67035 FRAGMENTAL POLYMICT BRECCIA 245 g

INTRODUCTION: 67035 is a very friable, light matrix breccia that was found to be in several pieces when returned from the Moon (Fig. 1). Relatively coherent, dark and light clasts are abundant with the dark clasts rather more common. Two clasts from this rock, a gabbro/norite and a cataclastic ferroan anorthosite, are chemically pristine.

This rock was a grab sample taken from just inside the southeast rim of North Ray Crater; its lunar orientation is unknown. Due to its friability, no original surface of the rock is recognizable.

PETROLOGY: 67035 is a fragmental, porous breccia which is predominantly made up of angular plagioclase grains (Fig. 2). Olivine, pyroxene, spinel, metal, troilite, opaque oxides, lithic fragments and some glass fragments are present. Some of the metal in the matrix and in some lithic clasts is rusty. The lithic clast population is varied, including dominant dark aphanitic melt breccias, and granoblastic and poikiloblastic impactites. At least two clasts—a gabbro/norite and an anorthosite—are chemically pristine.

FIGURE 1. Cube is 1 cm. S-72-37545.

The pristine gabbro/norite clast was completely extracted from the rock and, when split, revealed a marbled pattern of intergrown feldspar and pyroxene (Fig. 3). A thin selvage of glassy breccia coats the entire clast. Thin sections from this clast show a severely shocked and cataclastic anorthosite with ~10% pyroxene; the marbling is not present.

Grain size of the plagioclase is ~5 mm and despite the cataclasis some original grain boundaries are preserved. Most of the pyroxenes have been crushed and many have been plucked from the slides. A 2-3 mm pyroxene grain occupies the center of each section (Fig. 2). Our analyses indicate the pyroxene to be mainly augite (~$Wo_{30-40}En_{40}$) with an exsolved low-Ca phase (~Wo_3En_{60-65}). This is somewhat more ferroan than the pyroxenes in most other pristine norites but is similar to those in pristine anorthosites.

