67015 FRAGMENTAL POLYMICT BRECCIA 1194 g

INTRODUCTION: 67015 is a friable breccia with a light-colored matrix and light and dark colored clasts (Fig. 1). The light colored clasts include plagioclases, feldspathic granulitic impactites, and anorthositic breccias; the dark-colored clasts include aphanitic, glassy, and fine-grained basaltic impact melts.

The sample was collected from the southeast rim of North Ray Crater. It was approximately half-buried. It is subangular and fractured, and lacks zap pits, probably because its surface is fragile.

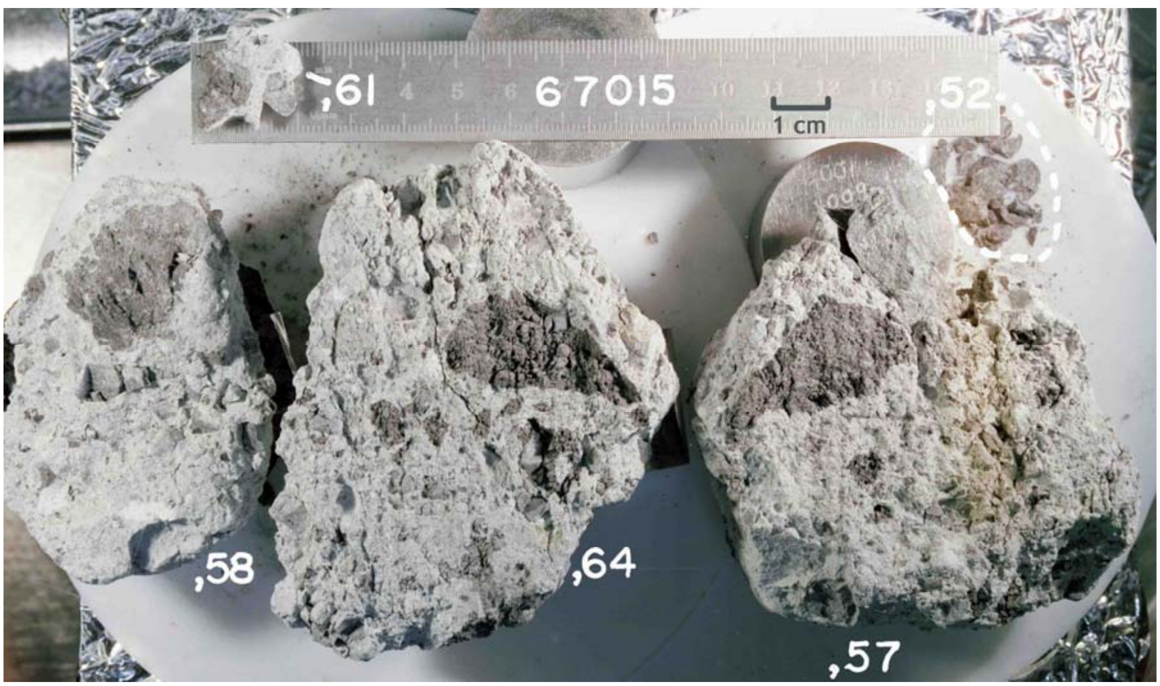

FIGURE 1. S-75-32669.

PETROLOGY: Brief petrographic descriptions are presented by Juan et al. (1974) and McGee et al. (1979). The latter also provide some microprobe data. A guidebook by Marvin (1980) reports macroscopic observations of several subsamples.

The sample is inhomogeneous on the centimeter scale. It is porous, fragmental, and polymict (Fig. 2). McGee et al. (1979) report a mode for thin section ,74: 55% matrix (fragments <39 μm), 13% mineral clasts (mainly plagioclase), 5% fragmental breccias, 17% crystalline breccias, and 10% granulitic/metamorphic fragments, ilmenite, spinel and orange glass are present. Most of the dark clasts are aphanitic or glassy to fine-grained basaltic impact melts (Fig. 2). Compositions of pyroxene and olivine fragments (McGee et al., 1979) are shown in Figure 3.

