76255

Banded Impact Melt Breccia
406.6 g, 11 x 8 x 6 cm

INTRODUCTION

Sample 76255 was chipped by the astronauts from across the contact between unit C and a large (1 m) clast seen in the surface photography of Block 1 of the large boulder at Station 6 (Fig. 1). According to Phinney (1981), the sample contains mostly crushed material from the clast, but from the maps of the sawn surface of the slab of 76255, it is obvious that the contact zone is quite mixed and that more than one clast was sampled.

Cautionary note: The exact details in the literature pertaining to which analyses are from which lithology are very confusing (at the time of compiling this catalog, it would require a research project by a new consortium to figure this out!). Please note the change in numbering of the lithologies between Warner et al. (1976) and Phinney (1981). See also Ryder and Norman (1979).

PETROGRAPHY

Sample 76255 is a banded impact melt breccia with a large clast of crushed norite and several small white clasts (Fig. 2). According to Warner et al. (1976), the matrix of 76255 is the finest-grained, most clast-laden, impact-melt polymict breccia sampled from the boulder at Station 6. The texture of the matrix is subophitic with pyroxene and olivine oikocrysts, small spherical vesicles, and abundant mineral and lithic clasts. Warner et al. give the mineralogical mode of the matrix as 45% plagioclase (An_{82-95})32% olivine (Fo_{73-77}), 12% pigeonite ($Wo_7En_{70}Fs_{23}$), 2% augite ($Wo_{38}En_{50}Fs_{12}$), and 3% ilmenite. However, the matrix is variable with finer-grained, dark material inter-mixed with coarser-grained light material. The plagioclase inclusions in the breccia matrix are very calcic (An_{95}) (Fig. 3).

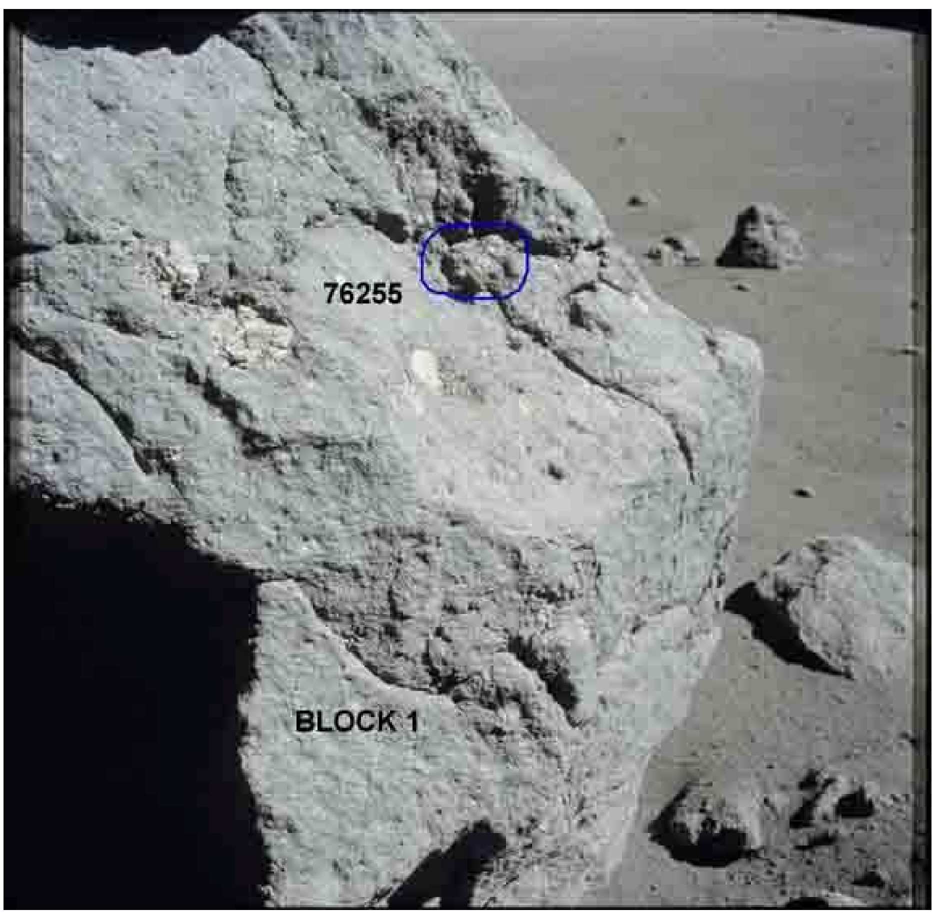

Figure 1: Photo of boulder surface showing large clasts in boulder matrix. 76255 was taken from one of these clasts (Wolfe and others, 1981). AS17-140-21443

Figure 2: Mugshot of 76255 showing banded nature of sample. Note the crushed appearance of the norite clast (center) and the while powder on the bottom surface. Scale is 1 cm. S72-56415.

