79135

Polymict Matrix Breccia
2283 g, 20 x 12 x 10 cm

INTRODUCTION

79135 was described as a medium to dark gray, angular to irregular breccia, with many penetrative fractures (Apollo 17 Lunar Sample Information Catalog, 1973). It has a homogeneous clast and matrix distribution (Fig. 1). On the original sample, T was freshly broken (Fig. 1 b), W had a few glass drops (lcm), and B was the original surface with minor amounts of glass coating. There are less than 1% cavities present of the surface of this sample and no zap pits. The fracturing caused the sample to break into plate-lets and rhombs - possibly there were two sets of joints, some with very fine slickensides.

PETROGRAPHY AND MINERAL CHEMISTRY

The Apollo 17 Lunar Sample Information Catalog (1973) described the petrography of thin section 79135,11 ,12 and ,13. 79135 was found to be a lithified mature soil, which contained orange glass similar to that from Station 4. Matrix makes up 25% of the rock and is mostly small mineral grains held in devitrified (opaque) glass (Fig. 2 a,b). The matrix is composed of 50% devitrifed glass (0.01 mm), 25% plagioclase (< 0.01 mm), and 25% pyroxene (< 0.01 mm). Mineral clasts form 25% of the rock. These are composed primarily of angular plagioclase (0.1-0.5 mm) and clinopyroxene (0.1-0.5 mm), with minor olivine, orthopyroxene (both 0.1-0.5 mm), opaques (0.1-0.5 mm) and FeNi metal (0.2-2 mm). Lithic clasts make up 20% of the rock, and of these, 40% are angular mare basaltic fragments (2-5 mm). Thirty percent of the lithic clasts have been described as angular "hornfels (norite)" clasts (2-5 mm) by the Apollo 17 Lunar Sample Information Catalog (1973). These hornfels have annealed breccia textures including orthopyroxene. A

Figure 1: Hand specimen photograph of 79135,0.

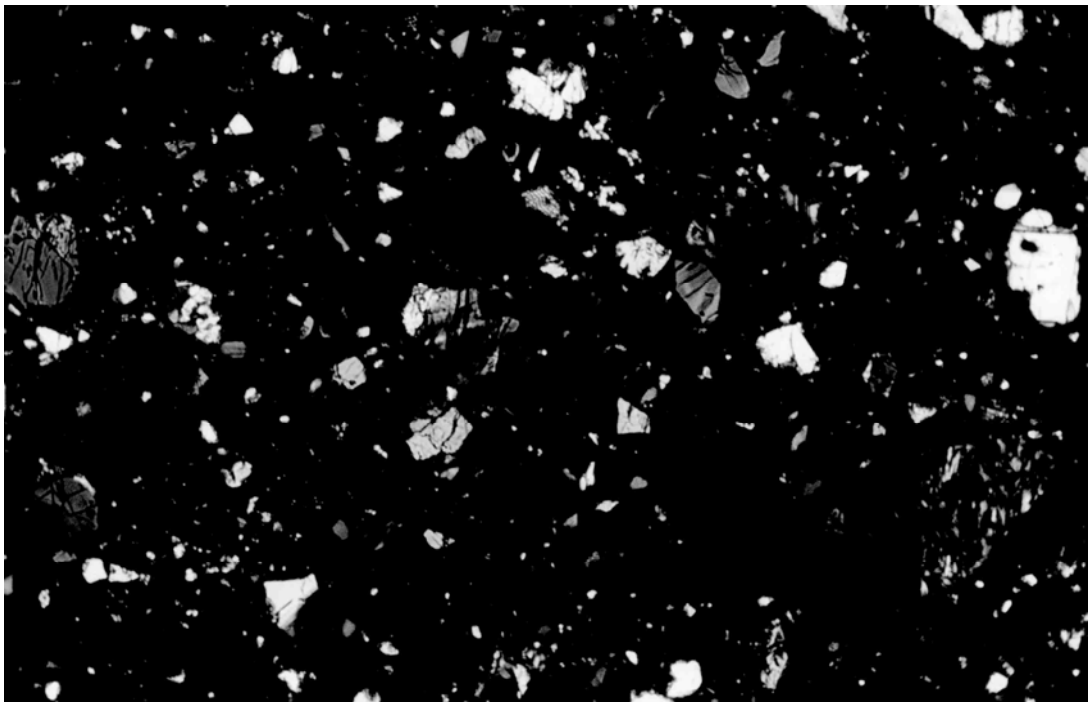

Figure 2: Photomicrograph of 79135,12. Field of view is 1.4 mm.

large (1 cm) hornfels clast has a mode of 10% opaques, 30% plagioclase, 50% orthopyroxene, and 10% augite. Grain size is 1 mm. Anorthositic clasts form 30% of the lithic clast population of 79135. Some of these are polygonized plagioclase.

