68815 GRAY GLASSY POLYMICT BRECCIA 1789 g

INTRODUCTION: 68815 is a polymict breccia (Fig. 1) consisting of a variety of clasts in a flow-banded, heterogeneous, and partly devitrified glass. The glass is extremely vesicular locally. Most clasts are small (1-2 mm) but two pale colored lithic clasts (fine-grained granoblastic/poikiloblastic, and feldspathic) are prominent (Fig. 2).

The medium dark-gray sample was chipped from a 1 m boulder which was macroscopically similar to most other rocks in the area. The boulder lay east of the LRV. The sample is coherent and fairly angular where broken, but subrounded on its exposed lunar surface, on which zap pits are common.

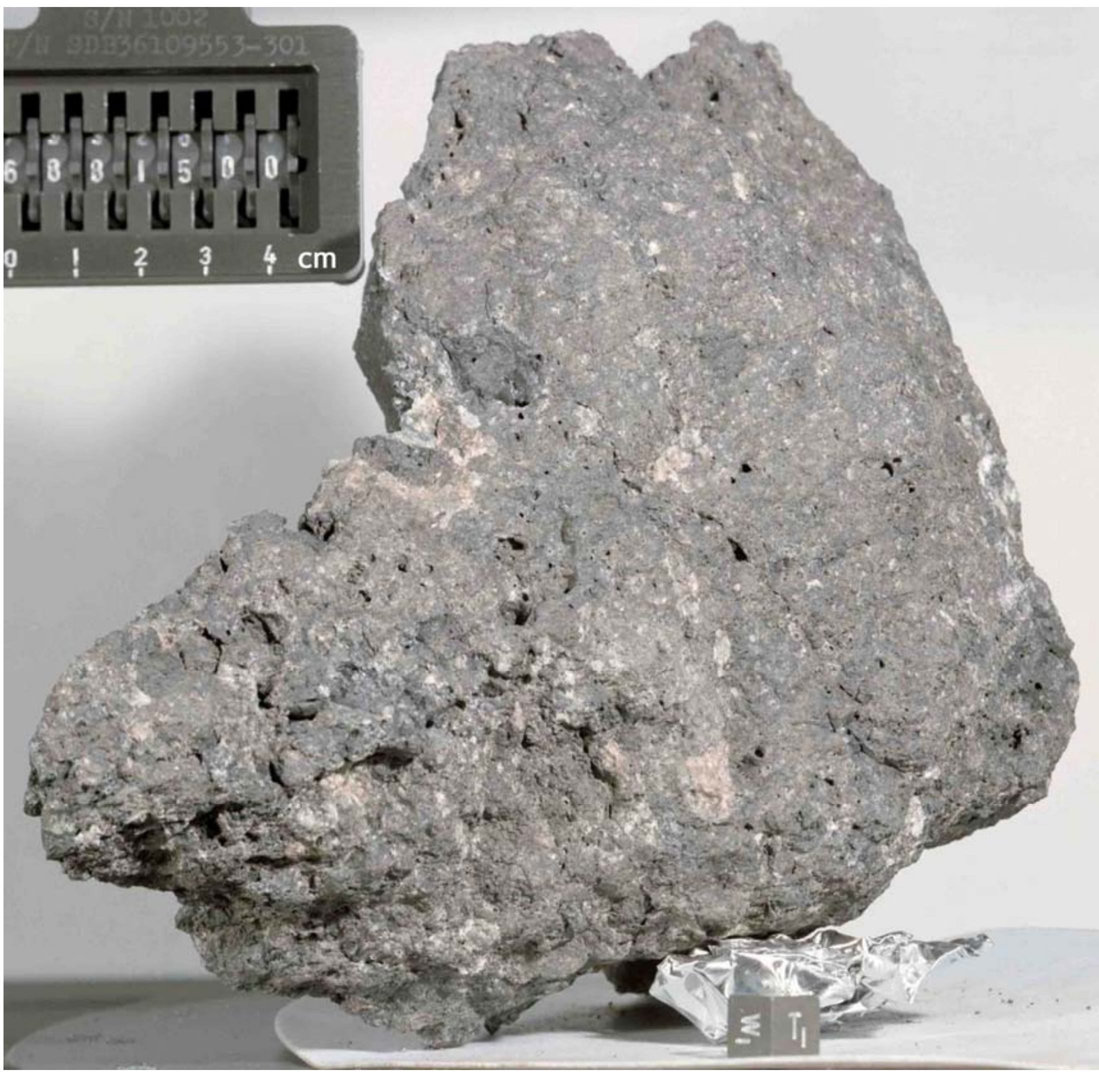

FIGURE 1. S-72-40986.

PETROLOGY: An overall petrographic description is given by Brown et al. (1973) and descriptions of the two prominent light-colored clasts (I and II, Fig. 2) are given by Dixon and Papike (1978). Analyses of metal grains are given by Misra and Taylor (1975).