Warner et al. (1976) have described the large crushed norite clast (called unit 3 in Warner et al. and unit 4 in Phinney, 1981). It has been crushed to a senate texture with fragments ranging in size from 2 pm to over 2 mm (Fig. 4). Because this crushed norite appears to be permeated with breccia matrix, Warner et al. claimed that clean separations of the norite clast were not possible for geochemical and age dating experiments. The mineralogical mode is 41% plagioclase (An_{87}), 31% pigeonite ($Wo_8 En_{61} FS_{31}$), and 9% augite ($Wo_{37}En_{45}FS_{34}$). The pyroxenes in the norite are coarsely exsolved (see below). The composition of pyroxenes and plagioclase in the norite clast are shown in Fig. 5.

Warner et al. also studied a 3 x 5 mm clast of gabbro that was broken off of 76255 (Phinney, 1981). It consists of large (2 mm) oscillatory-zoned plagioclase, large euhedral augite prisms that have exsolved thin lamellae of low-Ca pyroxene, and interstitial anhedral pigeonite masses with exsolved augite lamellae. The cores of the plagioclase are An_{89} while the rims are An_{75}. The large pyroxenes are $Wo_{36}En_{48}Fs_{16}$ and $Wo_{10}En_{61}Fs_{29}$, respectively (Fig. 6).

A 0.8 x 1.2 cm shocked troctolite clast has been studied by Warner et al. and others. It consists of 71% large (1 mm).euhedral plagioclase (An_{95}) and 23% crushed olivine (Fo_{89}) fragments up to 0.7 mm.

Two basalt clasts with mineralogies suggestive of mare affinities were reported by Warner et al. (1976). Because these clasts are enclosed within the boulder, which is dated at 3.96 b.y., they must be at least that old, indicating that mare volcanism began before this time. These basalt clasts were too small to analyze in bulk, but mineral compositions are given in Fig. 7.

James and Flohr (1982) have also studied the clasts in this breccia. They group the norite and the gabbro clasts in their category of Mg gabbro norites. Jolliff et al. (1993) have plotted the plagioclase vs. pyroxene composition of these clasts (Fig. 8).

MINERAL CHEMISTRY

Using the pyroxene data of Takeda and Miyamoto (1977), Anderson and L.indsley (1982) calculate a pyroxene equilibrium temperature of 800 °C. Takeda and Miyamoto have also studied the cooling rate of the inverted pyroxene in 76255. A deep-seated origin is indicated for the norite clast.

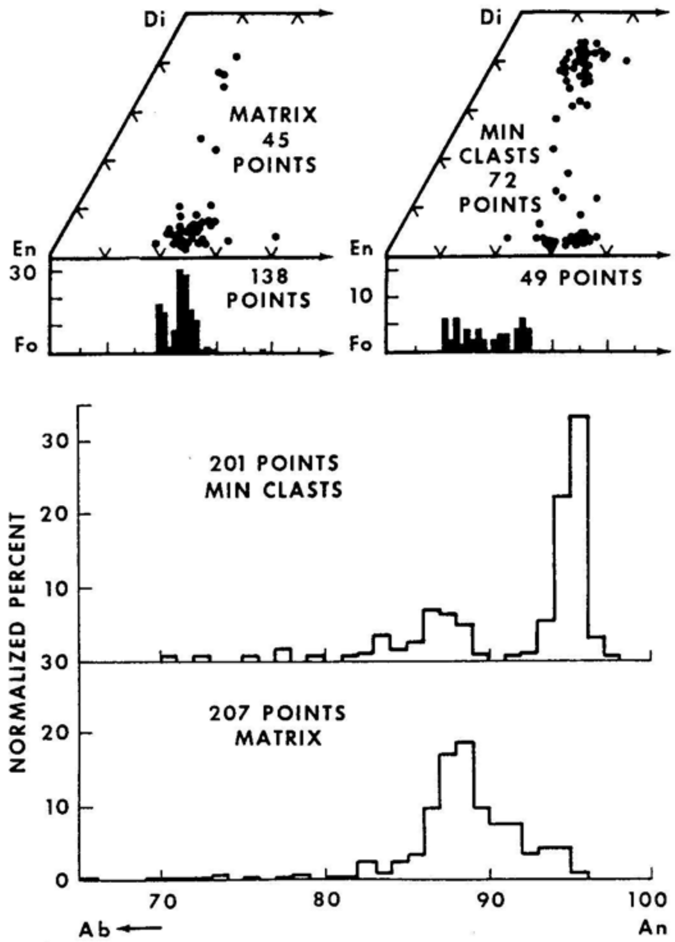

Figure 3: Pyroxene, olivine, and plagioclase compositions in 76255 matrix (Warner et al., 1976).

