



FIGURE 1. Smallest scale division in mm. S-72-47684.

INTRODUCTION: 65727 is a light gray, friable breccia collected as a rake sample (Fig. 1). A few large (up to 5 mm), gray, crystalline clasts and smaller, white, anorthositic clasts are present. It is subrounded with a few zap pits.

PROCESSING AND SUBDIVISIONS: This rock consists of the piece shown in Figure 1 and a smaller piece ~0.4 cm in diameter which were grouped as 65727,0 during initial processing in 1972.

FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65728 is a light gray, friable breccia (Fig. 1). Zap pits are very rare. One blue-green clast, one clear, dark red clast and two small, orange-pink clasts were observed macroscopically (Keil *et al*., 1972). This rock is a rake sample.

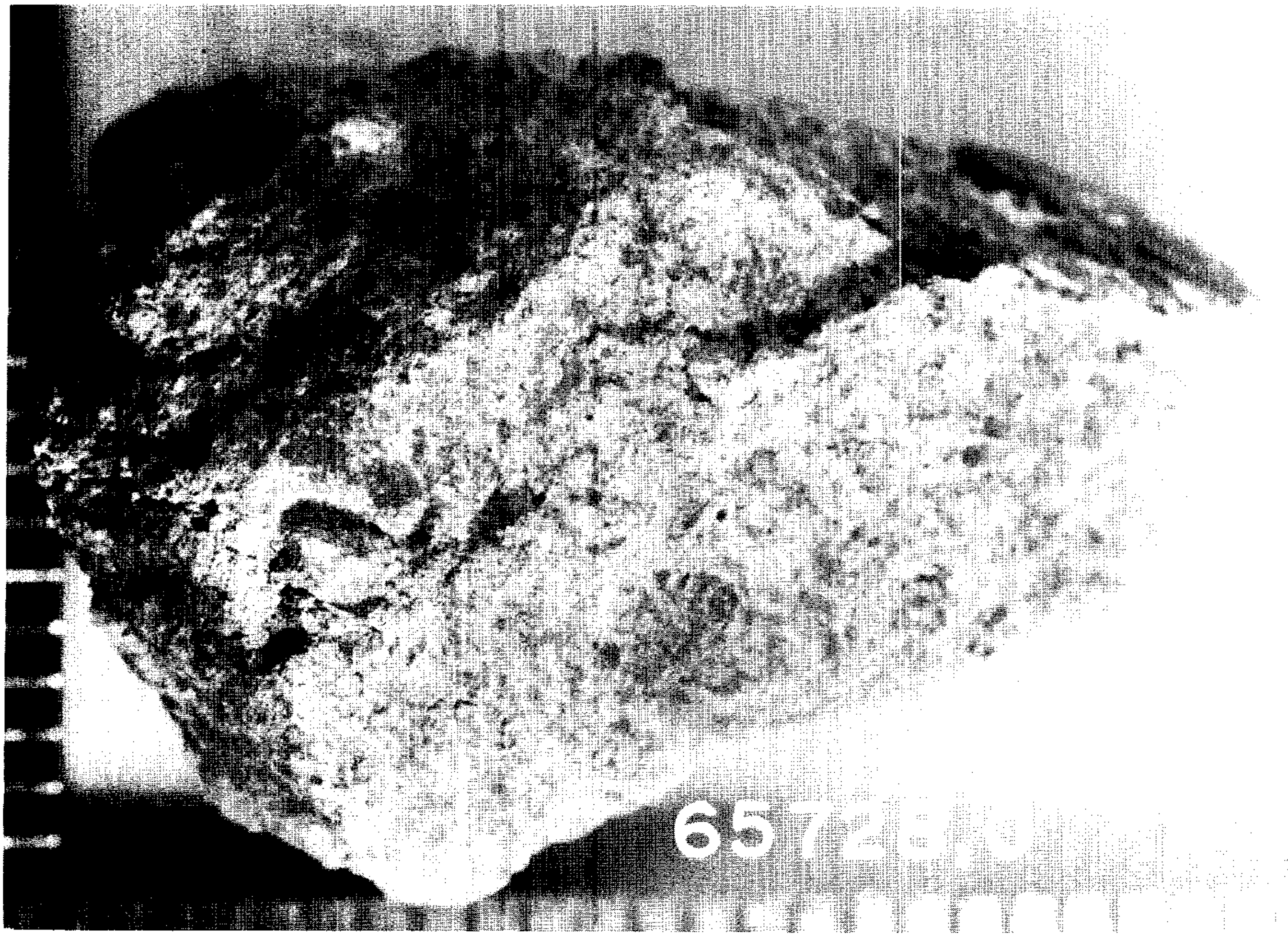



FIGURE 1. Smallest scale division in mm. S-72-47681.

PETROLOGY: A brief petrographic description is given by Warner *et al*. (1976b). 65728 is a clastic breccia composed of a heterogeneous mixture of mineral, lithic and glass fragments (Fig. 2). Lithic clasts include mesostasis-rich basaltic impact melt, granoblastic anorthositic fragments, a variety of breccias and a few "chondrules".

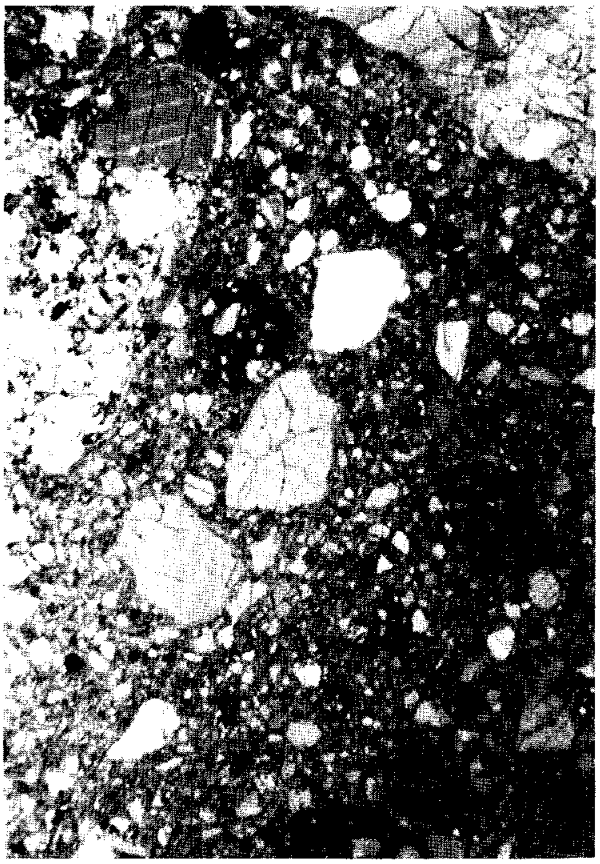


FIGURE 2. 65728,4. general view, partly xpl. width 2mm.

PROCESSING AND SUBDIVISIONS: In 1973 two chips were removed from the rock and one of these (,1) allocated to Keil for petrography.

INTRODUCTION: 65729 is a light gray, friable breccia collected as a rake sample (Fig. 1). Small clasts of gray crystalline rock and white, anorthositic material are abundant. It is subrounded with a few zap pits.

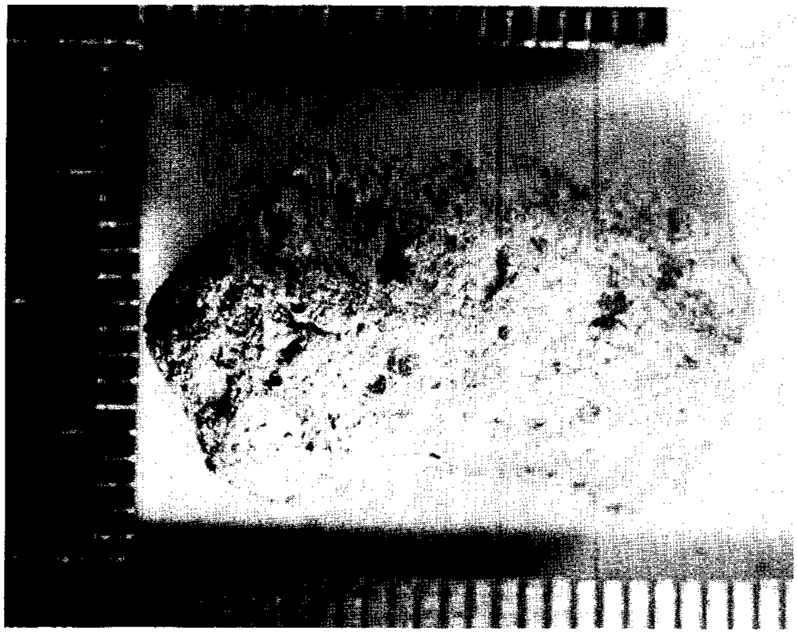


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65735 is a light gray, friable breccia collected as a rake sample (Fig. 1). Clasts of gray, crystalline rock (∿1 mm), white, anorthositic material (∿1 mm) and rare fragments of a yellow mafic(?) silicate (up to 3 mm) are present. It is subangular with few zap pits.

PROCESSING AND SUBDIVISIONS: During initial processing and macroscopic examination in 1972, this rock fell into two subequal pieces (Fig. 1). Both are grouped as 65735,0.

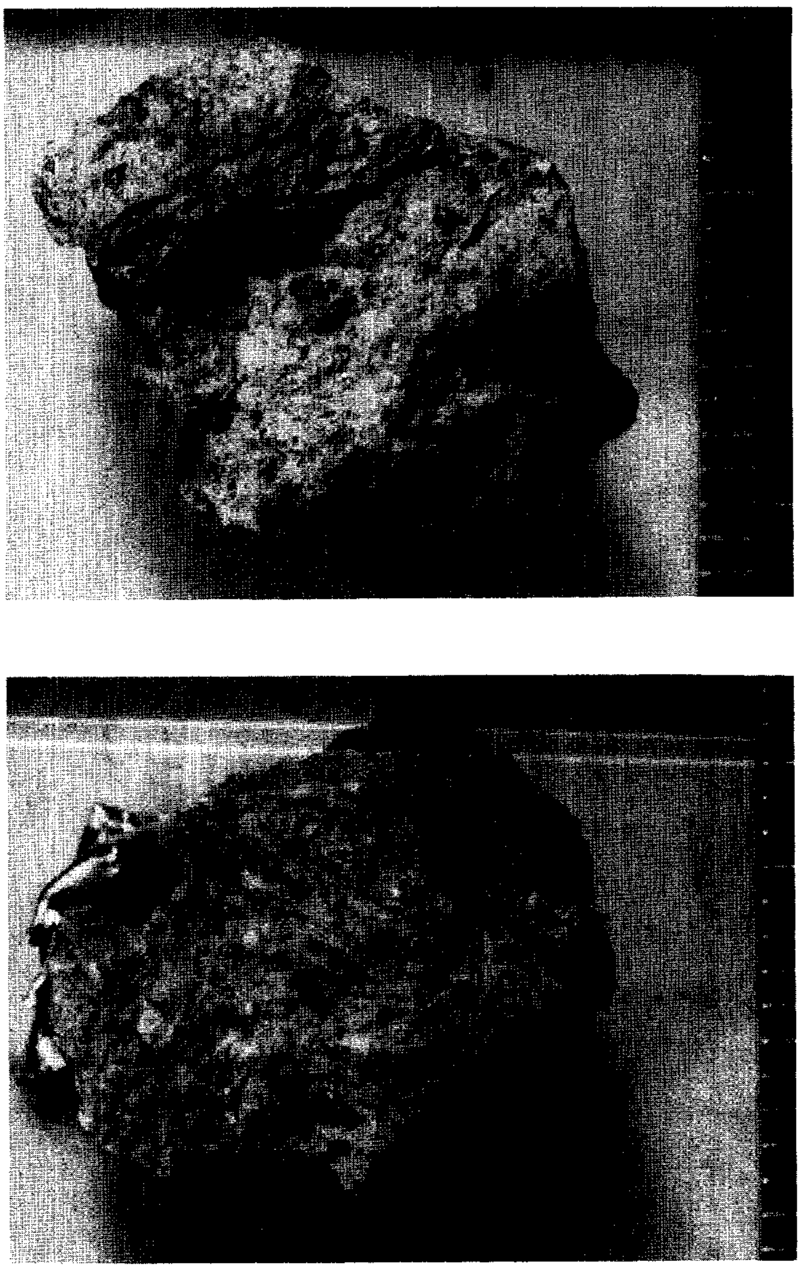


FIGURE 1. Smallest scale division in mm. Photos are of two separate pieces.

INTRODUCTION: 65736 is a light gray, friable breccia collected as a rake sample (Fig.1). Clasts of gray, crystalline rock (up to 5 mm) and white, anorthositic material are abundant. It is subangular with abundant patina and rare zap pits.

PROCESSING AND SUBDIVISIONS: This rock consists of the piece shown in Figure 1 and two smaller pieces (~0.3 and 0.15 cm in diameter) which apparently fell off during initial processing and macroscopic examination in 1972. No photo-documentation of the smaller pieces is available. All of the rock is grouped as 65736,0.

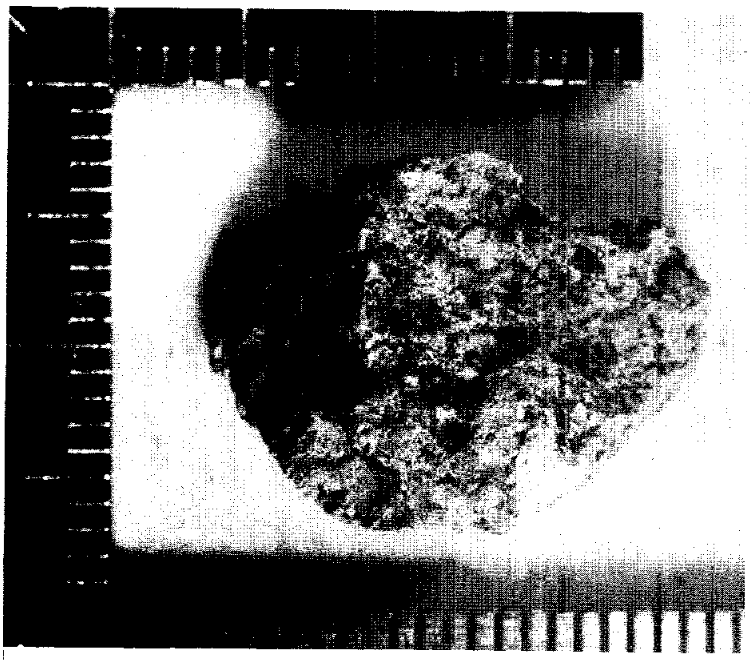


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65737 is a light gray, friable breccia collected as a rake sample (Fig. 1). Gray, crystalline clasts (up to 3 mm) and white, anorthositic clasts (up to 3 mm) are abundant. It is subrounded with a few zap pits.

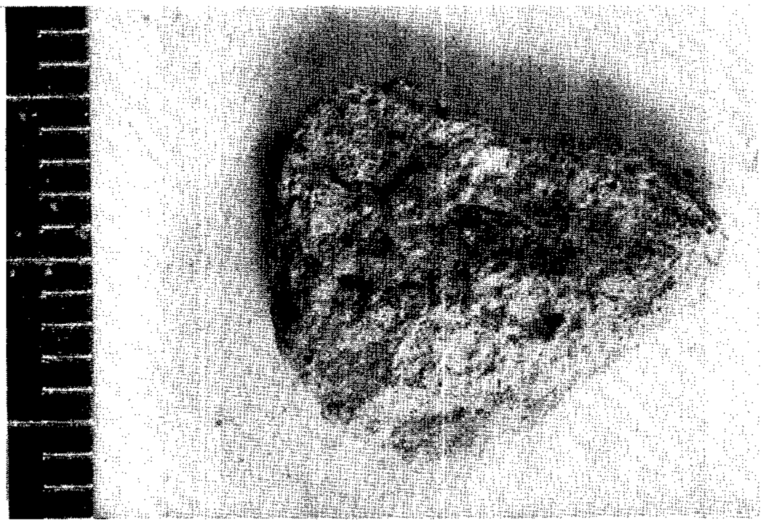


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65738 is a light gray, friable breccia collected as a rake sample (Fig. 1). Clasts of white, anorthositic rock (up to 4 mm) and gray, crystalline rock (∿1 mm) are abundant. It is subangular with rare zap pits.

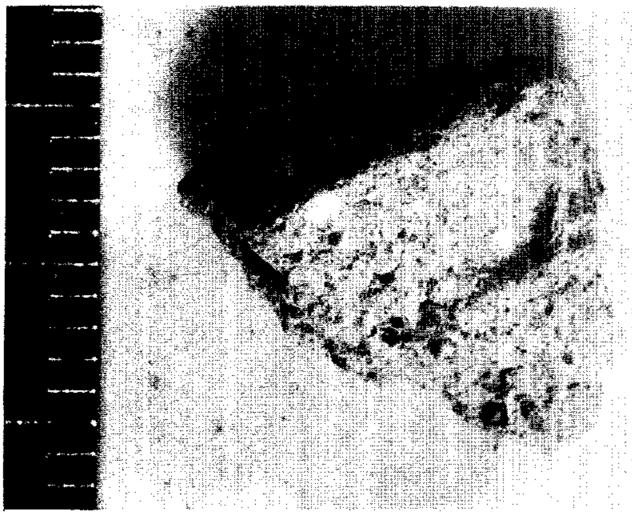


FIGURE 1. Smallest scale division in mm.

## 65739 FRAGMENTAL POLYMICT BRECCIA 0.95 g

INTRODUCTION: 65739 is a light gray, friable breccia collected as a rake sample (Fig. 1). Clasts of gray, crystalline rock (~1 mm) and white, anorthositic material (~1 mm) are abundant. It is subangular with a heavy coat of patina and a few zap pits.

FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65745 is a brownish gray, friable breccia (Fig. 1). Glass in its clast population indicates that it may be a regolith breccia. It is a rake sample and few, if any, zap pits occur on its powdery surface.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description. 65745 is a fragmental breccia composed of mineral, lithic and glass fragments (Fig. 2). Lithic clasts include numerous fine-grained breccias, a vesicular glass fragment with plagioclase xenocrysts and a large shard of clear glass with cryptocrystalline patches.

PROCESSING AND SUBDIVISIONS: In 1973 a single chip was removed (,1) and allocated to Keil for petrography.

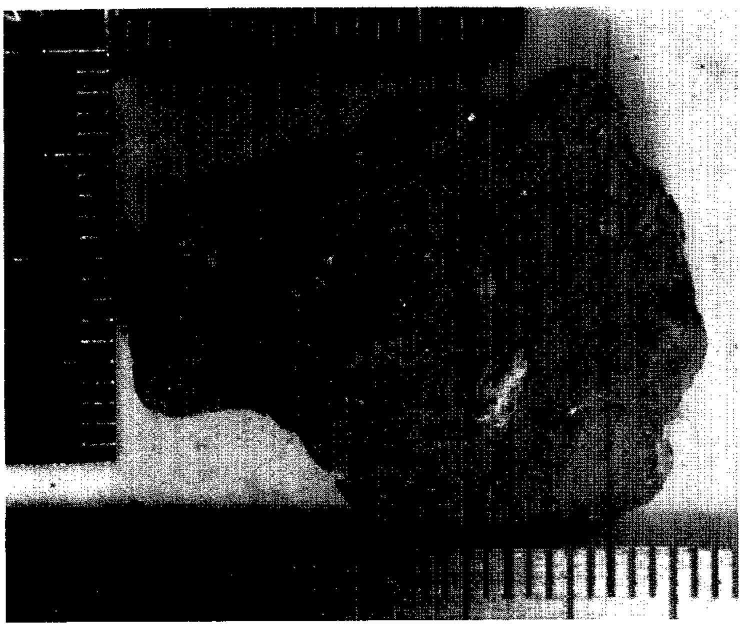


FIGURE 1. Smallest scale division in mm.

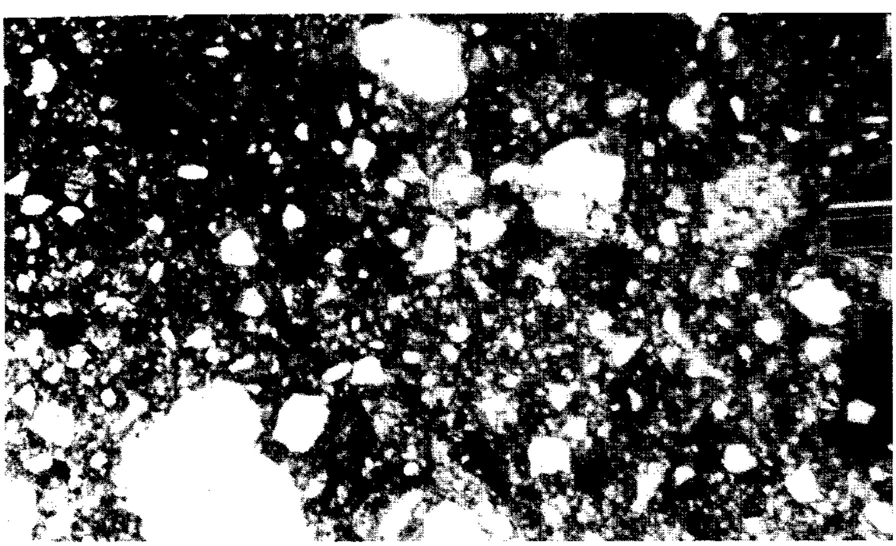


FIGURE 2. 65745,3. general view, partly xpl. width 3mm.

INTRODUCTION: 65746 is a brownish-gray, friable breccia (Fig. 1). Glass in its clast population indicates that it is probably a regolith breccia. It is a rake sample with few, if any, zap pits on its powdery surface.

FIGURE 1. Smallest scale division in mm. S-72-47691.

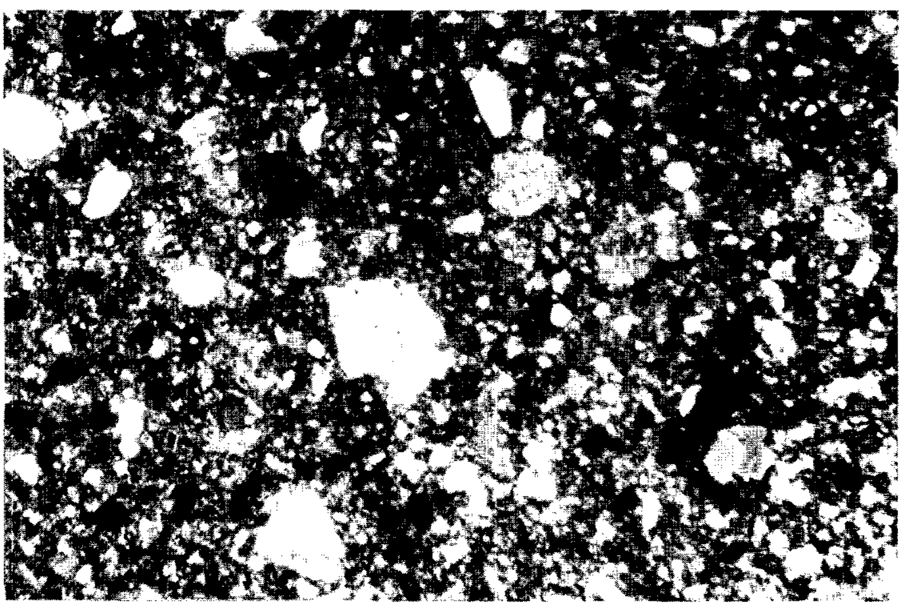


FIGURE 2. 65746,3. general view, partly xpl. width 3mm.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description. 65746 is a clastic breccia composed of mineral, lithic and glass fragments (Fig.2). Fine-grained breccia clasts are abundant. Several orange and pale yellow glass fragments are noted by Warner et al. (1976b).

PROCESSING AND SUBDIVISIONS: In 1973 three chips were removed and one of these (,1) allocated to Keil for petrography.

INTRODUCTION: 65747 is a pale brown, friable breccia collected as a rake sample (Fig. 1). Abundant clasts of white, anorthositic material (∿0.8 mm) and gray, crystalline rock (∿1 mm) and a few grains of a yellow mafic silicate rest in a very fine-grained matrix. It is rounded with few zap pits.

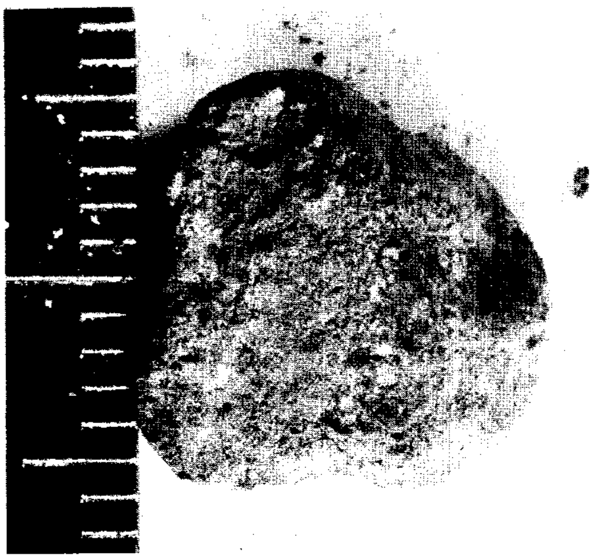


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65748 is a light brownish gray, friable breccia collected as a rake sample (Fig. 1). White, anorthositic clasts and gray, crystalline fragments are common. It is subrounded with rare zap pits.

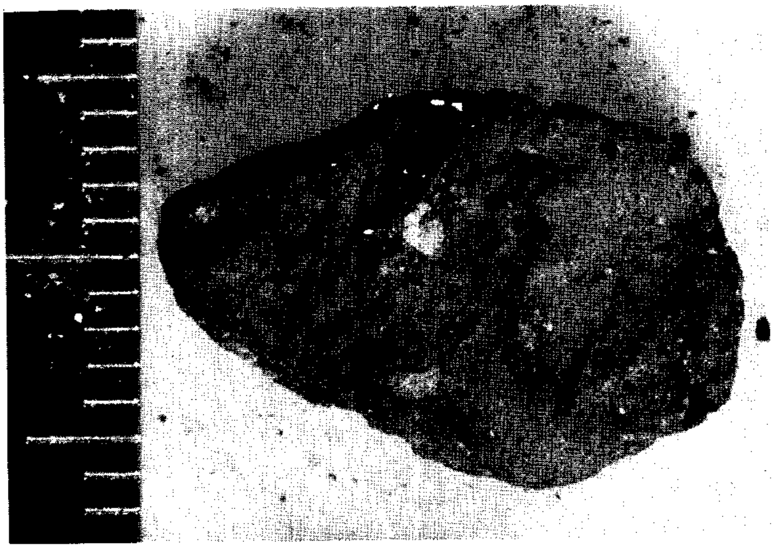


FIGURE 1. Smallest scale division in mm.

## 65749 FRAGMENTAL POLYMICT BRECCIA (REGOLITH BRECCIA ?) 0.95 g

INTRODUCTION: 65749 is a light brownish gray, friable breccia collected as a rake sample (Fig. 1). Small clasts of white, anorthositic material and gray, crystalline rock are scattered through the rock. It is subangular with rare zap pits.

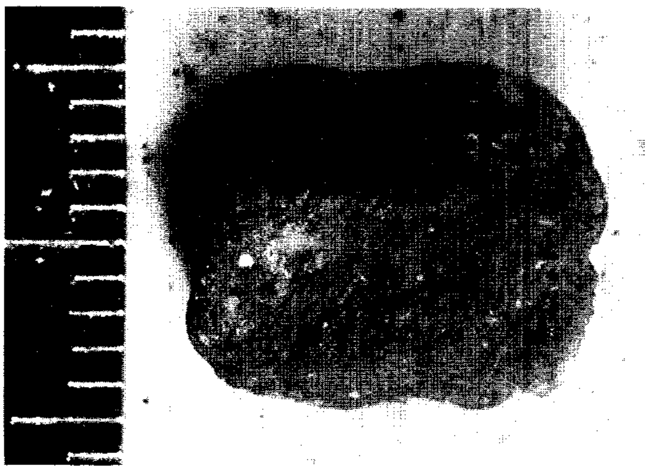


FIGURE 1. Smallest scale division in mm.

## 65755 GLASSY IMPACT MELT(?) OR REGOLITH BRECCIA(?) 1.42 g

INTRODUCTION: 65755 is a brownish gray, friable breccia with abundant white clasts and at least one glass spherule (Fig.1). Macroscopically this rock appears to be a typical clastic soil clod, but thin sections reveal a considerable amount of continuous glassy matrix. It is a rake sample and lacks zap pits.

PETROLOGY: Warner et al. (1976b) provide a brief petrographic description. Lithic and mineral fragments rest in a dark matrix which grades from cryptocrystalline to clear glass (Fig.2). Lithic clasts include several fragments of basaltic impact melt, various breccias and cataclastic anorthosites. All clasts show some evidence of assimilation by the melt matrix.

PROCESSING AND SUBDIVISIONS: In 1973 a single chip (,1) was taken for thin sections.

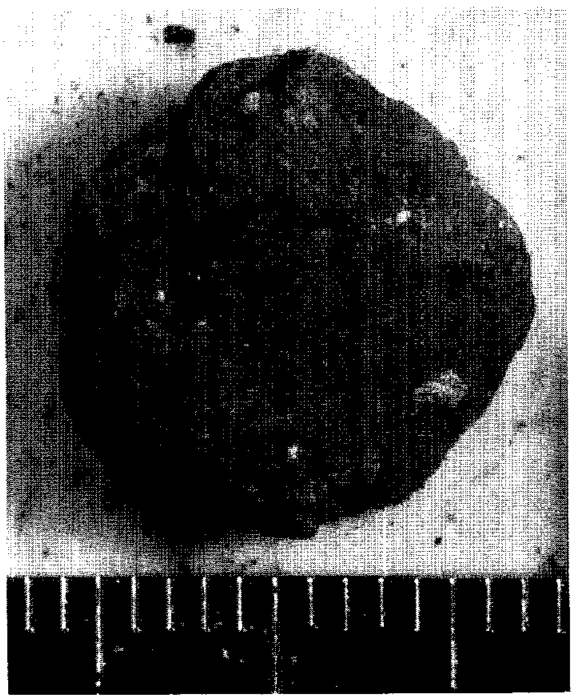


FIGURE 1. Smallest scale divisions in mm.

FIGURE 2. 65755,3. general view, partly xpl. width 2mm.

## 65756 FRAGMENTAL POLYMICT BRECCIA 0.77 g

INTRODUCTION: 65756 is a light brownish gray, friable breccia collected as a rake sample (Fig. 1). Clasts of anorthositic material with an associated yellow mafic silicate are common. The rock is subangular and devoid of zap pits.

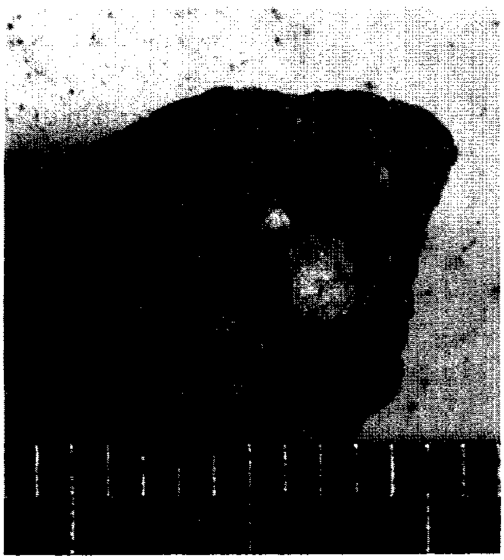


FIGURE 1. Smallest scale divisions in mm.

INTRODUCTION: 65757 is a medium gray, coherent breccia with several anorthositic clasts embedded in a matrix of very fine-grained impact melt (Fig. 1). Dark, vesicular glass coats ~10% of the surface of this rake sample, which has a few zap pits.