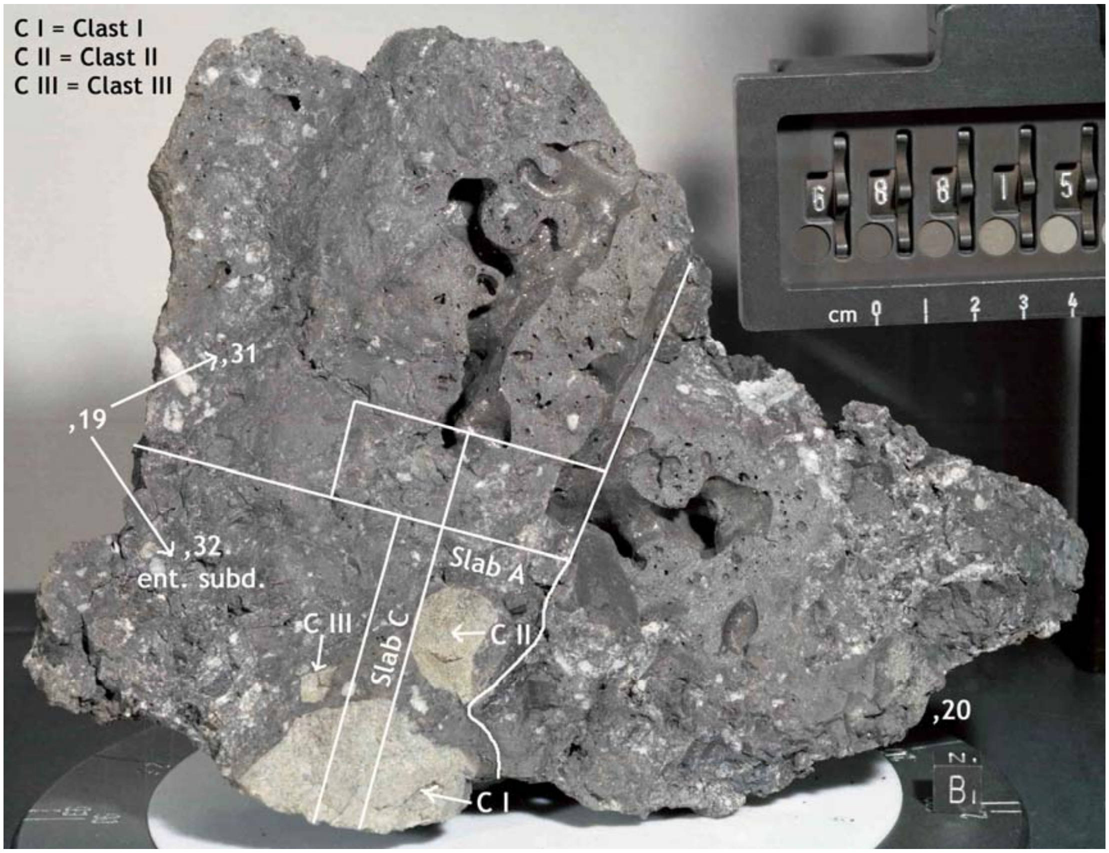

FIGURE 2. S-72-37155.

Much of 68815 consists of lobes of glass (Fig. 3) ranging from colorless to brown/yellow in color and frequently banded, such that Brown et al. (1973) described it as a "fluidized lithic breccia." The colorless glasses are anorthositic whereas the brown/yellow glasses have 26-30% Al_2O_3. The clasts are prominently fine-grained, brown impact melts, most of which have 22-23% Al_2O_3 (Brown et al., 1973). Most such clasts have sharp, frequently angular boundaries and some are several centimeters in diameter. Some clasts are aphanitic brown breccias, others are plagioclase vitrophyres. Rare mineral fragments analyzed by Brown et al. (1973) include olivine (up to Fo_{91}), magnesian orthopyroxene (up to En_{81}), magnesian ilmenite and pleonaste spinel. Schreibersite was observed in a troctolitic clast.

Metal grains in the glasses have an average 6.3% Ni and 0.4% Co (Misra and Taylor, 1975). They occur particularly as spherical inclusions, up to 20 µm across, which are particularly concentrated in the dark bands of flow-banded glass. Metal/troilite intergrowths are common.