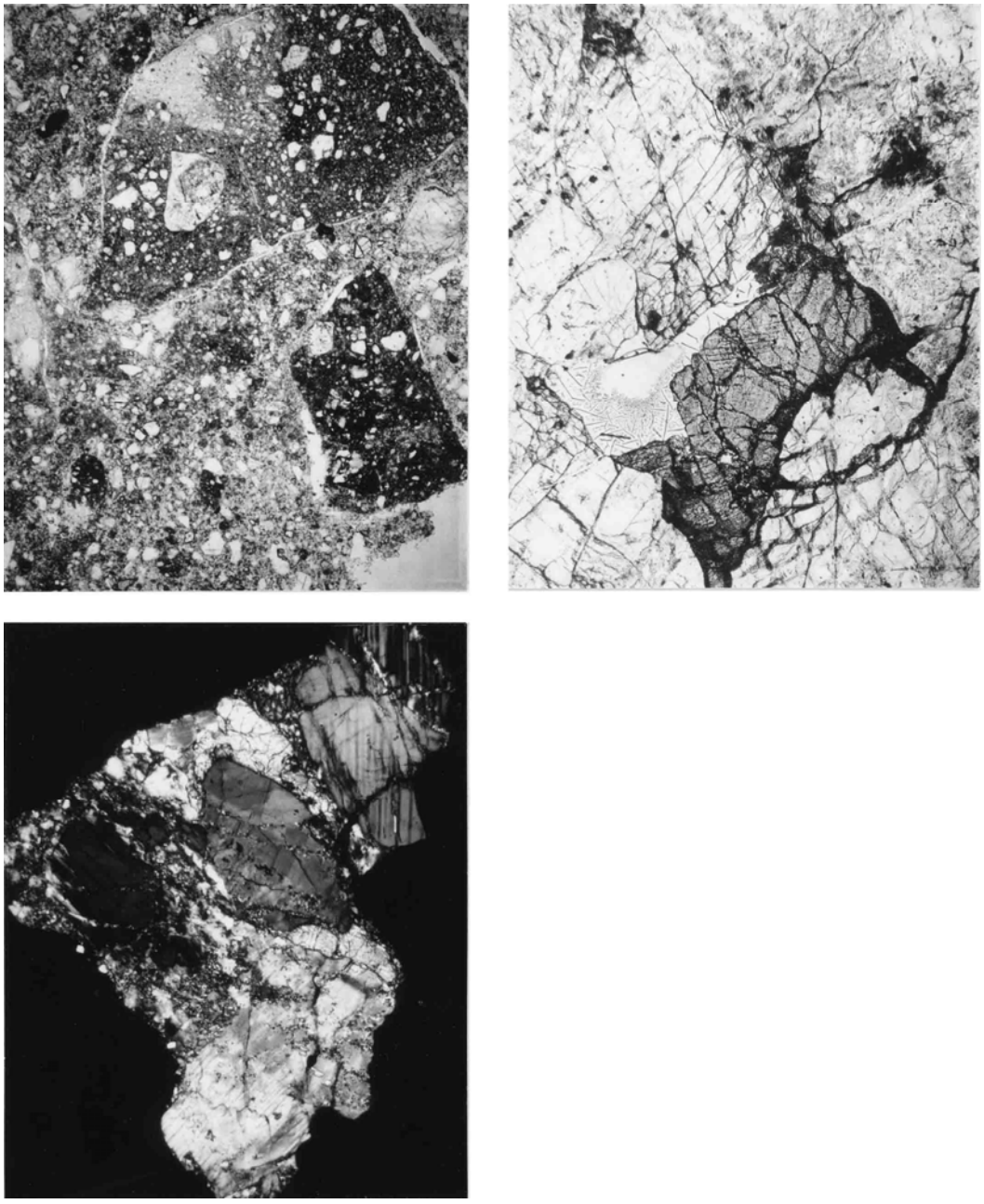

FIGURE 2.
a) 67035,13. Aphanitic breccia clasts, and fragmental matrix, ppl. Width 2 mm.
b) 67035,8. Pristine gabbro/ norite clast, ppl. Width 2 mm.
c) 67035,10. Pristine anorthosite clast, xpl. Width 2 mm.

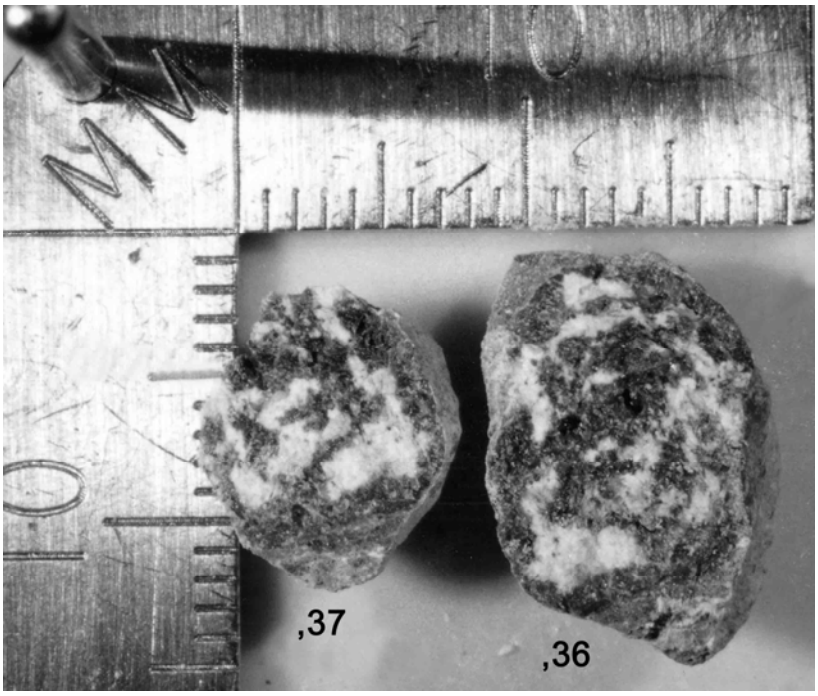

FIGURE 3. Pristine gabbro/ norite clast, mm scale.

The pristine cataclastic anorthosite clast was also completely extracted from the rock (Fig. 4). A relict cumulate texture with interstitial pyroxene has been retained despite cataclasis (Fig. 2). The original grain size was >2 mm. Our analyses indicate that the mafic phase is a low-Ca pyroxene averaging ~En_{60} (Fig. 5), not unusual for a pristine anorthosite.