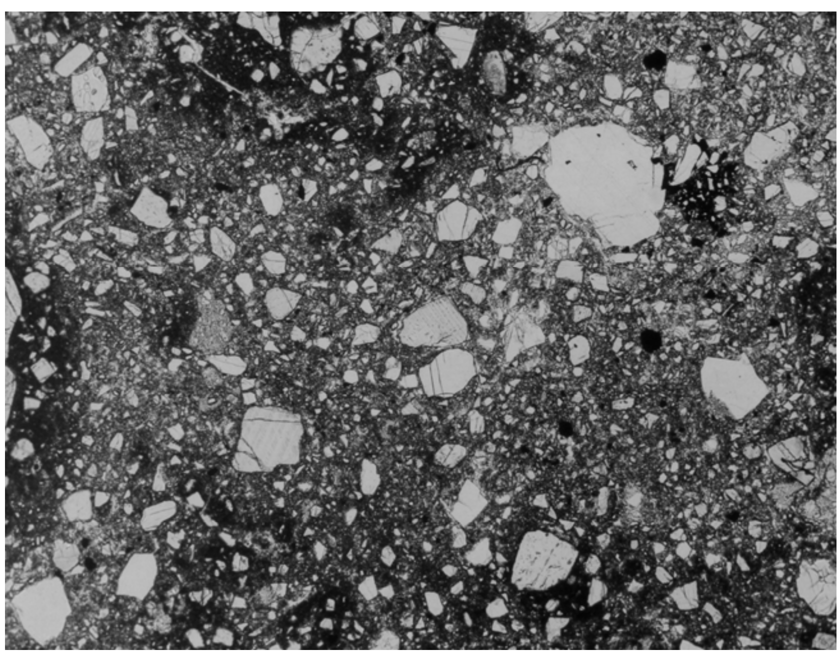

Figure 4: Photomicrograph of 76255,76 showing clastic texture of norite clast. Field of view is 4 x 5 mm.

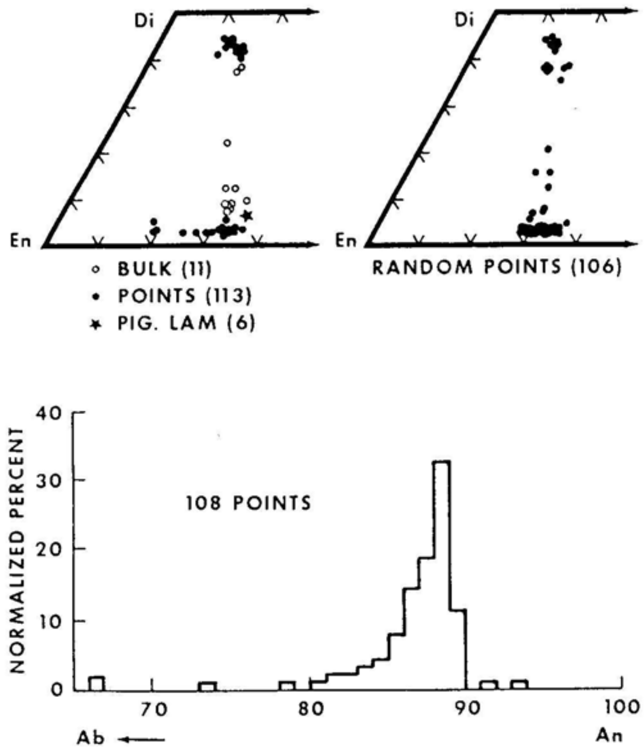

Figure 5: Pyroxene, olivine, and plagioclase compositions in 76255 norite clast.