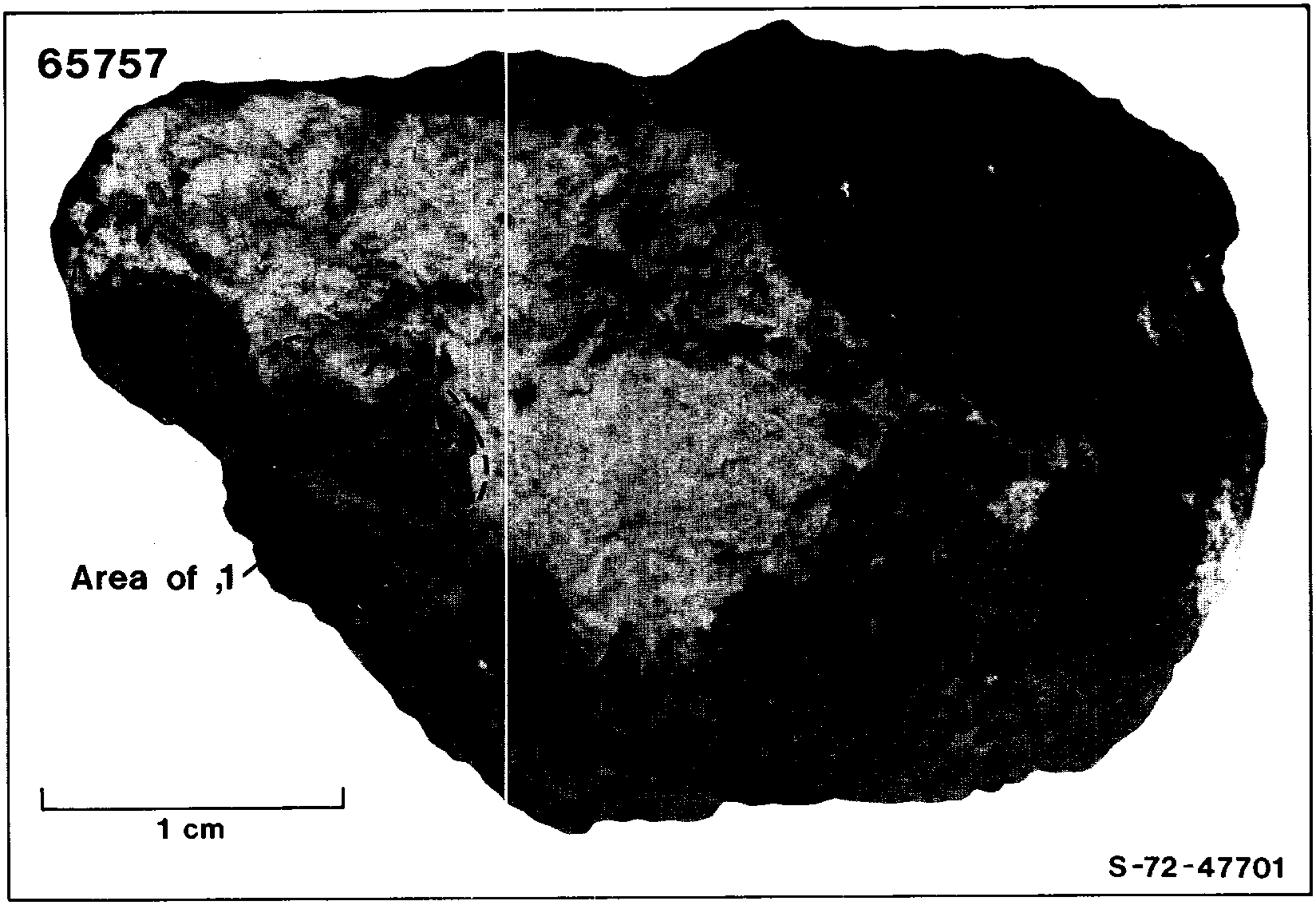



FIGURE 1.

PETROLOGY: Warner et al. (1976b) provide a petrographic description of the matrix and the large anorthosite clast seen in Figure 1. Dowty et al. (1974a) include this clast in a discussion of ferroan anorthosites.

The large white clast is a cataclastic anorthosite with moderately shocked clasts of plagioclase in a granulated matrix (Fig. 2). Pyroxene is the only mafic mineral present. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Accessory phases include spinel and Fe-metal (5.3-7.1% Ni, 0.45-0.48% Co). The metal compositions are within the "meteoritic field" and indicate that the clast is probably not chemically pristine.

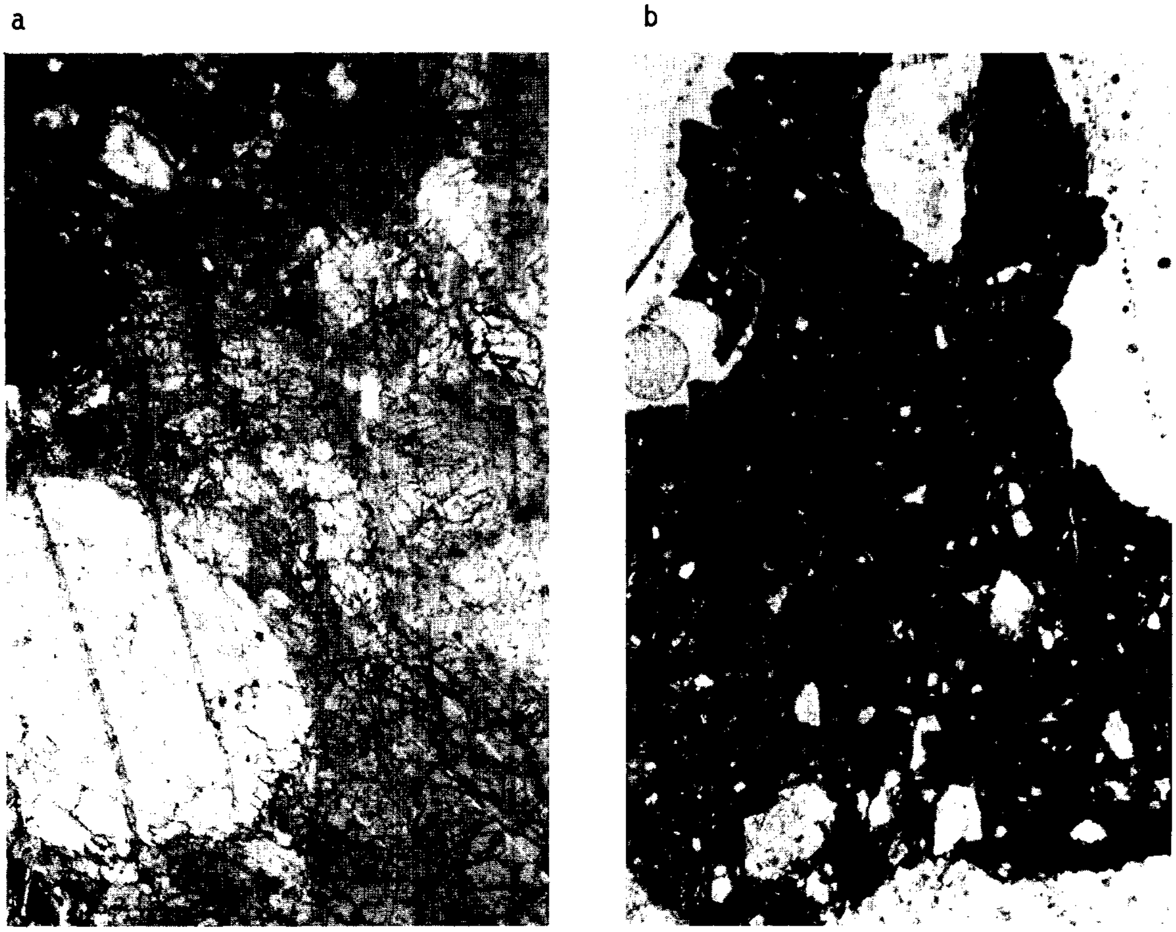



FIGURE 2. 65757,3. partly xpl. a) anorthosite clast. width 2mm. b) matrix impact melt. width 2mm.

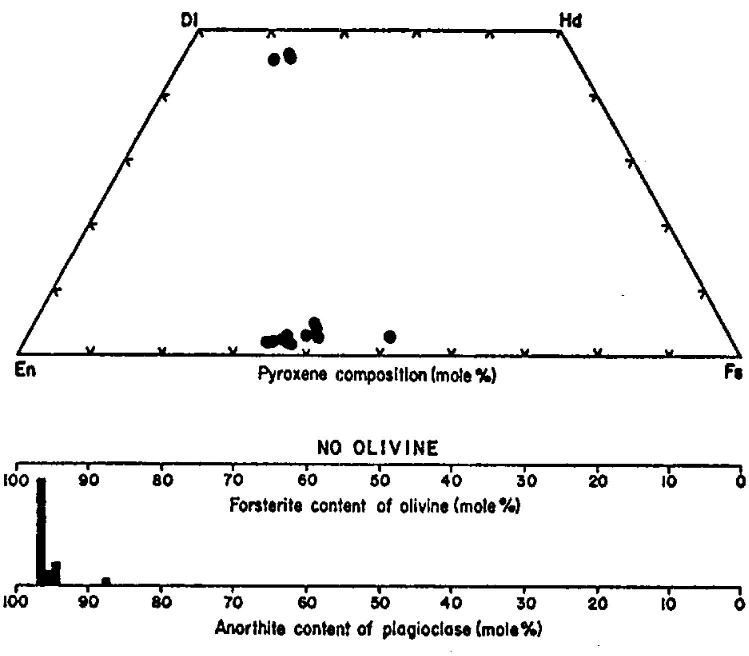



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

TABLE 1. Chemistry of 65757 anorthosite clast (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 44.4 |
| $TiO_2$ | 0.01 |
| $Al_2O_3$ | 35.1 |
| FeO | 0.50 |
| MgO | 0.39 |
| CaO | 19.1 |
| $Na_2O$ | 0.42 |
| $K_2O$ | 0.02 |
| $P_2O_5$ | 0.06 |

The <u>matrix</u> of 65757 consists of laths and tablets of plagioclase in a very fine-grained to glassy impact melt (Fig. 2). Angular clasts of plagioclase, and spinel crystals (up to 0.2 mm) are scattered through the glass.

<u>CHEMISTRY</u>: A defocussed electron beam analysis (DBA) of the cataclastic anorthosite clast is presented by Dowty *et al*. (1974a) and reproduced by Warner *et al*. (1976b) and here as Table 1.

<u>PROCESSING AND SUBDIVISIONS</u>: In 1973 a single chip was removed (,1) and allocated for Keil for petrography (Fig. 1).

## 65758 DILITHOLOGIC BRECCIA OR CRYSTALLINE POLYMICT BRECCIA 5.95 g

INTRODUCTION: 65758 is a coherent breccia apparently composed of only two lithologies: a gray, clast-laden breccia (∿25% of the rock) and a white, brecciated anorthosite (∿75% of the rock) (Fig. 1). The gray breccia is probably a very fine-grained impact melt. The surfaces of this rake sample are heavily abraded with abundant patina and a few zap pits.

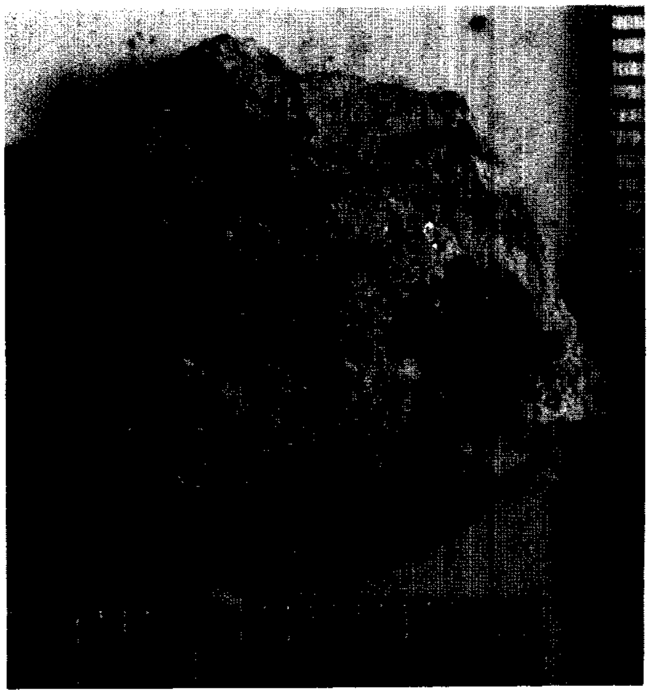


FIGURE 1. Smallest scale division in mm.

## 65759 CATACLASTIC ANORTHOSITE(?) 3.11 g

INTRODUCTION: 65759 is a very light gray, coherent anorthosite collected as a rake sample (Fig. 1). It is subangular and has a brecciated texture. Beads of splash glass and a sizable rusty patch decorate the surfaces. Zap pits are absent.

FIGURE 1. Smallest scale division in mm.

## 65765 DILITHOLOGIC BRECCIA OR MELT-COATED ANORTHOSITE 1.12 g

INTRODUCTION: 65765 is a coherent breccia apparently composed of only two lithologies: a white, brecciated anorthosite (~75% of the rock) and a dark gray, clast-laden breccia which is probably an impact melt. A thin layer of soil and glass coats one surface of the anorthosite. Zap pits are absent from this subangular rake sample.

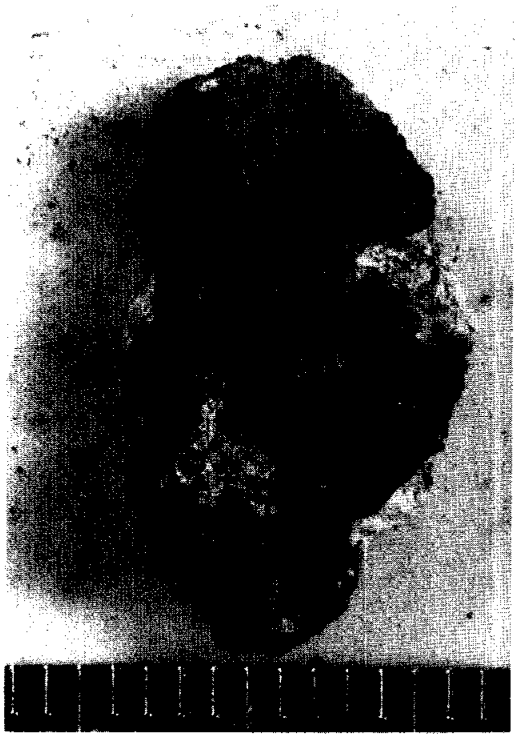


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65766 is a white to light gray, coherent anorthosite collected as a rake sample (Fig. 1). It is subangular and covered with a small amount of adhering soil. Some rust is present. Zap pits are rare.

PROCESSING AND SUBDIVISIONS: During initial processing this rock fell into two pieces. Both are grouped as ,0.

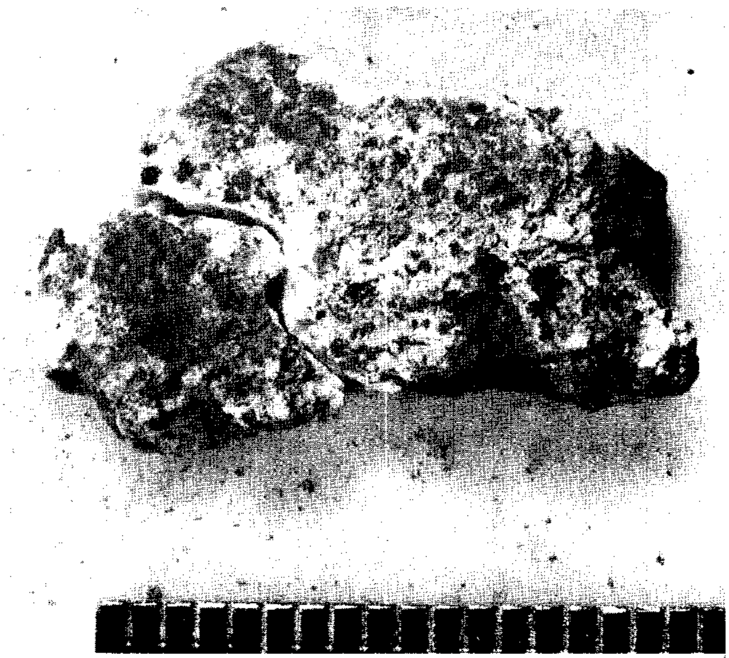


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65767 is a dark gray, coherent, vesicular glass with several large white clasts (Fig. 1), at least one of which is a ferroan anorthosite. It is a rake sample with rare zap pits.

PETROLOGY: Warner et al. (1976b) provide petrographic descriptions of the glassy matrix and an anorthosite clast. Dowty et al. (1974a) include the same clast in a discussion of ferroan anorthosites.

The anorthosite clast is a typical cataclastic and ferroan anorthosite (Fig. 2). Pyroxene is the only mafic mineral present. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976).

The matrix consists of spherulitic needles of plagioclase in abundant glass (Fig. 2). Warner et al. (1976b) mention several breccia clasts in addition to the large cataclastic anorthosite described above.

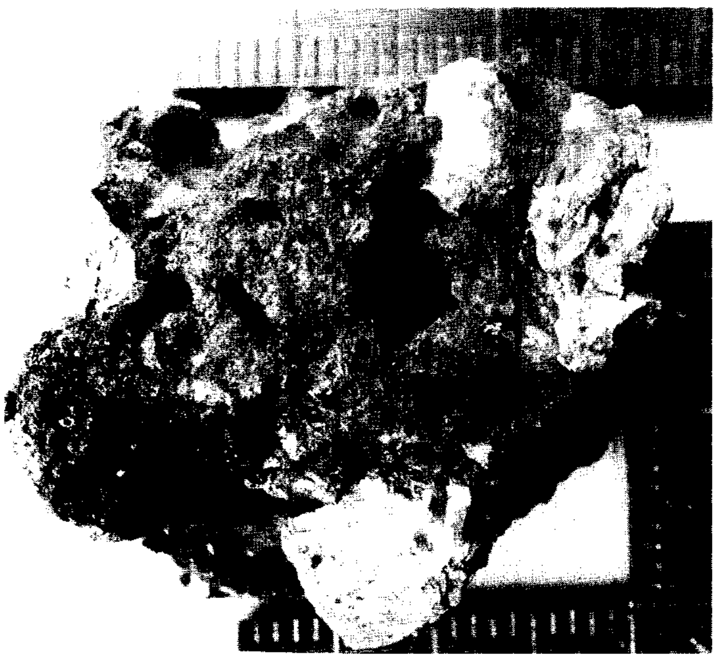


FIGURE 1. Smallest scale division in mm.

CHEMISTRY: A defocussed electron beam analysis (DBA) of the anorthosite clast is presented by Dowty et al. (1974a) and reproduced by Warner et al. (1976b) and here as Table 1. The clast is virtually pure plagioclase. No analysis of the matrix is available.

PROCESSING AND SUBDIVISIONS: In 1973 a single chip of matrix with some white clast was removed (,1) and allocated to Keil for petrography.

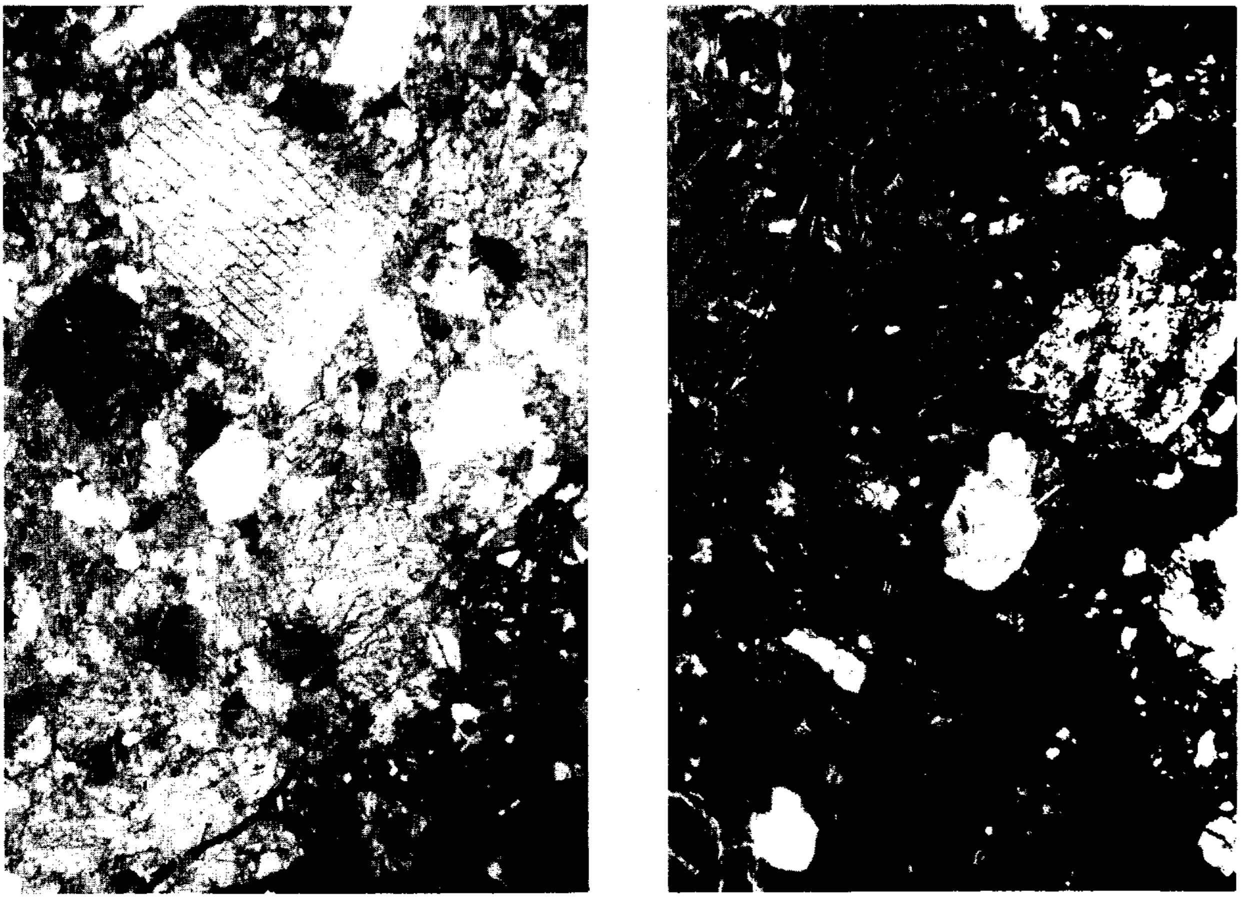


FIGURE 2. 65767,3. partly xpl. widths 2mm. a) anorthosite clast b) glassy matrix.

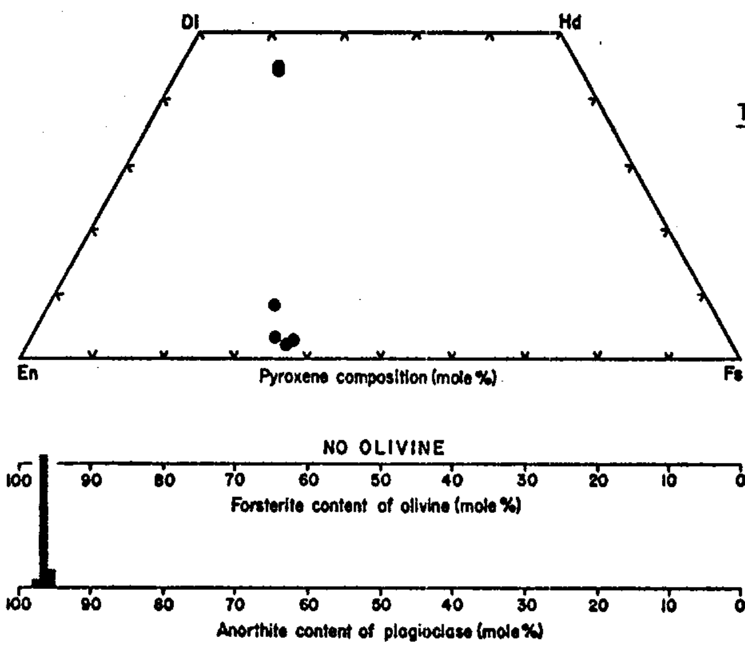



TABLE 1. Chemistry of 65767 anorthosite clast (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 44.5 |
| $TiO_2$ | 0.03 |
| $Al_2O_3$ | 35.0 |
| $Cr_2O_3$ | 0.01 |
| FeO | 0.41 |
| MnO | 0.01 |
| MgO | 0.30 |
| CaO | 19.3 |
| $Na_2O$ | 0.44 |
| $K_2O$ | 0.03 |
| $P_2O_5$ | 0.03 |

FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

INTRODUCTION: 65768 is a brownish gray, friable breccia that is ∿ 2/3 coated by a dark, vesicular glass (Fig.1). A sheared zone is present on one surface. Zap pits are absent. This rock is a rake sample from the rim of a subdued crater on the lower slope of Stone Mountain.

PETROLOGY: Warner *et al.* (1976b) provide a brief petrographic description of the glassy coat. Angular mineral and lithic fragments are suspended in abundant, glassy mesostasis (Fig.2).

PROCESSING AND SUBDIVISIONS: In 1973 a split of the glass coat (,1) was taken for thin sections (Fig.1).

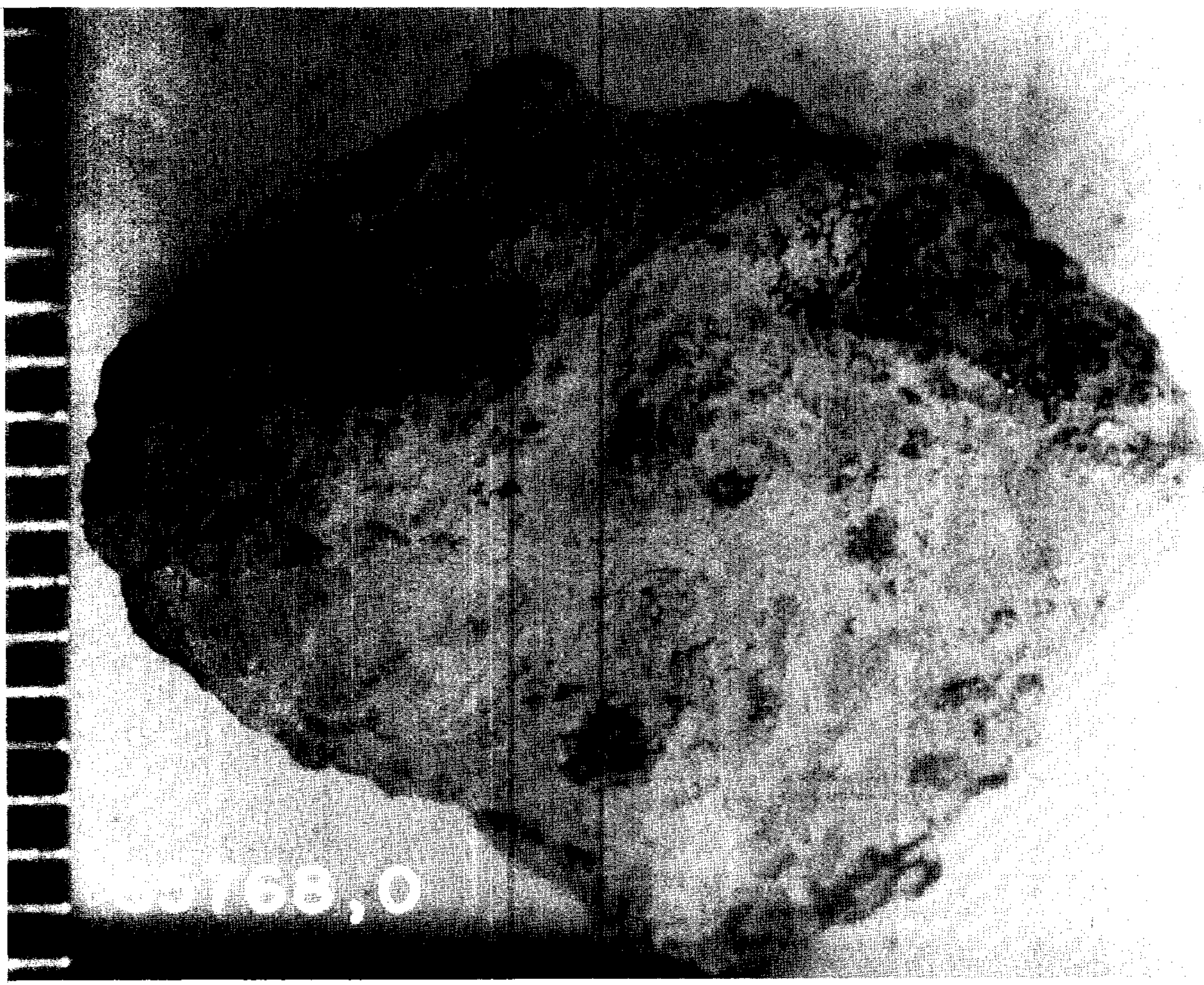



FIGURE 1. Smallest scale division in mm. S-72-48953.

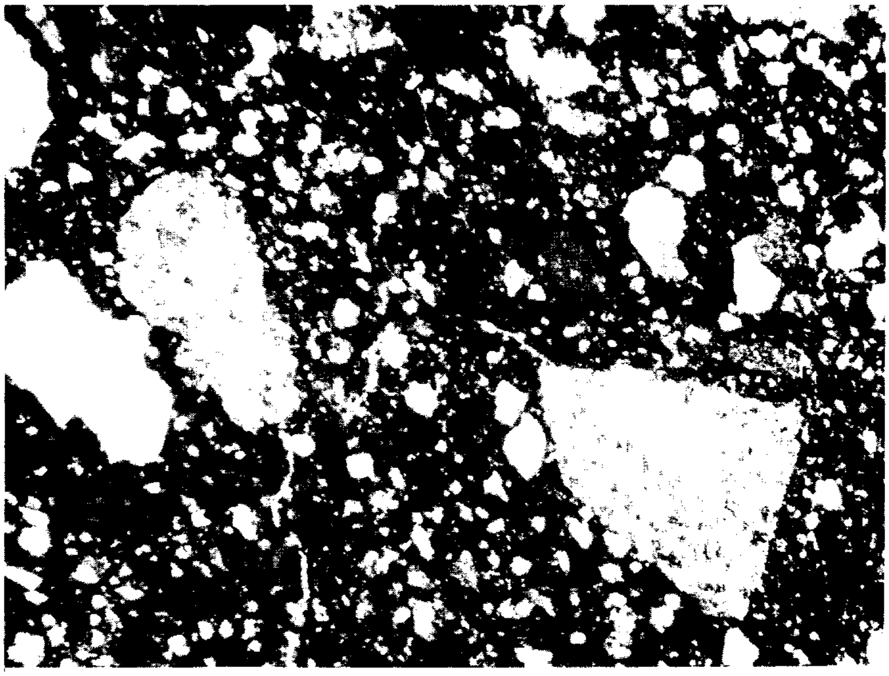


FIGURE 2. 65768,3. general view, partly xpl. width 3mm.

INTRODUCTION: 65769 is a light brownish gray, friable breccia partially coated by thin, vesicular glass (Fig. 1). The glass is gray green, contains a variety of clasts and many of its vesicles are filled with soil. The rock is subangular and devoid of zap pits. One face has a sheared appearance.

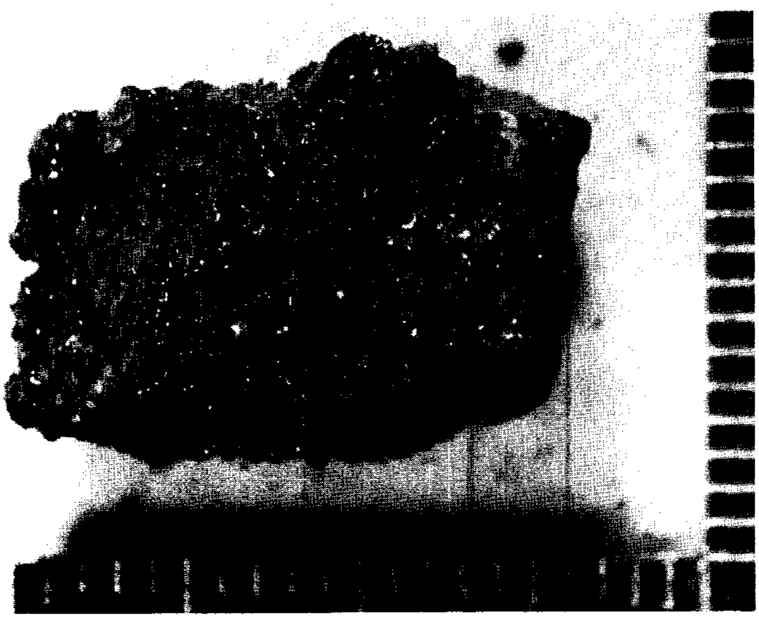


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65775 is a light brownish gray breccia of variable coherence and partially coated by vesicular glass (Fig. 1). It is a subangular rake sample, devoid of zap pits.

FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65776 is a medium gray, coherent, glassy impact melt collected as a rake sample (Fig. 1). It is blocky and irregular in shape with a very rough surface. Mineral and lithic clasts are minor constituents. Vesicles and zap pits are rare.

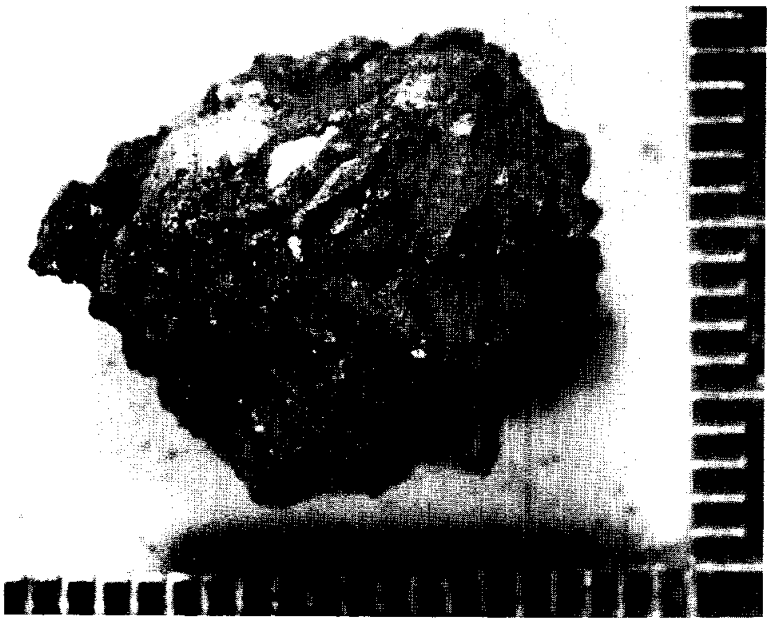


FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65777 is a light gray, coherent, poikilitic impact melt collected as a rake sample (Fig. 1). Some splash glass is present. Zap pits are rare.

PETROLOGY: A brief petrographic description and mineral compositions are given by Warner et al. (1976b). Texturally 65777 is a typical Apollo 16, fine-grained poikilitic impact melt. Oikocrysts of predominantly low-Ca pyroxene (~0.3 mm long) enclose abundant chadacrysts of plagioclase and subordinate olivine (Fig. 2). Clasts are relatively scarce. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Accessory phases include ilmenite, armalcolite, Fe-metal (4-7.7% Ni, 0.4-0.7% Co) and a "K-rich phase" (11.4-13.2% $K_2O$) (Warner et al., 1976b).

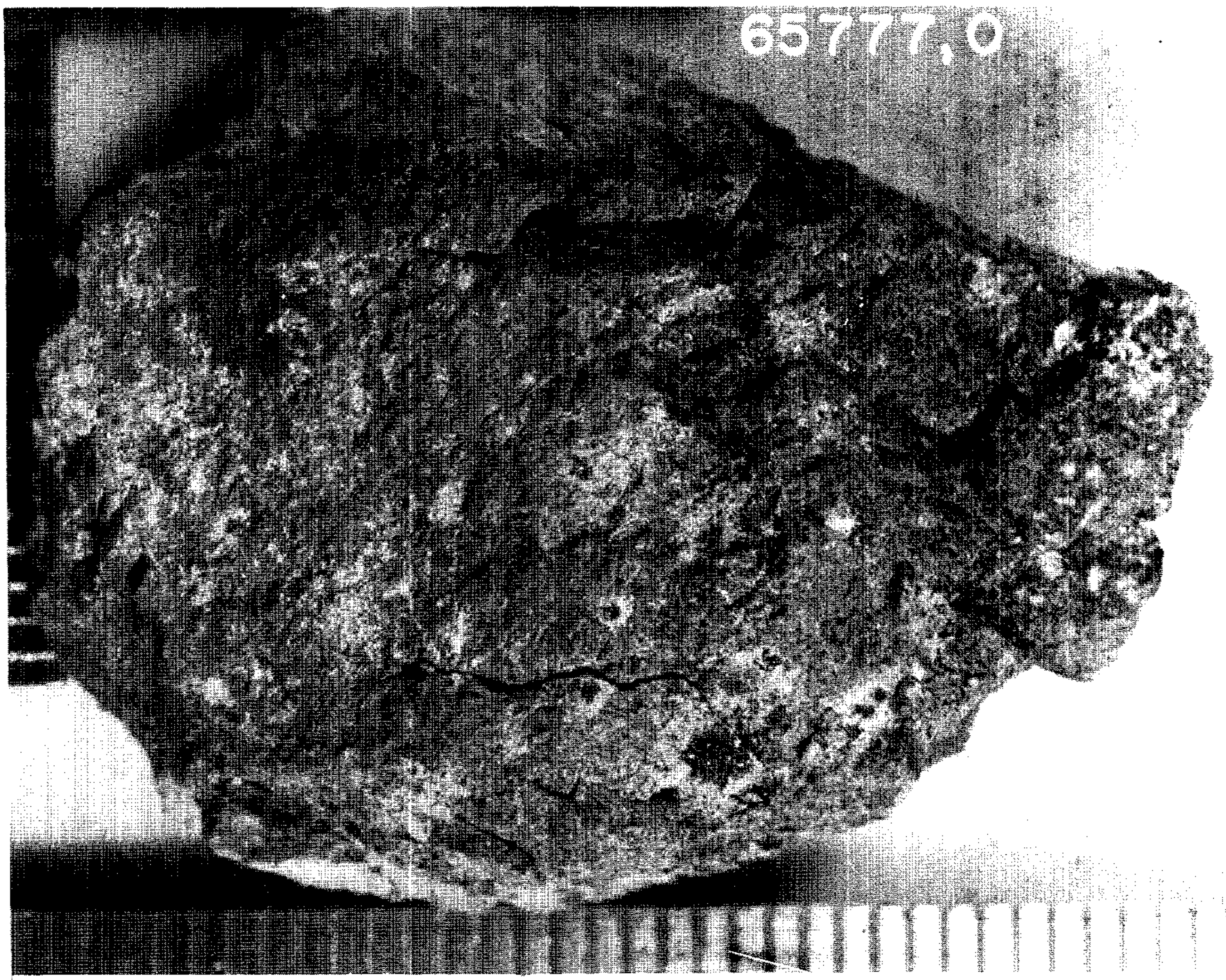



FIGURE 1. Smallest scale division in mm. S-72-48813.

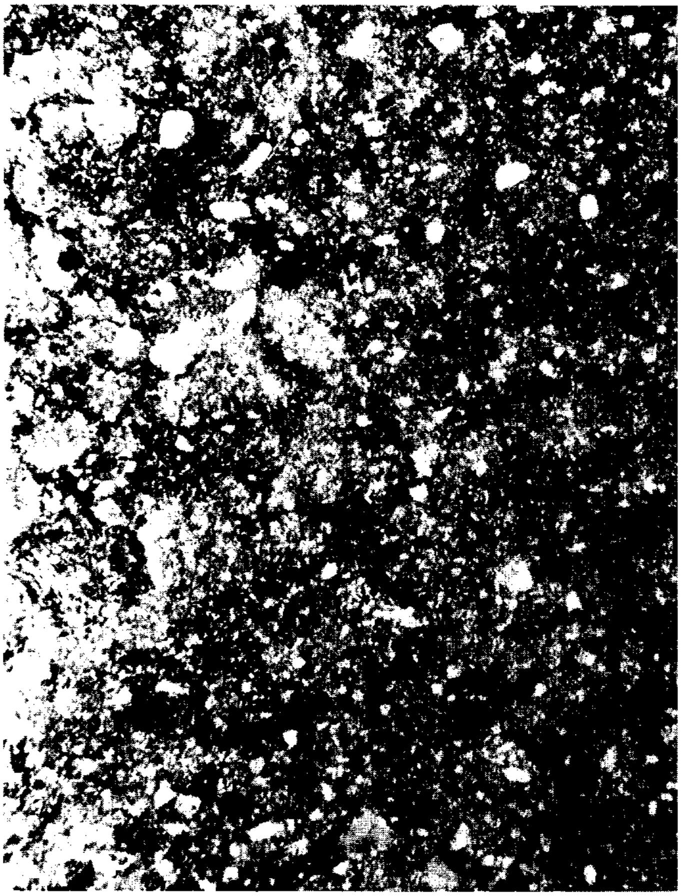


FIGURE 2. 65777,2. general view, partly xpl. width 2mm.

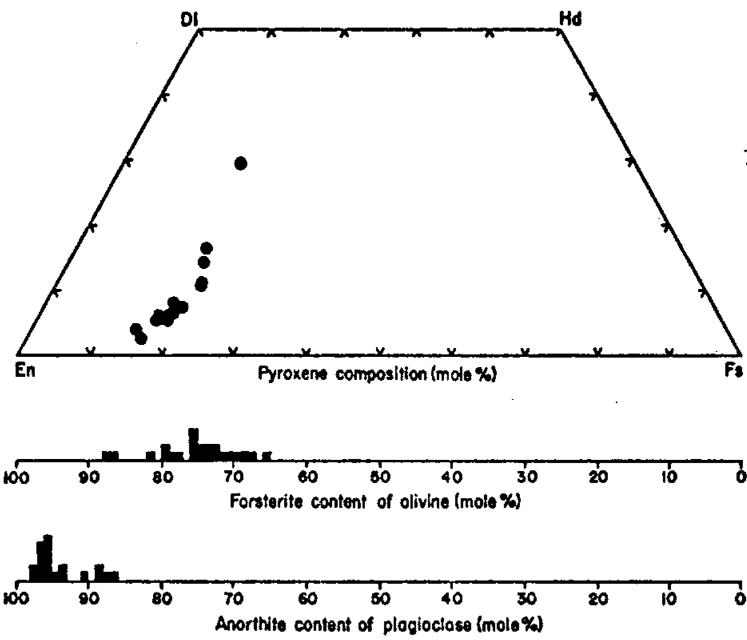



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

TABLE 1. Summary chemistry of 65777
(from Laul and Schmitt, 1973)

| | | | | |
|---|---|---|---|---|
| *$SiO_2$ | 47.7 | Sr | | |
| $TiO_2$ | 1.2 | La | | 53 |
| $Al_2O_3$ | 18.5 | Lu | | 2.1 |
| FeO | 9.0 | Rb | | |
| MnO | 0.106 | Sc | | 14 |
| MgO | ∿10 | Ni | | 1100 |
| CaO | 11.3 | Co | | 59 |
| $Na_2O$ | 0.660 | Ir | ppb | 17 |
| $K_2O$ | 0.37 | Au | ppb | 22 |
| *$P_2O_5$ | 0.43 | C | | |
| | | N | | |
| | | S | | |
| | | Zn | | |
| | | Cu | | |

Oxides in wt%; others in ppm except as noted.
(* from Warner et al., 1976b DBA)

CHEMISTRY: Major and trace element data are presented by Laul and Schmitt (1973). Warner et al. (1976b) give a defocussed electron beam analysis (DBA). Ca and K abundances are reported by Schaeffer and Schaeffer (1977) in an Ar geochronological study.

These data show 65777 to be compositionally similar to the well-studied poikilitic rocks such as 60315 (Table 1); alumina is relatively low for a highlands rock and incompatible elements and siderophiles are exceptionally high (Table 1).

RADIOGENIC ISOTOPES/GEOCHRONOLOGY: Ar isotopic data are provided by Schaeffer and Schaeffer (1977). These data yield an $^{40}Ar$-$^{39}Ar$ plateau age of 3.72 ± 0.02 b.y. The low temperature fractions show evidence of large $^{40}Ar$ losses by diffusion. Above 1100°C the age drops off to 3.57 b.y.

RARE GASES/EXPOSURE AGES: An $^{38}Ar$ exposure age of 8 m.y. is reported by Schaeffer and Schaeffer (1977).

PROCESSING AND SUBDIVISIONS: In 1973, three splits (,1-,3) were allocated for petrology, chemistry and geochronology. No further splits have been made.

INTRODUCTION: 65778 is a coherent, light gray, poikilitic impact melt (Fig. 1,2). It is a rake sample. Zap pits are abundant.

PETROLOGY: R. Warner *et al*. (1976b) provide a brief petrographic description and mineral compositions (Fig. 3). Dowty *et al*. (1976) tabulate the mineral analyses.

65778 is a poikilitic impact melt with oikocrysts of predominately low-Ca pyroxene enclosing abundant chadacrysts and clasts of plagioclase (Fig. 2). R. Warner *et al*. (1976b) mention "several lithic fragments". Accessory phases include ilmenite (4.8-5.4% MgO), Fe-metal (5-8.2% Ni, 0.4-0.5% Co), and a "K-rich phase" (10.1-14% $K_2O$).

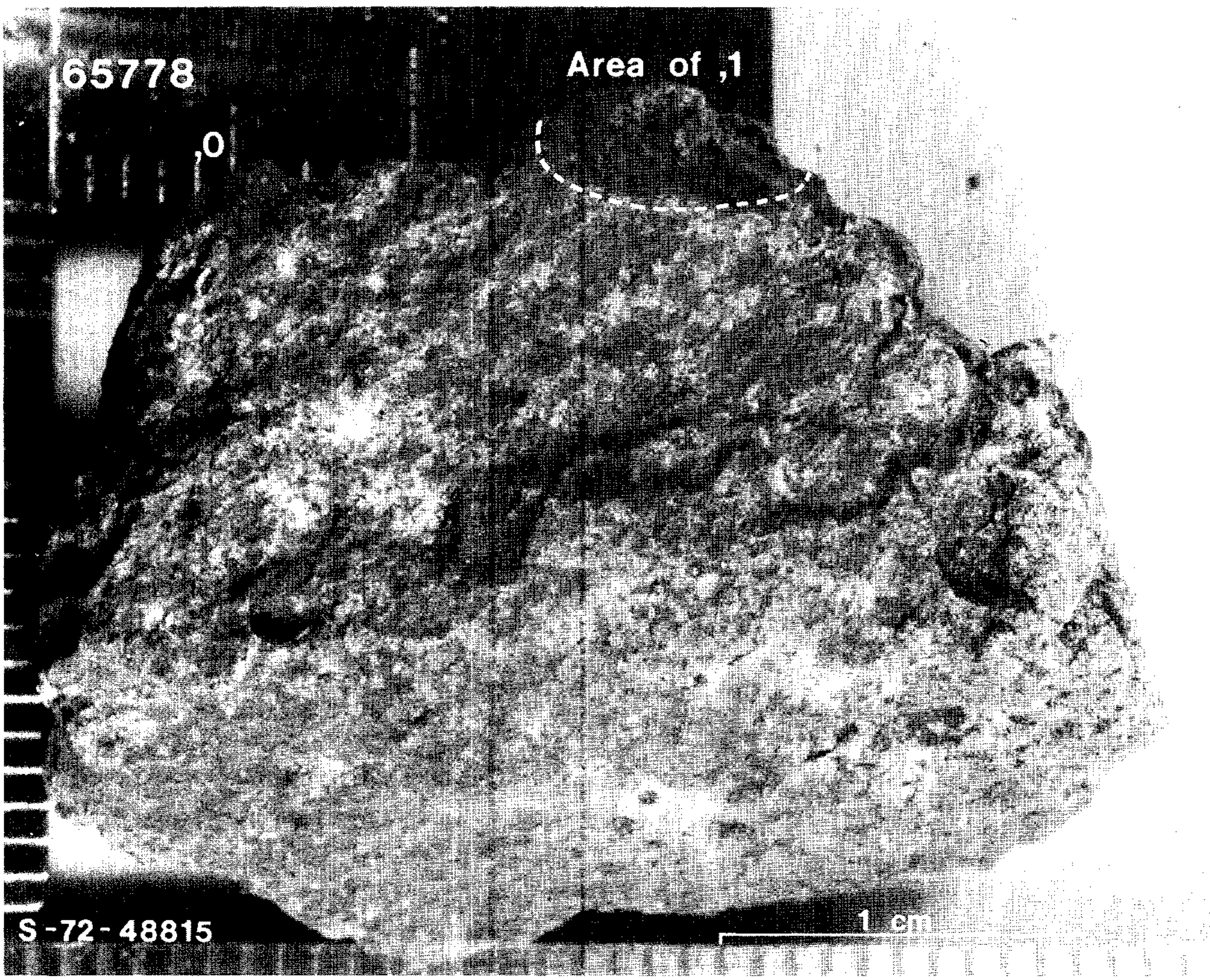



FIGURE 1.

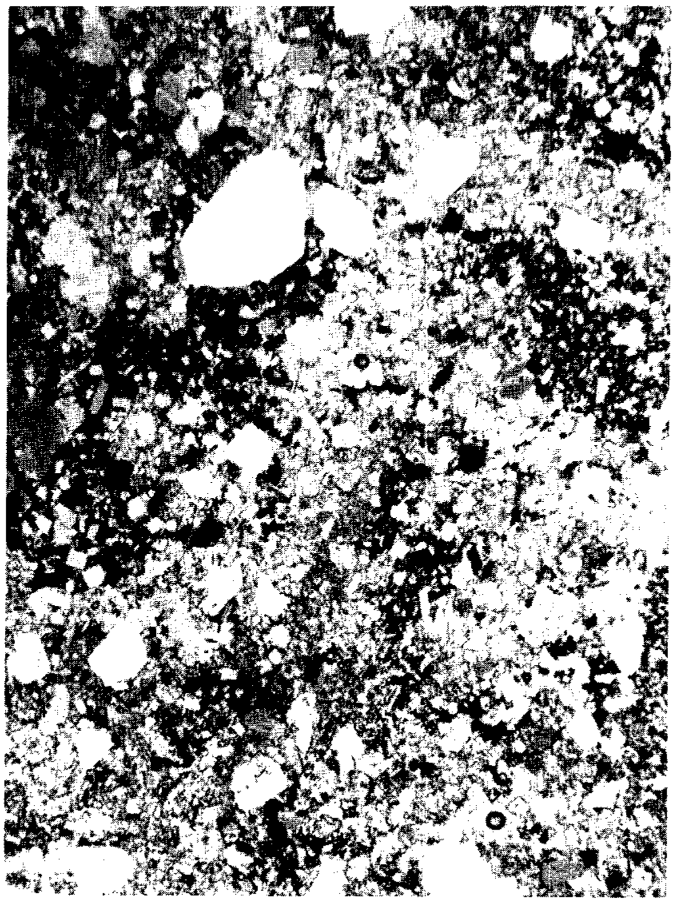


FIGURE 2. 65778,2. general view, partly xpl. width 2 mm.

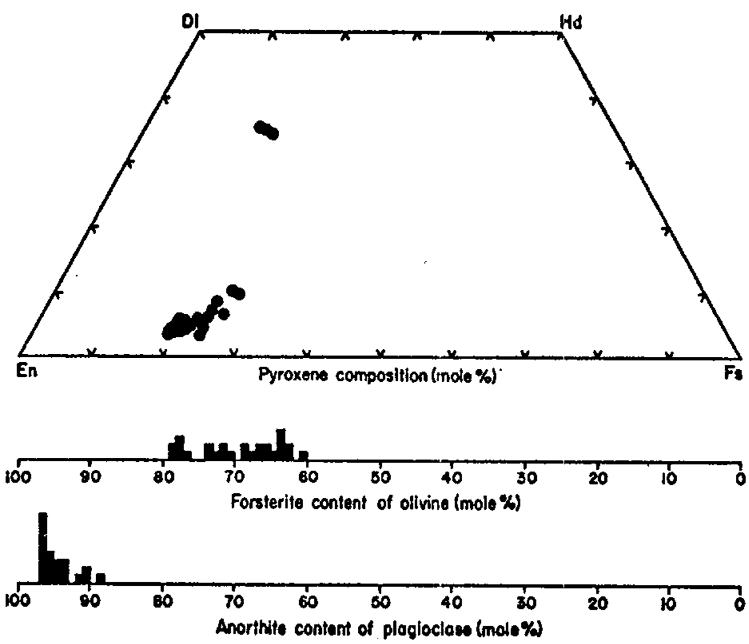



FIGURE 3. Mineral compositions; from R. Warner et al.(1976b).

TABLE 1. Summary chemistry of 65778 (wt%)

| | |
|---|---|
| $SiO_2$ | 47.3 |
| $TiO_2$ | 0.88 |
| $Al_2O_3$ | 21.6 |
| $Cr_2O_3$ | 0.13 |
| FeO | 6.8 |
| MnO | 0.06 |
| MgO | 9.7 |
| CaO | 12.5 |
| $Na_2O$ | 0.52 |
| $K_2O$ | 0.29 |
| $P_2O_5$ | 0.27 |

CHEMISTRY: A defocussed electron beam analysis of 65778 is given by R. Warner *et al.* (1976b) and reproduced here as Table 1.

PROCESSING AND SUBDIVISIONS: A chip (,1) was removed and allocated to Keil for thin sectioning and petrography.

INTRODUCTION: 65779 is a light gray, coherent, basaltic impact melt collected as a rake sample. One 4 mm, glass lined zap pit is present (Fig. 1), and there are abundant rusty spots.

PETROLOGY: Dowty et al. (1974b) and Warner et al. (1976b) provide petrographic descriptions. This rock is a very fine-grained impact melt with small plagioclase needles (∿ 0.05 mm long) subophitically enclosed by olivine and pyroxene (Fig.2). Dark, glassy mesostasis is abundant. Plagioclase clasts account for ∿ 8% of the rock with a few small olivine clasts also present. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Accessory phases include ilmenite, armalcolite, Fe-metal (3.7 - 5.9% Ni, 0.41 - 0.49% Co), troilite and schreibersite.

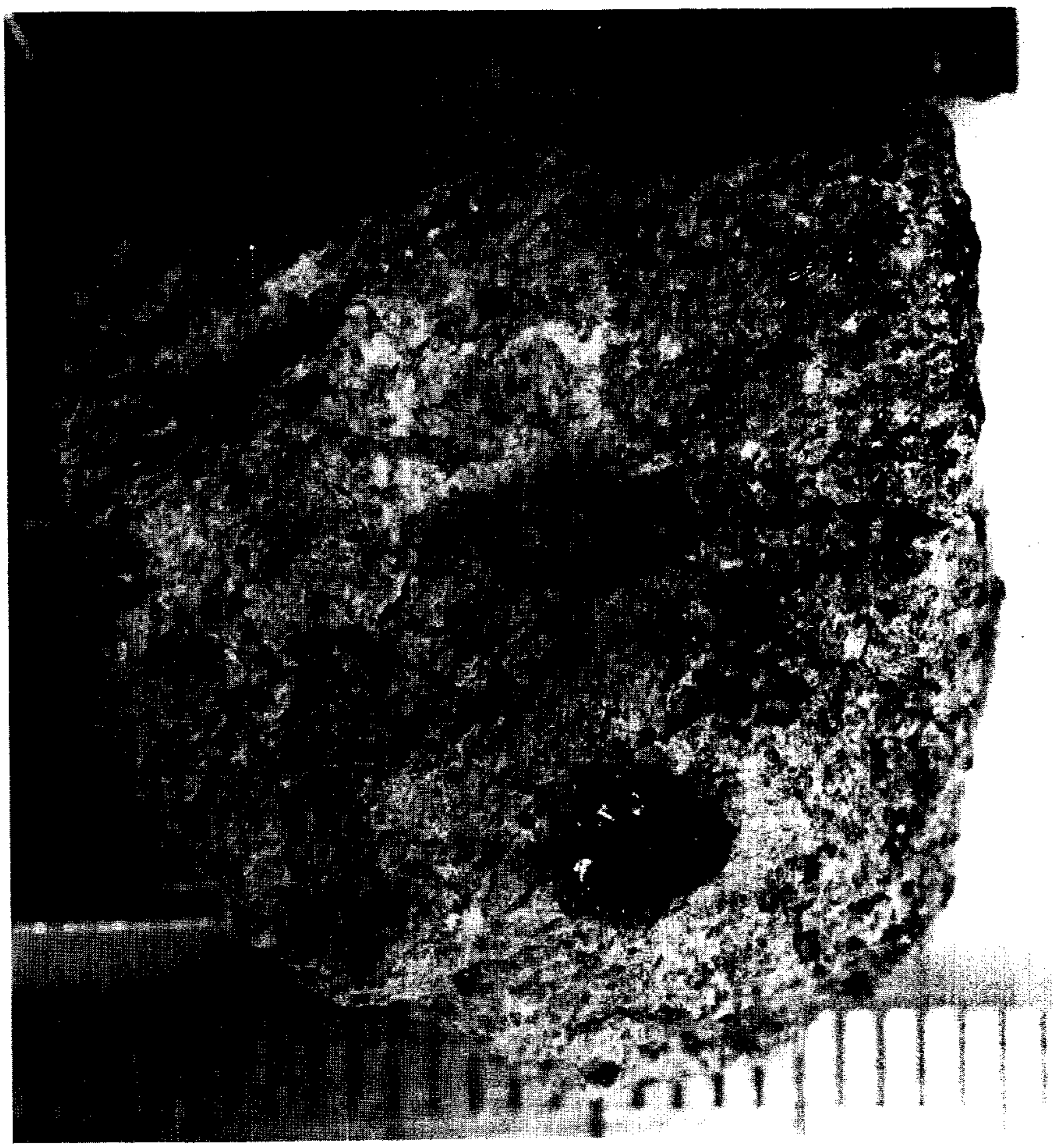


FIGURE 1. Smallest scale division in mm. S-72-48819.

FIGURE 2. 65779,4. general basaltic melt, partly xpl. width 2mm.

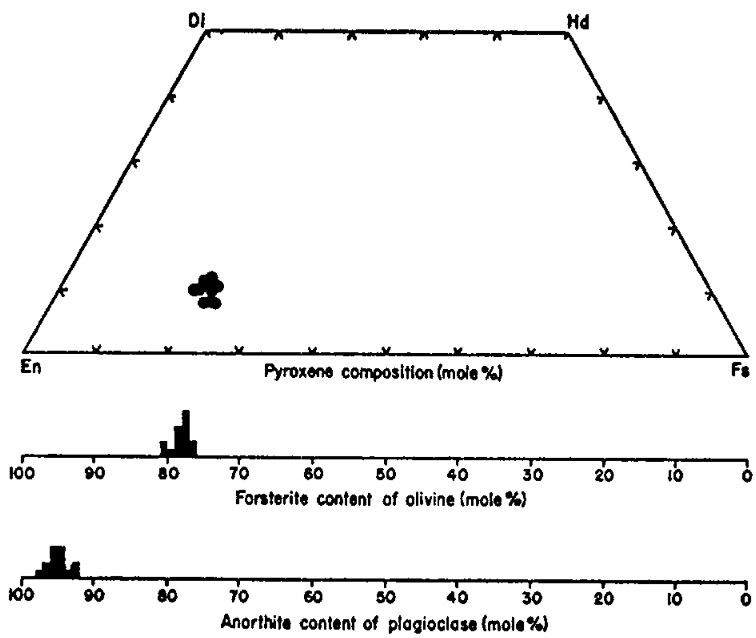



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

TABLE 1. Summary chemistry of 65779
(Wasson *et al.*, 1977)

| | | | |
|---|---|---|---|
| *$SiO_2$ | 45.6 | Sr | |
| $TiO_2$ | 0.95 | La | 29.5 |
| $Al_2O_3$ | 23.6 | Lu | 1.24 |
| $Cr_2O_3$ | 0.17 | Rb | |
| FeO | 8.3 | Sc | 11.6 |
| MnO | 0.09 | Ni | 1080 |
| MgO | 10.0 | Co | 69 |
| CaO | 12.7 | Ir ppb | 26 |
| $Na_2O$ | 0.50 | Au ppb | 24 |
| $K_2O$ | 0.21 | C | |
| *$P_2O_5$ | 0.19 | N | |
| | | S | |
| | | Zn | ≤9.2 |
| | | Cu | |

Oxides in wt%; others in ppm except as noted.
*from DBA by Dowty *et al.* (1974b)

CHEMISTRY: Major and trace element data are given by Wasson *et al.* (1977). Major elements by DBA are presented by Dowty *et al.* (1974b) and reproduced by Warner *et al.* (1976b).

The two analyses agree fairly well and indicate that 65779 is much less aluminous than the local bulk soils (Table 1). This rock is highly enriched in both incompatible elements and in siderophiles (Table 1).

PROCESSING AND SUBDIVISIONS: In 1973 four small chips (,1) were allocated to Keil for petrography. In 1976 several undocumented bits (,3) were allocated to Wasson for chemistry.

INTRODUCTION: 65785 is a light gray, coherent, basaltic impact melt that contains a large (5 mm) coarse-grained, spinel troctolite clast (Fig. 1). It is a rake sample and lacks zap pits.

PETROLOGY: Brief petrographic descriptions of the basaltic matrix and the spinel troctolite clast are given by Warner *et al.* (1976b). Dowty *et al.* (1974b) describe the spinel troctolite clast in more detail.

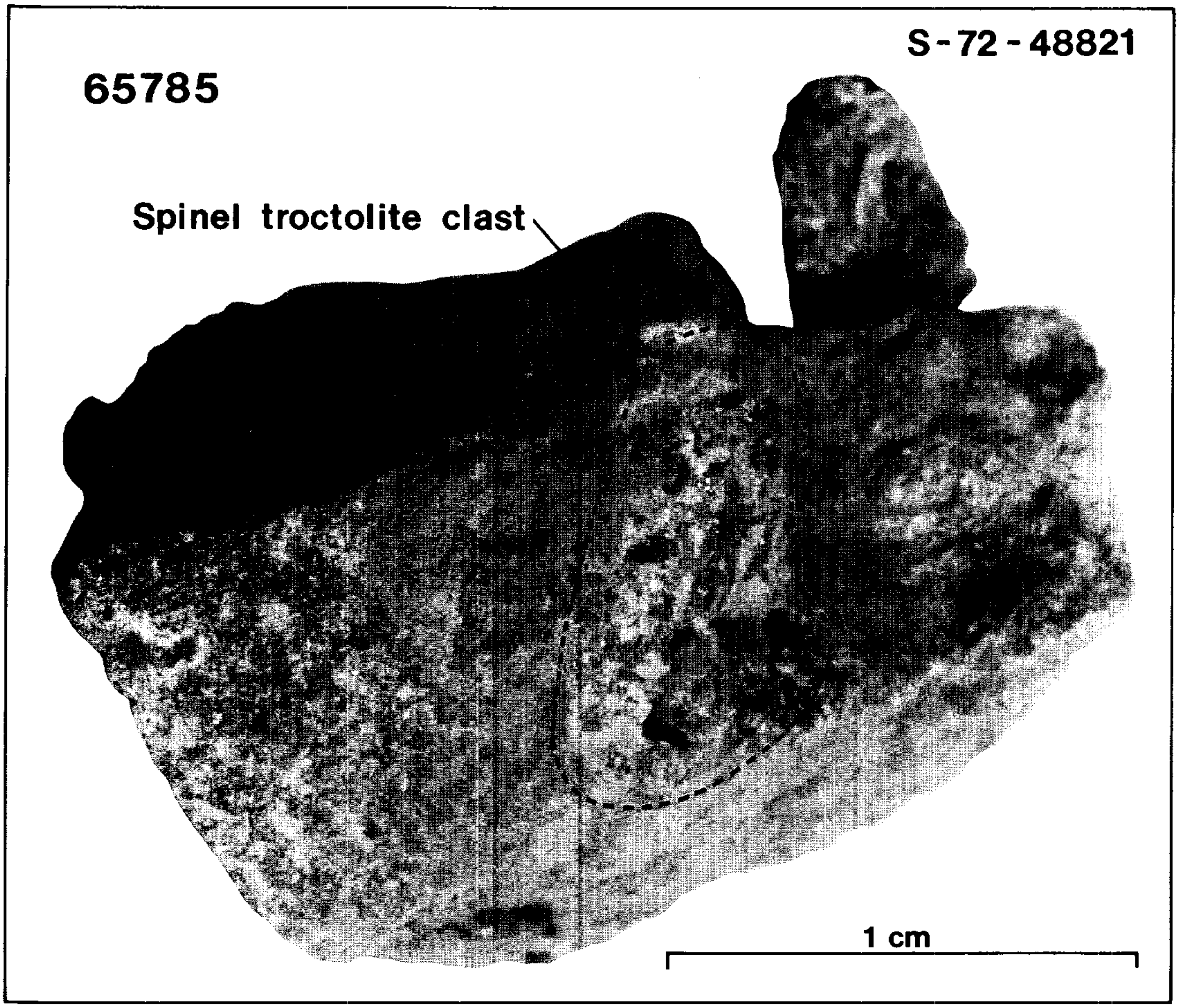



FIGURE 1.

a

b

FIGURE 2. a) 65785,4. basaltic melt,xpl. width 2mm. b) 65785,3. spinel troctolite clast, partly xpl. width 2mm.