CHEMISTRY: Major and trace element analyses of the bulk rock are given by Laul and Schmitt (1973) and Wasson et al. (1977). Hertogen et al. (1977) report siderophile, volatile and other trace element data on the bulk rock, the gabbro/norite clast and the pristine anorthosite clast. Nyquist (unpublished; in Ryder and Norman, 1978) provides major and trace element data for the pristine anorthosite clast. Clark and Keith (1973) give natural and cosmogenic radionuclide abundances for the large fragment ,17.

The bulk rock is highly aluminous and fairly low in siderophile and rare earth elements (Table 1, Fig. 6). These are common characteristics of many of the rocks considered to be North Ray ejecta. Laul and Schmitt (1973) note that their analysis of 67031,14 (actually a portion of 67035) is virtually identical to that of 60017, also North Ray ejecta. The rare earths in 67035 are significantly fractionated relative to KREEP (Wasson et al., 1977). The siderophiles in the bulk rock were tentatively assigned to meteoritic group 2 by Hertogen et al. (1977). This group dominates the Serenitatis ejecta at Apollo but may also be a mixture of other groups (Hertogen et al., 1977).

The gabbro/norite clast has very low levels of siderophiles confirming its pristine nature. Uranium (0.63 ppb) and Rb are also quite low compared to other pristine norites (Table 1).

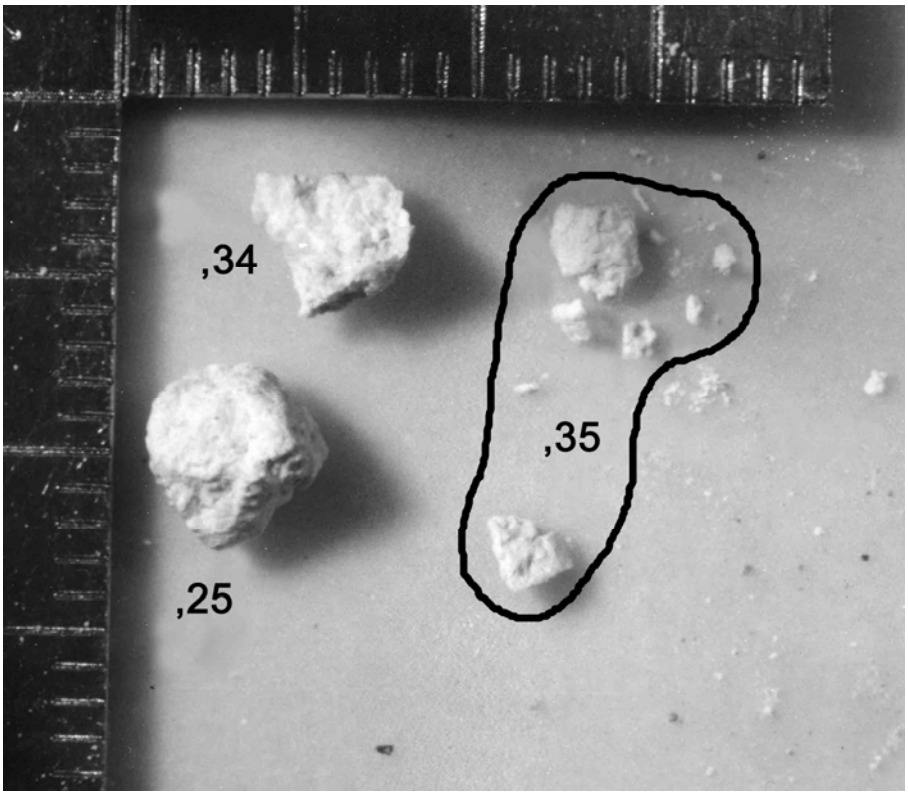

FIGURE 4. Pristine anorthosite, clast, mm scale.