Glass clasts form 30% of 79135. Fifty percent are round to angular orange glasses (~0.5 mm), 25% are rounded to angular opaque glasses (0.5 mm), and 25% are ropy to stringy multi-colored glasses (1-5 mm). Many of the orange glasses are partially devitrified and form a gradational sequence to the opaque glasses. The opaque glasses are devitrified with abundant ilmenite. Many of the orange glasses are spheres, although some are broken. The glass shards have sharp, unrounded corners and are often undevitrified. Therefore, this breccia could not have reached a very high temperature.

The matrix is devitrified, but not recrystallized. 79135 is dense with a few (< 5%) vuggy or open areas. A distinctive feature of this breccia is the presence of ropy or stringy glass and glass "bombs" which have a range in composition and color. Some contain microlites and partially melted inclusions of plagioclase.

The opaques were described from 79135,11 by Brett(' Apollo 17 Lunar Sample Information Catalog, 1973). He found this thin section to contain 15% of angular and feathery ilmenite (up to 1.5 mm), < 0.5% angular armalcolite (up to 0.1 mm), < 0.2% angular ulvospinel, < 0.2% rutile (lamellar), < 0.2% angular and lamellar spinel, < 0.3% angular and bleb-like FeNi metal, and < 0.2% bleb-like troilite. The ilmenite population is bi-modal - angular to sub-rounded large clasts and feathery intergrowths of much smaller grain size in de-vitrified glasses. Large ilmenite commonly contains rutile and spinel exsolution lamellae. Armalcolite and ulvospinel are rare. Brett concluded that the abundance of the opaques in 79135,11 suggested that the rock is a breccia of mare origin.

Marvin described the petrography of one 4 mm clast from sections,12 and,13 (Apollo 17 lunar Sample Information Catalog, 1973). This breccia clast is composed predominantly

of plagioclase. The dissemination of opaques resembles that in the matrices of many noritic lunar breccias. The clast is composed of 70% matrix, 20% mineral clasts, < 1% lithic clasts, and 10% glass clasts. The matrix (< 0.02 mm) is light colored, and contains vermicular intergrowths of feldspathic glass-and tiny (0.02 mm) disseminated opaques. Mineral clasts are of 80% plagioclase, 15% cl.inopyroxene, and 5% olivine which are all angular to subrounded. Most mineral clasts have margins intergrown with the matrix. One lithic clast of anorthositic gabbro (- 0.7 mm) is present. The glass clasts are light brown to colorless with an irregular shape. These are mostly devitrified to leafy intergrowths of feldspathic material, which have ragged margins that grade into the matrix.

Glass compositions from 79135 are reported in Chen et al. (1982) and Delano and Lindsley (1983). Haggerty (1974) also studied the glasses in 79135 and noted that devitrification is more advanced in the breccia glasses. Haggerty (1974) noted that the devitrification in the breccia glasses was initiated isotropically throughout the glass sphere. Shearer et al. (1991) analyzed very-low-Ti glass from 79135 as part of their investigation into the nature of the mantle source of lunar picritic glasses.

Stoller et al. (1979) defined a classification for impact breccias. These authors placed 79135 in the regolith breccia class of their polylithologic breccia subgroup.

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 79135 has been reported to various degrees by several authors (Table 1). The major element chemistry has been reported by LSPET (1973 a,b), Rhodes et al. (1974), Rose et al. (1974), and Wanke et al. (1974). The analyses are similar, but the MG# varies from 51.6 (Rose et al., 1974) to 57.0 (LSPET, 1973 a,b; Rhodes et al., 1974). TiO_2 contents also vary from 5.15 (LSPET, 1973 a,b; Rhodes et al., 1974) to 6.33 (Rose et al., 1974). The REE abundances have been determined by Phillpotts et al. (1974) and Wanke et al. (1974). The profiles are similar: the LREE are enriched over the HREE (relative to chondrites), but the maximum is in the middle REE (Fig. 3). The REE as a group are

