79155

Partially Glass-Coated Gabbro
318.8 g, 8 x 6 x 5 cm

INTRODUCTION

79155 was described as a light brown to brown-gray, subrounded, intergranular rock, with a homogeneous, coarse-grained, subdiabasic fabric (Apollo 17 Lunar Sample Information Catalog, 1973). A dark glass (~1 mm thick), covered all of the B face and greater than one third of W and S faces (Fig. 1). The glass dwindles to discontinuous smears on the E face. In the original sample, cavities were rare, with four to five irregular cavities (each 4-5 mm across) occurring in the center of the N face. A few rounded cavities were present in the glass. Zap pits were common on all exposures of gabbro. Zap pits were not observed in the glass coat on B, but were abundant in the glass coat on S. Zaps in the glass had fractured haloes that were conspicuously orange (Apollo 17 Lunar Sample Information Catalog, 1973).

To the naked eye, the glass is dark gray with a dull submetallic luster; where vesicles are broken open, the walls are smooth, bright, and vitreous. The glass also has a very few, small (< 1 mm), rounded blebs. Under the binoculars, the glass is a dark molasses brown, which is orange in the zap haloes. Thin veinlets of glass penetrate the gabbro (evident on T and W). Similar glass also partially fills the cavities on the N face where zaps are made conspicuous by orange haloes.

PETROGRAPHY AND MINERAL CHEMISTRY

During the preparation of this catalog, we examined thin sections 79155,58 and ,65. This sample is a coarse-grained basalt composed of mainly pyroxene (up to 2.2 mm), plagioclase (up to 2.5 mm), and ilmenite (up to 2.8 mm). Ilmenite contains spinel and rutile exsolution lamellae. Both

Figure 1: Hand specimen photograph of 79155,4.

the pyroxenes and plagioclase exhibit undulose extinction. Olivine is present only as rare cores (up to 0.3 mm) to pyroxene. Armalcolite (0.05-0.1 mm) without ilmenite mantles is found as inclusions in plagioclase and pyroxene. Troilite and FeNi metal form interstitial phases (< 0.05 mm). 79155 is similar to other coarse-grained Apollo 17 high-Ti mare basalts, except for the undulose extinction of the pyroxenes and plagioclase, and the presence of glassy "stringers" throughout the thin sections.

Brown et al. (1975) described 79155 as a Type 1B Apollo 17 mare basalt. These authors did not specifically describe either the petrography or mineral chemistry of this sample, but did report the mode of 79155,60: 0.9% olivine; 28.7% opaques; 21.6% plagioclase; 41.5% clinopyroxene; and 7.3% mesostasis. The high amount of mesostasis is probably due to the stringers of glass impregnating the sample from the adhering glass coat.

The mineral chemistry that has been reported for 79155 is of armalcolite (E1 Goresy et al., 1974; E1 Goresy and Ramdhor, 1975), the glass "stringers" (Mao et al., 1976) and the high-K, and anomalous low-K melt inclusions in ilmenite (Roedder and Weiblen, 1976). Schaal and Horz (1977) reported average plagioclase, augite, pigeonite, ilmenite, and glass compositions from 79155,60. Mao et al. (1974) noted that the glass coating gave an orange sheen due to the interaction of the absorption of $Fe^{2}\pm$, $Ti^{3}\pm$, and $Ti^{4}\pm$. These authors noted three reactions occurring between the glass and the basalt/gabbro: 1) between the silicate melt and armalcolite to form ulvospinel and ilmenite separately; 2) between silicate melt and rutile to form zones of armalcolite and ilmenite; and 3) armalcolite appears to have formed by the breakdown of ilmenite, accompanied by the production of metallic iron, and the release of oxygen (bubbles in glass).

WHOLE-ROCK CHEMISTRY

The whole-rock chemistry of 79155 has been determined to varying degrees by several authors (Tables 1 & 2). The major elements have been determined by Boynton et al. (1975) (except for MgO, K;,O, and $Si0_2$), Baedecker et al. (1974) (only FeO, MnO, and Cr_2O_3), Rose et al. (1975), Wanke et al. (1975), and Rhodes et al. (1975). These analyses are similar, with a range in MG# of 45.0-48.4 and in $Ti0_2$ of 12,38-12.99 wt%. The REE have been determined by Baedecker et al. (1974) (only Ce, Eu, Tb, and Yb), Boynton et al. (1975), Shih et al. (1975), and Wanke et al. (1975). Where profiles can be drawn, all analyses define LREE depleted patterns (Fig. 2). The post-Eu middle REE of Boynton et al. (1975) appear to be spurious [e.g., $(Eu/Eu^*)_N$ = 0.82], as the analyses of Shih et al. (1975) and Wanke et al. (1975) demonstrate much higher middle REE abundances (Table 1 and Fig. 2), with similar Eu anomaly magnitudes [Eu/Eu*)N = 0.54 and 0.5-5, respectively].