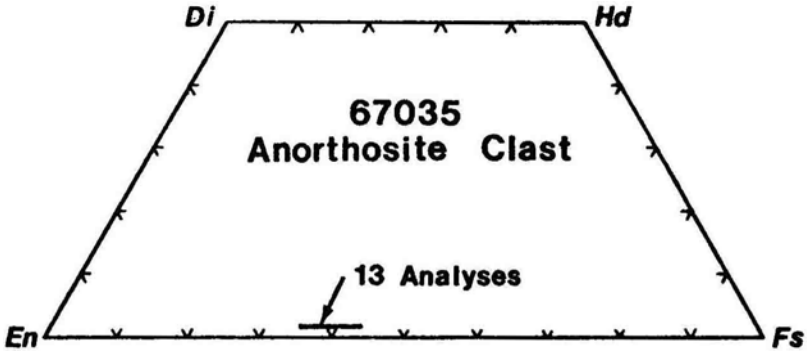

FIGURE 5. Pyroxene compositions of pristine anorthosite clast, from Ryder and Norman (unpublished).

The pristine cataclastic anorthosite clast is also low in siderophiles though Rb and U (6.2 ppb) are rather high for an anorthosite. The REE abundances of this clast are typical of pristine anorthosites (Table 1).

RADIOGENIC ISOTOPES/GEOCHRONOLOGY: Schaeffer and Schaeffer (1977) report an Ar-Ar plateau age of 3.95 ± 0.05 b.y. and a total K-Ar age of 3.89 ± 0.01 b.y. for the bulk rock.

TABLE 1. Summary chemistry of 67035 lithologies.

	Bulk rock	Cataclastic anorthosite clast	Gabbro/norite clast
SiO_2			
TiO_2	0.31	0.032	
Al_2O_3	29.8		
Cr_2O_3	0.059	0.017	
FeO	3.4		
MnO	0.05		
MgO	3.7	1.05	
CaO	16.5		
Na_2O	0.510		
K_2O	0.051	0.023	
P_2O_5			
Sr		164	
La	2.5	0.22	
Lu	0.15		
Rb	1.12	0.77	0.57
Sc	6.2		
Ni	~48	3.4	9.4
Co	~8		
Ir ppb	1.54	0.045	0.0043
Au ppb	0.842	0.031	0.012
C			
N			
S			
Zn	2.78	1.09	0.51
Cu			

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

Nyquist (unpublished; in Ryder and Norman, 1978) measured an $^{87}Sr/^{86}Sr$ ratio of 0.69976 ± 8 on the pristine cataclastic anorthosite clast.

RARE GASES/EXPOSURE AGE: Schaeffer and Schaeffer (1977)report Ar isotopic data and an average Ar exposure age of 35 m.y., consistent with the generally accepted age of North Ray Crater. Clark and Keith (1973) provide cosmogenic radionuclide data.

PROCESSING AND SUBDIVISIONS: In 1972, Documented Bag 382 was opened and found to contain two large (>50 g) pieces of friable rock, a number of >1 cm fragments, and abundant smaller chips and fines. The large pieces and about a dozen >1 cm fragments were given the generic 67035,0. The <1 cm fraction was sieved and numbered 67034 (4-10 mm), 67033 (2-4 mm), 67032 (1-2 mm) and 67031 (<1 mm).

67035,0 was subsequently entirely subdivided as ,1, ,17, and ,18 (Fig. 1). ,1 was made into thin sections. ,18 was further split to produce ,20 and ,24 - ,60 (Fig. 7). ,17 is preserved at JSC as an 87.1 g piece.

Laul and Schmitt's (1973) analysis was of a 0.25 g split of the <1 mm fraction (67031,14).