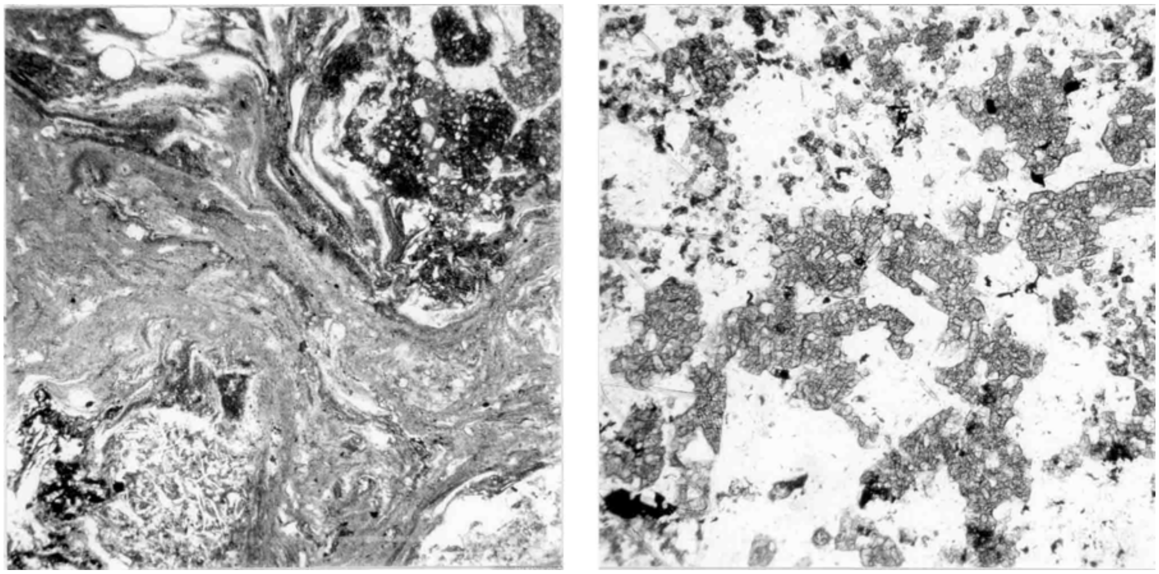

FIGURE 3.
a) 68815,18. General glassy breccia, ppl. Width 2 mm.
b) 68815,150. Clast II, ppl. Width 1 mm.

Clast I contains 60% plagioclase and 40% mafics, and a small amount of Fe-metal, Cr-spinel, and ilmenite. In general it has a fine-grained granoblastic or hornfelsic texture, but several poikiloblastic areas are present. In these, orthopyroxene (100-200 μm) encloses chadacrysts of plagioclase, olivine, and augite. Clast II is less mafic (30%) but has a similar mineralogy to Clast I. Its texture is mainly poikiloblastic (Fig. 3). Dixon and Papike (1978) provide mineral analyses showing that the groundmass plagioclases in these clasts range from $An_{96.5-89.5}$ and the chadacrysts are An_{97-91}. The chadacrysts contain more FeO and are deemed to be, on average, more sodic. Most pyroxenes are in the En_{65-75} range (Fig. 4) and olivines vary from ~Fo_{69} in groundmass to Fo_{73} chadacrysts.

CHEMISTRY: Chemical analyses are listed in Table 1 and a summary of the chemical composition of the bulk rock is given in Table 2. Additional information on Ca and K is provided in the Ar-Ar work on matrix and clasts (refs. below). Chemical analyses of clasts I and II have not been made.

Despite the heterogeneous nature of individual glasses as derived by microprobe analyses, four analyses for bulk rock Al are remarkably similar (Al_2O_3 26.8-27.6%) and the REE abundances of two splits not remarkably dissimilar (Fig. 5). The volatile elements are much lower in abundance than in local soils although the major element and rare-earth element composition is fairly similar to such soils. The bulk rock is greatly enriched in meteoritic siderophile elements (Krahenbuhl et al., 1973). The meteoritic signature was placed marginally in Group LN (possibly Imbrium) by Ganapathy et al. (1973) and revised to IH, though labeled an unreliable assignment, by Hertogen et al. (1977).

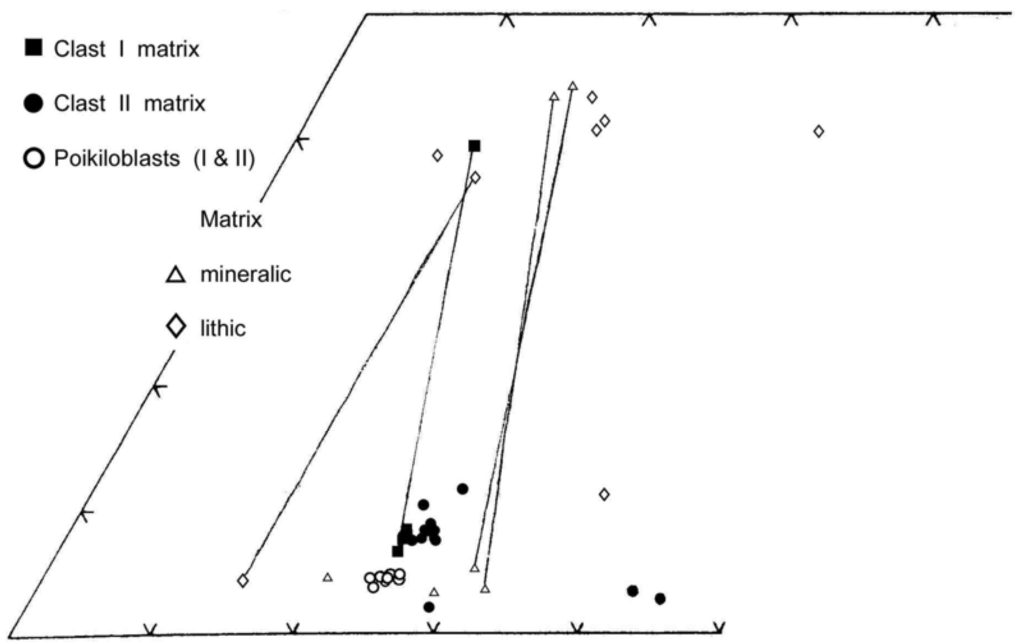

FIGURE 4. Pyroxenes in Clasts I and II, from Dixon and Papike (1978).

