60639

Breccia with Pristine Mare Basalt and Anorthosite clasts

175.1 grams

Figure 1: Photo of glass coated side of 60639. Cube is 1 cm. NASA S72-43469.

Introduction

60639 is from the rake sample collected near the Lunar Module (Sutton 1981). It is a breccia with a glass coating on one side (figure 1). The other side is peppered with micrometeorite craters, exposing clasts of mare basalt and anorthosite (figure 2). A small glob of glass (0.5 cm) is attached on the glass covered side. *Note that B1 was probably the top side before raking.*

Petrography

The matrix of 60639 is fragmental and polymict (Ryder and Norman 1980). Lithic clasts include anorthosite, mare basalt, and poikilitic, aphanitic and glassy breccias.

Significant Clasts

Mare Basalt: Dowty et al. (1974b, Delano (1975), Warner et al. (1976) studied a pristine clast of mare basalt (otherwise rare in the highlands). It is a coarse-grained, porphyritic, subophitic, feldspathic mare basalt containing ~ 5% olivine, ~35% plagioclase, ~ 5-10% ilmenite, ~59% pyroxene and accessory minerals. Plagioclase needles enclosed in clinopyroxene are 300-500 micron in size (figure 3).

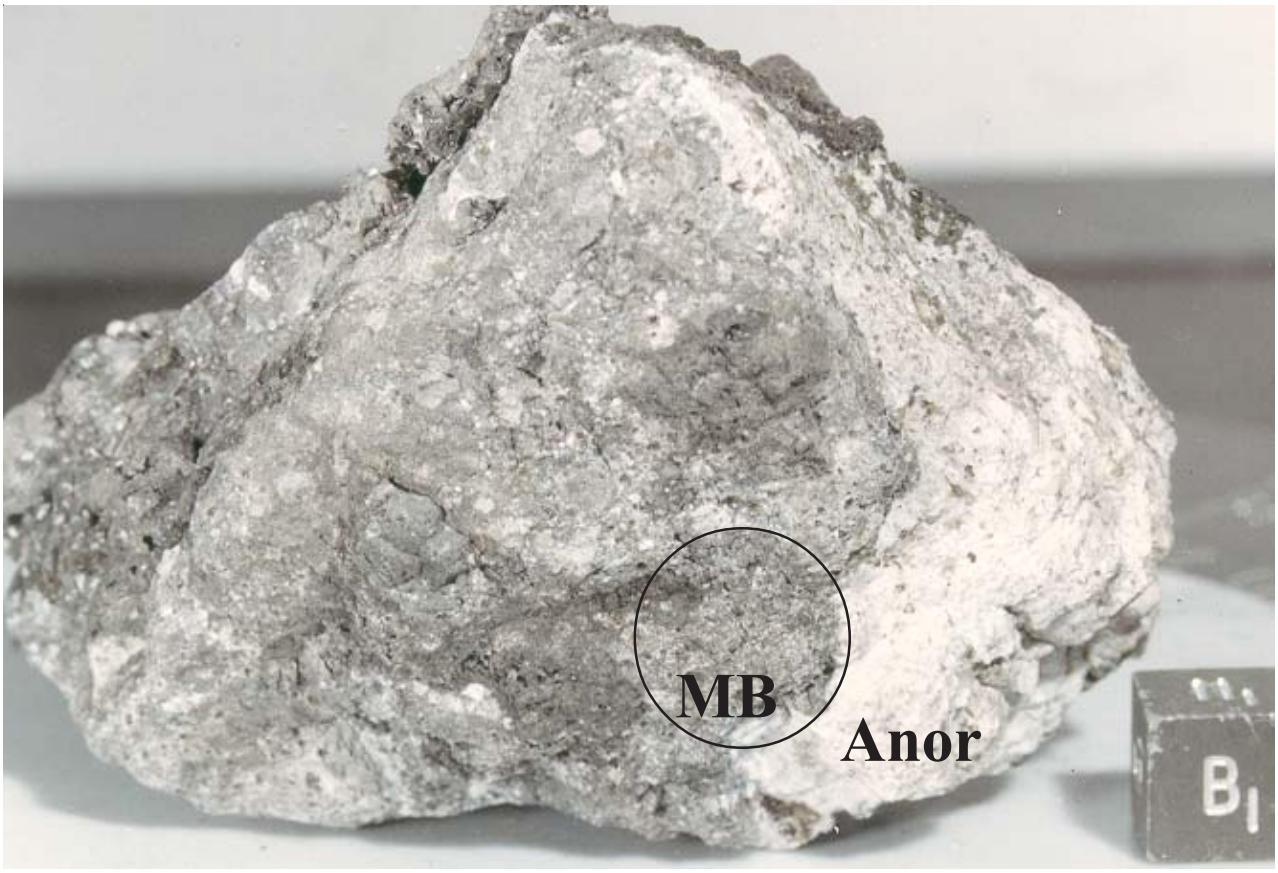


Figure 2: Photo of micrometeorite-exposed side of 60639 showing mare basalt clast (MB) and chalky-white anorthosite clast. Cube is 1 cm. NASA S72-43470.

Figure 3: Thin section photomicrograph of mare basalt clast in 60639 (from Delano 1975). Width of field is 5 mm.

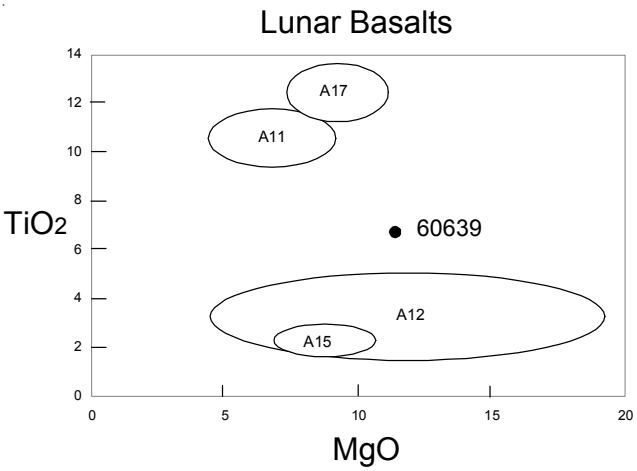


Figure 4: Composition of mare basalt clast in 60639 compared with other lunar basalts.

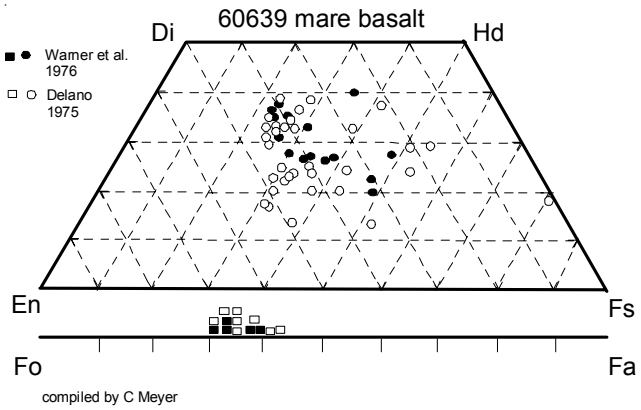


Figure 5: Pyroxene and olivine composition of mare basalt clast in 60639 (from Delano 1975 and Warner et al. 1976).

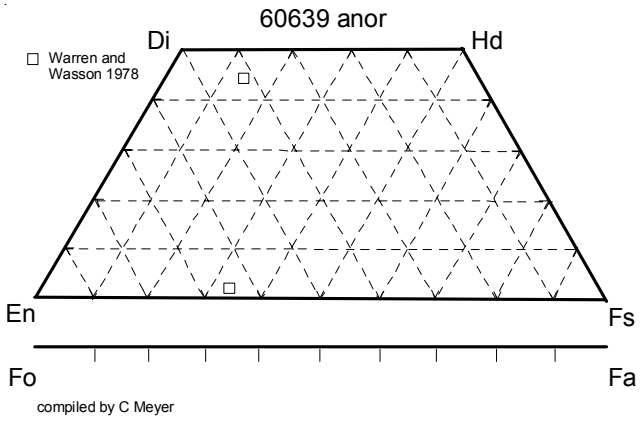


Figure 6: Composition of pyroxene in 60639 anorthosite (from Warren and Wasson 1978).