RADIOGENIC ISOTOPES

Ar-Ar, Rb-Sr, and U-Th-Pb isotopic compositions hav been determined for 79155 (Table 2). Kirsten and Horn (1973) analyzed 79155 for the Ar isotopes and reported a Total Ar Age of 3.73 ± 0.07 Ga and a Plateau Age of 3.80±0.04 Ga. Nyquist et al. (1975) analyzed 79155 for the Rb-Sr isotopes and reported the whole-rock compositions only (Table 2). Nunes et al. (1974) analyzed a spiked and unspiked aliquot of 79155 for the U-Th-Pb isotopes and concluded that a single stage evolution was not adequate to account for the observed isotopic ratios.

STABLE ISOTOPES

Oxygen isotopes for the various mineral phases in 79155 have been reported by Clayton and Mayeda (1975) and Mayeda et al. (1975) (Table 3). The ^{S18}O results of Clayton and Mayeda (1975) are consistently higher than those of Mayeda et al. (1975).

EXPOSURE AGES AND COSMOGENIC RADIONUCLIDES

Kirsten and Horn (1974) reported an Ar exposure age for 79155 of 575 ± 60 Ma. The cosmogenic radionuclides (Table 4) were determined by LSPET (1973) and O'Kelley et al. (1974), whereas Yokoyama et al. (1974) concluded that 79155 was saturated with respect to $^{2}6A1$ activity.

EXPERIMENTAL STUDIES

79155 has been used in four experimental studies. Two involved the study of micro-craters and shock features (Fechtig et al., 1974; Schaal and Horz, 1977). One involved 79155 in an examination of

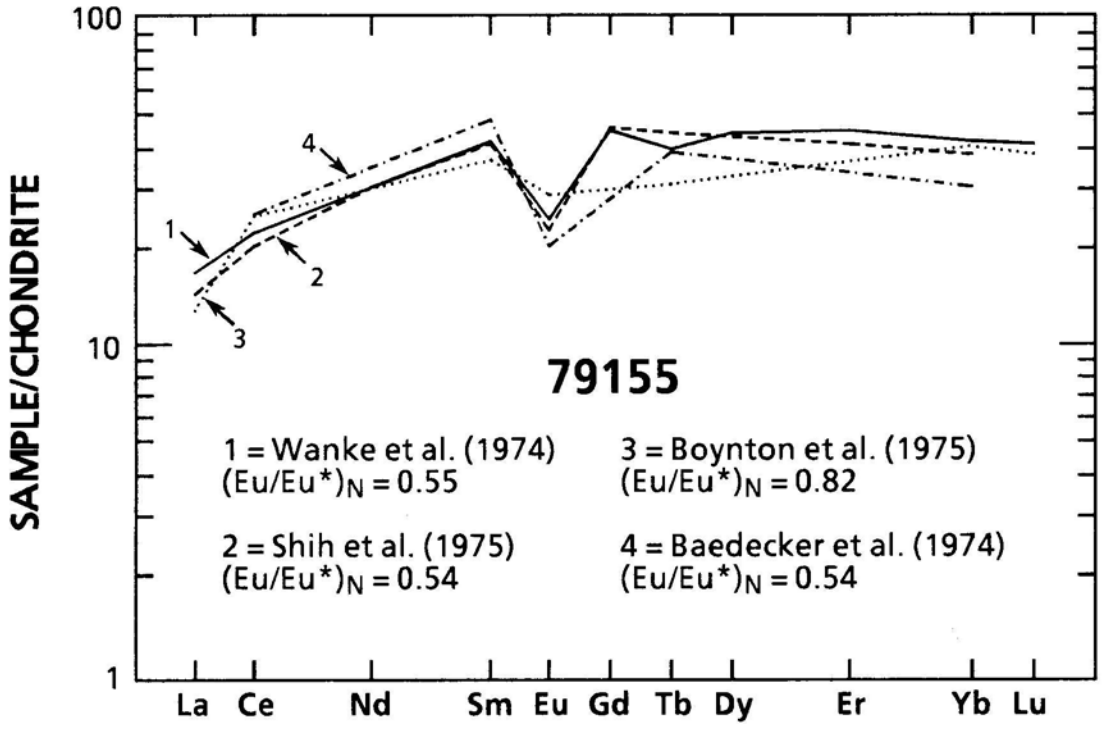

Figure 2: Chondrite -normalized rare earth element profiles of 79155.