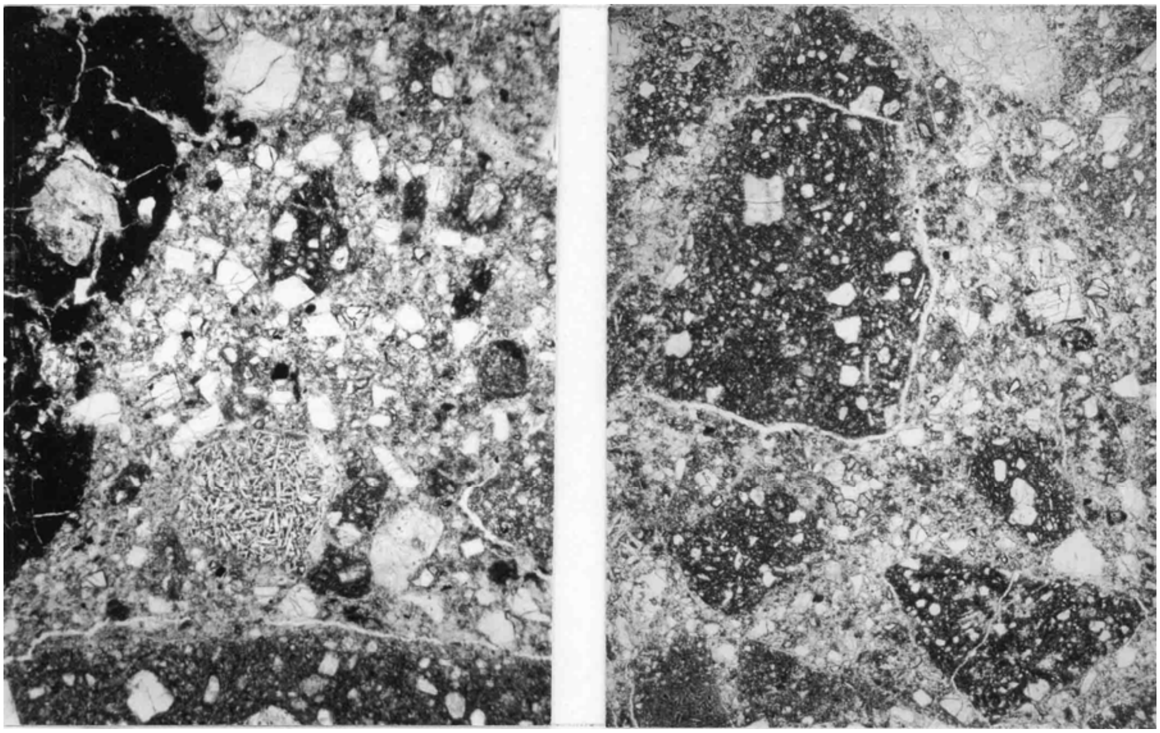

FIGURE 2. a) 67015,88. General view, ppl. Width 2 mm.
b) 67015,9. Dark clasts and fragmental matrix, ppl. Width 2 mm.

<u>CHEMISTRY</u>: Chemical studies of both matrix and dark clasts are listed in Table 1 and a summary chemistry of the matrix in Table 2. The rare earth element data of Wanke et al. (1975) on the matrix are plotted in Figure 4.

The matrix is very aluminous and although contaminated with meteoritic siderophiles, the level of contamination is quite low. The composition is distinct from that of local soils in its higher alumina and lower rare-earth and volatile elements. The rare-earth pattern has a distinct positive europium anomaly (Fig. 4). The matrix meteoritic signature is classified by Hertogen et al. (1977) as a hybrid lying between groups 5H and 5L. Because it lies on a mixing line between the group of other alkali-poor breccias (Group 7) and that of a separated dark clast (Group 1H), Hertogen et al. (1977) suggest that their matrix sample contained a small amount of dark clast material.

The partial analyses of dark clasts by Nunes et al. (1973), Rosholt (1974), and Hertogen et al. (1977) are similar to each other in U contents but the data pack evidence suggest that the analyses are of distinct clasts. The incompatible element abundances are ~5x those of the matrix and are similar to those of basaltic impact melts which have 23-25% Al_2O_3, and which petrographically appear to be the dominant dark clast type in 67015. The meteoritic signature (Group 1H) is similar to many other KREEP-rich crystalline Apollo 16 rocks (Hertogen et al., 1977).

STABLE ISOTOPES: Clayton et al. (1973) found δO^{18} (SMOW) values of +5.64 °/oo (matrix), +5.73 °/oo (plagioclase) and +5.64 °/oo (dark clast) in splits of ,32. The values are typical of lunar rocks.

Kerridge et al. (1975b) report C and S isotopic analyses for matrix splits ,31 and ,39 (Table 3). These values contrast with the strongly positive values of typical Apollo 16 soils.

GEOCHRONOLOGY AND RADIOGENIC ISOTOPES: Nunes et al. (1973) report U, Th, and Pb isotopic data for both matrix and dark clast materials. The lead in the dark clast is very radiogenic ($^{206}Pb/^{204}Pb$ ~1000), but the matrix only moderately so ($^{206}Pb/^{204}Pb$ ~300). The matrix plots well above concordia but the dark clast plots only slightly above it, and both lie within error of a 4.47-3.99 b.y. discordia line (Fig. 5). The precision of the data of Nunes et al. (1973) was questioned by Tera and Wasserburg (1974).