Anorthosite: The large white clast is cataclastic anorthosite (Warren and Wasson 1978). It is almost entirely plagioclase (An_{96}) with minor pyroxene (Wo_2En_{65} and $Wo_{43}En_{42}$)(figure 6). The anorthosite is ferroan (figure 7).

Mineralogy

Olivine: Delano (1975) report that olivine in the basalt clast is Fo72-64 and has ragged edges due to reaction with liquid during cooling.

Pyroxene: The pyroxene crystals in the mare basalt clast are chemically zoned and plot in the middle pyroxene quadrilateral (figure 5). Delano (1975) noted that the persistence of pyroxferroite in this clast means that the volcanic liquid and the breccia event cooled quickly.

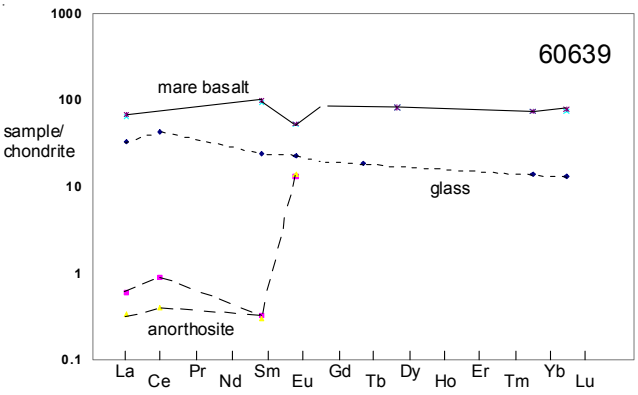


Figure 8: Normalized rare-earth-element patterns for mare basalt and anorthosite clasts and glass coating of 60639.

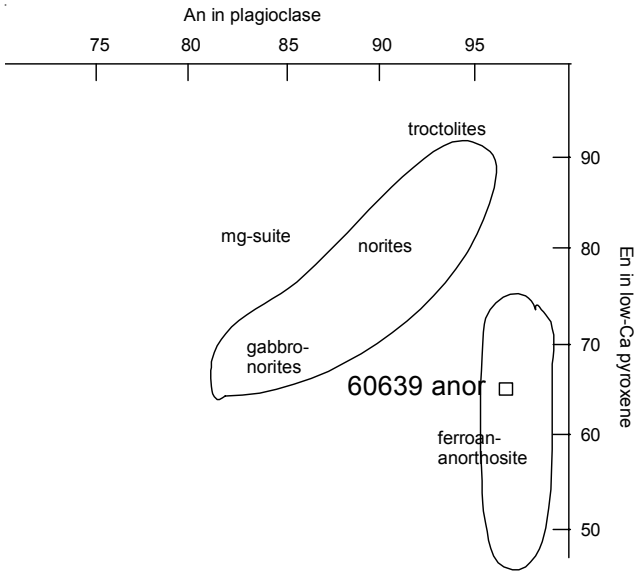
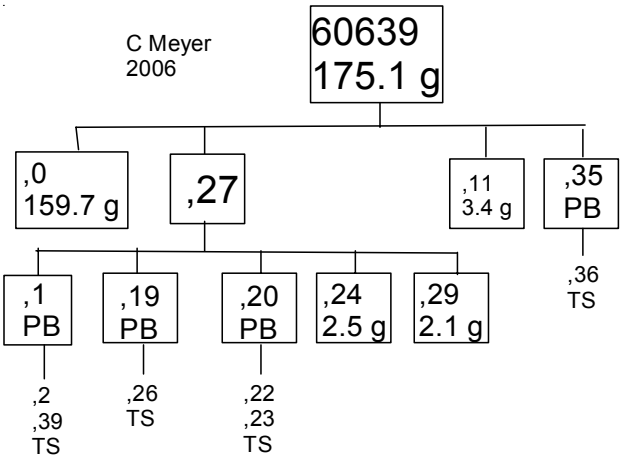


Figure 7: Plagioclase and pyroxene composition of anorthosite clast in 60639 (Warren and Wasson 1978).

Table 1. Chemical composition of 60639.