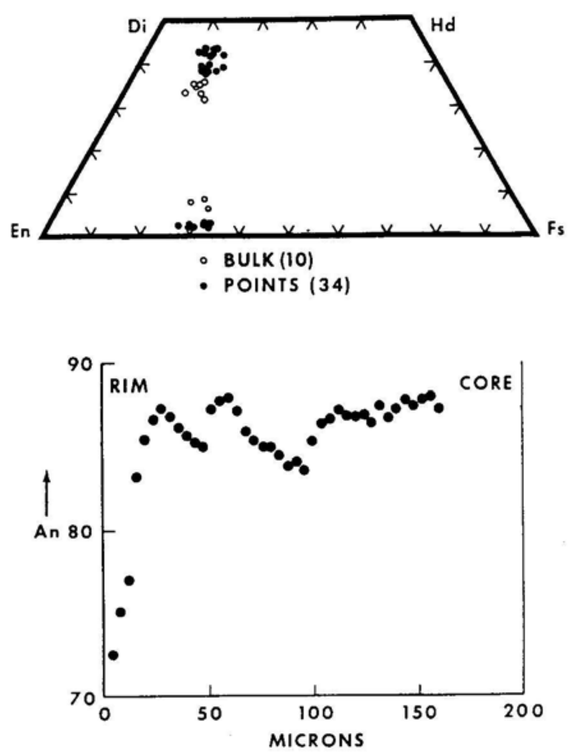

Figure 6: Pyroxene compositions in 76255 gabbro clast. From Warner et al. (1976).

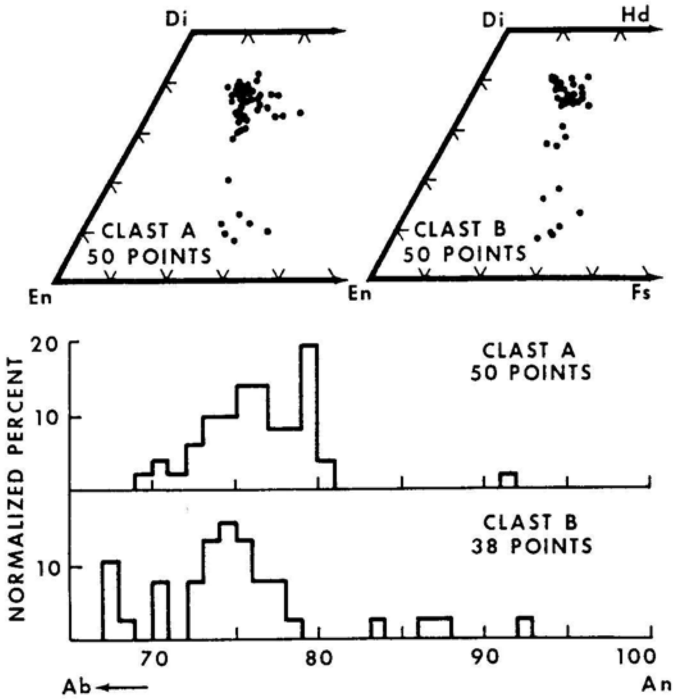

Figure 7: Pyroxene and plagioclase compositions in 76255 basalt clasts.