Rosholt (1974) analyzed samples of the solutions used by Nunes et al. (1973) for Th isotopic abundances.

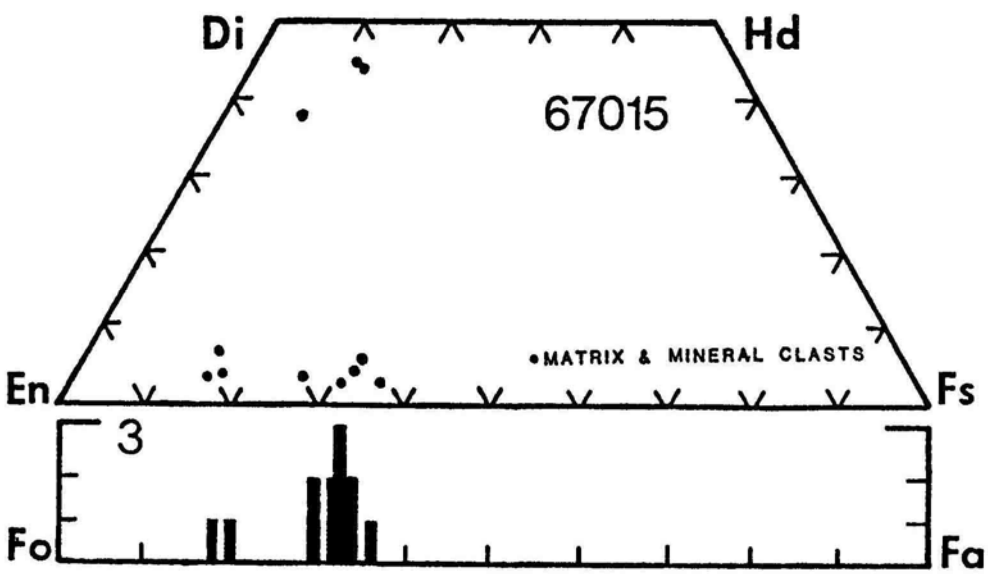

FIGURE 3. Olivine and pyroxene compositions, from McGee et al. (1979).

TABLE 1. Chemical references for 67015.

Reference	Split #	Description	Elements analyzed
Wänke *et al*. (1975)	,106	matrix	Majors, REEs, other trace (∿50 els.)
Wänke *et al*. (1977)	,106	matrix	V
Hertogen *et al*. (1977)	,104 m	matrix	Meteoritic siderophiles and volatiles
"	,104 c	dark clast	"
Modzeleski *et al*. (1973)	,33	matrix	C
Kerridge *et al*. (1975b)	,31	matrix	C,S Compounds
"	,39	matrix	"
Marti *et al*. (1973)	,14	matrix	K
Nunes *et al*. (1973)	,12	matrix	U, Th, Pb
"	,11	dark clast	"
Rosholt (1974)	,12*	matrix	U, Th
"	,11*	dark clast	"

*Same solutions as Nunes *et al*. (1973).