The spinel troctolite clast consists of ~65% plagioclase (0.1-1.0 mm), ~5% spinel (most of which is accounted for by a single 1 mm grain), and the remainder olivine (Fig. 2 and photomicrograph in Dowty et al., 1974b). Except for a few tiny grains, all of the olivine in the section studied by Dowty et al. (1974b) and Warner et al. (1976b) occurs as a single large poikilitic crystal. This clast is much more plagioclase-rich than the pink spinel troctolite clast in 67435. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1974b, 1976). Accessory phases include low-Ca and high-Ca pyroxene, ilmenite, armalcolite, Zr-rutile, Fe-metal (2-25% Ni, 0.5-1.5% Co), troilite, whitlockite, farringtonite (Mg-phosphate) and K-feldspar. The metal compositions suggest that this clast is not chemically pristine. Longhi et al. (1976) discuss the Fe-Mg partitioning between olivine and plagioclase in this clast.

The matrix is a fine-grained, basaltic impact melt (Fig. 2) with equant to lathy plagioclase (~0.1 mm long) and ophitic olivine and pyroxene (up to 0.3 mm). Xenocrysts are absent. Mineral compositions are slightly less magnesian than in the spinel troctolite clast (Fig. 3). Accessory phases include spinel, armalcolite, Fe-metal, schreibersite, zirkelite(?), whitlockite and apatite. Mineral analyses are tabulated by Dowty et al. (1976).

CHEMISTRY: Major and trace element analyses of the basaltic matrix are given by Murali et al. (1977) and Ehmann et al. (1975). Jovanovic and Reed (1976b) present halogen and other trace element abundances for the matrix. Microprobe defocussed-beam analyses of the matrix and the spinel troctolite clast are reported by Warner et al. (1976b) and Dowty et al. (1974b). Eldridge et al. (1975) give whole rock abundances of natural and cosmogenic radionuclides. Ca and K data are presented by Schaeffer and Schaeffer (1977) in an Ar geochronological study of the basaltic matrix.

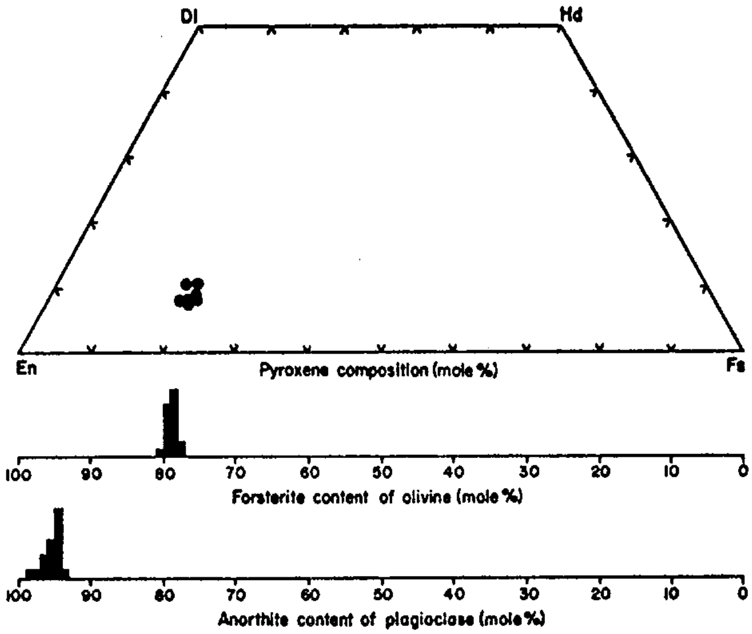



FIGURE 3a. Mineral compositions for host basaltic melt; from R. Warner *et al*. (1976b).

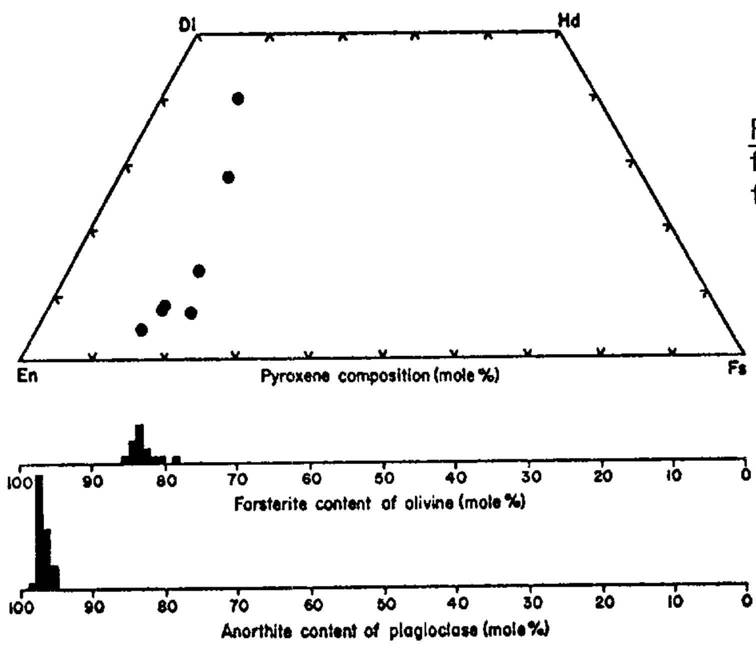



FIGURE 3b. Mineral compositions for spinel troctolite clast; from R. Warner *et al*. (1976b).

The gamma-ray data of Eldridge *et al*. (1975) show the whole rock to be rich in incompatible elements (K 1850 ppm, Th 3.03 ppm, U 0.97 ppm). This is confirmed by the analyses of the matrix, which also show a high Mg/Fe, consistent with the mineral compositions (Table 1). The spinel troctolite is compositionally distinct from the bulk matrix, having much more alumina and less silica and alkalis (Table 1).

RADIOGENIC ISOTOPES/GEOCHRONOLOGY: An $^{40}Ar$-$^{39}Ar$ plateau age of 3.97±0.02 b.y. was determined for the basaltic matrix by Schaeffer and Schaeffer (1977) (Fig. 4). Large amounts of low temperature gas loss with ages increasing from 1.38 b.y. to 3.47 b.y. and a high temperature drop-off to 3.70 b.y. are noted by Schaeffer and Schaeffer (1977).

TABLE 1. Summary chemistry of 65785 lithologies

| | 1) Basaltic matrix | 2) Spinel troctolite clast (DBA) |
|---|---|---|
| $SiO_2$ | 46.0 | 41.1 |
| $TiO_2$ | 0.7 | 0.07 |
| $Al_2O_3$ | 23.4 | 29.9 |
| $Cr_2O_3$ | 0.165 | 0.18 |
| FeO | 6-7 | 3.7 |
| MnO | 0.08 | 0.3 |
| MgO | 10-12 | 9.6 |
| CaO | ∿14 | 14.8 |
| $Na_2O$ | 0.54 | 0.29 |
| $K_2O$ | 0.26 | 0.04 |
| $P_2O_5$ | 0.12 | 0.04 |
| Sr | | |
| La | 19.2 | |
| Lu | 0.91 | |
| Rb | | |
| Sc | 9.9 | |
| Ni | 302 | |
| Co | 22 | |
| Ir ppb | 7 | |
| Au ppb | 14 | |
| C | | |
| N | | |
| S | | |
| Zn | | |
| Cu | | |

Oxides in wt%, others in ppm except as noted
1) from Ehmann et al. (1975) and Murali et al. (1977)
2) from Warner et al. (1976b)

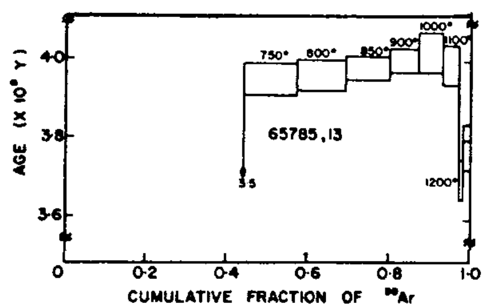



FIGURE 4. Ar release; from Schaeffer and Schaeffer (1977).

RARE GASES/EXPOSURE AGES: Whole rock $^{22}Na$ and $^{26}Al$ data are provided without comment by Eldridge et al. (1975). An $^{38}Ar$ exposure age of 271 m.y. is calculated by Schaeffer and Schaeffer (1977).

PROCESSING AND SUBDIVISIONS: In 1973 several small chips were allocated as ,1 to Keil for petrography. In 1975 the rock was extensively subdivided producing ,8- ,19 for allocations. ,8 (3.39 g) is the largest single piece remaining. Most of the large spinel troctolite clast (Fig.1) resides in ,8.

INTRODUCTION: 65786 is a coherent, medium gray, polymict breccia with abundant glass in the matrix. Slickensides and abundant fractures are present on four surfaces (Fig. 1). Greenish, vesicular glass thinly coats the other surfaces. The glass coat has apparently been smeared along the slickensides indicating that shearing occurred after the glass coat was emplaced.

This rock is a rake sample from the rim of a small, subdued crater on Stone Mountain. Zap pits are absent.

PETROLOGY: Abundant clasts of heavily shocked plagioclase, mafic silicates and cataclastic anorthosite rest in a chaotic, glassy matrix (Fig. 2). Blebs of Fe-metal and angular grains of ilmenite are accessory phases.

PROCESSING AND SUBDIVISIONS: In 1979 a chip (,1) was allocated for thin sections.

FIGURE 1. Smallest scale division in mm. S-72-48812.

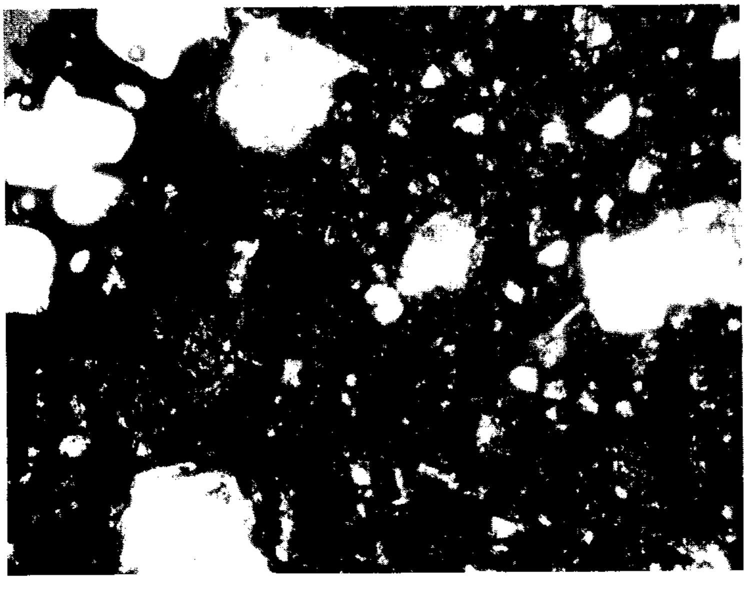


FIGURE 2. 65786,2. general breccia with vesicular glass coat in upper left, ppl. width 2.5mm.

INTRODUCTION: 65787 is a medium gray, coherent breccia collected as a rake sample (Fig. 1). A variety of clasts are scattered through the rock. It is subangular with some splash glass and a few zap pits.

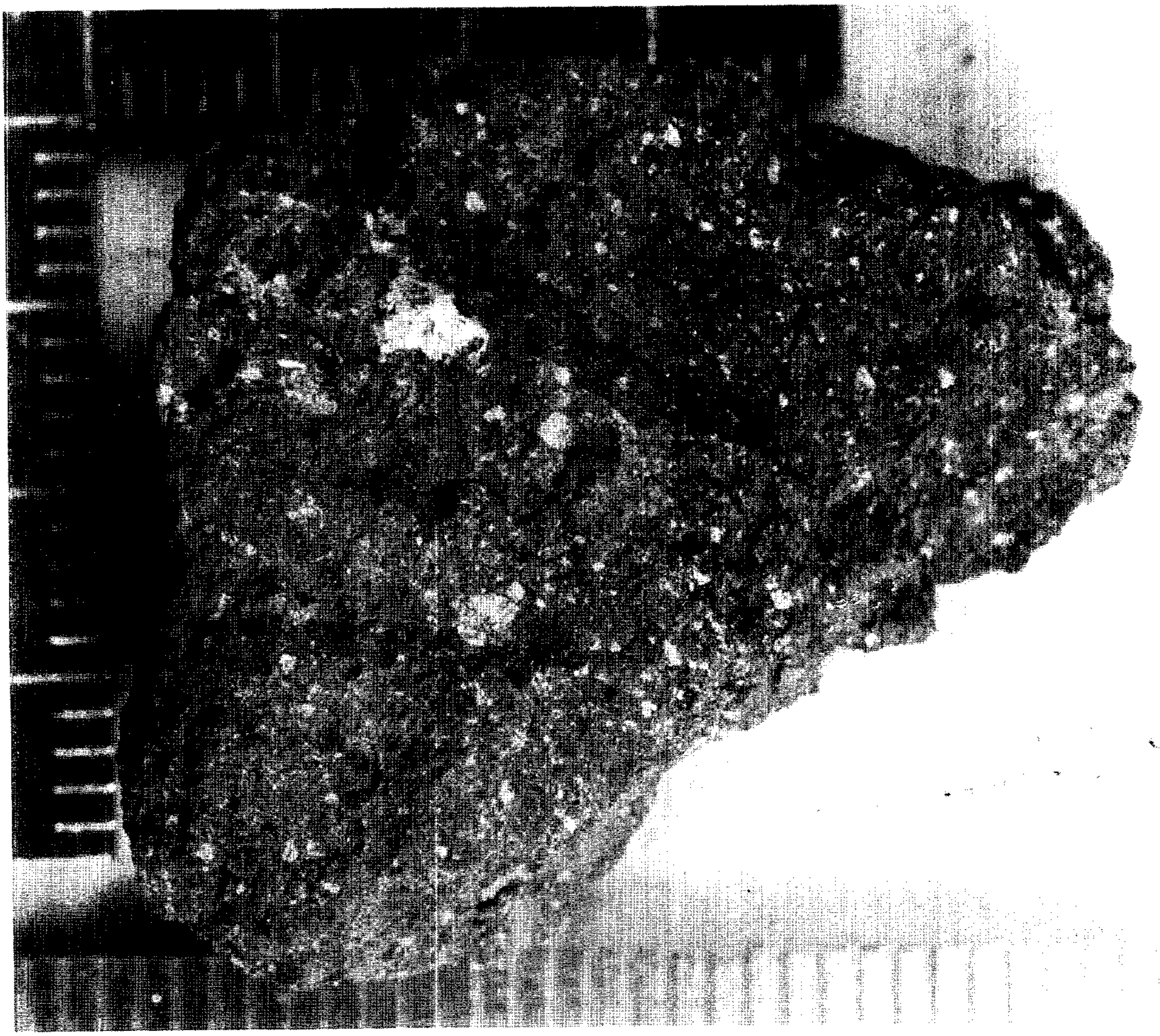


FIGURE 1. Smallest scale division in mm. S-72-48814.

INTRODUCTION: 65788 is a dark gray, coherent, glassy impact melt collected as a rake sample (Fig. 1). It is highly vesicular with considerable adhering soil. Isolated white fragments (up to 10 mm) and gray crystalline clasts (~1 mm) are common. Zap pits are rare.

FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 65789 is a white, moderately coherent, cataclastic anorthosite (Fig. 1). One small patch of brown glass coating is present. It is a rake sample with rare zap pits.

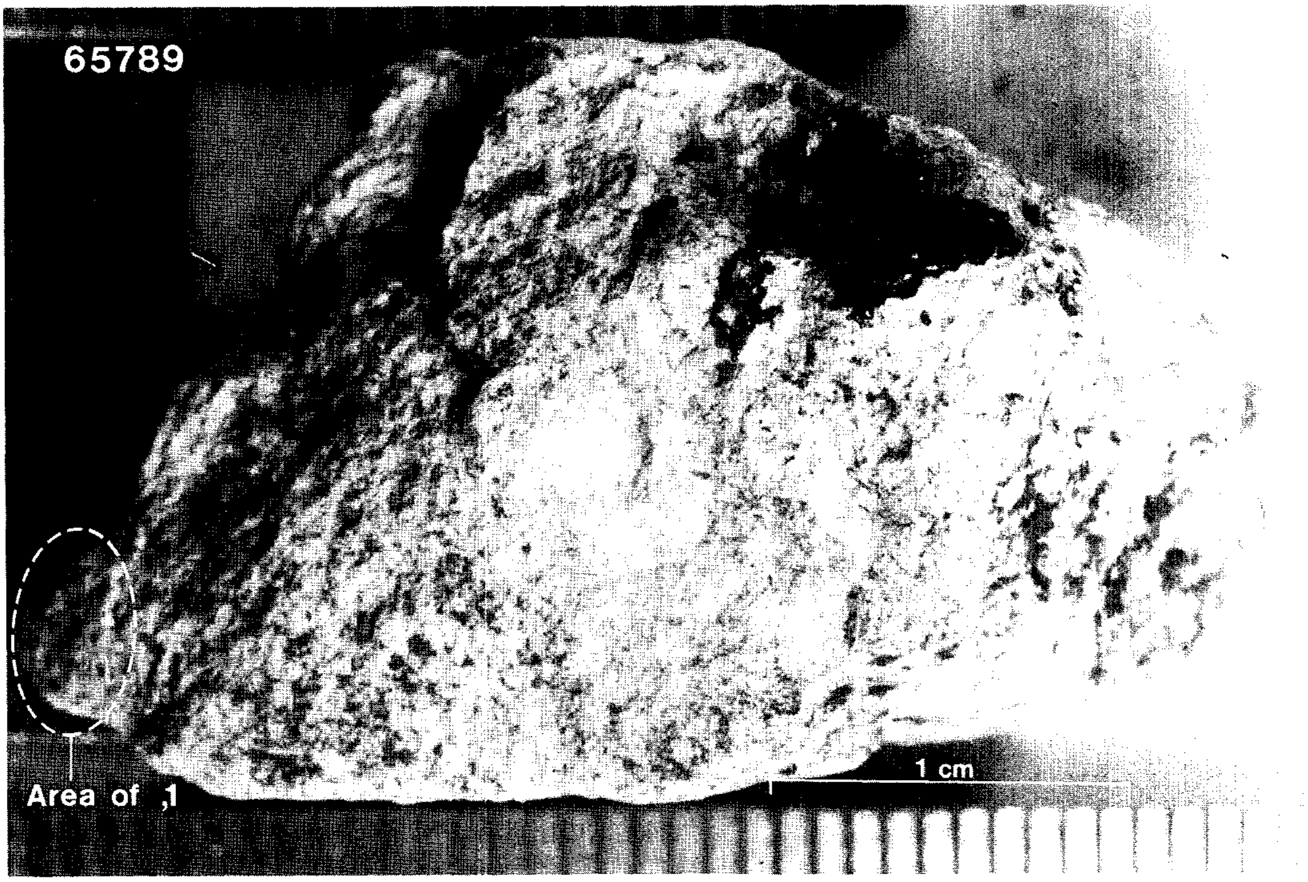



FIGURE 1.

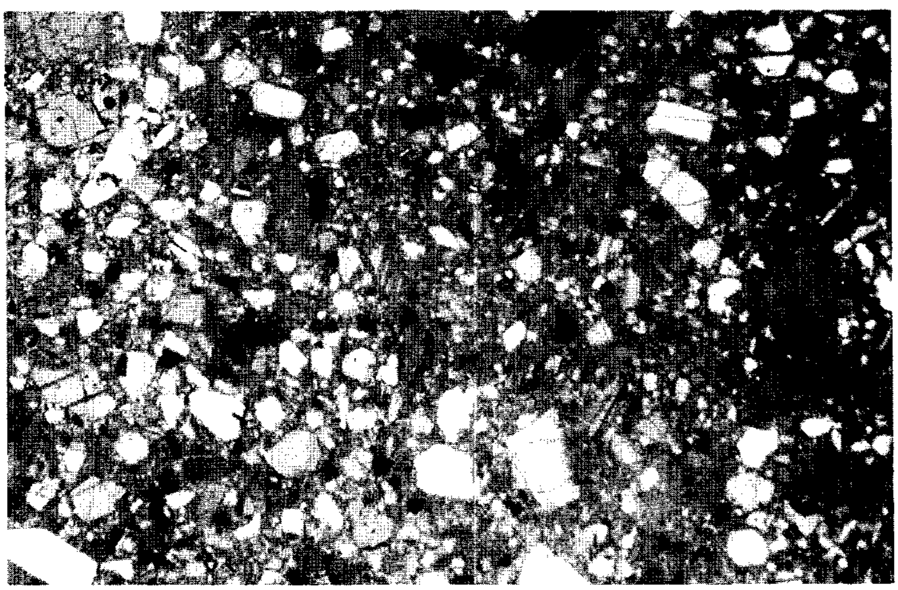


FIGURE 2. 65789,2. general view, partly xpl. width 3mm.

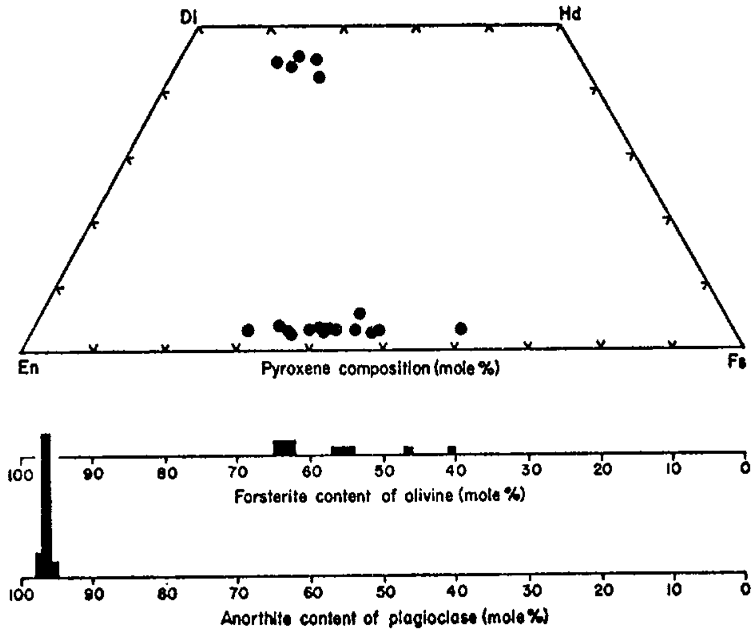



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

TABLE 1.

Chemistry of 65789 (DBA, normalized to 100%)

| | |
|---|---|
| $SiO_2$ | 44.9 |
| $TiO_2$ | 0.01 |
| $Al_2O_3$ | 34.3 |
| FeO | 0.96 |
| MgO | 0.63 |
| CaO | 18.8 |
| $Na_2O$ | 0.37 |
| $K_2O$ | 0.01 |
| $P_2O_5$ | 0.02 |

PETROLOGY: Dowty et al. (1974a) and Warner et al. (1976b) provide petrographic descriptions. 65789 is finer grained than most other cataclastic anorthosites. Plagioclase clasts are lightly shocked and somewhat rounded (Fig.2). Olivine and pyroxene are both present and have unequilibrated compositions. (Fig.3). Accessory phases include spinel and ilmenite. Mineral analyses are tabulated by Dowty et al. (1976).

CHEMISTRY: A defocussed electron beam analysis (DBA) is presented by Dowty et al. (1974a) and Warner et al. (1976b) and is reproduced here as Table 1.

PROCESSING AND SUBDIVISIONS: In 1973 several small chips (,1) were allocated to Keil for petrography (Fig.1).

INTRODUCTION: 65795 is a light gray, friable, basaltic impact melt collected as a rake sample (Fig.1). A few zap pits and vugs are present.

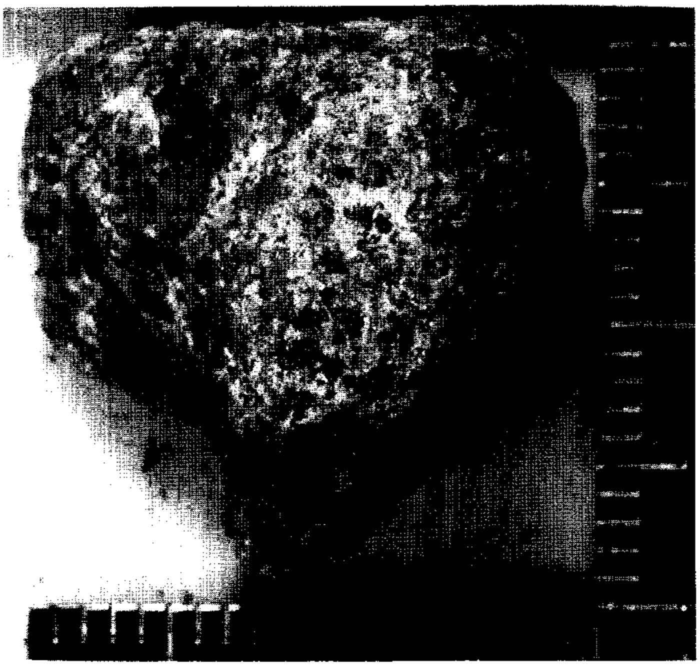


FIGURE 1. Smallest scale division in mm.

FIGURE 2. 65795,2. general view, partly xpl. width 3mm.

PETROLOGY: Dowty et al. (1974b) and Warner et al. (1976b) provide petrographic descriptions. This rock is generally coarse-grained with plagioclase (0.2-1.5 mm) in a variety of crystal forms subophitically to poikilitically enclosed by pyroxene (low Ca > high Ca) and minor olivine (Fig. 2). Some of the larger plagioclases may be xenocrysts. Mineral compositions are shown in Figure 3 and tabulated by Dowty et al. (1976). Accessory phases include ilmenite, Fe-metal (4.7-30.9% Ni, 0.5-1.2% Co), troilite, a high $SiO_2$ glass (∿ 75% $SiO_2$, 7-10% $K_2O$) and a silica phase.

X-ray precession data on two pigeonite grains are given by Dowty et al. (1974b) and indicate the presence of submicroscopic exsolution lamellae of augite.

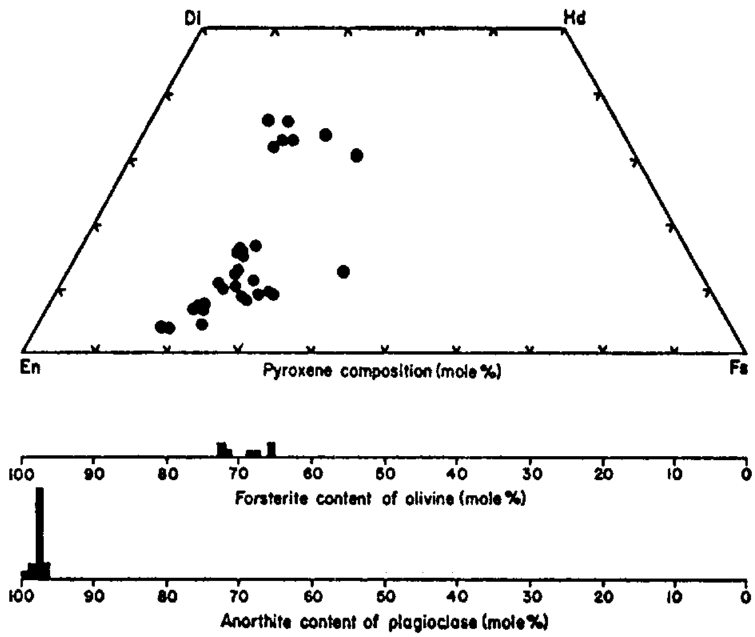



FIGURE 3. Mineral compositions; from R. Warner et al. (1976b).

TABLE 1. Chemistry of 65795 (DBA)

| | |
|---|---|
| $SiO_2$ | 45.2 |
| $TiO_2$ | 0.19 |
| $Al_2O_3$ | 31.4 |
| $Cr_2O_3$ | 0.05 |
| FeO | 2.25 |
| MnO | 0.02 |
| MgO | 2.78 |
| CaO | 17.3 |
| $Na_2O$ | 0.44 |
| $K_2O$ | 0.07 |
| $P_2O_5$ | 0.08 |

CHEMISTRY: A defocussed electron beam analysis (DBA) is presented by Dowty et al. (1974b) and reproduced by Warner et al. (1976b) and here as Table 1. The analysis shows 65795 to be very aluminous and poor in incompatible elements.

PROCESSING AND SUBDIVISIONS: In 1973 a single chip (,1) was taken for thin sections (Fig.1).

## 65905 BASALTIC IMPACT MELT(?) 12.08 g

INTRODUCTION: 65905 is a medium gray, angular, crystalline rock (Fig. 1). It has distinct light and dark crystals 500 μm - 1 mm diameter, and although laths are not apparent, some elongated plagioclase phenocrysts (~1 mm) suggest that the sample is a basaltic impact melt. Small vesicles are present. Clasts are not apparent. 65905 was taken from a soil sample collected on the inside south wall of a 20 m crater. It has a few zap pits on several surfaces.

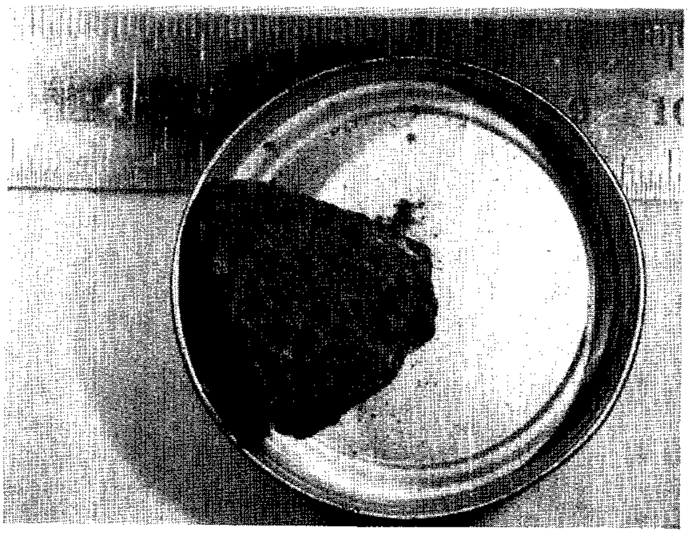


FIGURE 1. Smallest scale divisions are 0.5mm.

INTRODUCTION: 65906 is a medium gray, homogeneous, crystalline sample (Fig. 1). It is coherent but fractured. It has gray and white minerals, rare, small white clasts, some sulfides, and rusty spots. It is probably a basaltic impact melt with a grain size less than 1 mm. A glass coat is present in one area. 65906 was taken from a soil sample collected on the inside south wall of a 20 m crater. It has a few zap pits on several surfaces.