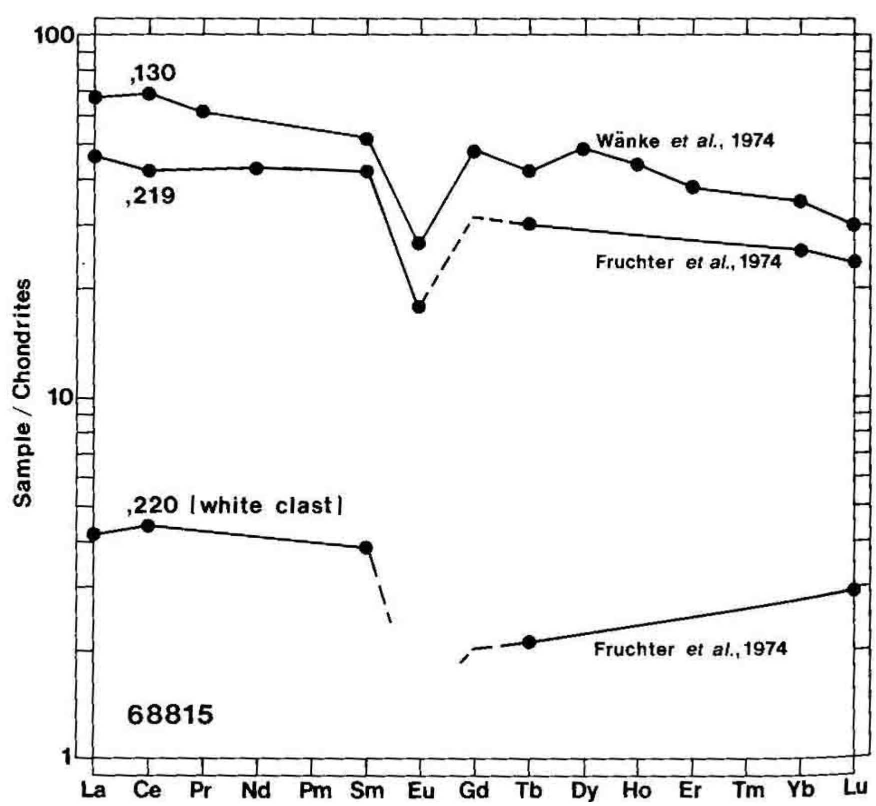

FIGURE 5. Rare earths.

TABLE 1. Chemical work on 68815.

Reference	Split #	Description	Elements Analyzed
Krähenbühl et al. (1973)	,124	bulk rock	meteoritic siderophiles and volatiles
LSPET (1973)	,9	bulk rock	majors, some trace
Clark and Keith (1973)	,2	bulk rock	K, U, Th
Jovanovic and Reed (1973)	,107	bulk rock	F, Cl, Br, I, Li, U
Wänke et al. (1974)	,130	bulk rock	major, minors, trace (∿50 elements)
Fruchter et al. (1974)	,220*	bulk rock	Al, Fe, REEs, other trace
Fruchter et al. (1974)	,219**	white clast	Al, Fe, REEs, other trace
Rees and Thode (1974)	,101	bulk rock	S
Jovanovic and Reed (1976a)	,107	bulk rock	Ru and Os
Jovanovic and Reed (1977)	,107	bulk rock	Hg
Reed et al. (1977)	,107	bulk rock	^{204}Pb, Tl, Zn
Wänke et al. (1977)	,130	bulk rock	V
Becker et al. (1976)	,66	bulk rock	N
Graf et al. (1973)	?	bulk rock ?	U
Goel et al. (1975)	?		N
Moore and Lewis (1976)	,129		N, C
Modzeleski et al. (1973)	,122; ,123	bulk rock	C and C compounds
Moore et al. (1973)	,7; ,129	bulk rock	C
Cripe and Moore (1974)	,129	bulk rock	S
Scoon (1974)	,120	bulk rock	majors
Leich et al. (1973)	,27	bulk rock	H, F with depth
Padawer et al. (1974)	,25	bulk rock	H with depth
Kohl et al. (1978)	,234	bulk rock	Al, Fe, Mn
Drozd et al. (1974)	?	bulk rock	U

*tabulated erroneously as ,61
**tabulated erroneously as ,w

TABLE 2. Summary chemistry of 68815 bulk rock.

SiO_2	46	Sr	170
TiO_2	0.49	La	15–22
Al_2O_3	27	Lu	0.9
Cr_2O_3	0.10	Rb	2–9
FeO	5.0	Sc	7.2
MnO	0.06	Ni	∿300
MgO	5.9	Co	∿40
CaO	15.4	Ir ppb	11
Na_2O	0.48	Au ppb	8–15
K_2O	∿0.15–0.20	C	6–17
P_2O_5	0.18	N	2–53
		S	550
		Zn	2.45
		Cu	7.8

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

STABLE ISOTOPES: Clayton et al. (1973) report a whole rock δO^{18} value of +5.72 for ,121. This is a typical lunar value.

Rees and Thode (1974) report a whole rock δS^{34} value of +0.4 for ,101, without discussion. This value is similar to other lunar breccias and much lower than the regolith values of +8 to +10.

Becker et al. (1976) report a δN^{15}_{air} value of +10.4 ± 1 5. Technical problems caused the sample to be exposed to air, and if any of the N analyses was atmospheric, then the indigenous lunar δN^{15}_{air} value is even higher.