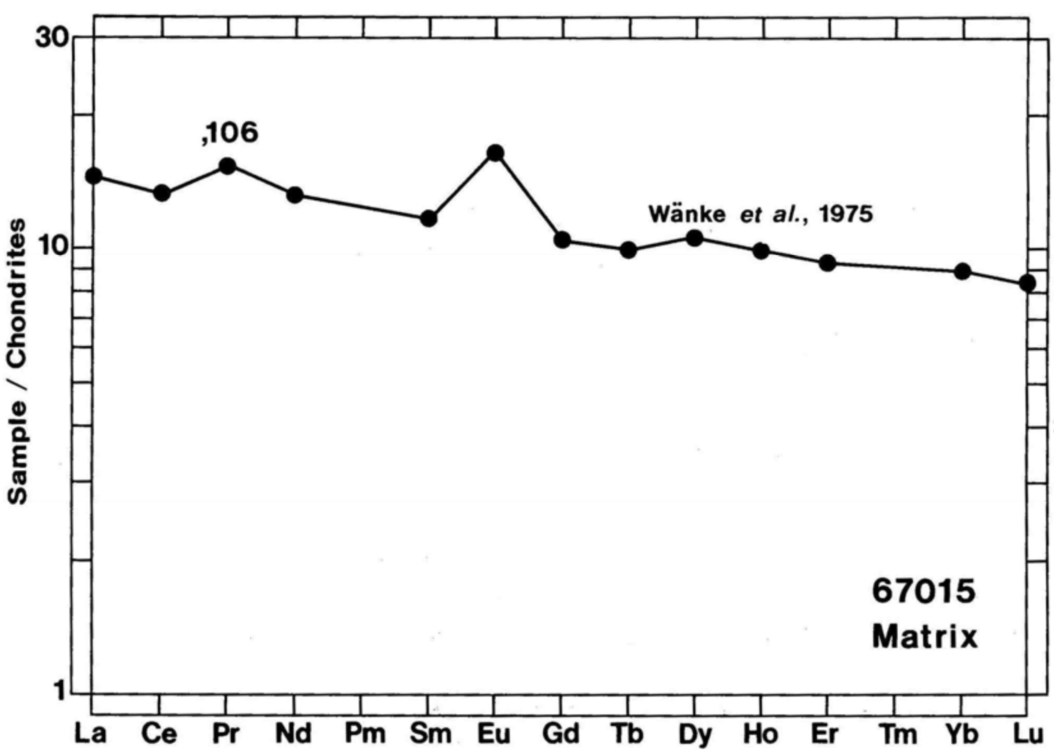

FIGURE 4. Rare earths.

TABLE 2. Summary chemistry of 67015 matrix.

SiO_2	46.0
TiO_2	0.48
Al_2O_3	29.5
Cr_2O_3	0.06
FeO	3.6
MnO	0.05
MgO	3.9
CaO	15.4
Na_2O	0.52
K_2O	0.08
P_2O_5	
Sr	195
La	4.9
Lu	0.24
Rb	∿1
Sc	7.5
Ni	39-110
Co	∿10
Ir ppb	1.8
Au ppb	0.6-1.0
C	∿20
N	
S	140-220
Zn	3-10
Cu	1.5

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

TABLE 3. C and S isotopic data for 67015 (Kerridge et al., 1975b).

	$\delta^{13}C$	$\delta^{34}S$
67015,31	-19.3	-0.02
67015,39	-17.9	-2.2

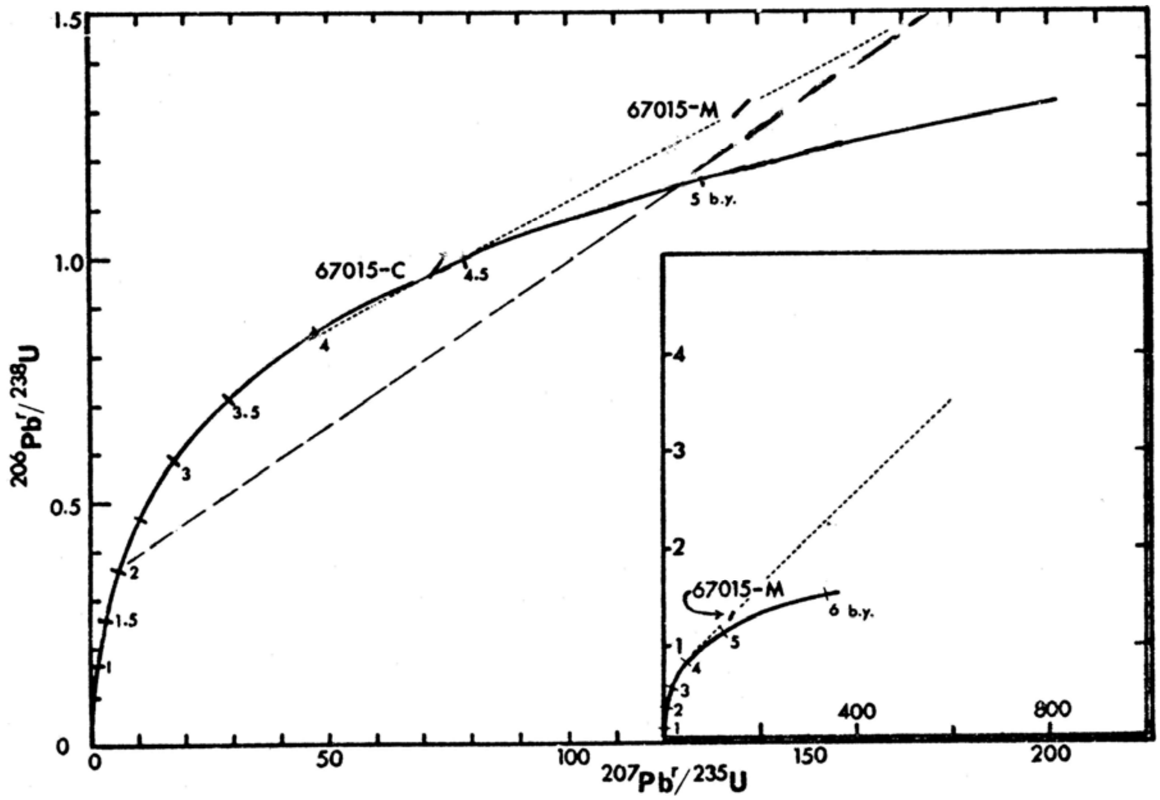

FIGURE 5. Concordia diagram, from Nunes et al. (1973).