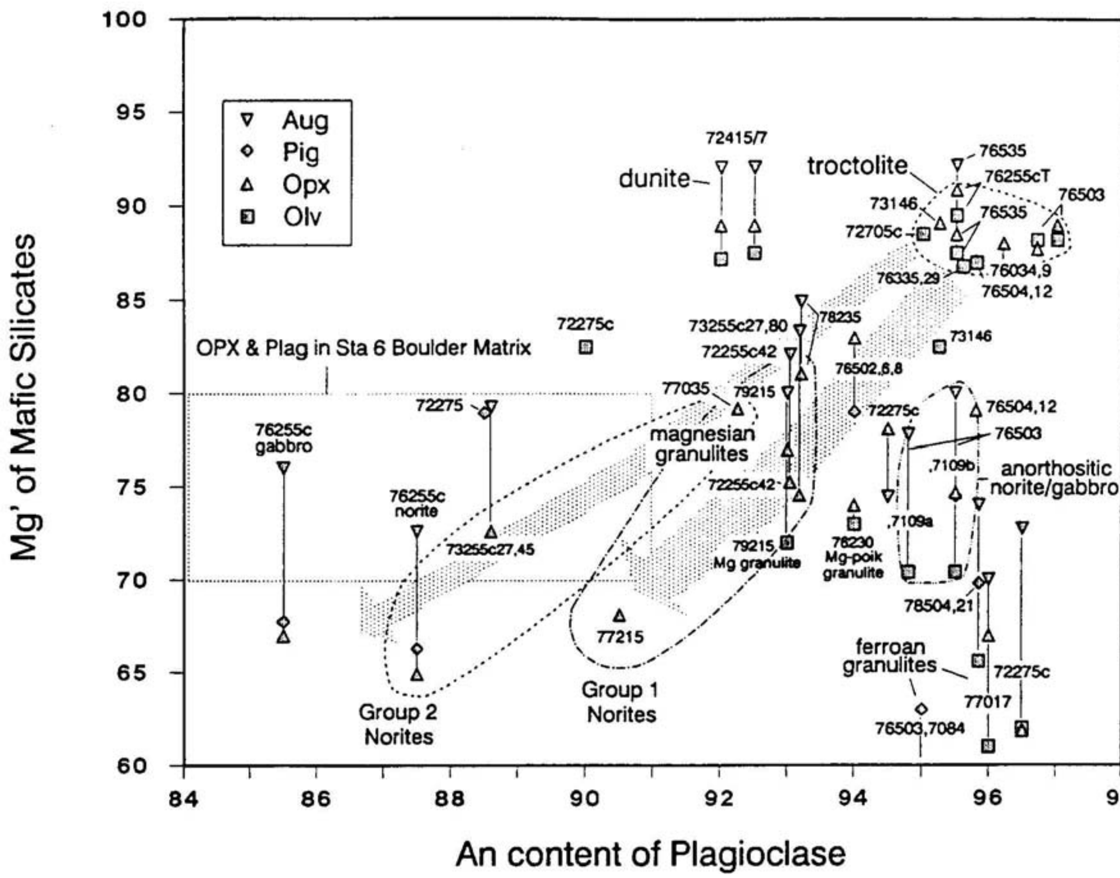

Figure 8: Composition of pyroxene and plagioclase compared with other plutonic clasts. From Jolliff et al. (1993).

Smith et al. (1980), Steele et al. (1980), and Bersch et al. (1991) have also reported analysis of minerals in 76255.

WHOLE-ROCK CHEMISTRY

Table 1 gives the major element analysis by Rhodes (unpublished in Phinney, 1981). Gros et al. (1976) and Wolf and Anders (1979) have analyzed the trace elements of the various clasts for the Phinney consortium (Table 2). Warren (1978, 1984, and 1986) has made several attempts to analyze the trace element content of the large norite clast (Table 3 and Fig. 9). Additional analyses are needed of carefully controlled samples.

SIGNIFICANT CLASTS

Several different clasts have been analyzed-see especially Ryder and Norman (1979), Phinney (1981), and Warren (1993).

Warner et al. (1976) first described the large clast (300 g?) of cataclastic norite in 76255. Ryder and Norman (1979) and Phinney (1981) have attempted to summarize what was known about this important class. Warner et al. reported that the clast is permeated with "pods and septa of material identical to the boulder's impact melt matrix." However, Gros et al. (1976) found that at least part of this norite clast was free of meteorite contamination (note that they apparently misnamed it as "troctolite"). Warren et al. (1986) attempted to reanalyze this clast, but found that their split was contaminated with "countless small dark aphanitic pods." However, their analysis also showed that this clast is a "possibly pristine" gabbronorite (James and Flohr, 1983; Warren, 1993).

The small clast of gabbro (~0.5 g) studied by Warner et al. (1976) has a coarse cumulate texture (Fig. U)) with oscillatory zoned plagioclase (An_{89-75}), augite ($Wo_{36}En_{48}$) with exsolved thin lamellae of low-Ca pyroxene, and interstitial pigeonite ($Wo_{10}En_{61}$) with exsolved thick lamellae. The location of this clast on 76255 is uncertain, but it is not from the slab as indicated by Warner et al. Sections ,71 ,72 and ,73 were derived from 76255,50, which was from the external surface of 76255.

RADIOGENIC ISOTOPES

76255,46 yielded a very well-defined Ar plateau age of 4.02 ±.04 b.y. (Cadogan and Turner, 1976) with no characteristic decrease in apparent age in the high-temperature gas release (Fig. 11). This age appears to be older than the ages determined for other samples of this boulder *(see table and discussion of Station 6 Boulder, page 5).*

Bogard has analyzed the rare gas isotopes in 76255 (see unpublished data in Phinney, 1981).