GEOCHRONOLOGY: Schaeffer et al. (1976) and Schaeffer and Schaeffer (1977) report ^{40}Ar-^{39}Ar data for glassy matrix and clasts in 68815. The results are summarized in Table 3 and release diagrams are given in Figure 6. In general good plateaus were not attained. The glassy matrix appears to be older than 3.76 b.y., clast II (,41A) has a plateau age of 4.12 b.y., and clast I (,60B) yields an age ~4.07 b.y. Even the 4.12 b.y. age appears to be unreliable because the plateau is considerably disturbed. Schaeffer et al. (1976) and Schaeffer and Schaeffer (1977) detail the complexities associated with the interpretation of each analysis.

TABLE 3. Summary of ^{40}Ar-^{39}Ar results from 68815.

Sample	Description	Plateau Age (b.y.)	K-Ar Age (b.y.)	Reference
,41A	Lt. clast CII	4.120±0.040	4.01±.01	Schaeffer *et al.* (1976)
,41B	Gy. clast	4.020±0.024	3.66±.04	Schaeffer *et al.* (1976)
,41C	Glass	3.630±0.054	3.05±.01	Schaeffer *et al.* (1976)
,60A	Glass	3.692±0.037	3.30±.01	Schaeffer *et al.* (1976)
,60B	Clast I	4.073±0.027	3.76±.01	Schaeffer *et al.* (1976)
,141B	Glass		2.681±0.003	Schaeffer & Schaeffer (1977)
,133B	Glass		3.015±0.003	Schaeffer & Schaeffer (1977)
,133C	Wh. clast	3.811±0.012	3.686±0.007	Schaeffer & Schaeffer (1977)
,67D	Wh. clast		3.54±0.02	Schaeffer & Schaeffer (1977)

RARE GASES AND EXPOSURE AGES: Rare gas isotopic data is presented by Behrmann et al. (1973), Drozd et al. (1974), Schaeffer et al. (1976), and Schaeffer and Schaeffer (1977). Behrmann et al. (1973) report Ne, Kr (including spallation spectra data, and conclude that 68815 contains a small concentration of solar rare gases as compared with soils. ^{81}Kr-^{83}Kr and ^{81}Kr-^{78}Kr exposure ages are both 2.0 ± 0.2 m.y. A ^{22}Na-^{21}Ne age, calculated directly, is 1.5 ± 0.4 m.y. (when normalized to 67195 = 50.6 m.y., age is 1.7 ± 0.4 m.y.). The absence of prominent neutron effects implies that prior to ejection 68815 must have been buried deeper than 7 m. Drozd et al. (1974) report Kr isotopic data (including spallation spectra) and calculate a ^{81}Kr-Kr age of 2.04 ± 0.09 m.y. (^{21}Ne age, 1.21 ± 0.29 m.y. and ^{38}Ar, 2.18 ± 0.98 m.y.). Pepin et al. (1974) used the Drozd et al. (1974) data to calculate cosmic ray exposure ages using effective production rates v. depth expressions, and find that their derived ^{21}Ne age (1.97 ± 0.32) and ^{38}Ar (1.98 ± 0.26) are in agreement with the Kr ages. They also find that an irradiation history of ~70 m.y. at ~6.5 m depth, followed by a 2 m.y. residence at the surface is consistent with spallation Ne and Ar concentrations.