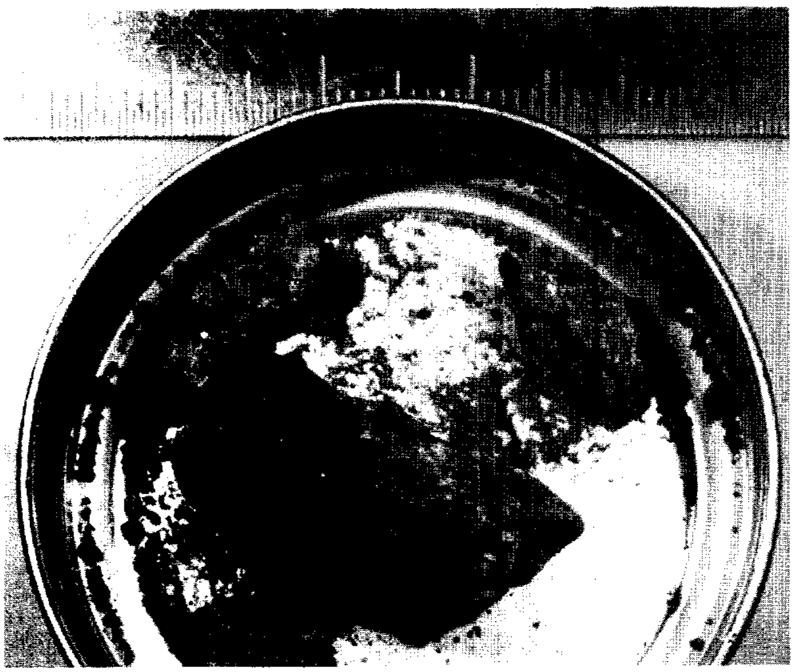


FIGURE 1. Smallest scale divisions are 0.5mm.

INTRODUCTION: 65907 is a pale gray, fragmental breccia (Fig. 1) which is fairly coherent. It is rounded and contains abundant dark and light clasts. It was taken from a soil sample collected on the inside south wall of a 20 m crater. It lacks zap pits.

FIGURE 1. Smallest scale divisions are 0.5mm.

INTRODUCTION: 65908 is a coherent, black, vesicular glass (Fig. 1) with a few small white clasts. A crystalline clast may be a core to the glass. The sample was taken from a soil collected on the inside south wall of a 20 m crater. It lacks zap pits.

FIGURE 1. Smallest scale divisions are 0.5mm.

INTRODUCTION: 65909 is a coherent, white, rounded fragment (Fig. 1) which appears to lack mafic minerals and thus is probably a cataclastic anorthosite. It was taken from a soil sample collected on the inside south wall of a 20 m crater. Its surface has some zap pits and patina.

FIGURE 1. Smallest scale divisions are 0.5mm.

## 65915 GLASS OR FINE-GRAINED IMPACT MELT 2.06 g

INTRODUCTION: 65915 is a dark gray, coherent, vesicular sample (Fig. 1). It is homogeneous and probably glass. A few small white clasts are present. There is no obvious original exterior surface of a molten mass, rather all surfaces are fractures. 65915 was taken from a soil sample collected on the inside south wall of a 20 m crater. It has rare zap pits.

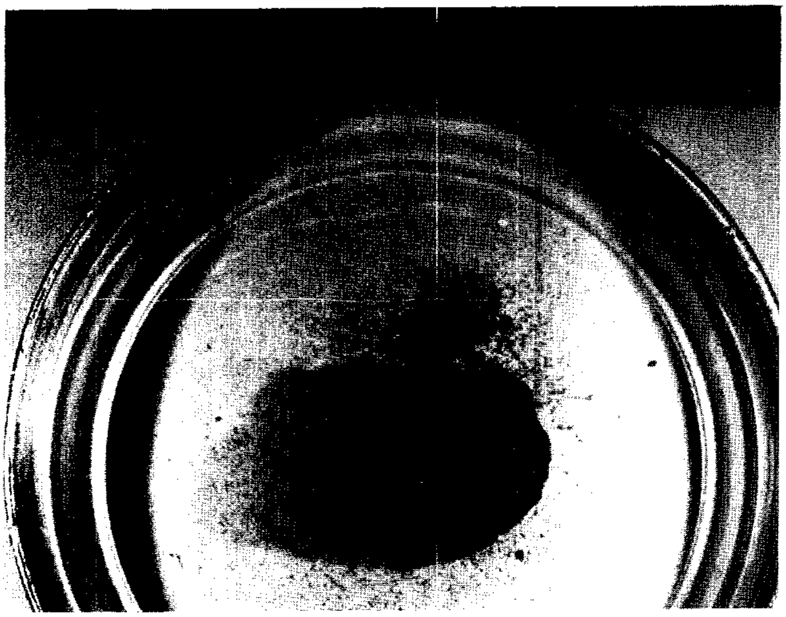


FIGURE 1. Smallest scale divisions are 0.5mm.

INTRODUCTION: 65916 is a coherent white, crystalline fragment with several thin glass veins (Fig. 1). The white material lacks mafics and is probably a cataclastic anorthosite. The sample is irregularly shaped and fractured. It was taken from a soil sample collected on the inside south wall of a 20 m crater. It lacks zap pits.

FIGURE 1. Upper small scale divisions are mm.

INTRODUCTION: 65925 is a subangular light brownish gray, friable breccia (Fig. 1). Various white and gray clasts are scattered through a very fine-grained matrix. It is a rake sample with few, if any, zap pits on its powdery surface.

PROCESSING AND SUBDIVISIONS: During initial processing 65925 fell into two pieces, numbered together as ,0.

FIGURE 1. Smallest scale division in mm.

## 65926 FRAGMENTAL POLYMICT BRECCIA (REGOLITH BRECCIA?) 3.03 g

INTRODUCTION: 65926 is a light brownish gray, friable breccia (Fig. 1). White, anorthositic clasts and gray crystalline clasts occupy about 20% of the sample. It is a rake sample with few, if any, zap pits on its powdery surface.

PROCESSING AND SUBDIVISIONS: During initial processing this rock fell into three pieces, numbered together as ,0.

FIGURE 1. Smallest scale division in mm.

65927 FRAGMENTAL POLYMICT BRECCIA 0.72 g

INTRODUCTION: 65927 is a subangular, light brownish gray, friable breccia (Fig. 1). Anorthositic clasts, gray crystalline clasts, rare yellow mafic silicate fragments and a few glassy or metallic spherules occupy about 20% of the sample. It is a rake sample with few, if any, zap pits on its powdery surface.

FIGURE 1. Smallest scale division in mm.

INTRODUCTION: 66035 is a moderately coherent, light gray breccia with abundant dark and light clasts. Two large, coarse-grained clasts occur on the B and W surfaces respectively (Fig. 1). A very thin film of glass partially coats the N surface.

This rock was collected from the base of Stone Mountain about 10 cm from 66055. Its lunar orientation is known. Zap pits are abundant on all surfaces.

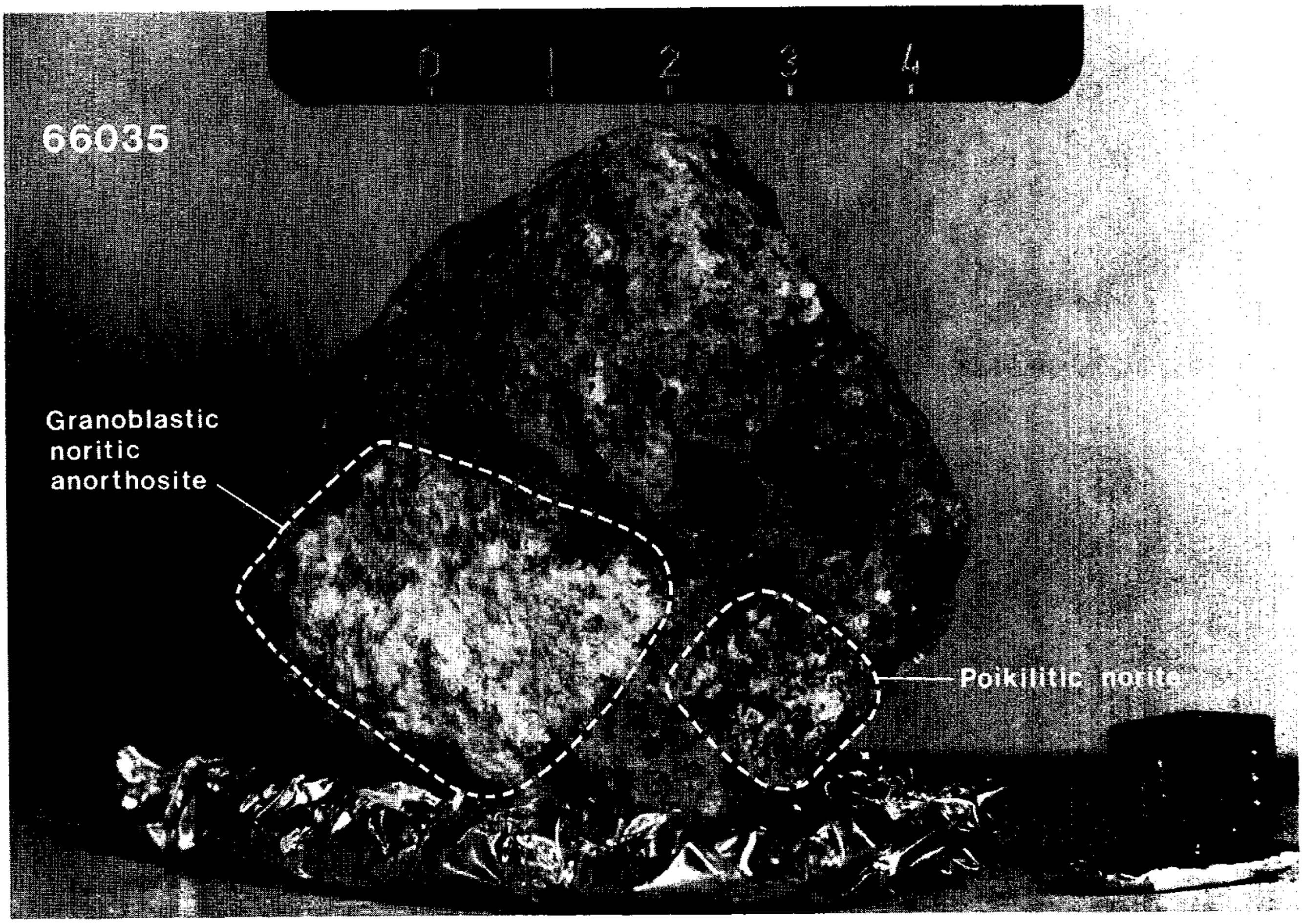



Figure 1.

Scale in cm.

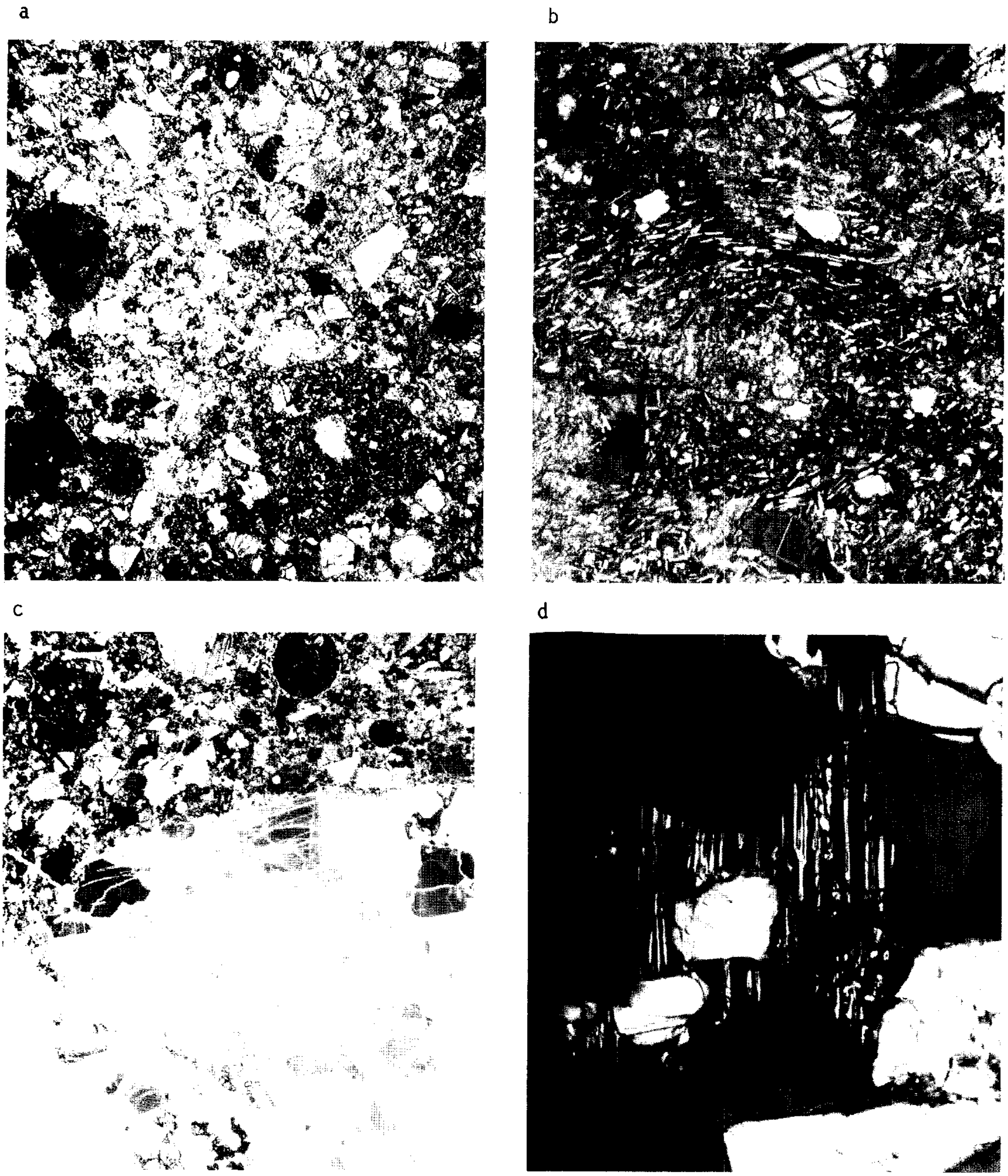



Figure 2.
a) 66035,2, fragmental matrix, ppl. width 2mm.
b) 66035,2, poikilitic clast, xpl. width 1mm.
c) 66035,14, noritic anorthosite clast and fragmental matrix, partly xpl. width 2mm.
d) 66035,14, exsolved pyroxene in noritic anorthosite clast, xpl. width 0.5mm.

PETROLOGY: A general petrographic description is given in the Apollo 16 Lunar Sample Information Catalog (1972), and Grieve et al. (1974) describe a variety of impact melt clasts. The breccia is fragmental and polymict, containing light and dark clasts, including glass spheres, in a matrix of comminuted mineral grains (Fig. 2).

The 3.5 cm white clast (Fig. 1) is a noritic anorthosite with a coarse granoblastic texture (Fig. 2). It is not chemically pristine. The grain boundaries are smooth, and small, anhedral pyroxenes reside in triple junctions. Plagioclase is $An_{94-95}$; pyroxene is heterogeneously distributed and is principally $Wo_{3-6}En_{66-68}$ (Fig. 3) (Warren and Wasson, 1978, 1979). We have also observed a limited amount of pyroxene exsolution (Fig. 2). The norm of Warren and Wasson's (1978) analysis shows 9% olivine, 4% orthopyroxene and 3% clinopyroxene.

The coarse-grained poikilitic norite clast (Fig. 1) is described in the Apollo 16 Lunar Sample Information Catalog as having 55-60% plagioclase with the remainder deep honey-colored pyroxene enclosing a trace of opaques.

Other clasts include fragments of finer-grained poikilitic (Fig. 2) and basaltic impact melts, clast-rich vitric matrix breccia, abundant mineral grains, rusty metal and a varied glass population. Grieve et al. (1974) recognize several compositional groups of glass clasts, including high-MgO "troctolitic" glasses, high-$SiO_2$ "granitic" glasses, plagioclase glasses, glasses with compositions approximating Apollo 16 poikilitic melt rocks ("Fra Mauro basalt") and glasses with local soil compositions.

Warren and Wasson (1979) also note a 200x100 μm, porous olivine fragment with the composition $Fo_{97.5}$,$Fa_{1.3}$ and 1.2 mole % $Ca_2SiO_4$ (Fig. 3). They interpret this grain to be of meteoritic origin.

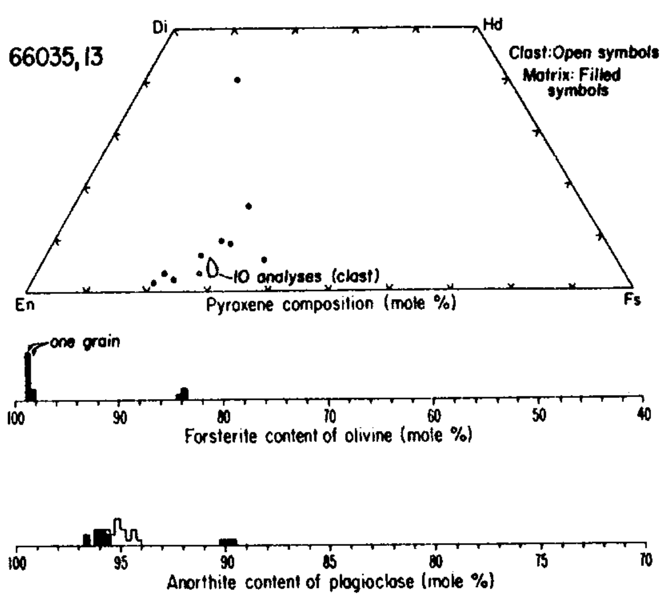



Figure 3. Mineral compositions, from Warren and Wasson (1979).

CHEMISTRY: Eldridge et al. (1973) proved K ($K_2O$ .09%), U (0.49 ppm), and Th (1.87 ppm) abundances in the bulk rock as determined by gamma-ray spectroscopy. The levels of these elements in 66035 are very similar to those of the local soils.

Warren and Wasson (1978, 1979) report major and trace element abundances for the large white clast (Table 1). It is very aluminous and has low levels of lithophile elements (Fig. 4) but has been contaminated by meteoritic siderophile elements and is therefore not chemically pristine. The tabulated values of Cr and Mn for this clast are erroneously low by a factor of ten in Warren and Wasson (1978). The correct values are given in Warren and Wasson (1979).

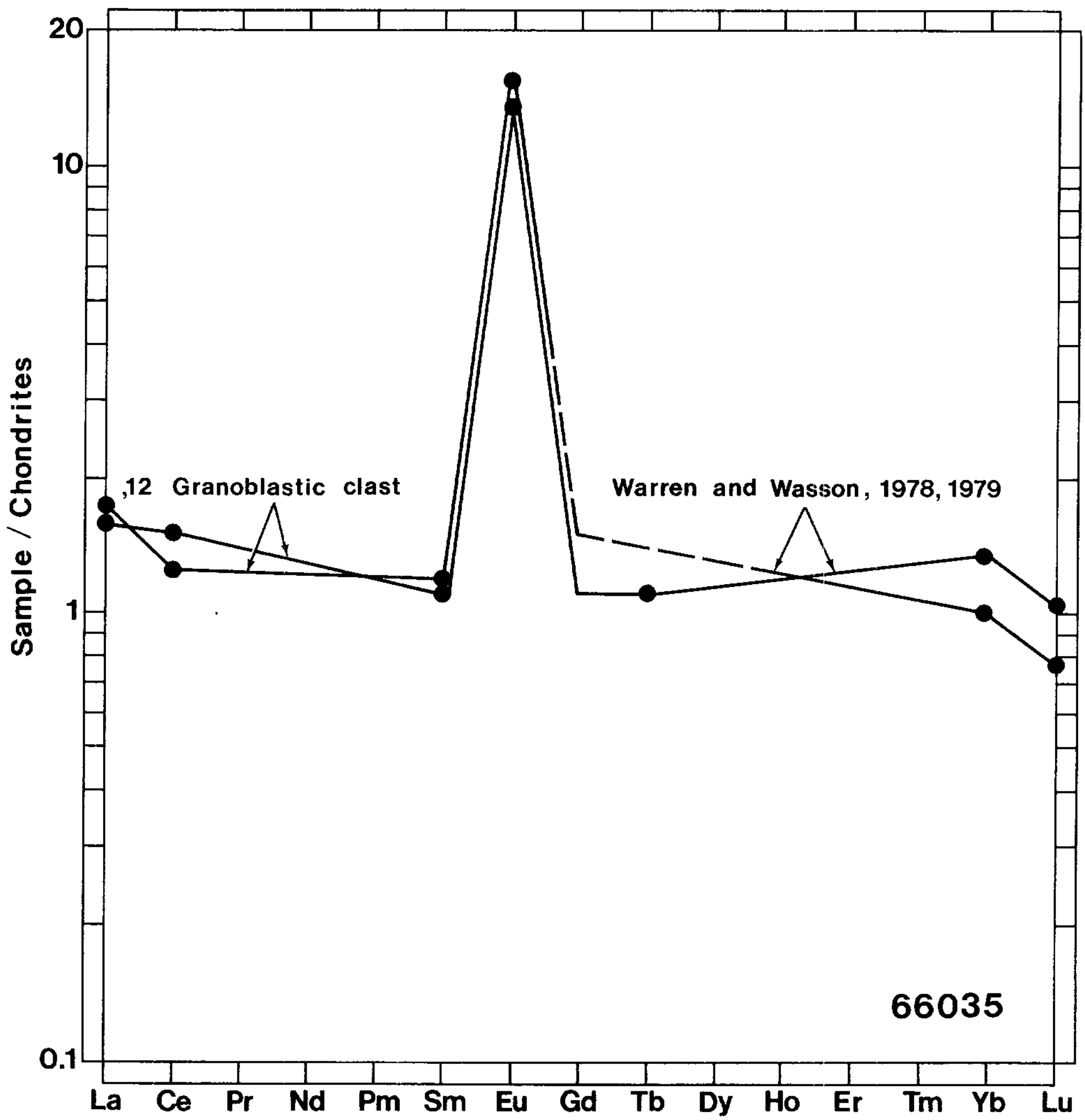



Figure 4. Rare earths.

TABLE 1. Summary chemistry of granoblastic clast in 66035

| | |
|---|---|
| $SiO_2$ | 44.3 |
| $TiO_2$ | 0.076 |
| $Al_2O_3$ | 30.4 |
| $Cr_2O_3$ | 0.036 |
| FeO | 3.0 |
| MnO | 0.037 |
| MgO | 4.2 |
| CaO | 17.0 |
| $Na_2O$ | 0.42 |
| $K_2O$ | 0.013 |
| $P_2O_5$ | |
| Sr | |
| La | 0.56 |
| Lu | 0.031 |
| Rb | |
| Sc | 2.7 |
| Ni | 20.4 |
| Co | 7.5 |
| Ir ppb | 0.60 |
| Au ppb | 0.14 |
| C | |
| N | |
| S | |
| Zn | 0.9 |
| Cu | |

Oxides in wt%; others in ppm except as noted.

EXPOSURE AGE: $^{26}Al$ and $^{22}Na$ abundances in the whole rock are given without comment by Eldridge *et al.* (1973).

PROCESSING AND SUBDIVISIONS: 66035 has never been sawn. A few chips of matrix have been taken for thin sections. Wasson received allocations from both the large white clast and the poikilitic norite clast. The largest single piece remaining is ,0 (197 g).

INTRODUCTION: 66036 is a friable, light gray, clastic breccia (Fig. 1). It was collected on the rim of a 10 m crater near the base of Stone Mountain. A few zap pits are present on all sides.

PETROLOGY: Fragments of plagioclase dominate a clast population that also includes basaltic impact melt, glassy, clast-laden breccia, beads and fragments of pale brown glass, and Fe-metal. The matrix is an unequilibrated mixture of finely comminuted mineral grains (Fig. 2).

PROCESSING AND SUBDIVISIONS: In 1972 two chips (,1 and ,2) were removed and ,1 allocated for thin sections.

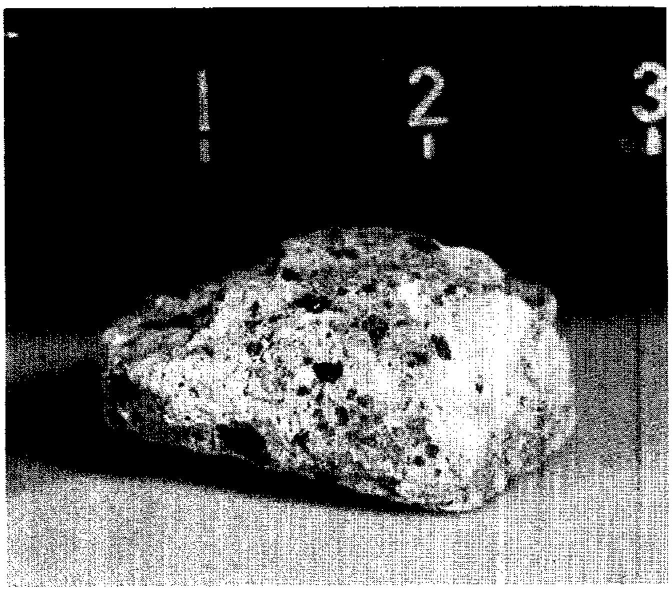


Figure 1. S-72-40389, cm scale.

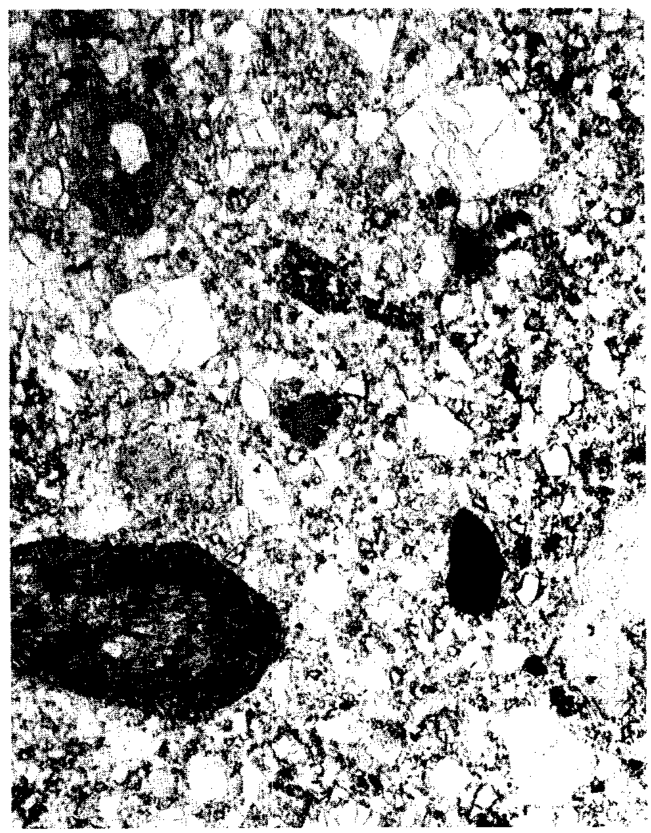


Figure 2. 66036,5, general view, ppl. width 2mm.

INTRODUCTION: 66037 is a moderately coherent, light gray, glassy breccia (Fig. 1). It was collected from the rim of a 10 m crater near the base of Stone Mountain. Zap pits and patina are abundant on all surfaces.

PETROLOGY: Mineral fragments, dominantly plagioclase, and clasts of fragment-laden, glassy impact melt and rare poikilitic impact melt rest in a continuous glassy matrix (Fig. 2).

PROCESSING AND SUBDIVISIONS: In 1973 a chip (,1) was removed for thin sections.

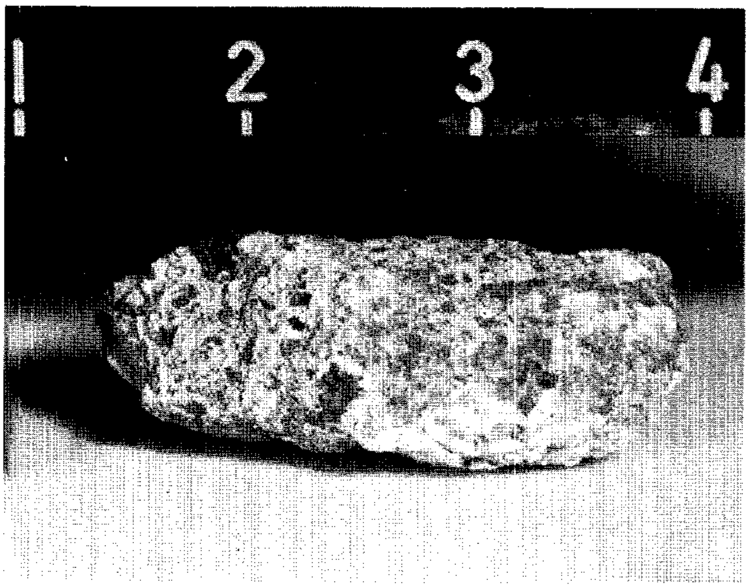



Figure 1. S-72-40391, cm scale.

Figure 2. 66037,5, general view, ppl. width 2mm.

INTRODUCTION: 66055 has petrological characteristics intermediate between polymict fragmental breccias and dimict black and white rocks. Like dimict rocks the variety of lithic types within the broad dark and light divisions is restricted, and the clast-matrix relationships of dark and light are inconsistent. Like the fragmental breccias the lithologies are well-mixed on a small scale (Fig. 1) and include glass. The light material consists of fragments of anorthosite-noritic-troctolitic material and its degraded debris. The dark material varies from brown glass through fine-grained clast-rich breccia to mesostasis-rich impact basalt. Some white fragments are rimmed by dark material (Fig. 1).

66055 was collected from the north rim of a 10 m crater near the base of Stone Mountain. The sample is sub-angular, coherent, and has some penetrative fractures. It was only slightly buried and its orientation is known. The buried side had no zap pits and most occur on one side rather than the top.

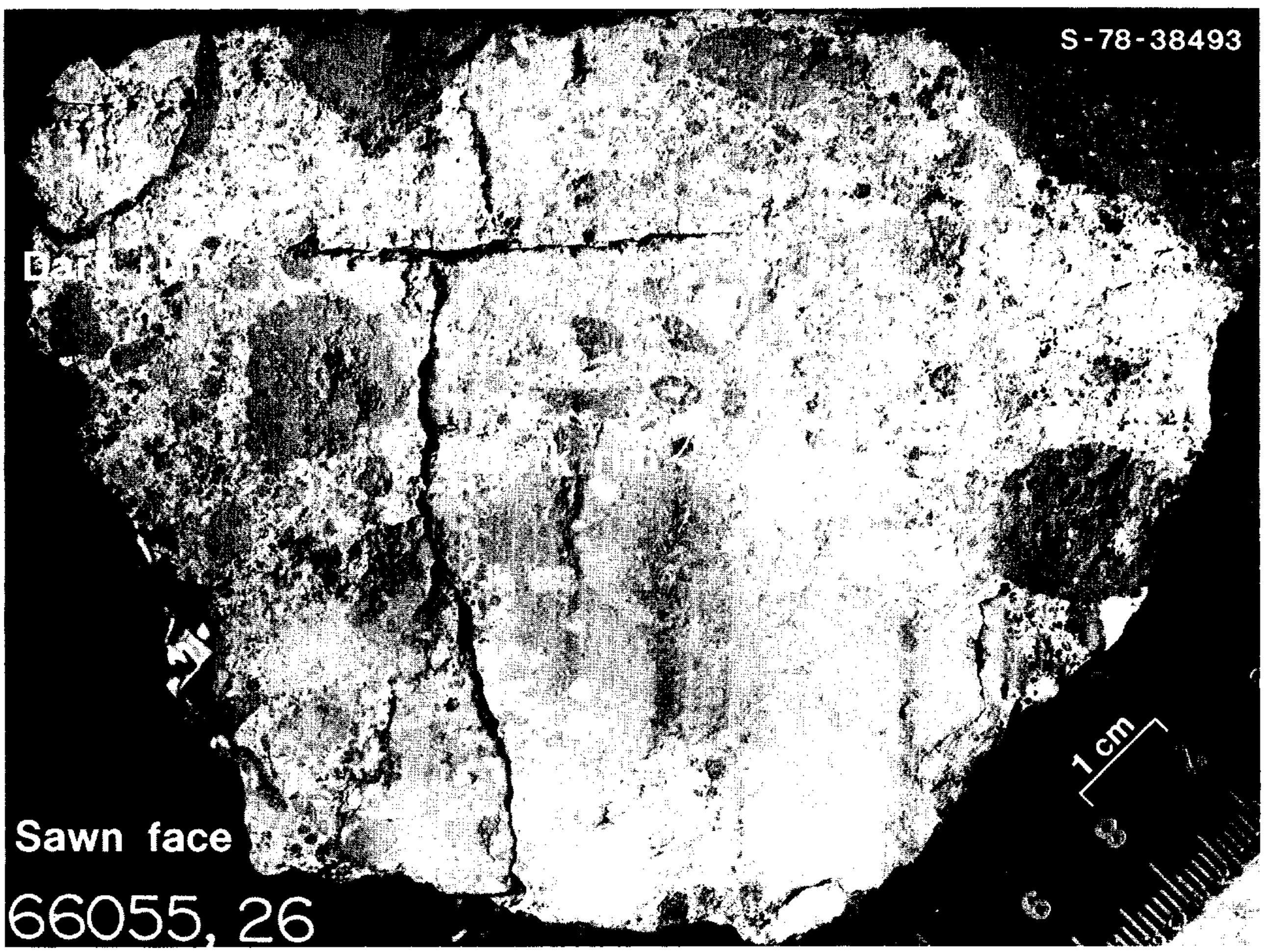



Figure 1.