glass formation (Uhlmann et al., 1979), and the fourth involved the study of viscosity, crystallization behavior, and the thermal history of 79155 (Klein et al., 1975) (Figs. 5 and 6).

MAGNETIC STUDIES

The magnetic properties of 79155 have been determined by Cisowski et al. (1977, 1983). Cisowski et al. (1977) examined the alternating field demagnetization of 79155,31:2 (Fig. 7) and demonstrated that a complicated post-formation history was recorded by the magnetic data. The magnetization changes observed in 79155 are consistent with the observation of changes brought about by shock experimentally (Cisowski et al., 1977). Cisowski et al. (1983) used 79155 as part of a suite of lunar samples to demonstrate the existence of a strong lunar magnetic field between 3.8 Ga and 3.6 Ga.

PROCESSING

The original sample, 79155,0, has been entirely subdivided. The largest remaining subsamples are; ,10 (~185g) which is a display sample; ,8 (~20g);,7 (- 18g);,16 (~ 18g). Sixteen thin sections have been made of 79215:,57-,68-,,144, and ,9003-,9005.

Table 1: Whole-rock composition of 79155.

Sample	,34	,34	,39	,33	,38	,38					
Method	N	R	X	N,X	X	I,N	C		G-Ray	G-Ray	N,R
Reference	1	2	3	4	5	6	7	8	9	10	11
SiO_2 (wt%)			39.13	38.37	37.5						
TiO_2	12.38		12.56	12.53	12.99						
Al_2O_3	8.13		9.40	8.81	8.58						
Cr_2O_3	0.51	0.526	0.50	0.538	0.46						
FeO	19.09	20.51	18.19	19.73	19.04						
MnO	0.26	0.27	0.27	0.259	0.28						
MgO			9.58	9.07	9.14						
CaO	10.78		10.19	10.48	10.29						
Na_2O	0.385	0.39	0.36	0.35	0.38						
K_2O			0.08	0.053	0.06	0.055			0.053	0.049	
P_2O_5			0.04	0.055	0.05						
S				0.141	0.17		0.2025				
Nb (ppm)			<10	17.4							
Zr		255	255	197		222					
Hf	8	8.5		8.77							
Ta	2.0	1.1		1.70							
U				0.109		0.092			0.11	0.12	0.178
Th		<0.64							0.32	0.31	
W				0.066							
Y			104	70							
Sr			148	158		173					
Rb			<1	0.41		0.485					
Li			8.0			9.0					
Ba			180	65		65.3					
Cs				0.021							0.042
Be			<1								
Zn	2.9	1.9	4.6	2.7							2.6
Pb			1.8								
Cu			3.7	4.66							
Ni	4.4	2.7	<1								79
Cr	3500	3600		3680							
Co	22	24	30	22.5		20.7					
V			62								
Sc	80	68	78	87.4		82.5					
La	4.6		<10	5.79		5.20					
Ce	23	23		20.6		17.9					
Nd				20		20.1					

Table 1: (Concluded).

Sample Method Reference	,34 N 1	,34 R 2	,39 X 3	,33 N,X 4	,38 X 5	,38 I,N 6	C 7	8	G-Ray 9	G-Ray 10	N,R 11
Sm	7.7	10		8.86		8.50					
Eu	2.2	1.6		1.90		1.88					
Gd				12.8		13.2					
Tb	1.8	2.3		2.3							
Dy				15.2		15.6					
Er				10.3		9.22					
Yb	9.0	6.8	9.7	9.3		8.51					
Lu	1.3			1.40							
Ga	4.09	4.34	6.8	3.36							
F											
Cl											
C											
N								<8			
H											
He											
In (ppb)	0.62	0.226									3.5
Ge	2.0		<50								2.4
Re			<0.2								0.143
Ir	0.13	0.069									2.40
Au		0.26		0.097							0.81
Cd	8.0	<6.5									
Sb											2.45
Se											205
Ag											5.1
Br											14.3

References: 1 = Boynton et al. (1975); 2 = Baedecker et al. (1974); 3 = Rose et al. (1975); 4 = Wanke et al. (1974); 5 = Rhodes et al. (1976); 6 = Shih et al. (1975); 7 = Gibson et al. (1976); 8 = Muller et al. (1974); 9 = Eldridge et al. (1974); 10 = LSPET (1973); 11 = Morgan et al (1974).