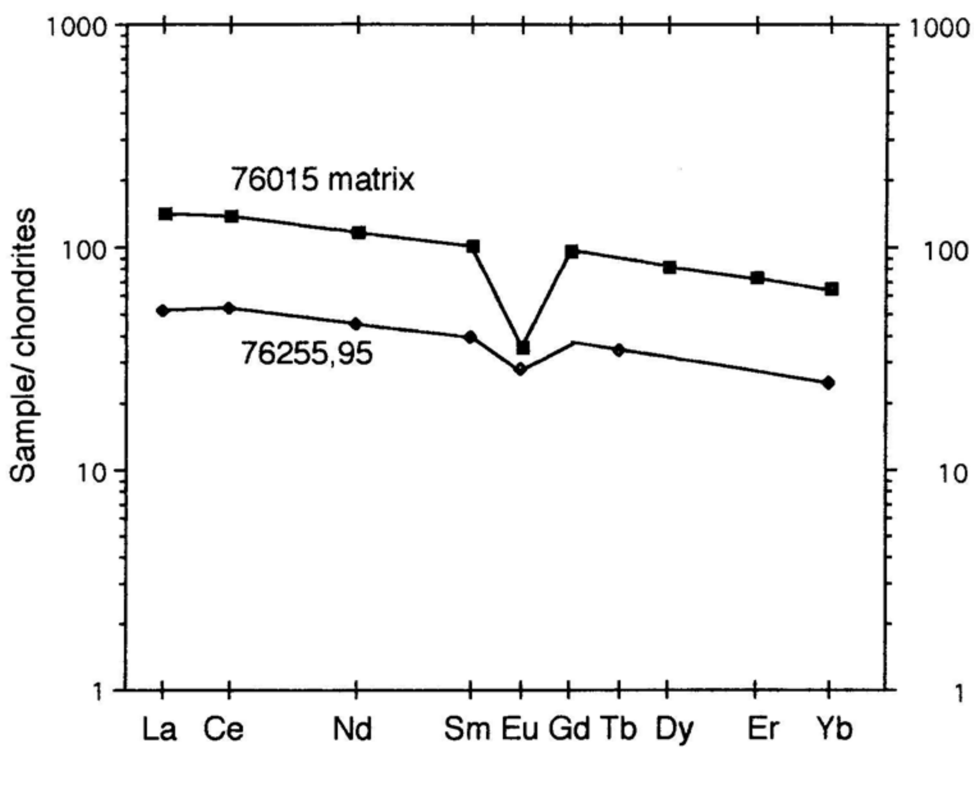

Figure 9: Normalized rare earth element diagram for norite clast in 76255 compared to boulder matrix. According to Warner et al. (1976) and Warren et al. (1986), this clast may contain some matrix material.

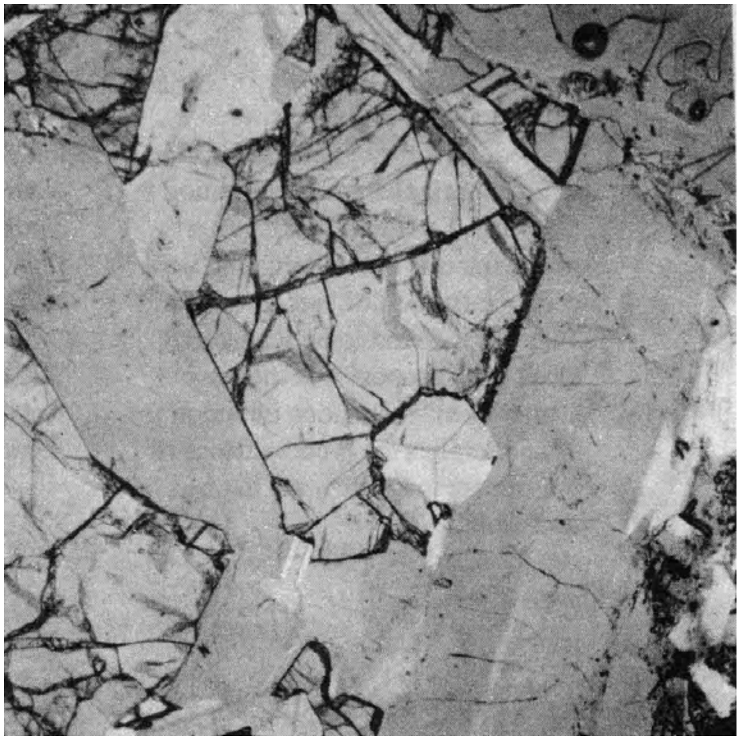

Figure 10: Photomicrograph of gabbro clast in 76255,72. Field of view is 2 mm.