	Mare Basalt		Mare Basalt		Mare Basalt clast			Anorthosite clast			glass		Anor	matrix	
reference	Wolf 79		Warner 76		Murali 76			Warren 78			Morris 86		Ebihara 92		
weight	,5		Dowty 74					,19	,19		See 86				
SiO2 %			44.8	(b)				44.3	44.7	(a)	44.9	(d)			
TiO2			6.3	(b)	7.9	6.8	(a)				0.28	(d)			
Al2O3			15.1	(b)	12.4	12.4	(a)	35.4	34.7	(a)	29.15	(d)			
FeO			16	(b)	20.1	19.9	(a)	3.6	3.2	(a)	4.11	(d)			
MnO			0.01	(b)	0.255	0.249	(a)								
MgO			5.2	(b)	5.5	7.5	(a)	0.38	0.32	(a)	4.72	(d)			
CaO			11.5	(b)	10.6	10.7	(a)	19.3	19.6	(a)	16.47	(d)			
Na2O			0.68	(b)	0.563	0.592	(a)	0.38	0.38	(a)	0.47	(d)			
K2O			0.15	(b)	0.13	0.14	(a)				0.09	(d)			
P2O5			0.12	(b)											
S %															
sum															
Sc ppm					75	71	(a)				4.42	(a)			
V					79	76	(a)								
Cr			1026	(b)	1970	2135	(a)	43	43	(c)	545	(a)			
Co					19	21	(a)	1.08	0.93	(c)	35	(a)			
Ni	6	(c)						9.5	0.7	(c)	627	(a)	2.92	2040	(c)
Cu															
Zn	1.14	(c)						2.7	1.1	(c)			1.49	10.5	(c)
Ga								4.08	3.3	(c)					
Ge ppb	2.53	(c)						13.3	14.1	(c)			15.1	4900	(c)
As															
Se	137	(c)											3	271	(c)
Rb	2.11	(c)											0.105	3.86	(c)
Sr															
Y															
Zr															
Nb															
Mo															
Ru															
Rh															
Pd ppb	1	(c)											<0.7	86.3	(c)
Ag ppb	0.57	(c)											0.721	4.58	(c)
Cd ppb	19350	(c)						76	65	(c)			35.7	209	(c)
In ppb	5.64	(c)						159	176	(c)			154	197	(c)
Sn ppb	52	(c)													
Sb ppb	35	(c)											0.77	9.58	(c)
Te ppb	5	(c)											1.74	46.2	(c)
Cs ppm	0.085	(c)											0.0079	0.202	(c)
Ba					180	160	(a)				78	(a)			
La					15	16	(a)	0.14	0.08	(c)	7.9	(a)			
Ce								0.55	0.25	(c)	25.8	(a)	0.445	44.7	(c)
Pr															
Nd													0.279	27.9	(c)
Sm					13.7	14.7	(a)	0.049	0.044	(c)	3.56	(a)			
Eu					2.91	2.95	(a)	0.75	0.79	(c)	1.27	(a)	0.833	1.16	(c)
Gd															
Tb											0.67	(a)	0.012	1.5	(c)
Dy					20	20	(a)								
Ho															
Er															
Tm															
Yb					12.1	12	(a)				2.35	(a)	0.0231	5.24	(c)
Lu					1.8	1.9	(a)				0.31	(a)	0.004	0.76	(c)
Hf											2.41	(a)			
Ta											0.38	(a)			
W ppb															
Re ppb	0.0057	(c)						0.013		(c)			0.017	3.22	(c)
Os ppb	0.05	(c)											<0.09	44.7	(c)
Ir ppb	0.048	(c)						0.042	0.01	(c)			0.048	40	(c)
Pt ppb															
Au ppb	0.04	(c)			14	19	(a)	0.02	0.017	(c)			<0.028	35	(c)
Th ppm											1.62	(a)			
U ppm	0.51	(c)									0.48	(a)	0.0023	0.732	(c)

technique: (a) INAA, (b) broad beam elec. Probe, (c) RNAA



Plagioclase: The plagioclase in 60639 mare basalt clast is An_{78-96}, that in the anorthosite is An_{96}.

Chemistry

Dowty et al. (1974), Murali et al. (1976) and Wolf et al. (1979) determined the composition of the basalt clast in 60639 (figure 8). Delano (1975) noted the similarity to the Luna 16 mare component. The low Ir content shows that it was a pristine volcanic liquid. Warren and Wasson (1978) studied the anorthosite clast and reported analyses indicating it is also meteorite-free.

Processing

60639 was chipped, not sawn.

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