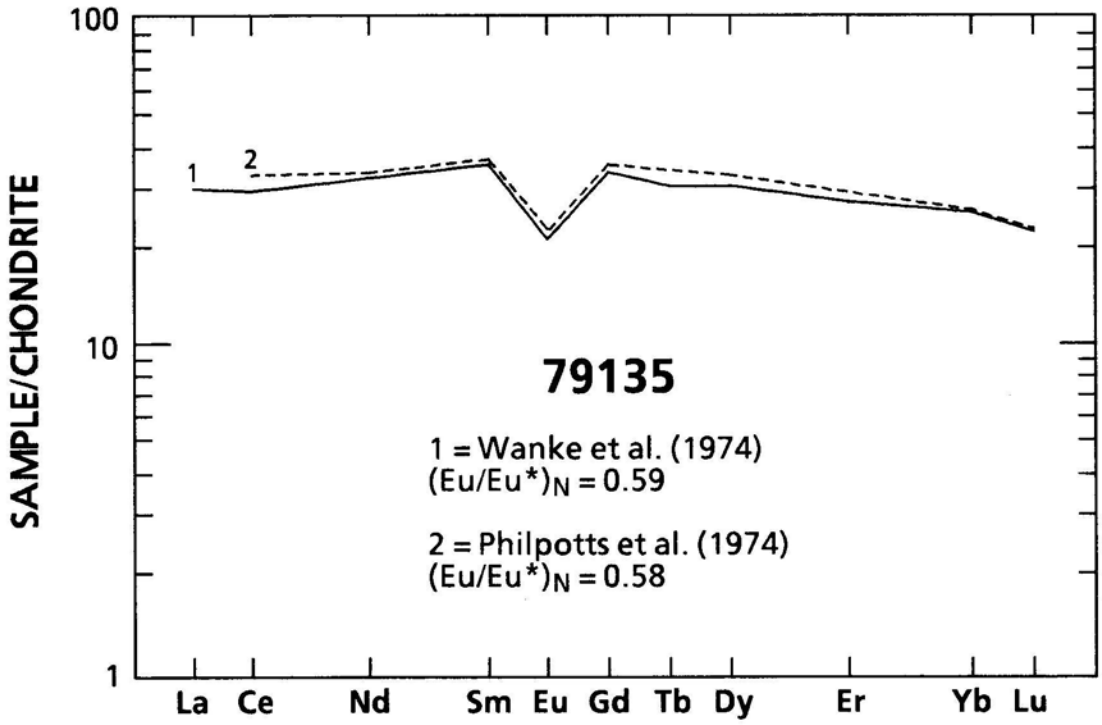

Figure 3: Chondrite -normalized rare earth element profiles of 79135.

slightly more enriched in the analysis of Phillpotts et al. (1974) (Table 1 and Fig. 3). Both profiles exhibit a negative Eu anomaly of similar magnitude [(Eu/Eu*).4 = 0.57 and 0.60]. Surface chemical compositions of 79135 have been reported by Gold et al. (1976) (Fe, Ti, Ca, Si) and Filleux et al. (1978) (C).

RADIOGENIC ISOTOPES

The U-Th-Pb and Rb-Sr isotopic compositions of 79135 have been reported by Church and Tilton (1975) and by Nyquist et al. (1974) (Table 2). Note the discrepancy in model ages calculated from U-Th-Pb and Rb-Sr results.

STABLE ISOTOPES

The S, C, and N isotopes have been determined for 79135 (Table 3). Rees and Thode (1974) reported a $^{s34}S_{CDT}$ of ± 9.4 %o. Becker and Epstein (1981) and Norris et al. (1983) reported $6^{13}C$ values of 0.0 %o and -1.0 %o, and 0.0 %o, respectively, and $^{s15}N_{AIR}$ values of - 137 %o and -139 %o, and -86 %o, respectively (Table 1).

EXPOSURE AGES AND COSMOGENIC RADIONUCLIDES

Hintenberger et al. (1974, 1975) reported a ^{21}Ne exposure age for 79135 of 810±60 Ma. These authors also reported the isotopic abundances and ratios of He, Ne, Ar, Kr, and Xe. Wieler et al. (1983) reported the results of a size-fraction and mineralogical study of the rare gas isotopes in lunar breccias. This was aimed at evaluating the solar flare/solar wind flux ratio. Wieler et al. (1983) documented the isotopic abundances and ratios of He, Ne, and Ar.

MAGNETIC AND ELECTRICAL STUDIES

Magnetic data for 79135 have been reported by Pearce et al. (1974) and Cisowski and Fuller (1983). Pearce et al. (1974) used magnetic techniques to calculate the Fe^o content or 79135 (~ 0.92 equivalent vit% Fe^o) and the $Fe0/Fe^2$ ± ratio (0.066). Cisowski and Fuller (1983) used 79135 in a study to demonstrate that a strong lunar magnetic field existed between 3.8 and 3.6 Ga.

SPECIALIZED STUDIES

Gold et al. (1976) measured the dielectric constant (0.0051) and the voltage absorption wavelength of 79135. These measurements can be related to the transition element concentration in the sample (Gold et al., 1976).