PETROLOGY: Petrological descriptions, including microprobe data, of the rock are presented by McKay et al. (1973a,b) and Fruchter et al. (1974). Reed and Taylor (1974) discuss and provide metal compositions (lithology not stated) and MacDougall et al. (1973) report high-voltage electron microscope observations on dark materials. Wilshire and Moore (1974) depict the rock as a typical "black and white" breccia.

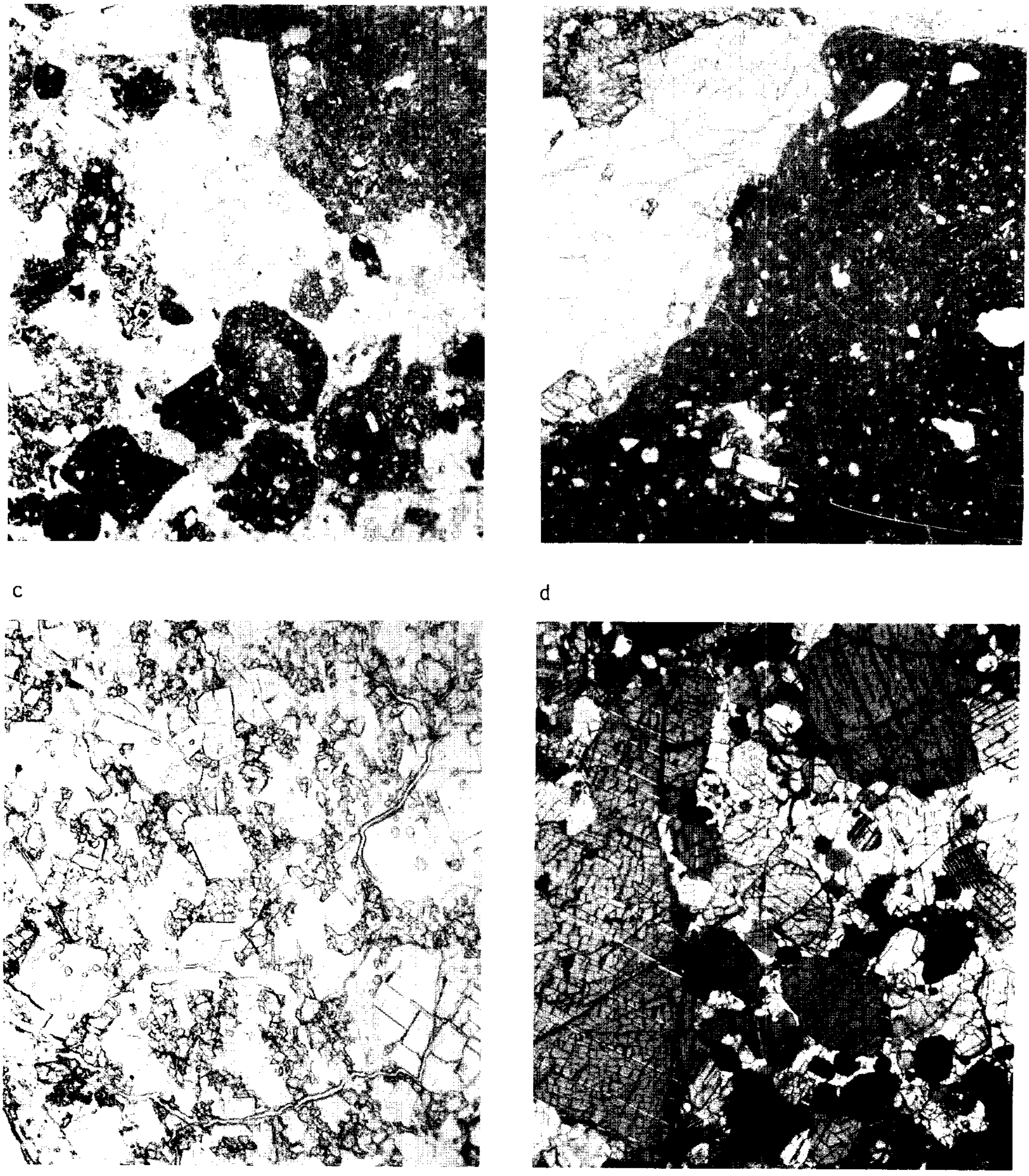
66055 consists of fragments of aphanitic dark materials and coarse light materials (Figs. 1 and 2). The dark materials vary from brown glass to mesostasis-rich basalt, with some fragments showing a gradation from one to the other (Fig. 2). The white fragments mainly have poikiloblastic (Fig. 2) or granoblastic textures while others are apparently cumulate (Fig. 2). Wilshire and Moore (1974) interpret the rock textures as indicating that dark material formed the original matrix to the rock and the white material was remobilized later; broken fragments of dark material have thin glassy selvages.

Fruchter et al. (1974), expanding on their previous work (McKay et al., 1973a) describe 66055 as containing clasts of brown glass, non-recrystallized breccia, partially-molten microbreccia (= basaltic impact melt), and anorthositic-noritic-troctolitic (ANT) clasts. A feldspathic matrix is difficult to distinguish from the ANT clasts. (They refer to the sample as a regolith breccia but regolith characteristics such as a wide variety of clasts including agglutinates are in fact absent). The brown glass contains plagioclase clasts ($An_{93-95}$). The non-recrystallized breccias ("equivalent to light and dark-matrix breccias") contain pyroxene (Fig. 3), olivine, and plagioclase. The partially molten microbreccia is subophitic-ophitic. It contains clasts of plagioclase, olivine, and pyroxene in a medium-grained to cryptocrystalline matrix of plagioclase ($An_{93-95}$), olivine ($Fo_{75-82}$), and mesostasis. This lithology is distinctive for its metal blebs. The white clasts are anorthositic-noritic-troctolitic with textures ranging from primary igneous to cataclastic to poikiloblastic. Pyroxene compositions are shown in Figure 3. The matrix material described has fragments from 10 or 20 μm to 1 mm in diameter (the phrase "vast majority near 0.25 μm" in Fruchter et al. (1974) must be in error and probably should read 0.25 mm). Plagioclase, olivine, two pyroxenes, ilmenite, metal and troilite are present, with rare pink spinel.

McKay et al. (1973b) and to a lesser extent Fruchter et al. (1974) report kamacite-schreibersite compositions and relationships. Schreibersite is present most commonly in the subophitic melt but also occurs in the brown glass. Kamacite typically has ∿4.4% Ni and ∿0.4% Co. Experiments on melt compositional analogs produced an immiscible Fe-Ni-P liquid which crystallized to Fe-Ni metal and schreibersite. In the rock, the distribution of Ni between kamacite and schreibersite suggests that the particles last equilibrated at ∿550°C. Reed and Taylor (1974) report metal compositions with 4-8% Ni, 0.2-0.5% Co, and up to 0.4% P, and note the presence of taenite.

MacDougall et al. (1973) report high-voltage electron microscope (HVEM) observations on the brown "glassy" lithology. The HVEM reveals that these in fact consist of packed agglomerations of submicron-sized crystallites which are severely deformed. A lack of solar flare tracks in the rock lead MacDougall et al. (1973) to conclude that 66055 is highly metamorphosed.

a b



c d

Figure 2. a) 66055,63, general view, ppl. width 2mm.
b) 66055,71, general view, ppl. width 2mm.
c) 66055,63, poikiloblastic white material, ppl. width 1mm.
d) 66055,75, possible cumulate, xpl. width 2mm.

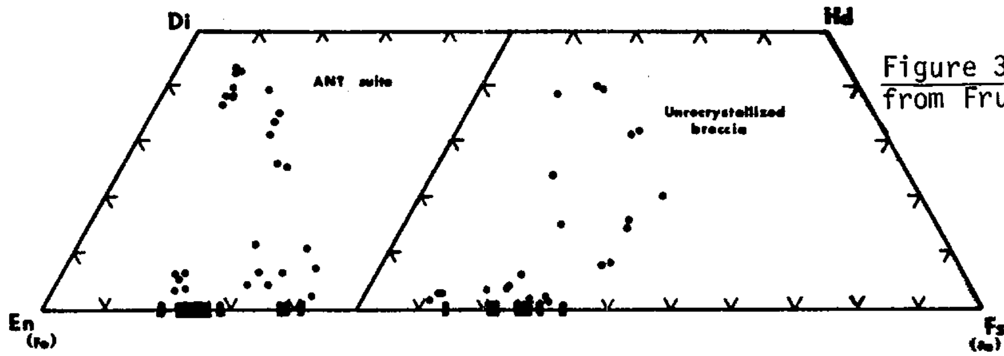



Figure 3. Mineral compositions, from Fruchter et al. (1974).

CHEMISTRY: Fruchter et al. (1974) report partial analyses, including trace elements, for matrix, and for white basaltic impact melt, unrecrystallized breccia, and unassigned clasts. They also report defocussed beam microprobe analyses of brown glass, unrecrystallized breccia, and basaltic impact melt fragments. S.R. Taylor et al. (1973) report a major and trace element analysis of white material (apparently white clasts and white matrix). The split number analyzed, reported as ,32, was in fact ,42. Moore et al. (1973), Cripe and Moore (1974) and Moore and Lewis (1976) report C, S (for white and mixed materials) and N (for white material) abundances respectively.

The data are summarized in Tables 1 and 2 and Figure 4. In general the distinction of white clast and matrix is difficult physically and the chemical ranges of these two are similar with an average of ~30% $Al_2O_3$. The brown glasses and unrecrystallized breccias are less aluminous than the basaltic impact melts, which appear to be similar to other aluminous melts among the Apollo 16 rocks. Nonetheless the range of compositions is not great. None of the materials are similar to local regolith although the average of the rock (light plus dark) might be. The low C abundances are not compatible with 66055 being a regolith breccia.

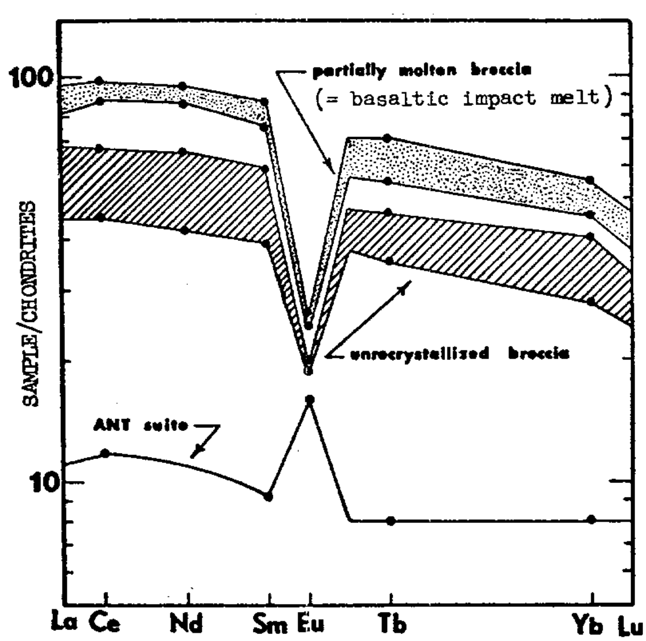



Figure 4. Rare earths, from Fruchter et al. (1974).

TABLE 1. Summary chemical data for 66055 lithologies

| | Light, matrix a) | Light, matrix b) | Subophitic melt c) | Unrex. breccia c) | White clasts c) |
|---|---|---|---|---|---|
| $SiO_2$ | 43.6 | | | | |
| $TiO_2$ | 1.8* | | | | |
| $Al_2O_3$ | 31.4 | 29.4 | 23.7 | 25.9 | 27-36 |
| $Cr_2O_3$ | | 0.10 | 0.16 | 0.11 | 0.003-0.14 |
| FeO | 2.2 | 4.4 | 8.5 | 5.4 | 0.1-4.3 |
| MnO | | | | | |
| MgO | 4.1 | | | | |
| CaO | 16.8 | | | | |
| $Na_2O$ | 0.37 | 0.40 | 0.51 | 0.46 | 0.27-0.41 |
| $K_2O$ | 0.10 | 0.11 | 0.25 | 0.22 | <0.08 |
| $P_2O_5$ | | | | | |
| Sr | | | | | |
| La | 3.2 | 9.3 | 29.1 | 16.9 | <3.7 |
| Lu | 0.14 | 0.55 | 1.3 | 0.85 | |
| Rb | 0.98 | | | | |
| Sc | | 6.5 | 11.9 | 8.7 | 0.4-6.5 |
| Ni | | | | | |
| Co | | 25 | 62 | 32 | 1-22 |
| Ir ppb | | | | | |
| Au ppb | | | | | |
| C | | 22 | | | |
| N | | 49 | | | |
| S | | 520 | | | |
| Zn | | | | | |
| Cu | | | | | |

Oxides in wt%; others in ppm except as noted.

a) S.R. Taylor et al. (1973)
b) Fruchter et al. (1974), and others
c) Fruchter et al. (1974)
* Possibly a typographical error; should be 0.18?

TABLE 2. Defocussed beam microprobe analyses of 66055 lithic types (Fruchter et al., 1974)

| wt.% | brown glass | unrecrystallized breccia | basaltic impact melt |
|---|---|---|---|
| $SiO_2$ | 46.9 | 45.4 | 45.1 |
| $TiO_2$ | 1.2 | 1.1 | 0.9 |
| $Al_2O_3$ | 19.1 | 20.9 | 23.2 |
| $Cr_2O_3$ | 0.19 | 0.16 | 0.16 |
| FeO | 7.8 | 7.5 | 5.8 |
| MgO | 10.6 | 9.1 | 9.1 |
| CaO | 11.9 | 12.1 | 13.0 |
| $Na_2O$ | 0.65 | 0.69 | 0.04* |
| $K_2O$ | 0.35 | 0.35 | 0.27 |
| $P_2O_5$ | 0.36 | 0.30 | 0.20 |

*probable typographical error; should be 0.4?

STABLE ISOTOPES: Clayton et al. (1973) report $\delta O^{18}$ values for splits of 66055 (Table 3). These values are typical of lunar rocks.

TABLE 3. $\delta O^{18}$ for subdivisions of 66055,13

| | |
|---|---|
| whole rock | :+ 5.58 ‰ |
| light clast | :+ 5.75 ‰ |
| dark clast | :+ 5.48 ‰ |

GEOCHRONOLOGY: Phinney et al. (1975) report $^{40}Ar$-$^{39}Ar$ data for a mixed split of 66055. Its apparent age behavior (Fig. 5) is like that of Apollo 14 breccias. Because there is no unambiguous plateau, Phinney et al. (1975) calculate only a K-Ar age of 3.90±0.02 b.y. The data also imply that K and Ca are well-mixed in the sample. (Note that an explanation of the release pattern from recoil in fine-grained material is based on information from Fruchter et al. (1974) that most matrix grains are ∿0.25 μm which is probably erroneous).

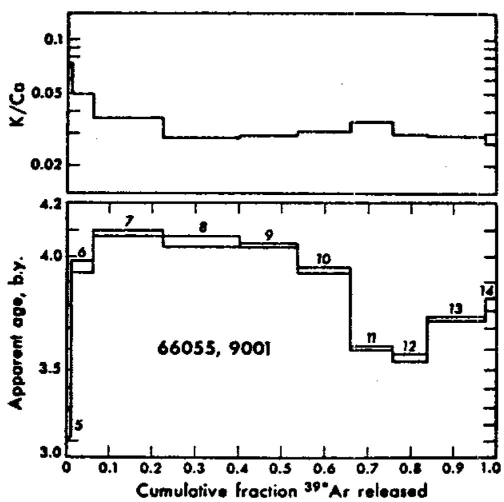



Figure 5. Ar releases, from Phinney et al. (1975).

EXPOSURE AGE: Phinney et al. (1975) report a $^{38}Ar$-Ca exposure age of 55±13 m.y. for a mixed split of 66055. MacDougall et al. (1973) found no solar flare tracks in the rock.

PHYSICAL PROPERTIES: Collinson et al. (1973) report natural remanent magnetization (NRM) data for subsplits of a mixed sample. A chip had an NRM of 18.1 x $10^{-6}$ emu·g$^{-1}$, and after being split, the four subsplits had values of 30.0, 7.9, 7.3, and 15.6 x $10^{-6}$ emu·g$^{-1}$ i.e. quite variable. The variability showed no obvious correlation with the proportion of dark to light material. Figure 6 shows that the direction of NRM of the subsplits (A,B,F,R) are in reasonable agreement. A,F, and R had a dominantly soft NRM component; A had no detectable hard component at all. The changes in directions during demagnetization of the subsplits were different. A possible interpretation is that the breccia was not heated above the Curie point (∿780°C) during formation and thus old hard componets are preserved. After formation, a soft, stronger remanence of homogeneous direction was acquired. The variation in intensity could then be a result of variable iron contents of subsplits. Brecher (1975) interprets the inhomogeneity of NRM as supporting the model of "textural remanence".

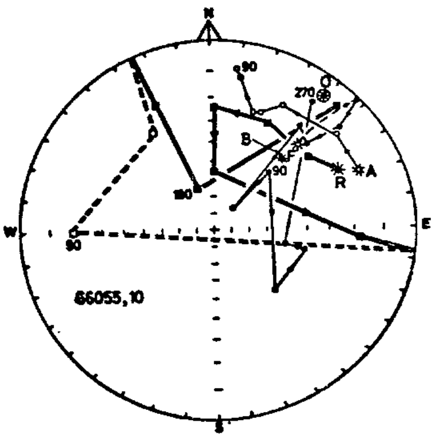



Figure 6. AF-demagnetization, from Collinson *et al*. (1973).

Nagata *et al*. (1973) tabulate basic magnetic properties for a mixed split and derive an average Ni content for kamacite of 6.0±0.5% from magnetic methods. An extensive discussion of the intensity and stability of NRM is presented. Schwerer and Nagata (1976) use the previously reported magnetic data to obtain the size of the superparamagnetic iron particles (mean diameter of fine-grained particles = 54 Å). They also summarize some of the magnetic properties relevant to the characterization of the superparamagnetic and ferromagnetic components. Schwerer *et al*. (1973) and Huffman *et al*. (1974) repeat some of the data of Nagata *et al*. (1973) but also report Mossbauer analyses for the distribution of Fe between phases, and the $Fe^0/Fe^{2+}$ ratio. The latter (0.045) is much lower than the value derived by magnetic measurements (0.205), a discrepancy typical of olivine-rich rocks and for which possible explanations are presented. 57.4% of the total Fe of the sample analyzed is in olivine, 37.8% in pyroxene, ∿0.5% in ilmenite, and 4.3% in metallic iron.

Cisowski *et al*. (1974) plot $Fe^0$ of 0.4% (from their magnetic measurements) on an $Fe^0$ v. $Fe^0 + Fe^{2+}$ diagram. The determination is derived from the value of saturation magnetization, and assumes the metal to be entirely $Fe^0$, neglecting other possible ferromagnetic phases.

Katsube and Collett (1973a) report electrical properties (Fig. 7) for a mixed chip which is mainly dark. The characteristics are unusual: in particular K′ (real relative permittivity) varies with frequency more than other lunar rocks and similarly to terrestrial pyroxenes and serpentines.

Warren and Trice (1975) illustrate the variations of dynamic modulus (from acoustic measurements), and static bulk modulus (from strain gauge measurements) with pressure. Apparently the sample used was a mixed dark and light chip.

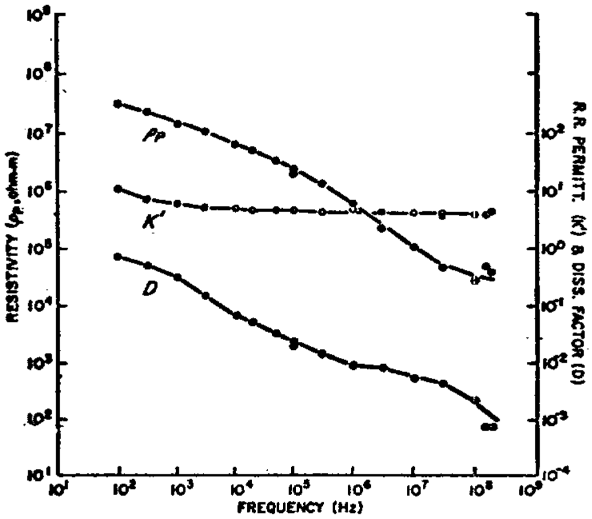



Figure 7. Electrical parameters, K'= real relative permittivity, Pp= parallel resistivity, D= dissipation factor, from Katsube and Collet (1973a)

PROCESSING AND SUBDIVISIONS: 66055 was sawn in 1972, producing two end pieces (,25; 231 g and ,26; 673 g) and a slab piece (Fig. 8). The two end pieces remain intact except for a few small chips removed from ,25. The slab has been extensively dissected (Fig. 9). A large split ,24 (151 g) has broken into several pieces. More splits than are shown on Figures 8 and 9 have been made.

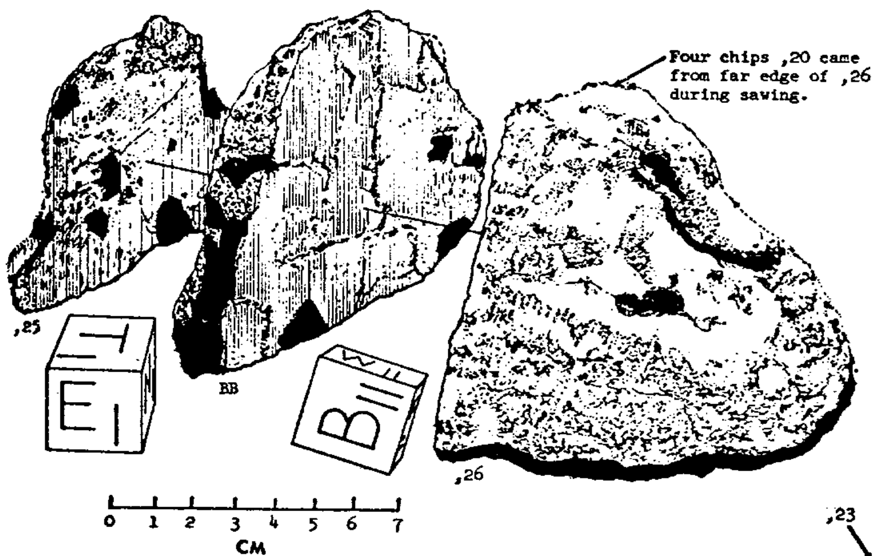



Figure 8. Cutting diagram.

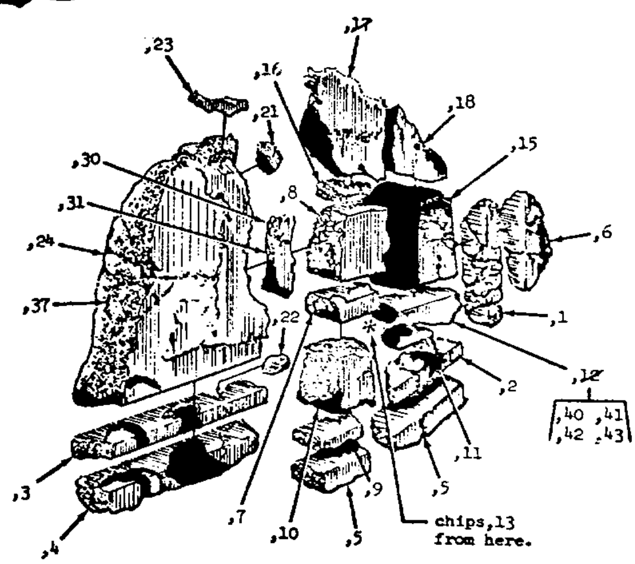



Figure 9. Slab subdivisions.

INTRODUCTION: 66075 is a coherent, light gray breccia (Fig. 1) with a significant regolith component. Dark and light clasts are more or less equal in abundance. 66075 was collected from the rim of a small, unnamed crater. Zap pits saturate the "lunar top" surface but are absent from unexposed surfaces.

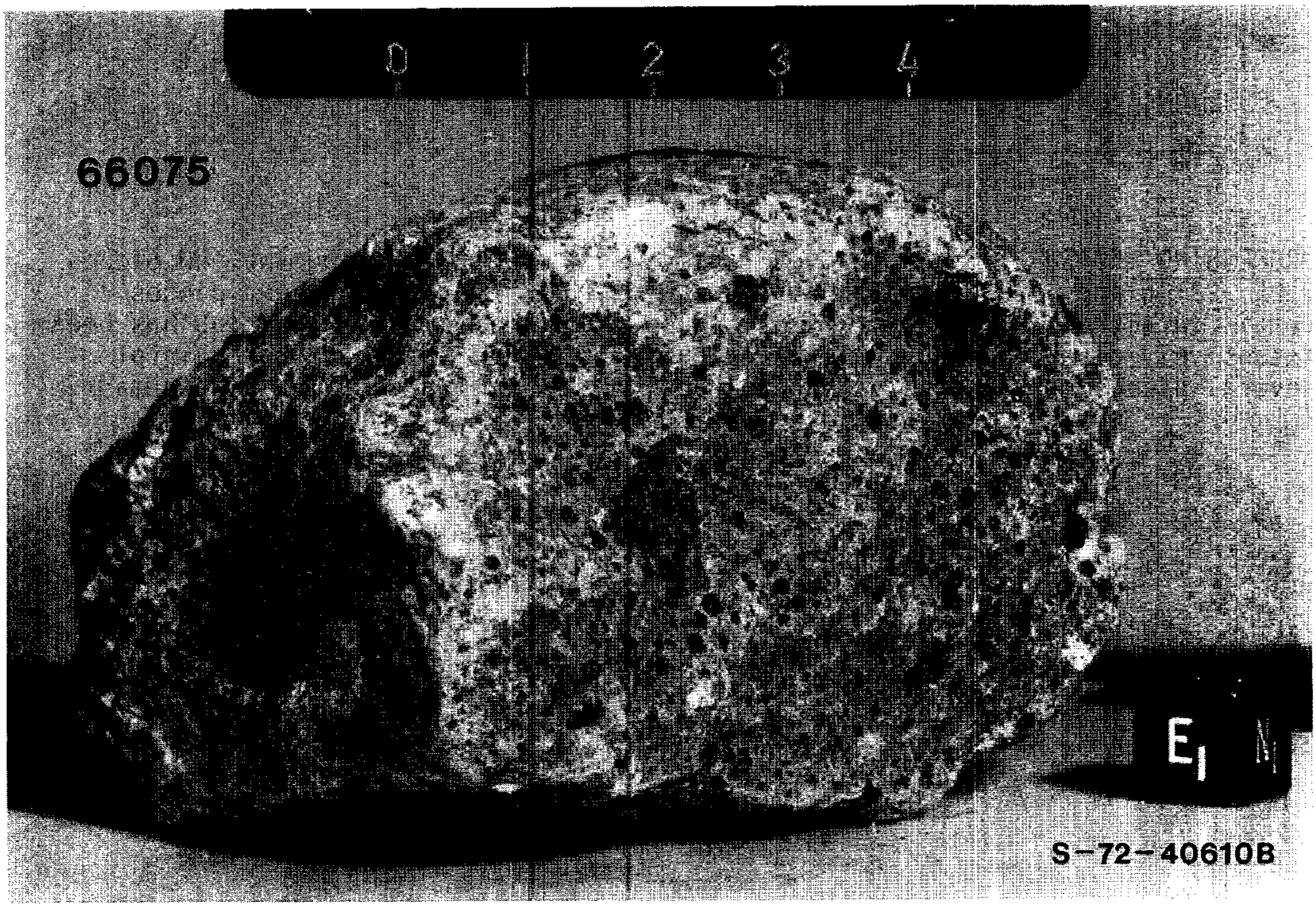



Figure 1. cm scale.

PETROLOGY: A petrographic description is given by Quick et al. (1978). This rock is a clastic breccia with a seriate grain size distribution and a diverse clast population (Fig. 2). 10-20% of the rock is composed of clasts >4 mm with the remainder smaller clasts and matrix (Quick et al., 1978). Lithic fragments predominate over mineral and glass fragments; mineral compositions are given in Figure 3.

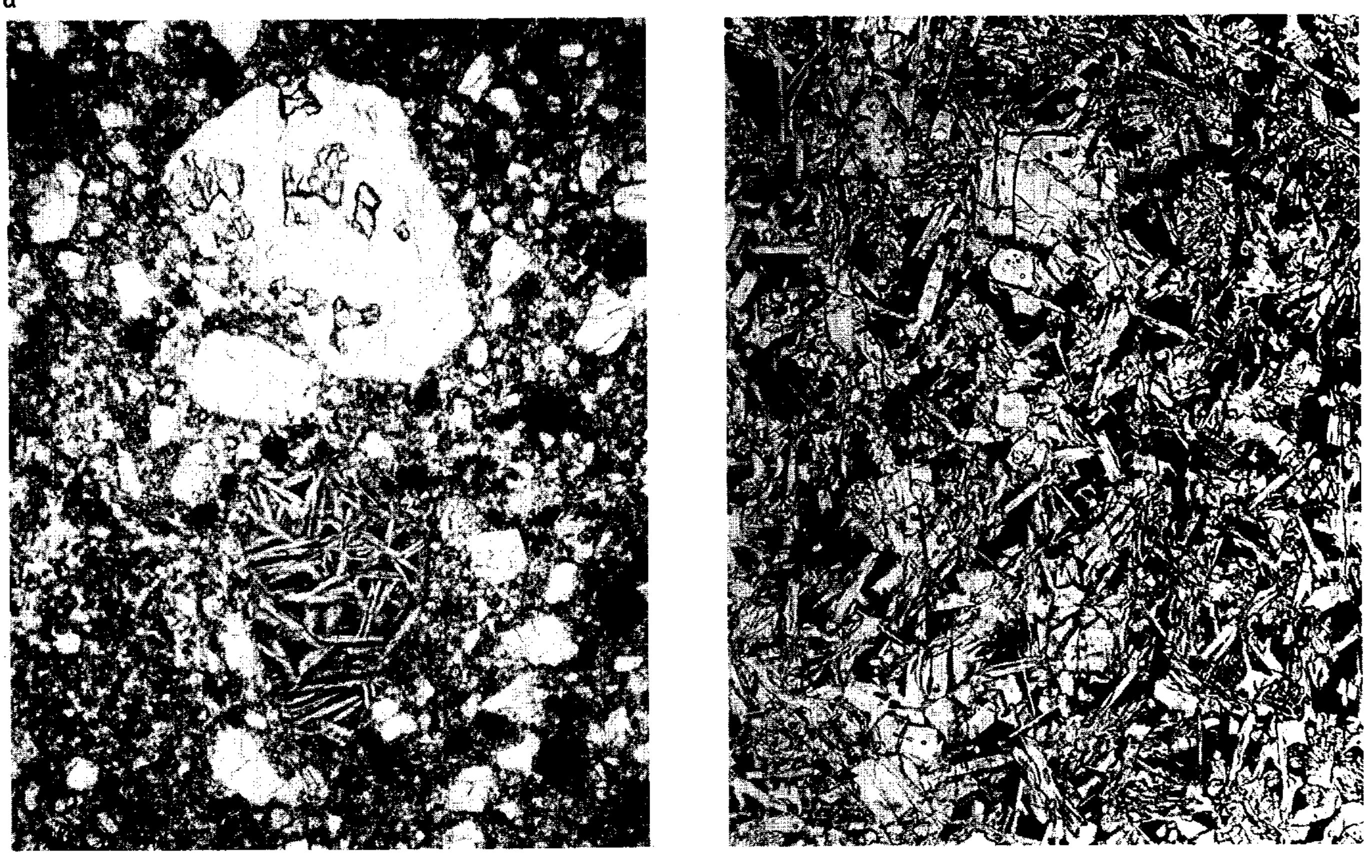


Figure 2. a) 66075,62, general view, ppl. width 2mm.
b) 66075,65, dark clast, ppl. width 0.5mm.