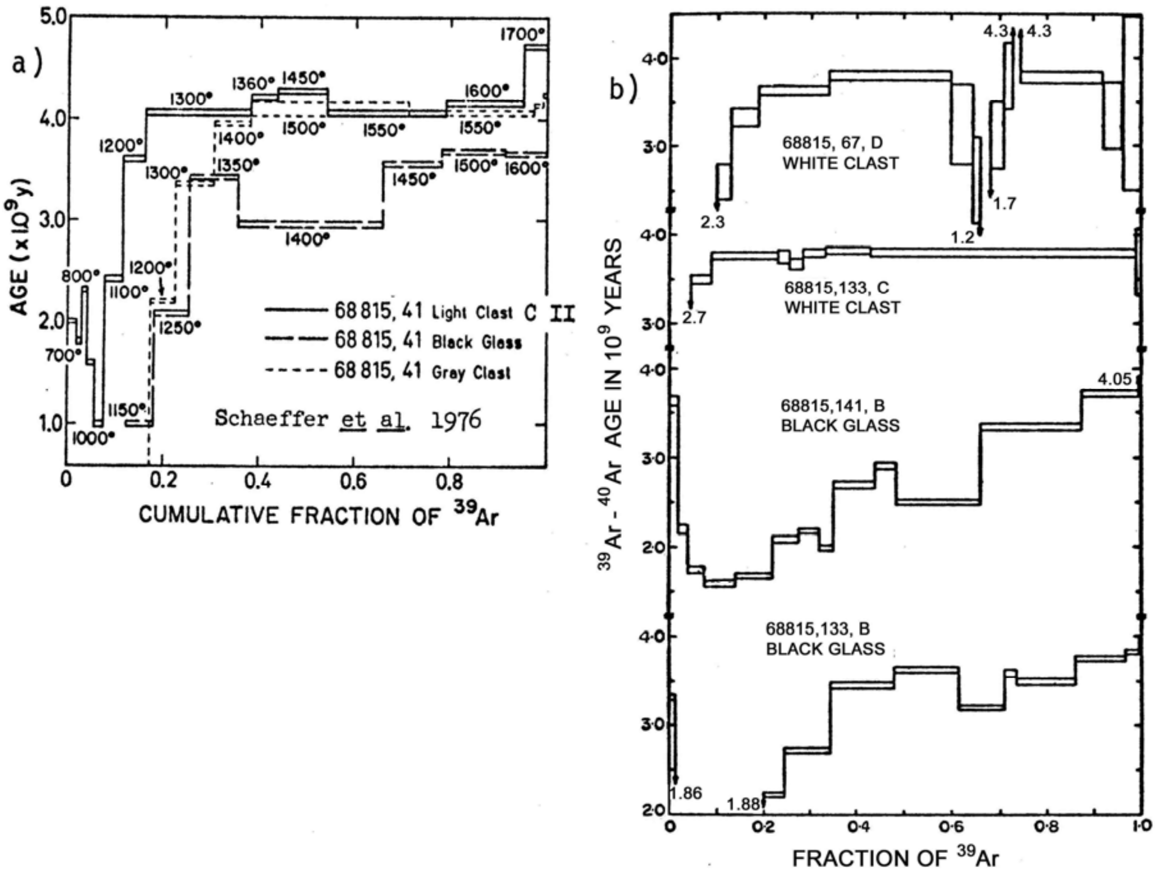

FIGURE 6. Ar release.
a) from Schaeffer et al. (1976). b) from Schaeffer and Schaeffer (1977).

Schaeffer et al. (1976) tabulate Ar exposure ages, but note in the text that such ages are actually invalid because of the production of ^{38}Ar from Cl during irradiation. The calculated ages of 34 to 201 m.y. are indeed totally out of agreement with those derived by other methods. Schaeffer and Schaeffer (1977), to overcome this problem, measured argon isotopes on five unirradiated samples. One sample requires a large correction for trapped ^{38}Ar; the other four give exposure ages ranging from 1.51 to 2.43 m.y. (average 1.83 ± 0.24 m.y.) in agreement with other published exposure ages.

Yaniv et al. (1980) report that their ^{81}Kr-Kr data confirm a 2 m.y. exposure age for 68815 but do not tabulate data. They also discuss observed increases in ^{3}He and ^{81}Kr in the surface of 68815 due to solar cosmic ray effects. Hohenberg et al. (1978) calculate the cosmogenic contribution to ^{21}Ne, ^{38}Ar, ^{83}Kr and ^{126}Xe in ,113, but do not specify the data sources.

Cosmogenic radionuclide data are presented by Clark and Keith (1973), Fruchter et al. (1977, 1978) and Kohl et al. (1978). Fruchter et al. (1977) measure ^{53}Mn at 2 cm depth and derive a ^{53}Mn age of 1.9 m.y. The ^{26}Al data suggest 85% saturation, in agreement with this age. The data indicate that no substantial exposure at a depth less than 60 cm occurred prior to the 2 m.y. excavation. In Fruchter et al. (1978) the same data are presented but ages of 2.1 ± 0.3 m.y. (^{26}Al) and 1.7 ± 0.2 m.y. (^{53}Mn) are tabulated. Data for ^{53}Mn and ^{26}Al in 14 samples from the upper 1.5 cm of 68815 reported by Kohl et al. (1978) are fairly constant, agree with other data, and are consistent with a 2 m.y. exposure age. Activity v. depth for three different faces shows that surface activity is nearly independent of inclination.

Yuhas and Walker (1973; quoted in Crozaz et al., 1974) derived a track density/ depth exposure age of 2.0 m.y., and Dust and Crozaz (1977) found track density/ depth data to be consistent with the 2 m.y. age.