X = XRF; N = INAA; I = Isotope dilution; C = Combustion; R = RNAA; G-Ray = Gamma Ray Spectrometry.

Table 2: Radiogenic isotope composition of 79155.

Sample No.	79155,24	79155,38	79155	79155	79155
Reference	1	2	3	3	3
Run				P	Cl^S
^{40}Ar (10^{-8}cc STP/g)	1865				
$^{39}Ar_K$ (10^{-8}cc STP/g)	10.0				
$^{38}Ar_{Ca}$ (10^{-8}cc STP/g)	69.6				
$^{37}Ar_{CORR}$ (10^{-8}cc STP/g)	1085				
$^{36}Ar_T$ (10^{-8}cc STP/g)	3.80				
K(ppm)	390 ± 30				
Ca (%)	7.1 ± 0.5				
Total Ar Age (Ga)	3.73 ± 0.07				
Plateau Age (Ga)	3.80 ± 0.04				
Wt (mg)		51	152.8	92.0	158.0
Rb (ppm)		0.485			
Sr (ppm)		173			
$^{87}Rb/^{86}Sr$		0.0081 ± 3			
$^{87}Sr/^{86}Sr$		0.69966 ± 5			
T_B[a] (Ga)		4.8 ± 0.6			
T_L[b] (Ga)		5.4 ± 0.6			
U (ppm)			0.2198		
Th (ppm)			0.7930		
Pb (ppm)			0.6517		
$^{232}Th/^{238}U$			3.73		
$^{238}U/^{204}Pb$			138		
$^{206}Pb/^{204}Pb$*				147.2	158.4
$^{207}Pb/^{204}Pb$*				106.5	115.3
$^{208}Pb/^{204}Pb$*				152.6	
$^{206}Pb/^{204}Pb$@				168.9	172.7
$^{207}Pb/^{204}Pb$@				121.9	125.5
$^{208}Pb/^{204}Pb$@				172.3	
$^{207}Pb/^{206}Pb$@				0.7217	0.7266
$^{208}Pb/^{206}Pb$				1.020	
$^{206}Pb/^{238}U$#				1.180	1.183
$^{207}Pb/^{235}U$#				113.8	114.9
$^{207}Pb/^{206}Pb$#				0.6993	0.7050
$^{208}Pb/^{232}Th$#				0.2835	

Table 2: (Concluded).

Sample No.	79155,24	79155,38	79155	79155	79155
Reference	1	2	3		3
Run				P	Cls
$^{206}Pb/^{238}U$ +				5.074	5.079
$^{207}Pb/^{235}U$ +				4.879	4.889
$^{208}Pb/^{232}Th$ +				5.114	

References: 1 = Kirsten and Horn (1975); 2 = Nyquist et al. (1975); 3 = Nunes et al. (1974).

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

* = Observed ratios; @ = Corrected for analytical blank; S = totally spiked prior to digestion; # = Corrected for blank and primordial Pb; + = Single-stage ages in Ga.

Table 3: Oxygen isotopic ratios from 79155.

Sample No.	79155,36				79155,64		
Reference	1				2		
Mineral	Cristobalite*	Plagioclase	Pyroxene	Ilmenite	Plagioclase	Clinopyroxene	Ilmenite
$\delta^{18}O_{SMOW}$ (e)	6.71	5.88	5.47	4.03	6.13	5.59	4.20
$\delta^{17}O_{SMOW}$(e)					3.11	2.74	2.18

* = mixture of cristoblaite and glass.

Table 4: Cosmogenic radionuclide abundances from 79155.

Sample No.	*79155*	*79155*
Reference	1	2
Wt (g)	316	316
^{26}Al	70 + 3	70 + 10
^{22}Na	63 + 3	77 + 10
^{54}Mn	120 + 12	110 + 20
^{56}Co	153 + 8	155 + 30
^{46}Sc	65 + 3	62 + 10

References: 1 = O'Kelley et al. (1974); 2 = LSPET (1975).