<u>RARE GASES, EXPOSURE AGES AND TRACKS</u>: Marti et al. (1973) report Kr isotopic data for interior chip ,14. They calculate an exposure age of 51.1 ± 5 m.y. which is similar to that of most other North Ray Crater samples. Lightner and Marti (1974b) report Xe isotopic data for the same chip.

Hohenberg et al. (1978) report Kr, Ar, and Xe isotopic data (also for ,14) and compare the observed with the predicted rates of production of cosmogenic noble gases.

MacDougall et al. (1973) did not find solar flare-produced particle tracks in either olivine or plagioclase grains in the matrix, and suggest that particle tracks have faded during heating events.

Horz et al. (1975) quote a subdecimeter age (i.e. length of residence at less than 10 cm burial) of 15 m.y. from Lal (pers. comm.) derived from particle track data. However, Horz et al. (1975) list the sample mass appropriate for 67016, and according to curator records, Lal received a sample of 67016 but not 67015. This track age therefore probably has no relevance to 67015.

PHYSICAL PROPERTIES: Brecher (1977) reports that initial magnetic measurements were made on a 12 g bulk rock sample (,42) but the data are not reported. The sample was unreliable for a study of the influence of rock fabric as it affects magnetic characteristics.

Tsay and Baumann (1975) measured the ferromagnetic resonance of chip ,30. The results indicate that the metallic iron annealed to multidomain phases at temperatures of 800°-1000°C. ,30 contains a large portion of dark clast material, thus the data probably pertains to basaltic and glassy impact melts rather than bulk matrix.

PROCESSING AND SUBDIVISIONS: 67015 has been sawn in half and substantially subdivided as described by Marvin (1980). The initial subdivision was the removal of several small chips for various allocations (Fig. 6). In 1975 ,0 was sawn; the friability of the matrix caused pieces to break off. One end piece is ,57 (342 g) (Fig. 7). The other end piece (,0) split into 2 main pieces numbered ,64 (340.5 g) ,58 (109.14 g) and a small piece ,61 (2.24 g) (Figs. 7 and 8). ,64 is in remote storage. ,58 has been entirely subdivided leaving ,161 (32.7 g) and ,162 (31.0 g) as the larger of its derivatives.

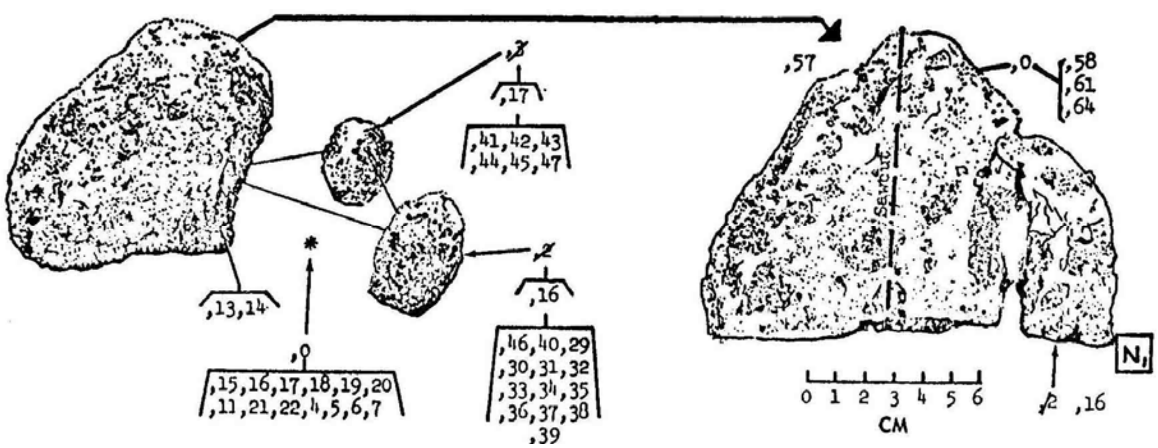

FIGURE 6. Major subdivisions of 67015.