Nagle (1982) used 79135 in a study of subcrater lithification processes in lunar breccias. Nagle (1982) concluded that 79135 had experienced such lithification.

PROCESSING

Approximately 14348 of 79135,0 remains. The largest subsamples are: ,4 1428; ,18 - 50g;,102 1- 101g;,103 ~85g;,104 - 56g; ,109 - 89g; and ,110 56g. 79135,102 is a display sample. Nineteen thin sections have been made: 79135,11-,14; ,23-,24; ,42-,50; 106;, 150-,151; and,154.

Table 1: Whole-rock composition of 79135.

Sample	,1	,35	,34	,38	,39	,1	,27	,1	,27	,36	,77
Method	X	X	I	N	NR	C		I			
Reference	1,2,3	4	5	6	7	8	9	10	10,11	10,11,12	13
SiO_2 (wt%)	42.29	42.57		42.59							
TiO_2	5.15	6.33		5.36							
Al_2O_3	15.08	14.74		13.83							
Cr_2O_3	0.39	0.45		0.373							
FeO	14.01	15.19		15.02	20.51						
MnO	0.19	0.19		0.195	0.271						
MgO	10.42	9.1		10.82							
CaO	11.44	10.91		11.06							
Na_2O	0.40	0.40		0.469	0.395						
K_2O	0.10	0.11	0.104	0.098							
P_2O_5	0.07	0.09		0.076							
S	0.10					0.102	0.11			0.083	
Nb (ppm)	14	17		12.6							
Zr	185	260		186	255						
Hf				5.70	8.5						
Ta				0.94	1.1						
U				0.33							
Th					<0.64						
W				0.18							
Y	55	64		47							
Sr	166	163	171	200							
Rb	2.1	1.5	1.99								
Li		8.9	10.6	10.4							
Ba		129	123	120							
Cs				0.05							
Be		1.5									
Zn	72	39		97.6	98						
Pb		<2									
Cu		26		19.6							
Ni	218	280		170	161						
Cr				2550	3600						
Co		52		38.3	24						
V		76									
Sc		50									
La		<10		9.88							
Ce			29.2	25.8	23						
Nd			21.7								

Table 1: (Concluded).

Sample	,1	,35	,34	,38	,39	,1	,27	,1	,27	,36	,77
Method	X	X	I	N	NR	C		I			
Reference	1,2,3	4	5	6	7	8	9	10	10,11	10,11,12	13
Sm			7.51	7.26							
Eu			1.64	1.60	1.6						
Gd				9.5							
Tb				1.8	2.3						
Dy			11.7	10.5							
Er				6.2							
Yb		6.4	5.85	5.71	6.8						
Lu			0.792	0.78							
Ga		7.5		8.0	8.57						
F				90							
Cl				26							
C							150		150		146
N									120		77
H								55.8			
He											
In (ppb)					6.9						
Ge				440	286						
Re				0.88							
Ir				10	5.8						
Au				3.1	2.6						
Cd					112						
Os											

References: 1 = LSPET (1973a); 2 = LSPET (1973b); 3 = Rhodes et al. (1974); 4 = Rose et al. (1974); 5 = Phillpotts et al. (1974); 6 = Wanke et al. (1974); 7 = Baedecker et al. (1974); 8 = Gibson and Moore (1974); 9 = Moore et al. (1974); 10 = Gibson et al. (1987); 11 = Moore and Lewis (1976); 12 = Rees and Thode (1974); 13 = Becker and Epstein (1981).

X = XRF; N = INAA; I = Isotope dilution; C = Combustion; P = Pyrolysis; NR = INAA and RNAA.

Table 2: Radiogenic isotope composition of 79135.

Sample No. Reference	79135,37B 1	79135,37B 1	79135,1 2
Wt (mg)	64.2	55.1	46.1
U (ppm)		0.342	
Th (ppm)		1.144	
Pb		1.863	
Pb (blank ng)		0.75	
$^{204}Pb/^{206}Pb^*$	0.01221	0.01244	
$^{207}Pb/^{206}Pb^*$	0.9521	0.9183	
$^{208}Pb/^{204}Pb^*$	1.1453		
$^{206}Pb/^{238}U$ (Ga)		6.670	
$^{207}Pb/^{206}Pb$ (Ga)		5.092	
Rb (ppm)			1.937
Sr (ppm)			168.6
$^{87}Rb/^{86}Sr$			0.0332 + 4
$^{87}Sr/^{86}Sr$			0.70119 + 5
T_{BABI}[a]			4.39 + 0.10
T_{LUNI}[b]			4.53 + 0.10

a = I = 0.69910 (BABI + JSC bias); b = I = 0.69903 (A16 Anorthosite, T = 4.6 Ga).