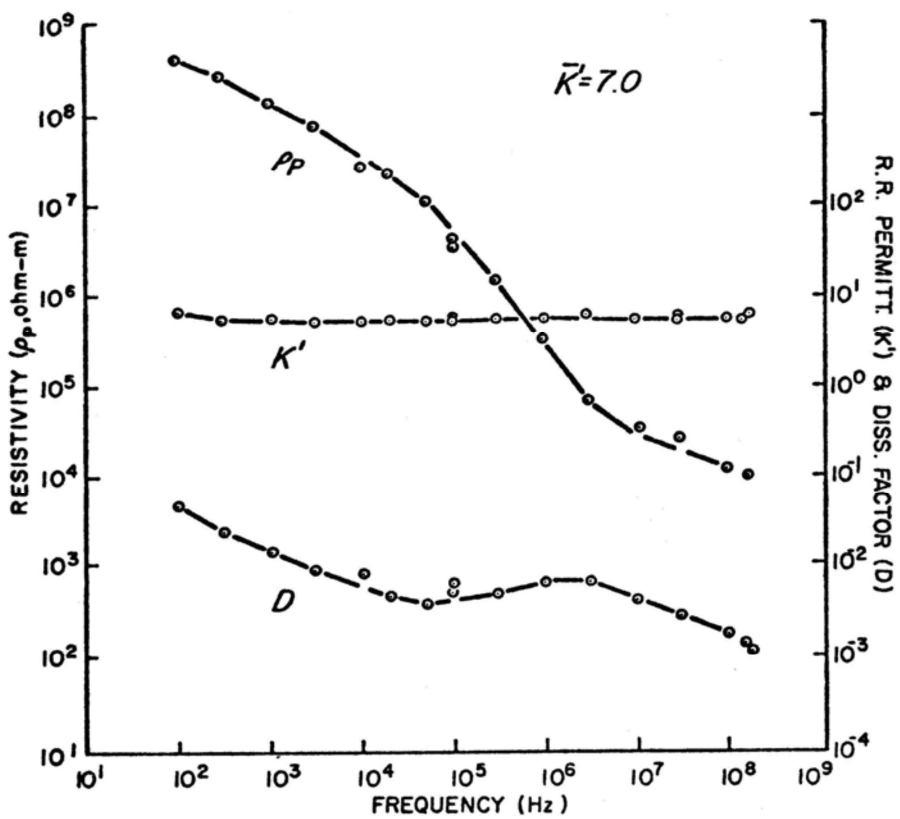

FIGURE 7. Electrical data from Katsube and Collett (1973a).

MICROCRATERS, TRACKS, AND SURFACES: Behrmann et al. (1973) counted 30 to 50 pits larger than 30 µm diameter on a 0.5 cm^2 surface area of 68815.

Walker and Yuhas (1973) used 68815 to derive an "empirical track production energy spectrum" with a track profile. Three samples from depths of 0-5 mm (,74), 2.8 ± 0.3 cm (,109) and 5.5 ± 0.3 cm (,113) were used and only tracks >2 µm in length were measured. The average for these was 4.9 µm and the largest was 9 µm. Yuhas and Walker (1973) and Dust and Crozaz (1977) also studied track density profiles; the solar flare track profile is typical. Graf et al. (1978) used a track method to determine the U concentration of the sample.

Chemical studies of surface and near-surface regions for light elements were reported by Leich et al. (1973, 1974), Padawer et al. (1974), and Stauber et al. (1973). Goldberg et al. (1976) studied F on vesicle surfaces. Leich et al. (1973, 1974) studied H and F to 2000 Å depth from the surface for a chip exposed on the lunar surface. A peak of 700 ppm H near the surface falls to 150 ppm in the interior. F also shows a surface peak. In Leich et al. (1973), the results are interpreted as indigenous H in the interior and terrestrial contamination on the exterior, but Leich et al. (1974) apparently reinterpret the surface H to be from tile solar wind. Padawer et al (1974) got similar results (~400 ppm H at surface, to less than 50 ppm at 10,000 Å depth) for a chip of interior material, not exposed at the lunar surface. This strongly suggests that such H peaks are from terrestrial contamination, not from the solar wind. Stauber et al. (1973), using nuclear microprobe analysis on a clast embedded in the lunar exterior surface of the rock, also found a H peak (~150 ppm) near the surface.

Goldberg et al. (1976) found a distinct F peak on vesicle walls, but inter-vesicular areas also showed F peaks (the samples were processed without exposure to Teflon) making equivocal the interpretation of the vesicle F peaks as lunar volatile deposits.

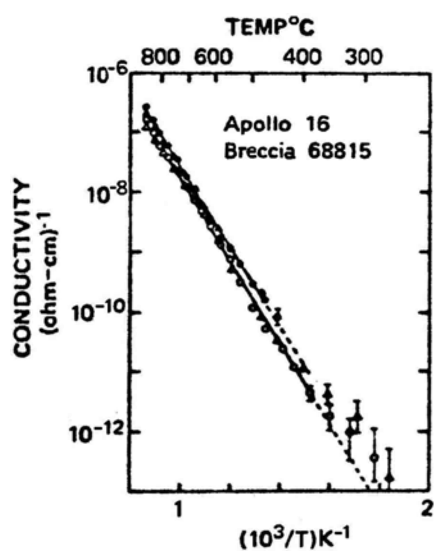

FIGURE 8. Electrical data; Schwerer et al. (1974).

PHYSICAL PROPERTIES: Nagata et al. (1973) tabulate the basic magnetic properties of ,70, a bulk rock chip, tabulate the coercive force, the saturation remanent magnetization, and saturation magnetization at 4.2°K, 300°K, and tabulate the natural remanent magnetization and its stability against alternating field demagnetization. An acquisition experiment on the piezoremanent magnetization indicated the ambient magnetic field to be about 200 γ. Cisowski et al. (1974) plot Fe^0 v. $Fe^0 + Fe^{2+}$; Fe^{2+} (~4.5%) is from published paramagnetic susceptibility measurements and Fe^0 (~0.06%) is from the value of saturation magnetization. Schwerer and Nagata (1976) tabulate magnetic data relevant to the characterization of superparamagnetic ferromagnetic components, without discussion.