Most of the lithic fragments are varieties of impact melt: vitric to aphanitic matrix breccia, poikilitic breccia, intergranular basaltic impact melt, and plagioclase and olivine vitrophyres (Fig. 2). Xenocrysts or xenoliths are present in most, but not all, of these clasts. The poikilitic fragments (the "hornfels" clasts of Quick et al., 1978) generally have a very fine-grained texture, with poorly developed oikocrysts. Most of the impact melt fragments are rounded and not deformed by shock.

Coarser-grained granoblastic lithic fragments tend to be more angular than the impact melt clasts discussed above, and have textures indicative of subsolidus annealing (Fig. 2). Granoblastic anorthosite, gabbroic and noritic anorthosite, and troctolite were recognized by Quick et al. (1978). Mafic minerals tend to occur as small (<50 μm), anhedral grains interstitial to larger (<500 μm), anhedral plagioclase, though locally pyroxenes enclose equant plagioclases poikilitically. Most of the coarser-grained granoblastic fragments show shock-related features, such as undulose extinction and fracturing.

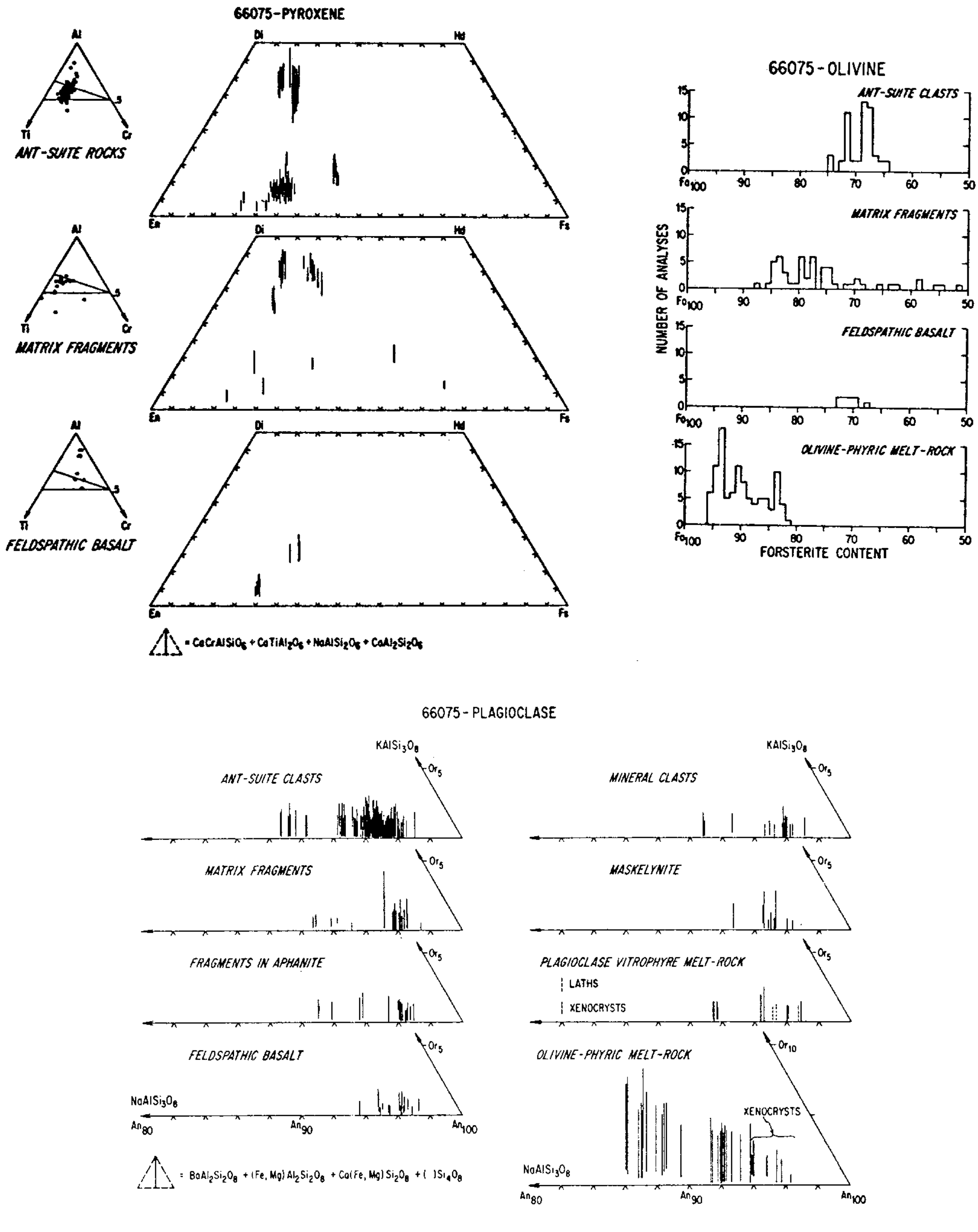
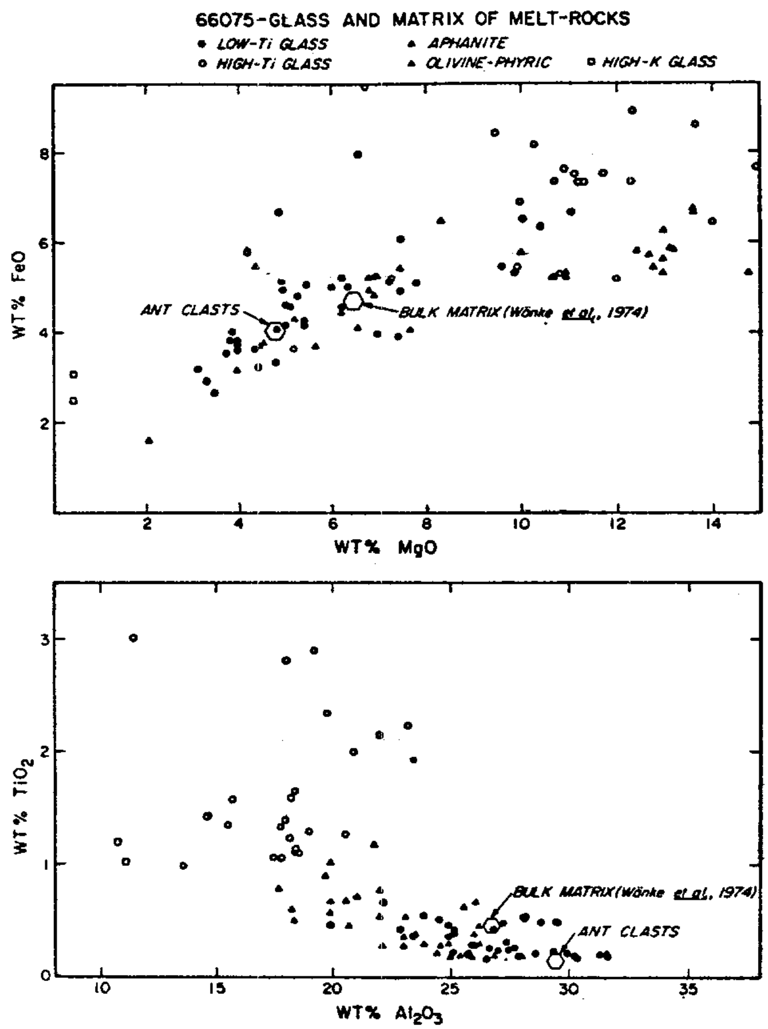



Figure 3. Mineral compositions, from Quick et al. (1978).

Beads and fragments of various types of glass are also present. Three compositional groups were recognized by Quick et al. (1978): high-Ti glass (1-3% $TiO_2$), low-Ti glass (<0.6% $TiO_2$) and rare high-K "granitic" glass (∿6% $K_2O$ and ∿75% $SiO_2$) (Fig. 4). The low-Ti glass approximates local soil compositions whereas the high-Ti glass approximates the composition of most Apollo 16 poikilitic impact melts ("Fra Mauro basalt") (Table 1).

Mineral fragments are dominated by plagioclase with lesser amounts of olivine, pyroxene , pink spinel, troilite,and metal (Figs. 3 and 5).




Compositions of glass fragments and spheres, and groundmass of melt-rocks in 66075.

Figure 4. Glass compositions, from Quick et al. (1978).

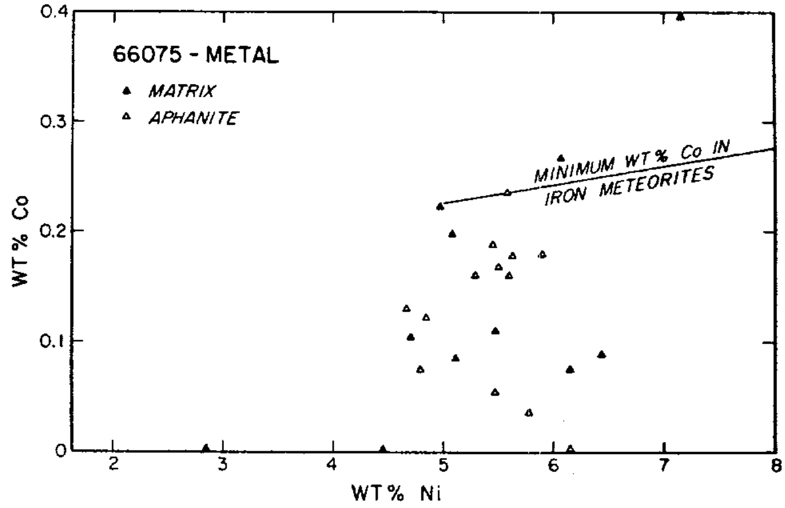



Figure 5. Metals, from Quick et al. (1978).

CHEMISTRY: Major and trace element analyses of the bulk rock are presented by Wänke et al. (1974, 1977), Boynton et al. (1975) and Garg and Ehmann (1976). Miller et al. (1974) give major elements and Wasson et al. (1975) report siderophiles and volatiles of the bulk rock. Moore and Lewis (1976) provide bulk N and C data.

Natural and cosmogenic radionuclide abundances in the whole rock were determined by Eldridge et al. (1973) and Clark and Keith (1973). Quick et al. (1978) report electron microprobe analyses of glass fragments and defocussed beam microprobe analyses of some impact melt fragments (Table 1).

The bulk rock has a major element composition very similar to the local soils (Table 1). REEs in the rock are slightly lower than most of the soils (Fig. 6). Wasson et al. (1975) note that 66075 is rich in volatiles and that Ge is especially enriched relative to other volatile elements.

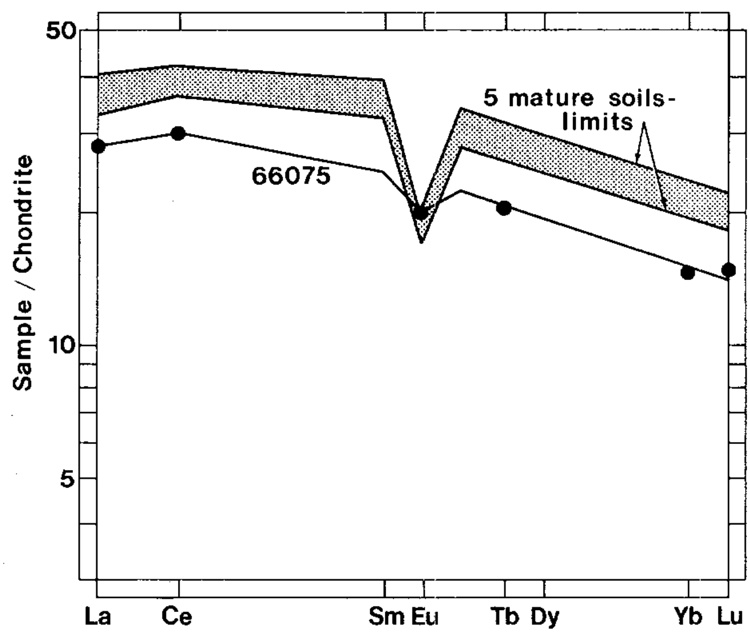



Figure 6. Rare earths, from Boynton et al. (1975).

TABLE 1. Summary chemistry of 66075

| | Bulk rock | Low-Ti glass | High-Ti glass | High-K glass | Olivine* vitrophyre | Aphanite* |
|---|---|---|---|---|---|---|
| $SiO_2$ | 45.4 | 45.59 | 49.06 | 75.38 | 46.9 | 45.9 |
| $TiO_2$ | 0.45 | 0.34 | 1.58 | 1.10 | 0.6 | 0.4 |
| $Al_2O_3$ | 27.3 | 27.02 | 18.30 | 10.87 | 20.0 | 24.7 |
| $Cr_2O_3$ | 0.08 | 0.07 | 0.21 | 0.0 | 0.2 | 0.1 |
| FeO | 4.8 | 4.61 | 7.31 | 2.80 | 5.7 | 4.6 |
| MnO | 0.06 | 0.07 | 0.11 | 0.08 | 0.1 | 0.1 |
| MgO | 6.5 | 5.80 | 10.96 | 0.20 | 12.4 | 6.5 |
| CaO | 15.7 | 15.80 | 11.33 | 1.80 | 12.6 | 15.5 |
| $Na_2O$ | 0.486 | 0.40 | 0.62 | 0.57 | 0.5 | 0.5 |
| $K_2O$ | 0.095 | 0.07 | 0.39 | 6.19 | 0.2 | 0.1 |
| $P_2O_5$ | 0.11 | 0.05 | 0.28 | 0.10 | 0.1 | 0.1 |
| Sr | 193 | | | | | |
| La | 10 | | | | | |
| Lu | 0.48 | | | | | |
| Rb | 2.1 | | | | | |
| Sc | 6.9 | | | | | |
| Ni | 280 | ∿240 | ∿160 | | <790 | ∿800 |
| Co | 26 | | | | | |
| Ir ppb | ∿8 | | | | | |
| Au ppb | ∿6 | | | | | |
| C | 54 | | | | | |
| N | 28 | | | | | |
| S | | | | | | |
| Zn | 9 | | | | | |
| Cu | 4.3 | | | | | |

Oxides in wt.%; others in ppm except as noted.

*Defocussed beam analyses

RADIOGENIC ISOTOPES AND GEOCHRONOLOGY: Rb-Sr, Sm-Nd and U-Pb data are given by Oberli et al. (1978, 1979) (Table 2). The U-Pb whole rock data are highly discordant but fall along a linear 3.9-4.5 b.y. "cataclysm array" (Fig. 7). An internal isochron from whole rock, acid soluble Pb and leached residue splits yields an age of 3.83 (+ 0.10, -0.05) b.y. (Fig. 8). Oberli et al. (1979) interpret these data to suggest a two stage U-Pb history with an inherited Pb fraction which evolved from 4.47-3.83 b.y. and a radiogenic component produced by the in situ decay of U since 3.83 b.y. ago.

TABLE 2. Rb-Sr and Sm-Nd data for 66075,11 (Oberli et al., 1979)

| Rb (ppm) | Sr (ppm)* | $^{87}Sr/^{86}Sr$ measured | $T_{BABI}$ (b.y.) |
|---|---|---|---|
| 2.25 | 185 | 0.70112±5 | 4.24±0.10 |

| Sm (ppm) | Nd (ppm)** | $^{143}Nd/^{144}Nd$ | $T_{JUV}$ (b.y.) | $T_{CHUR}$ (b.y.) |
|---|---|---|---|---|
| 5.50 | 19.5 | 0.511073±23 | 4.53±0.02 | 4.81±0.19 |

*Calc. from $^{88}Sr$ value
**Calc. from $^{144}Nd$ value

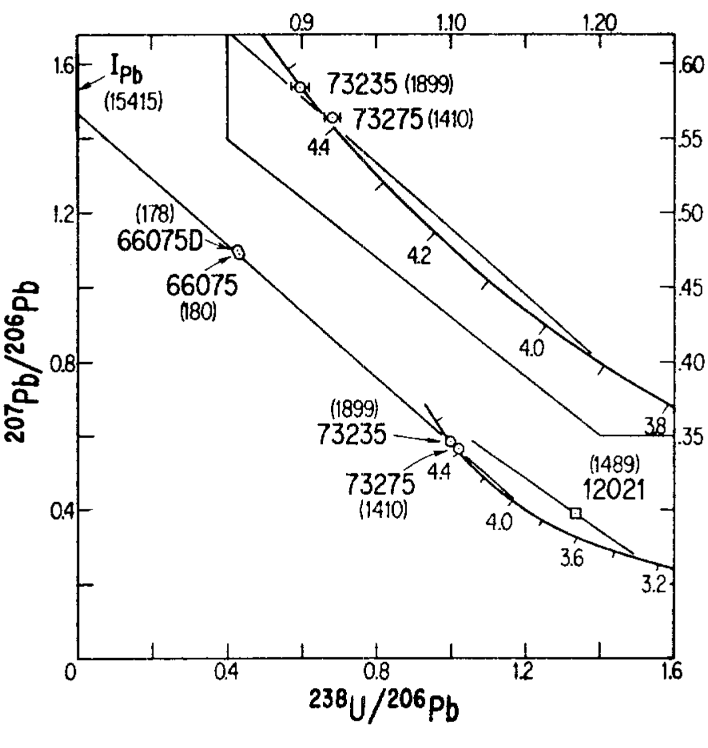



Figure 7. U-Pb evolution diagram, from Oberli et al. (1978).

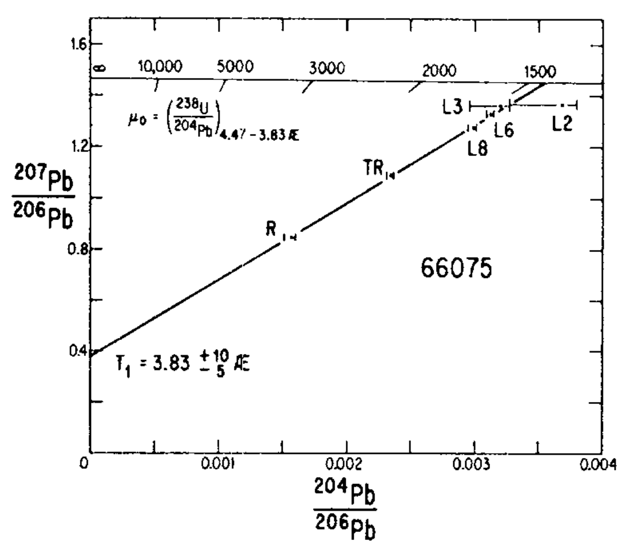



Figure 8. Internal isochron, from Oberli et al. (1979).

EXPOSURE AGE: Eldridge et al. (1973) and Clark and Keith (1973) provide whole rock, cosmogenic radionuclide data as determined by gamma-ray spectroscopy. From these data, Yokoyama et al. (1974) conclude that 66075 is saturated in $^{26}Al$ activity.

MICROCRATERS: Zap pits occur only on the surfaces exposed at the time of collection indicating that 66075 has had a simple exposure history. Morrison et al. (1973) and Neukum et al. (1973) give size-frequency data (Fig. 9). Both consider the exposed surfaces to represent an equilibrium population of pits. Morrison et al. (1973) calculate a "best guess" exposure age of at least 7-10 m.y.

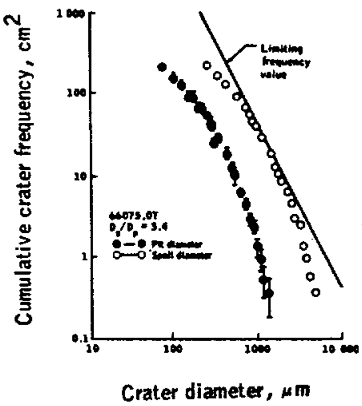



FIGURE 9. Microcraters; from Morrison et al. (1973).

PROCESSING AND SUBDIVISIONS: 66075 was slabbed in 1973 and the slab subdivided (Fig. 10). ,11 was allocated to Wasserburg and yielded the age data. A portion of the large dark clast in ,25 was extracted together with associated matrix as ,19 and made into thin sections. (,25 is incorrectly numbered as ,9 on the slab photo # S-73-28303, published in Quick et al., 1978). ,15 and a portion of the large dark clast on the exterior surface of ,12 were also made into thin sections. All of the chemical analyses were made on representative interior chips from the S area of butt end ,24.

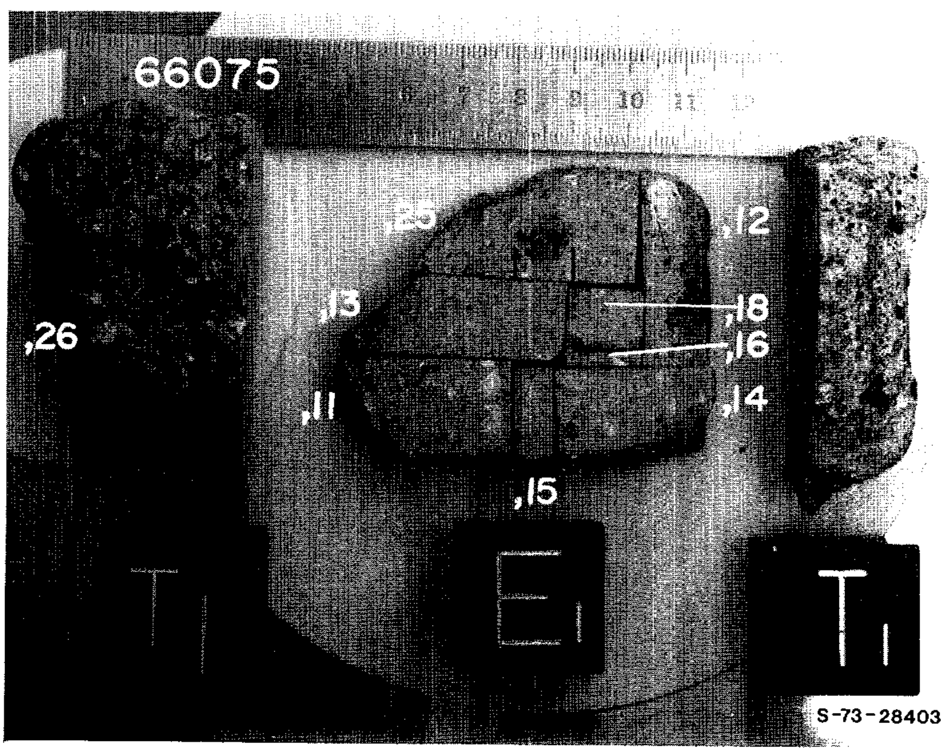



Figure 10. Smallest scale subdivision 0.5mm.

INTRODUCTION: 66085 is a pale gray, very friable breccia (Fig. 1) with many small dark and light clasts. It was taken from a soil sample collected on the inside wall of a 10 m crater, and is too friable to have retained zap pits.

Figure 1. Smallest scale subdivision 0.5mm.

INTRODUCTION: 66086 is a light medium gray, polymict breccia (Fig. 1) with small light and dark angular clasts. It is fairly coherent but not tough. 66086 was taken from a soil sample collected on the rim of a 10 m crater. It lacks zap pits.

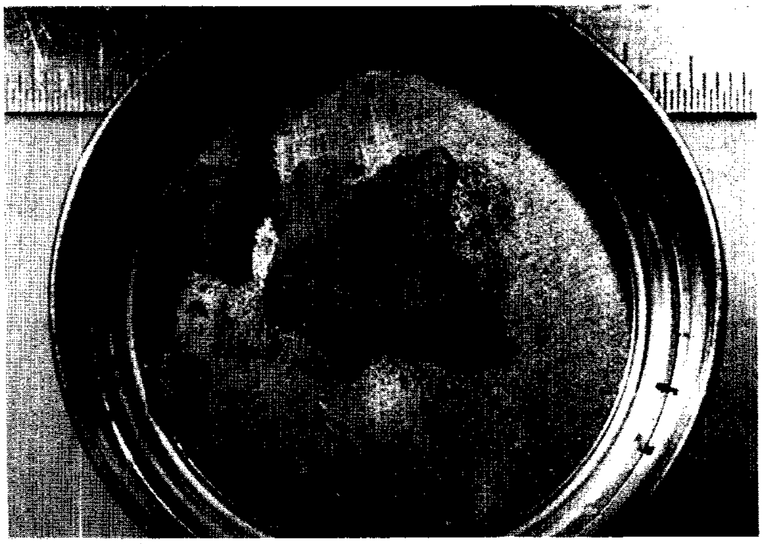


Figure 1. Smallest scale subdivision 0.5mm.

INTRODUCTION: 66095 is a fine-grained, subophitic impact melt, containing lithic and mineral clasts. A distinctive characteristic of 66095 is its abundant rust (β-FeOOH, akaganeite), a secondary consequence of its great abundance of volatiles. The origin of the volatiles is controversial. A small part of the surface of 66095 has a glass coat.

66095 consists of two contiguous pieces (Fig. 1) broken from a block (50x25x15 cm) on the south rim of a 10 m crater near the base of Stone Mountain. Their orientation is known. The parent block was rectangular; the two fragments are subrounded except for a fracture face. The light gray sample has numerous fractures producing a friability, whereas individual pieces are tough. Zap pits are present on the lunar-exposed surfaces.

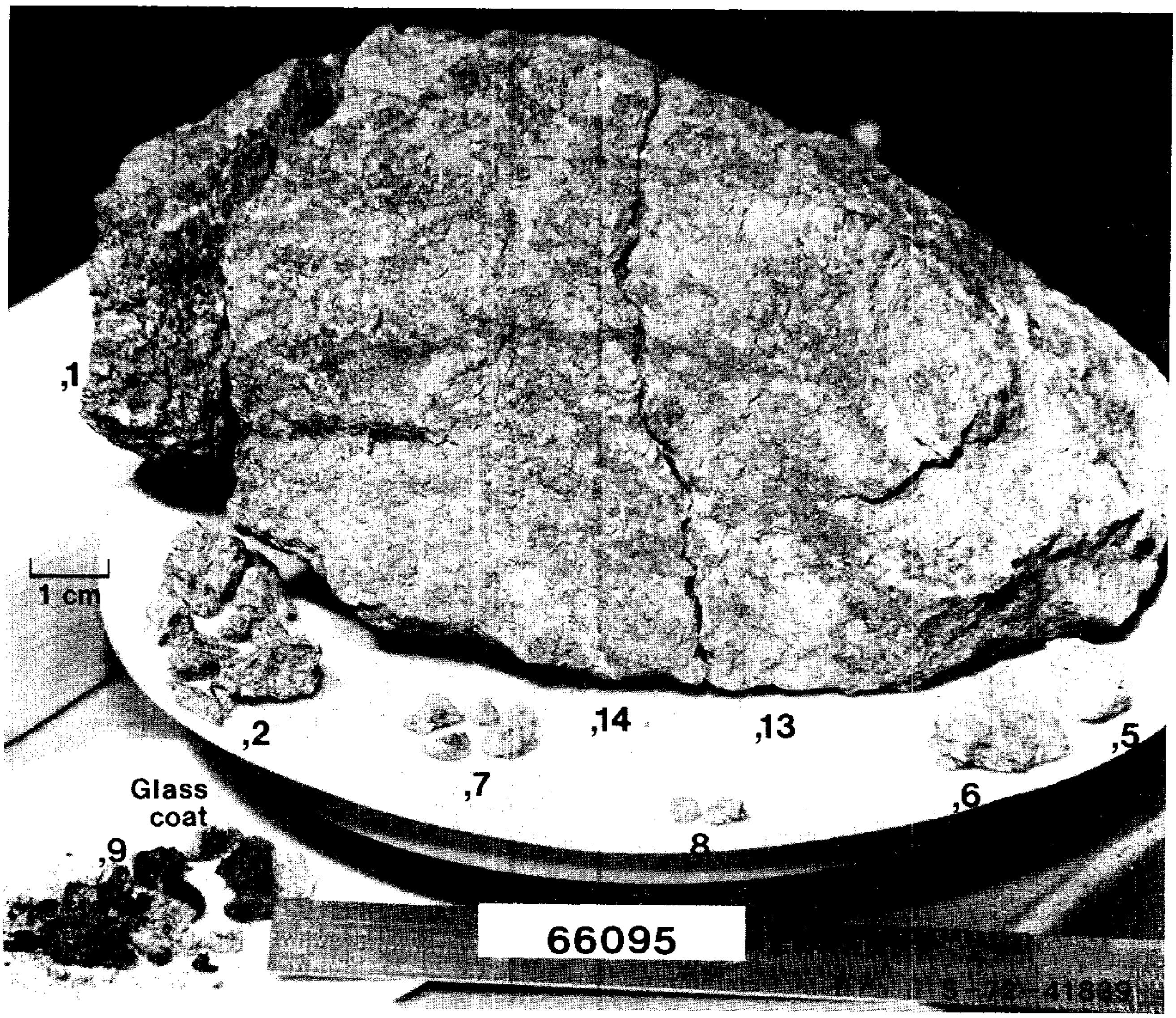



Figure 1.

PETROLOGY: General petrographic descriptions with mineral analyses are provided by Garrison and Taylor (1979a,b, 1980), Meyer et al. (1979), and Vaniman and Papike (1981). Emphasis on studies of opaque and/or volatile-rich mineral phases is made by El Goresy et al. (1973a,b), L. Taylor et al. (1973a,b, 1974a,b) and Misra and Taylor (1975). Bell and Mao (1973) report the abundances of minor elements in plagioclase. (LSPET (1973) obliquely and erroneously refers to 66095 as a high grade breccia).

Most of 66095 is a fine-grained, subophitic to ophitic impact melt (Fig. 2); the remainder is lithic and mineral clasts. The melt contains 50-60% plagioclase laths, up to 30% pigeonite, and about 10% olivine with some interstitial glassy material; and accessory amounts of FeNi metal, troilite, sphalerite schreibersite, cohenite, and ilmenite (Garrison and Taylor, 1980). Rare transparent spinels are also present. Reported silicate mineral compositions are summarized in Table 1 and phase compositions in Figures 3a and 3b.

a b

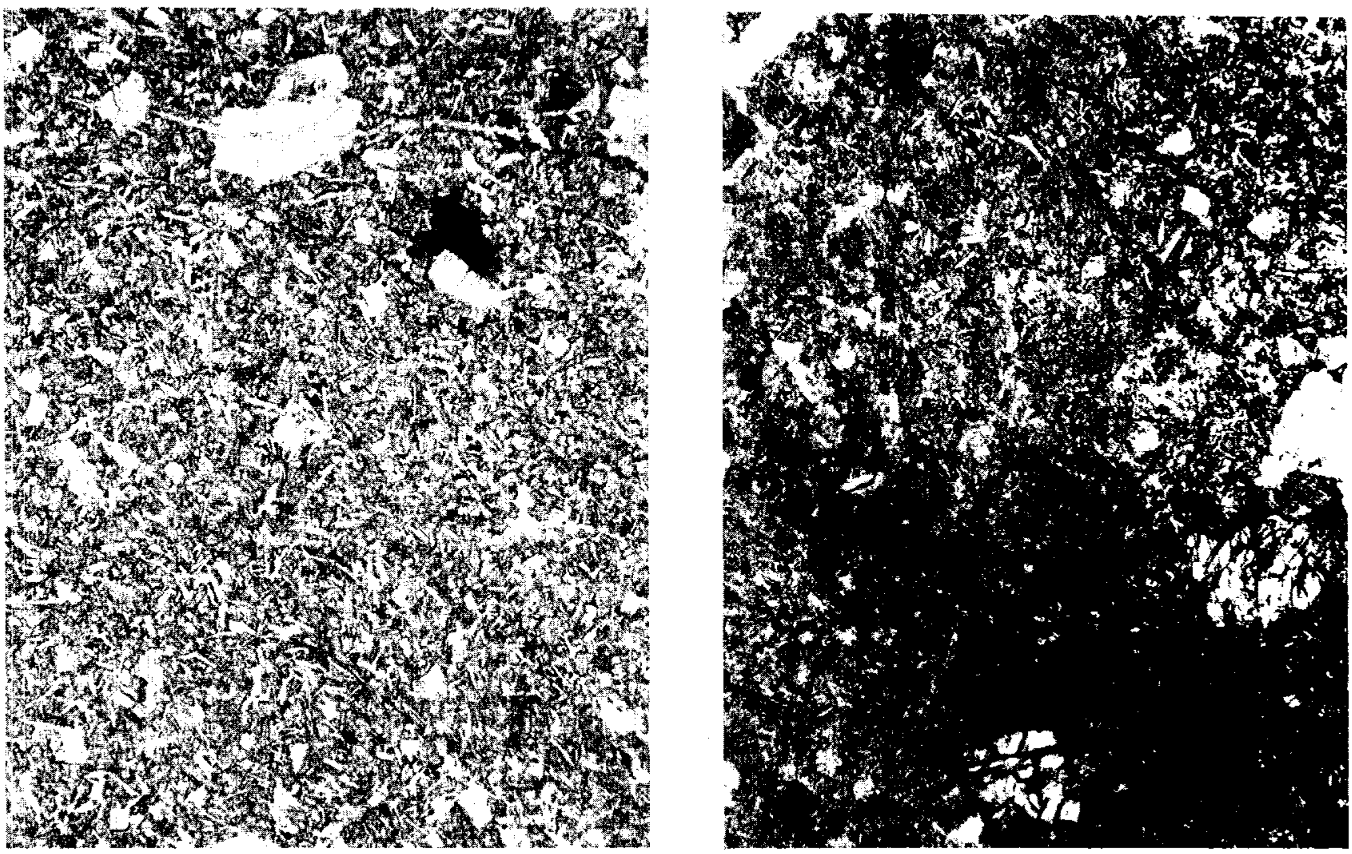


Figure 2. a) 66095,85, general view, ppl. width 1mm.
b) 66095,82, large rusty patch, ppl. width 1mm.