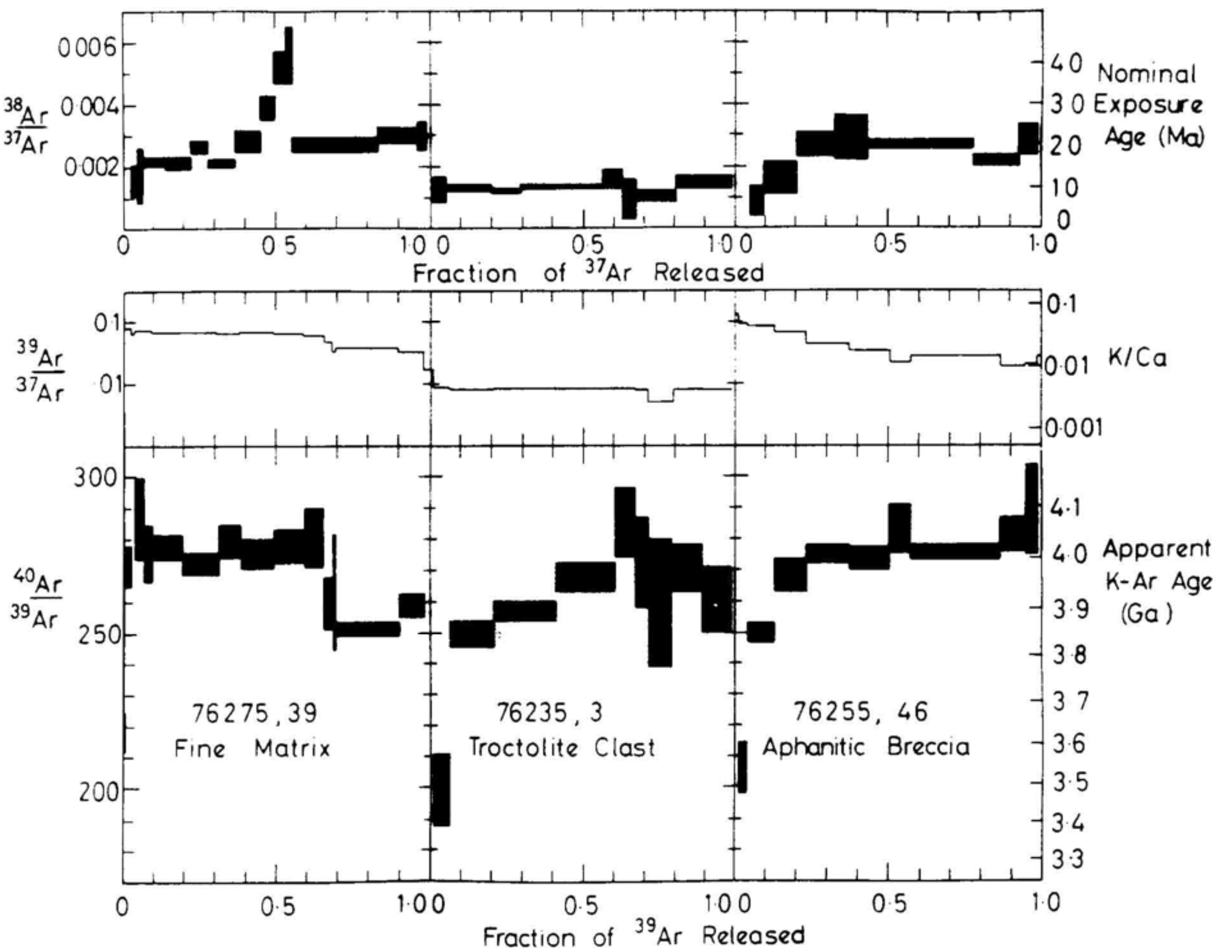

Figure 11: Ar- Ar plateau age for 76255. From Cadogan and Turner (1976).

COSMOGENIC RADIOISOTOPES AND EXPOSURE AGES

Some of the Apollo 17 samples (including 76255) provided a unique opportunity to study the energy spectrum (and potential angular anisotropy) of the incident proton flux from the August 1972 solar flare (Rancitelli et al., 1974; Keith et al., 1974). Table 4 compares the induced activity of 76255 with other samples of the boulder.

MAGNETIC STUDIES

Gose et al. (1978) have carefully studied the remanent magnetization of 26 subsamples from the Station 6 Boulder. The direction of magnetization after alternating field demagnetization of breccia sample 76255 was found to be scattered. Gose et al. propose that the large scatter of magnetization direction for 76255 implies the predominance of pre-impact magnetization in this sample.

PROCESSING

A slab and a column were cut from this rock (see lithology maps and diagrams in Phinney, 1981). The distribution of samples is recorded in Phinney (1981) and Ryder and Norman (1979).

The largest remaining piece of 76255 weighs 166 g. There are 15 thin sections.

Table 1: Whole-rock chemistry of 76255.
From Rhodes (unpublished, reported in Phinney, 1981).