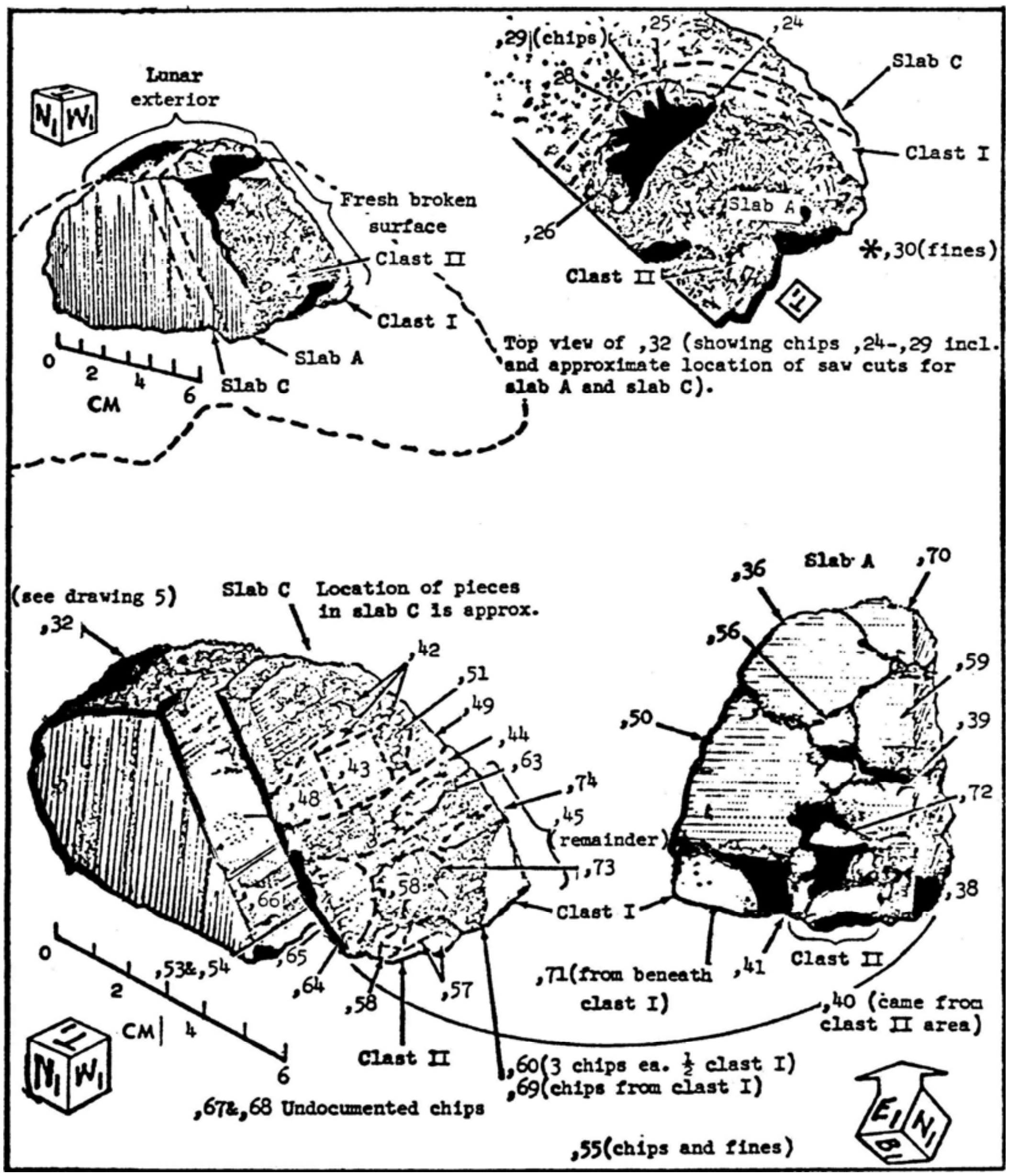

FIGURE 9. Cutting diagram.

Mossbauer spectroscopic data are presented by Schwerer et al. (1973), Huffman et al. (1974) and Huffman and Dunmyre (1975) (all the same group). The data show that the ratio of olivine:pyroxene is about 2:1. 7% of the total iron present is Fe^0 (Schwerer et al., 1973). Huffman et al. (1974) reproduce the data of Schwerer et al. (1973) but from magnetic analysis also deduce that Fe^0 total = 0.62 wt% and Fe^{2+} total = 6.28 wt%. Approximately 2% of the total Fe is in an unidentified phase (possibly chromite) which is not ordered at room temperature. Huffman and Dunmyre (1975) note that no Fe occurs in superparamagnetic clusters in olivine in 68815.

Katsube and Collett (1973a, b)report electrical data: real relative permittivity, parallel resistivity, and dissipation factor (Fig. 7). Schwerer et al. (1974) measured electrical conductivity as a function of temperature (Fig. 8) and tabulate conductivity parameters.

Charette and Adams (1977) illustrate spectral reflectance v. wavelength for powders made from 68815. Only weak pyroxene and plagioclase bands are present.

PROCESSING AND SUBDIVISIONS: 68815 has been substantially subdivided. A fracture split the sample into two main pieces, one of which (,20, 545 g) remains intact. The other (,19, originally 1235 g) has been totally subdivided with extensive chipping and sawing (Figs. 2, 9, and 10) to produce slabs and columns. Considerably more subdivisions occur than are apparent in the illustrations. Thin sections occur for clast I and II and for several matrix areas.

FIGURE 10. S-74-27981.