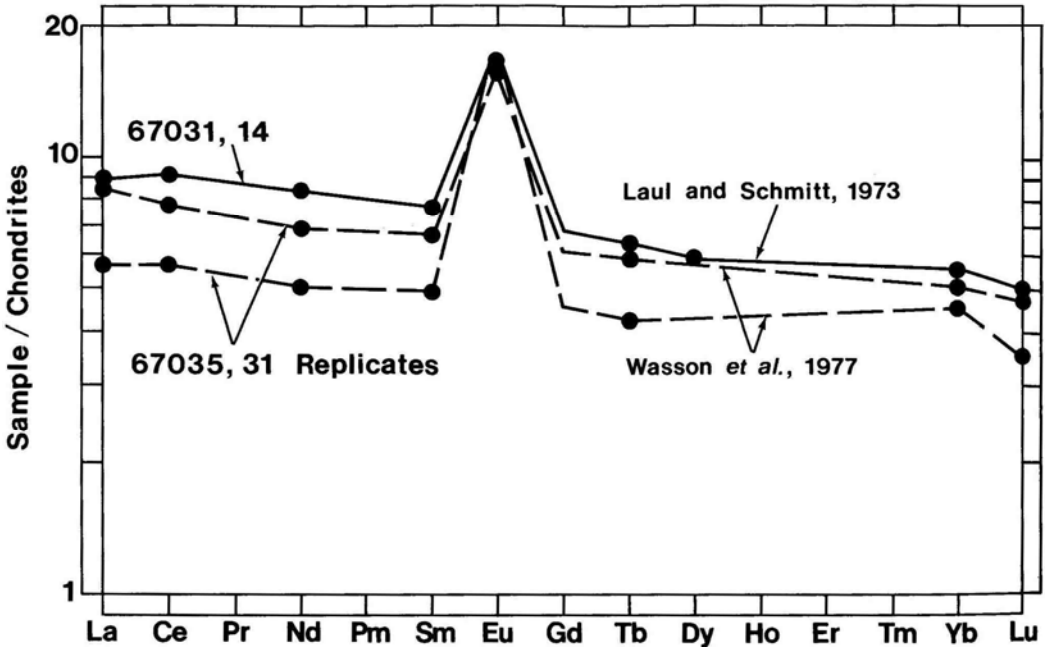

FIGURE 6. Rare earths of bulk rock.

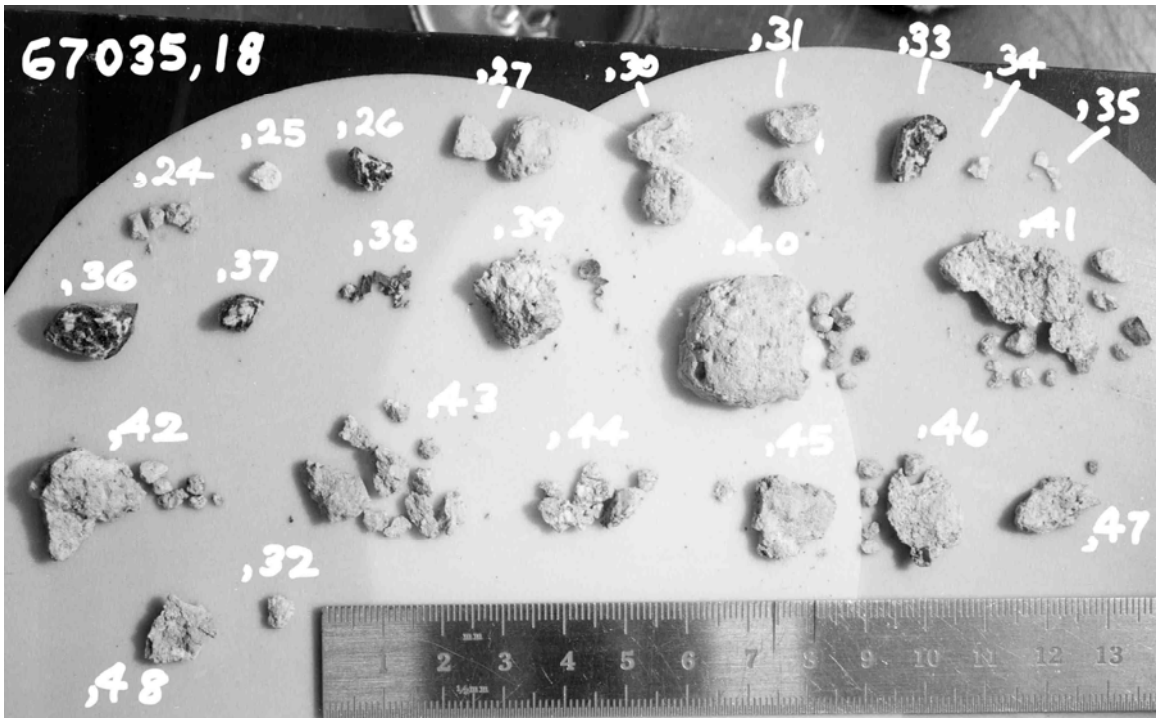

FIGURE 7. Major subdivisions of 67035,18. S-74-31234.