Split Technique	,38 XRF norite	,44 XRF matrix	,51 XRF matrix and clast	,55 XRF clast	,58 XRF clast
SiO_2 (wt%)	50.61	45.45	46.94	59.68	43.84
TiO_2	0.75	1.60	1.66	1.37	0.25
Al_2O_3	15.37	18.91	19.04	15.89	25.15
Cr_2O_3					0.04
FeO	9.8	7.40	7.21	9.36	4.23
MnO	0.19	0.11	0.13	0.17	
MgO	11.14	13.88	11.86	11.23	11.02
CaO	11.05	11.78	12.47	11.17	14.20
Na_2O	0.74	0.68	0.76	0.73	0.40
K_2O	0.37	0.17	0.18	0.32	0.08
P_2O_5	0.03	0.24	0.22	0.01	
S	0.09	0.03	0.03	0.03	

Table 2: Trace element compositions of 76255. Concentrations in ppb.
a) Gros el: al. (1976); d) Wolf and Anders (1979)

	Sample 76255,47 (a) matrix	Sample 76255,52 (a) matrix	Sample 76255,56 (a, d) clast	Sample 76255,57 (a, d) clast
Ir	1.13	1.21	0.042	0.019
Os	1.11	1.91	0.035	<0.03
Re	0.132	0.112	0.028	0.0068
Au	0.843	0.38	0.178	0.0093
Pd	<2.5	<2.5	<0.7	<4.3
Ni (ppm)	90	62	31	<15
Sb	2.2	0.2	0.11	2.4
Ge	34.2	9.6	6.6	2.2
Se	41	19	49	0.6
Te	1.6	2.5	1.1	5.9
Ag	12.9	1.29	0.7	0.34
Br	35.9	15.8	9.2	7.8
In	0.61	9.76	0.3	0.77
Bi	0.31	0.37	0.2	<2
Zn (ppm)	2.4	2.3	2	0.5
Cd	8.2	6.4	2	67.5
Tl	0.89	1	0.96	5.4
Rb (ppm)	5.36	3.68	12.8	0.19
Cs	184	175	842	6.3
U	3150	1170	445	19

Table 3: Composition of 76255.
a) Warren and Wasson (1978); b) Warren et al. (1986)

	Sample 76255,58 (a)	Sample 76255,95 (b)	Sample 76255,95 (b)
Na (%)	0.347	0.509	0.495
Mg (%)	6.13	7.3	
Al (%)	13.8	8.9	
Si (%)	20.6	22.8	
K (%)		0.158	0.124
Ca (%)	10.7	8.3	8.3
Sc (ppm)	4.7	17.3	16.2
Ti (%)	0.16	0.5	
Cr (ppm)	461	1310	1320
Mn (ppm)	367	1010	975
Fe (%)	3.3	6.3	6
Co (ppm)	19.4	14.3	16.2
Ni (ppm)	<70	23	13
Zn (ppm)	53.2		
Ga (ppm)	4.81	4.2	4
Ge (ppb)	22	1.3	
Zr (ppm)	150	120	196
Cd (ppm)	6.4		
In (ppm)	<5		
Ba (ppm)	240	184	178
La (ppm)	16.1	12.1	13.7
Ce (ppm)	38	32	37
Nd (ppm)	24	20.2	22.2
Sm (ppm)	5.4	5.8	6.3
Eu (ppm)	1.77	1.57	1.55
Tb (ppm)	0.94	1.23	1.34
Yb (ppm)	3.4	4	4.3
Lu (ppm)	0.46	0.63	0.68
Hf (ppm)	3	3.8	4.3
Ta (ppm)	0.27	0.41	0.42
Re (ppb)		0.017	
Ir (ppb)	0.63	0.077	
Au (ppb)	10.8	0.139	0.05
Th (ppm)	1.3	1.4	1.58
U (ppm)	0.38	0.38	0.38

Table 4: Solar flare induced activity from large solar flare, August 1972.
a) Keith et al., (1974); b) Rancitelli et al., (1974); c) O'Kelley et al., (1974)

	Sample 76215 (a)	**Sample 76255 (b)**	**Sample 76275 (b)**	**Sample 76295 (b)**	**Sample 76295 (c)**
dpm/Kg					
^{26}Al	56 ± 3	79 ± 4	110 ± 3	71 ± 4	67 ± 5
^{22}Na	60 ± 4	71 ± 4	100 ± 3	64 ± 3	54 ± 4
^{54}Mn	22 ± 17	38 ± 9	103 ± 20	69 ± 26	38 ± 15
^{56}Co	45 ± 6	37 ± 4	86 ± 9	35 ± 5	41 ± 7
^{46}Sc	5 ± 3	3.9 ± 1.2	7 ± 2	6.4 ± 2.6	5 ± 2
^{48}V					
Natural activity					
Th (ppm)	4.6	2.33	5.69	5.76	
U (ppm)	1.27	.58	1.40	1.55	
K (ppm)		2900	2250	2300	