TABLE 1. Compositions of silicates in 66095 melt.

| Plag (An) | Px (En/Wo) | Olivine (Fo) | Reference |
|---|---|---|---|
| 89-94 | 72/7 - 65/18 | 77 | Garrison and Taylor (1979a,b,1980) |
| 95±2 | - | 80.5±1 | L. Taylor *et al*. (1973b) |

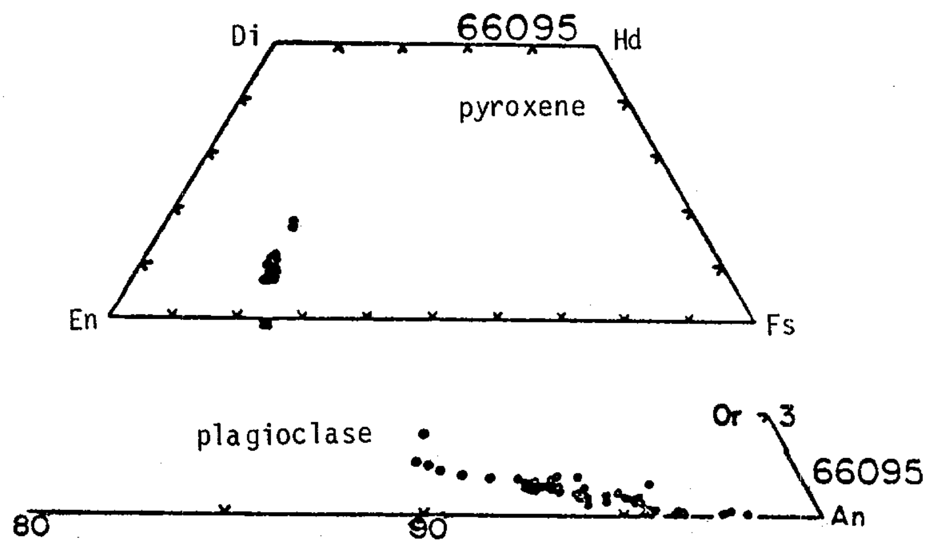



Figure 3a. Silicate mineral compositions, olivine plotted along base of pyroxene diagram, from Vanimam and Papike (1981).

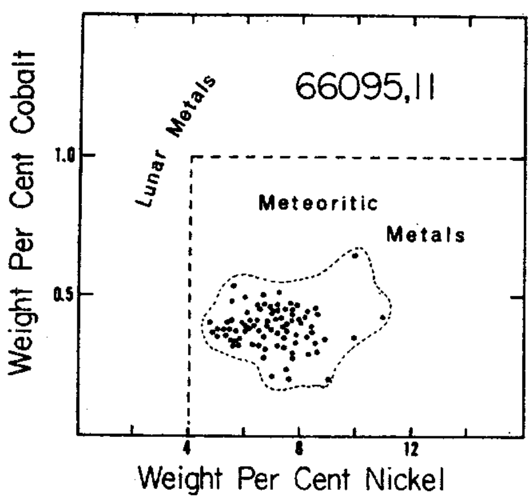



Figure 3b. Metal compositions, from L.A. Taylor *et al*. (1973b).

El Goresy et al. (1973a,b) report the presence of, and analyze, sphalerite, a Cl-bearing Zn-rich sulfate, a Cl-bearing Zn-rich phosphate, and a Pb-rich phase, in association with "geothite", and in one grain cohenite coexisting with FeNi metal and schreibersite. They favor a cometary or Cl meteorite impact origin for the volatiles, with Pb distilled from adjacent rocks, rather than a fumarolic origin.

L. Taylor et al. (1973b) studied opaque minerals, providing analyses. Noting the presence of Cl in the "goethite", they suggest that lawrencite ($FeCl_2$) was present in the rock which has been oxidized to create the rust. While rust is being created at present, they suggest it was also present on the Moon. L. Taylor et al. (1973b, 1974a,b) defined the "goethite" phase as akaganeite (β-FeOOH) from x-ray diffraction and crystal field spectra. The water required for the rapid oxidation of lawrencite is believed to be terrestrial and possibly from in the spacecraft.

Misra and Taylor (1975) studied FeNi and schreibersite and their relationships. Geothermometry based on FeNi and schreibersite compositions suggests an equilibration temperature of 600-650°C.

The basaltic impact melt contains ∿20% lithic and mineral clasts (Fig. 2), described and analyzed by Garrison and Taylor (1979a,b, 1980) and Meyer et al. (1979). The lithic clasts are summarized in Table 2. Mineral clasts are dominated by plagioclase but include olivine and rare pleonaste.

TABLE 2. Summary characteristics of clasts in 66095 (from Meyer et al.,1979)

| CLAST TYPE | TEXTURE | MODES | MIN COMPS |
|---|---|---|---|
| ANORTHOSITE | Coarse-grained Granulitic (various degrees of shock) Plag 10-500μm; Ol 1-100μm | Plag 90-100% Ol 0-10% | An 91-99 Fo 75-80 |
| ANORTHOSITE-TROCTOLITE | Coarse-grained Equigranular Plag 450-1600 μm; Ol 20-200 μm. | Plag 90-95% Ol 5-10% | An 98 Fo 61-69 |
| | Cataclastic - Stringers Plag 30-300 μm; Ol 5-200 μm | Plag 80-95% Ol 5-20% | An 91-98 Fo 78-81 |
| PLAGIOCLASE | Coarse-grained (various degrees of shock up to Maskelynite) Plag .04-1cm | Plag 100% | An 91-99 |
| BASALT | Fine-grained Porphyritic Plag 10-300 μm, Ol + Px 10-100 μm as Phenocrysts | Matrix <50% (Plag + Px) | An 92-95 Fo 74-76 |

The "basalts", interpreted as clasts by Meyer et al. (1979) and Garrison and Taylor (1980), are mineralogically similar to the basaltic impact melt host and may be textural variants (common in impact melts) of the melt rather than clasts. The other, non-melt, clasts have olivine rather than pyroxene as the dominant mafic phase. Metal analyses for all metal-bearing clasts lie in the range 4-12% Ni, 0.4-1.2% Co (Garrison and Taylor, 1980).

66095 is shocked, and penetrated by several "rootless" veins filled with shock-melted silicate glass (El Goresy et al., 1973a; Garrison and Taylor 1979a, 1980) Complete major element analyses are given by Garrison and Taylor (1980). The compositions vary from vein to vein but are roughly equivalent to the compositions of bulk rock.

CHEMISTRY: Published chemical studies of 66095 are listed in Table 3. A summary chemistry of the bulk rock is given in Table 4.

TABLE 3. Chemical work on 66095

| Reference | Split Analyzed | Elements Analyzed |
|---|---|---|
| Duncan et al. (1973) | ,47 | Majors, some trace |
| Nakamura et al. (1973) | ,52 | Majors, REEs |
| Brunfelt et al. (1973) | ,48 | Majors, REEs, other trace, incl. vols. |
| Hubbard et al. (1973) | ,37 | Majors |
| Jovanovic and Reed (1973) | ,17 ,23 | F, Cl, other vols. and refractories. |
| Krahenbühl et al. (1973) | ,55 | Meteoritic siderophiles and volatiles. |
| LSPET (1973) | ,5 | Majors, some trace. |
| Nava (1974) | ,50 | Majors |
| Allen et al. (1974) | ,23 | $^{204}$Pb, Bi, Tl, Zr |
| Kerridge et al. (1975b) | ,43 | C, S, C-compounds |
| Gibson and Moore (1973) | ,40 | $H_2O$, $Co_2$ |
| Hubbard et al. (1974) | ,36 ,37 | REEs, other traces |
| Jovanovic and Reed (1976a) | ,23 | Ru, Os |
| Des Marais (1978) | ,198 | C, N, S |
| Hughes et al. (1973) | ,56 | Os, Ir, Au, Ag, Re |
| Friedmann et al. (1974) | ,20 ,31 ,62 | C, $H_2O$ |
| Nunes and Tatsumoto (1973), Nunes et al. (1973) | ,41 | U, Th, Pb |
| Nyquist et al. (1973) | ,37 | Rb, Sr |
| Rancitelli et al. (1973b) | ,13 | K, U, Th |

The chemistry of 66095 is similar to that of other basaltic impact melts at the Apollo 16 site, except for its volatiles. It is less feldspathic and more enriched in incompatible elements than local soils. REE plots are given in Figure 4. The split ,37 analyzed by Hubbard et al. (1973, 1974) and Nyquist et al. (1973) is atypical in that much of it is a single white clast, according to data pack photographs.

Of significance is the high volatile content, eg, Cl, Pb, Zn, Ir, Cd, Tl, and water (Brunfelt et al. 1973; Jovanovic and Reed, 1973; Krähenbühl et al. 1973; Nunes and Tatsumoto, 1973, and others). Jovanovic and Reed (1973) and Allen et al. (1974) note that most of the Cl and other volatiles are leached by hot water. Krähenbühl et al. (1973) suggest that a fumarolic rather than an impact origin for the volatiles is most likely because (i) the volatiles are not in Cl chondrite proportions and (ii) Pb is also enriched and is lunar (from Nunes and Tatsumoto, 1973). Most of the chemical discussions in the listed references concern volatiles, but Nakamura et al. (1973) note that their analysis has a 9% positive Ce anomaly (normalized to the Leedy chondrite REE abundances) (note however that the La/Ce ratio of 66095 by NaKamura et al. and other authors is not significantly different from any other lunar rock with a significant KREEP content, nor is a significant Ce anomaly present when normalization is to an average chondrite composition.

Ganapathy et al. (1973) place 66095 in their meteoritic Group R, later updated to Group 1H (Hertogen et al., 1977).

TABLE 4

Summary chemistry of 66095

| | |
|---|---|
| $SiO_2$ | 45 |
| $TiO_2$ | 0.72 |
| $Al_2O_3$ | 24 |
| $Cr_2O_3$ | 0.14 |
| FeO | 6.7 |
| MnO | 0.08 |
| MgO | 9.0 |
| CaO | 13.5 |
| $Na_2O$ | 0.45 |
| $K_2O$ | 0.15 |
| $P_2O_5$ | 0.24 |
| Sr | 159 |
| La | 22.5 |
| Lu | 1.00 |
| Rb | 3.9 |
| Sc | 6.8 |
| Ni | ∿ 650 |
| Co | ∿ 45 |
| Ir ppb | 16-33 |
| Au ppb | ∿ 18 |
| C | 10-90 |
| N | < 0.1 |
| S | ∿ 1000 |
| Zn | 20-92 |
| Cu | ∿ 3 |

Oxides in wt%; others in ppm except as noted.

Cirlin and Housley (1980) established thermal release profiles for Pb, Zn, and Cd for grains disaggregated from 66095. The profiles demonstrate that the major fraction of these volatiles is released below 1000°C and were present on the surfaces of the grains.

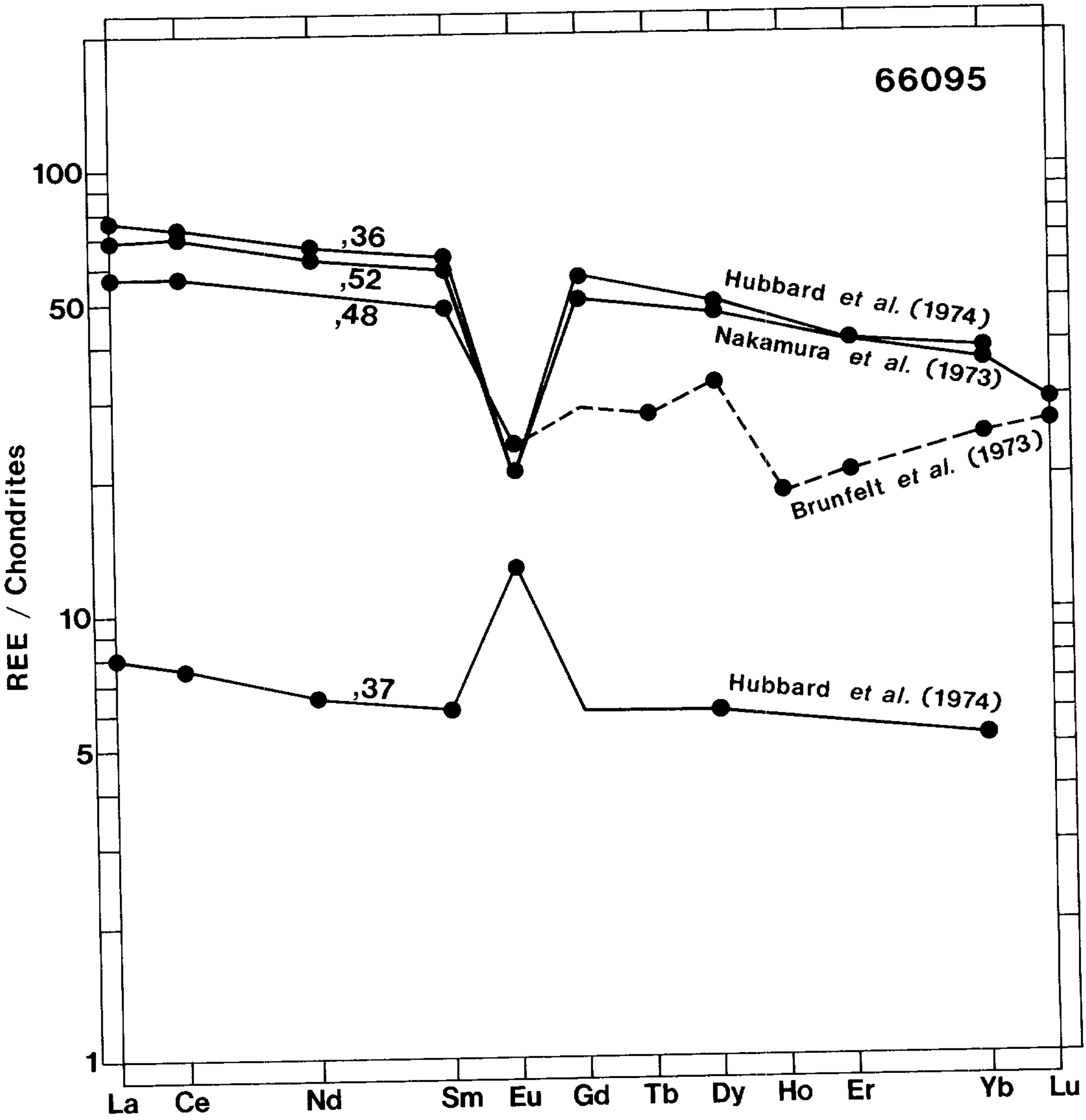



Figure 4. Rare earths.

STABLE ISOTOPES: Considerable work on stable isotopes has been performed on 66095, mainly in attempts to elucidate the origin of the volatiles. Clayton et al. (1973) established that the silicates in 66095 have normal lunar oxygen isotopic ratios: $\delta^{18}O$ of a plagioclase was + 5.73 and of a light clast was + 5.81.

Friedmann et al. (1974) measured O and H isotopic ratios on water released by heating 66095, and the C and O isotopic ratios of similarly released $CO_2$ (Tables 5a,b). They also analyzed $\delta^{18}O$ of water released from heating an iron oxide sample from 66095 (Table 5c) and $\delta^{18}O$ of 66095 silicates.

Table 5. C, H, and O isotopic data, from Friedmann et al. (1974).

a)

| Temperature (°C) | Water (ppm) | δD | $CH_4$, CO C (ppm) | $CH_4$, CO $\delta^{13}C$ | $CO_2$ C (ppm) | $CO_2$ $\delta^{13}C$ |
|---|---|---|---|---|---|---|
| *Rock 66095-62 (2.46 g)* | | | | | | |
| 100°–270° | 223 | − 80 | 0.2 | | 1.9 | − 43 |
| 270°–690° | 158 | − 75 | 0.1 | | 6.3 | − 12 |
| 690°–935° | 7.2 | − 200 | | | 2.4 | − 22 |
| 935°–1350° | 1.8 | − 170 | | | 0.2 | |
| Total | 390 | | | | 11.1 | |
| Weighted average | | − 81 | | | | −20 |
| *Rock 66095-31 (4.67 g)* | | | | | | |
| 100°–270° | 60 | − 100 | | | 1.1 | − 24 |
| 270°–690° | 156 | − 140 | 0.02 | | 21.7 | − 26 |
| 690°–970° | 9.0 | − 150 | | | 14.9 | − 38 |
| 970°–1350° | 4.5 | − 160 | 4.5 | − 19 | 16.7 | − 33 |
| Total | 230 | | | | 59 | |
| Weighted average | | − 130 | | | | − 30 |
| *Rock 66095-31 (2.27 g)* | | | | | | |
| Combustion (+ 975°) | 137 | − 110 * | | | 15.0 | − 21 |

b)

| Temperature (°C) | Water ppm | Water δD | Water $\delta^{18}O$ | $CO_2$ C (ppm) | $CO_2$ $\delta^{18}O$ | $CO_2$ $\delta^{13}C$ | $CH_4$, CO C (ppm) |
|---|---|---|---|---|---|---|---|
| *Rock 66095-20 (6.19 g)* | | | | | | | |
| 25° | 1,300 | − 140 | − 1 ± 1 | 3.6 | + 44 | − 18 | |
| 25°–110° | 360 | − 160 | + 6 ± 2 | 7.1 | + 31 | − 17 | |
| 110°–200° | 500 | − 140 | + 5 ± 2 | 2.9 | + 48 | − 12 | |
| 200°–350° | 240 | − 85 | + 5 ± 2 | 20 | + 28 | − 17 | ~ 2 |
| 350°–490° | ~ 15 | Sample lost | | ~ 1 | + 46 | | ~ 1 |
| 490°–670° | 20 | − 183 | + 20 ± 10 | 2.6 | + 24 | − 18 | |
| 110°–350° | 740* | | + 5 ± 2 | | | | |

c)

| Weight (g) | Temperature (°C) | Water ppm | Water $\delta^{18}O$ |
|---|---|---|---|
| *Rock 66095-20* | | | |
| 1.15 | 115°–280° | 150 | + 5 ± 2 |
| | 280°–400° | 75 | |

The isotopic composition of C is not unusual by comparison with other lunar rocks. The water released has δD $^{o}/oo$ similar to terrestrial water, but the $\delta^{18}O$ ($\sim$ + 5 $^{o}/oo$) is dissimilar to terrestrial water and similar to typical lunar silicates. Similarly, the water released by the iron oxide phase had $\delta^{18}O$ of + 5 $^{o}/oo$ and the silicates had $\delta^{18}O$ of + 6.3 $^{o}/oo$. They conclude that the water is not a terrestrial contaminant. Contrarily, Epstein and Taylor (1974) found that the water released from 66095 had both δD and $\delta^{18}O$ (-100 and -15 $^{o}/oo$ respectively) similar to terrestrial water. They find it inconceivable that the large quantities of water produced (loosely bound and most released by 200°C) could have been present in a lunar oxidation and temperature environment. Friedman et al. (1974) suggest that the water in the sample analyzed by Epstein and Taylor (1974) (which had been stored longer prior to analysis) had exchanged water with terrestrial sources.

Kerridge et al. (1975b) report $\delta^{34}S$ (+ 1.9 $^{o}/oo$) and $\delta^{13}C$ (-24.2, -23.5 $^{o}/oo$) values but do not specifically discuss them. The $\delta^{13}C$ values, like those reported by Friedman et al. (1974) for released $CO_2$, are considerably less than those of local soils ($\delta^{13}C$ $\sim$ + 12 $^{o}/oo$), as are the $\delta^{34}S$ values (soils $\sim$ + 6 to + 10 $^{o}/oo$). Des Marais (1978) reports $\delta^{13}C$ values for different temperature releases ranging from -13.1 to -22.7 $^{o}/oo$. Allen et al. (1974) report the abundance of $^{204}Pb$ (considered stable because of its exceptionally long half-life).

GEOCHRONOLOGY AND RADIOGENIC ISOTOPES: Nyquist et al. (1973) report Rb-Sr isotopic data for ,37 (Table 6). This split is a white-clast-rich fragment not typical of the whole rock, and, although not specifically discussed by Nyquist et al. (1973) this is reflected in the low Rb content and low $^{87}Sr/^{86}Sr$ as compared with typical lunar basaltic impact melts.

TABLE 6. Rb-Sr data for 66095,37 (from Nyquist et al.,1973; Nyquist 1977)

| Rb ppm | Sr ppm | $^{87}Sr/^{86}Sr$ | $T_{BABI}$ | $T_{LUNI}$ | Calc.I at 3.9 b.y. |
|---|---|---|---|---|---|
| 1.591 | 162.7 | 0.70068±7 | 3.9±.27 b.y. | 4.15±.27 b.y. | 0.68998 |

Adjusted for interlaboratory bias to conform to Cal Tech Data.

Turner et al. (1973) report Ar isotopic data for 66095. The release patterns (Fig. 5) are complex and do not yield a well-defined $^{40}Ar$ - $^{39}Ar$ age. However Turner et al. (1973) tabulate an age of 3.6-3.8 b.y. The release patterns may be complicated by the presence of old relict clasts.

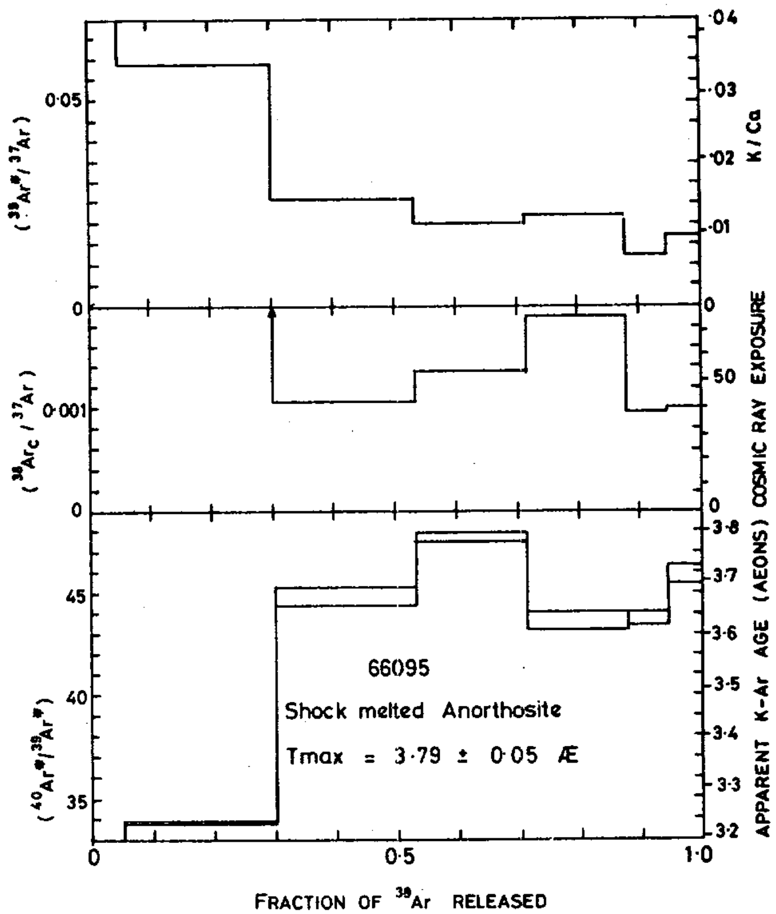



Figure 5. Ar releases, from Turner et al.(1973).

Nunes and Tatsumoto (1973) report U, Th, and Pb isotopic abundances, also summarized in Nunes et al. (1973). The data are for whole rock and for separates, and include acid leaches. The rock is unusually abundant in lead, 85% of which is excess, i.e. unsupported by in situ U and Th. The leachable lead is isotopically distinct from the residual lead, which is similar to Apollo 16 soils. An internal U-Pb isochron gives an age of 3.82 b.y. (Fig. 6). Nunes and Tatsumoto (1973) conclude (i) the excess lead is lunar and (ii) the excess lead was introduced into the rock in a discrete event 3.8-4.0 b.y. years ago. The data also are consistent with, and suggest, major lunar crustal differentiation ∿ 4.47 b.y. ago.

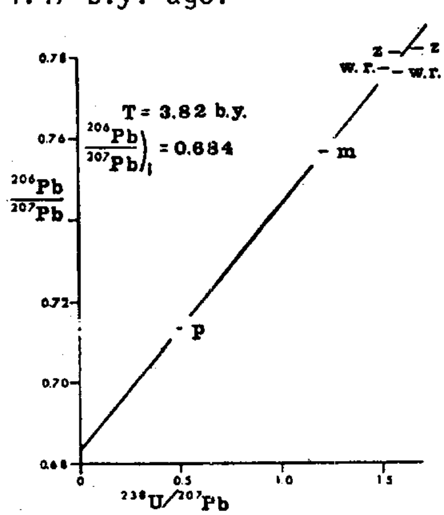



Figure 6. Internal isochron, from Nunes and Tatsumoto (1973).

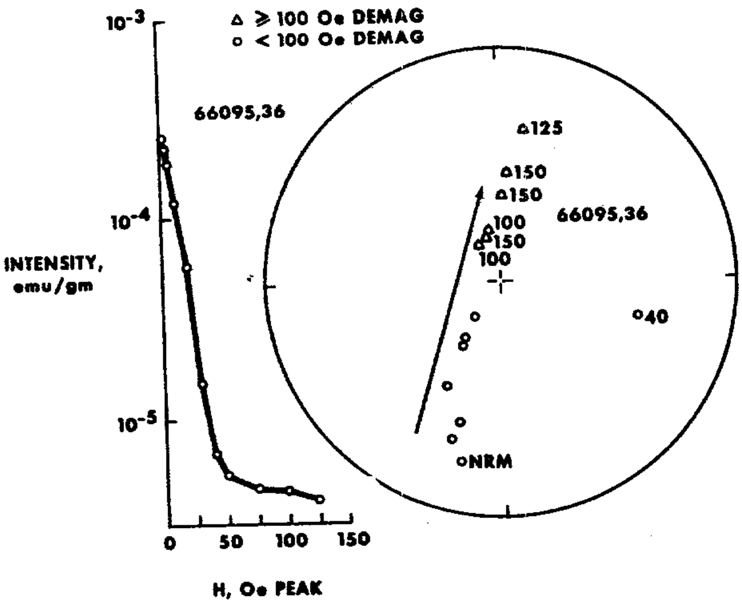
Hinthorne and Andersen (1974) report ion microprobe analyses for $^{207}Pb/^{206}Pb$ and $^{208}Pb/^{206}Pb$ in four Cl-rich areas in 66095,81. The ratios are similar to those in the leached materials analyzed by Nunes and Tatsumoto (1973). Thus the latter is associated with oxide and Cl-rich regions of troilite alteration. Hinthorne and Andersen (1974) suggest that the leachable lead has the same origin as Cl, S, and OH and that it is not lunar. Th and Pb are localized differently: Th with FeNi grains and Pb with Cl-rich areas.

RARE GASES AND EXPOSURE AGES: Heymann and Hübner (1974) analyzed a portion of ,17 for inert gases. They suggest that contamination of 66095 with as little as 0.2% Apollo 16 fines, possibly in the form of the glassy veins, can produce the observed isotopic ratios and abundances of inert gases. They calculate a $^{21}Ne$ spallation age of 1.1± 0.5 m.y., although this age is imprecise because the sample irradiation history is unknown. Turner et al. (1973) report Ar isotopic data but the release patterns are complex (Fig.5). Taken at face value the variations correspond to exposure ages of 40-80 m.y. and possibly imply a complex history of near surface irradiation for the components prior to their incorporation into 66095.

Rancitelli et al. (1973a) provide $^{22}Na$ and $^{26}Al$ data without discussion. Bhandari et al. (1976) report $^{26}Al$ data, a track density/depth profile, and residence time/depth analyses. Solar flare tracks suggest an exposure age of 1 m.y., and a crater count exposure age is ∿ 0.2 m.y. Bhandari et al. (1976) report a $^{26}Al$ exposure age of 0.7 ± 0.1 m.y. Fruchter et al. (1978) report $^{26}Al$ and $^{53}Mn$ data providing exposure ages of 0.9 ± 0.2 and 1.4 ± 0.3 m.y. respectively. The sample is substantially undersaturated with $^{26}Al$ and $^{53}Mn$ suggesting that its excavation postdates South Ray. The data are indicative of a relatively simple surface history.

PHYSICAL PROPERTIES: Nagata et al. (1973) tabulate the basic magnetic properties of 66095 and also measured the stability of natural remanent magnetization (NRM) against alternating field (AF) demagnetization. The magnetic data also provide a total $Fe^{0}$ content of 1.21% and the nickel content of kamacite: 5.5-6.0%. Pearce et al. (1973) also provide basic magnetic data and derive a total $Fe^{0}$ of 1.44% and a total $Fe^{2+}$ of 5.55-5.57%. The change in intensity and direction of NRM with AF demagnetization is shown in Figure 7; there is a very pronounced soft NRM. Cisowski et al. (1974) use the value of saturation magnetization to calculate a $Fe^{0}$ abundance of 1.2% and ∿ 7% total iron. Schwerer and Nagata (1976) tabulate some magnetic properties relevant to the characterization of the superparamagnetic-ferromagnetic components. Brecher (1975) lists 66095 as an example of a rock having "textural remanence".

Weeks (1973b) provides electromagnetic resonance spectra for several fragments from the rock. Tsay and Live (1976) and Tsay and Baumann (1977) use electron spin resonance to detect the presence of minute amounts of paramagnetic $Fe^{3+}$ (detected at 77°K) which they infer is probably from terrestrial oxidation. They detected 82 ppm $Fe^{3+}$ and 6900 ppm (0.69%) Fe°




Change in intensity and direction upon AF demagnetization of sample 60095,36. Arrow indicates directional trend.

Figure 7.

From Pearce et al. (1973).

PROCESSING AND SUBDIVISIONS: 66095 has been extensively subdivided. The first divisions are shown in Figure 1. ,1 (233 g) and ,13 (495 g) remain as large pieces, but ,14 (433 g) has been totally subdivided and renumbered. Its two largest daughters were ,60 (60 g) and ,61 (155 g), with most other splits much smaller. In 1980, ,60 was sawn into three pieces and renumbered: ,294 (22.8 g) and ,296 (16.9 g) are the end pieces and ,295 (17.7 g) is the slab. Small chips, all but one being basalt, were taken from these three pieces.