10058

Ilmenite Basalt (low K)

282 grams

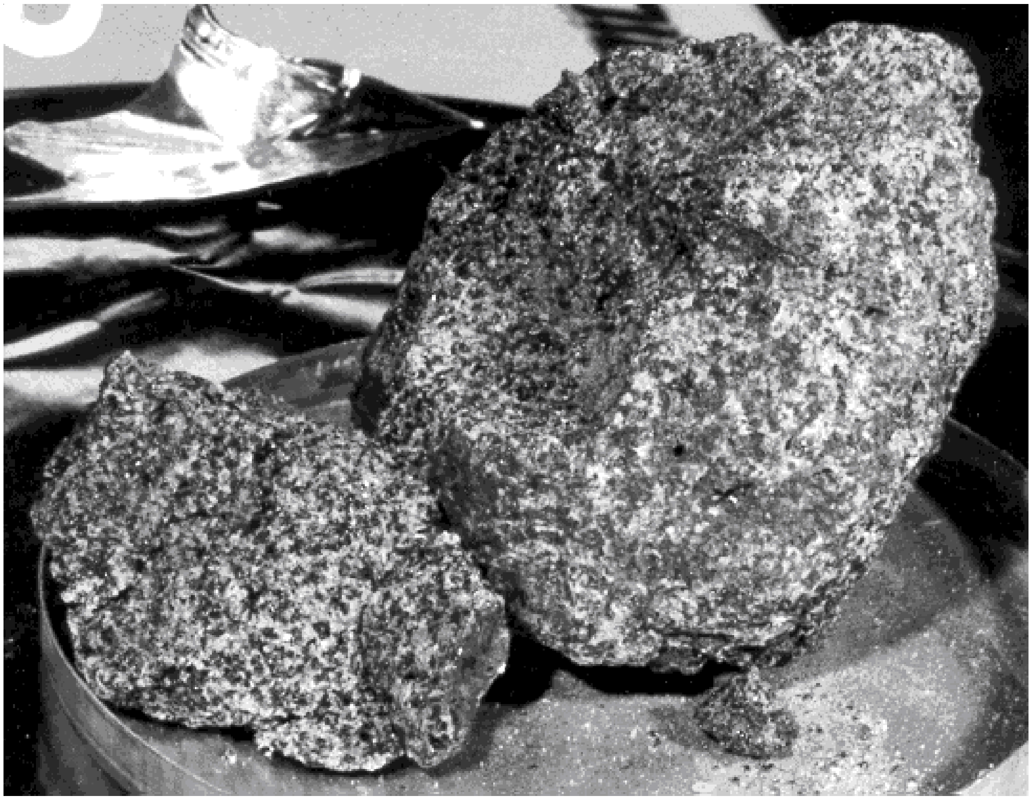


Figure 1: Photo of 10058 after breaking. Large piece is 5 cm. NASA S69-47475.

Introduction

Lunar sample 10058 is a low-K, ilmenite basalt with a relatively coarse texture (figure 1). It has a crystallization age of 3.7 b.y. with a cosmic ray exposure age of 70 m.y.

Petrography

Schmitt et al. (1970) termed 10058 as a "medium-grained, vuggy, ophitic, cristobalite basalt." James and Jackson (1970) termed it a medium grained ophitic basalt. Brown et al. (1970) termed the texture of 10058 as "gabboic", but found no evidence for crystal accumulation or flow orientation. Beaty and Albee (1978) note that 10044, 10047 and 10058 "are so similar to one another that it seems quite likely that these rocks are fragments of a larger block." Ilmenite grains up to 2 mm are reported (Simpson and Bowie 1970).

Brown et al. (1970) and Beaty and Albee (1978) studied the mineral chemistry in 10058.

Mineralogy

Olivine: Beaty and Albee (1978) found one rounded, anhedral olivine grain mantled by a large zoned pyroxene. The olivine is chemically zoned (Fo_{68-58}). Brown et al. (1970) reported trace fayalite in the mesostasis.

Pyroxene: Hargraves et al. (1970) and Beaty and Albee (1978) studied the sector-zoned pyroxene in 10058. Brown et al. reported optically-visible pigeonite exsolution.

Amphibole (?): Gay et al. (1970) reported finding dark green clinoamphibole in a vug.

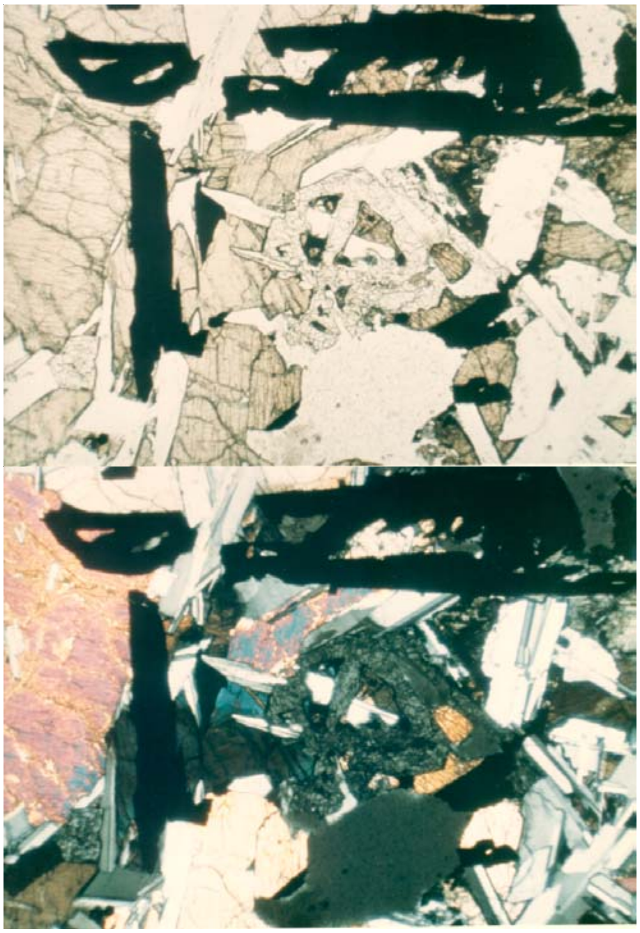


Figure 2: Photomicrographs of thin section of 10058. Top is plane-polarized light and bottom is crossed Nicols. Scale is 2.5 mm. Note patch of silica in center shapped like a "chinese character". NASA S70-49011 and 12.

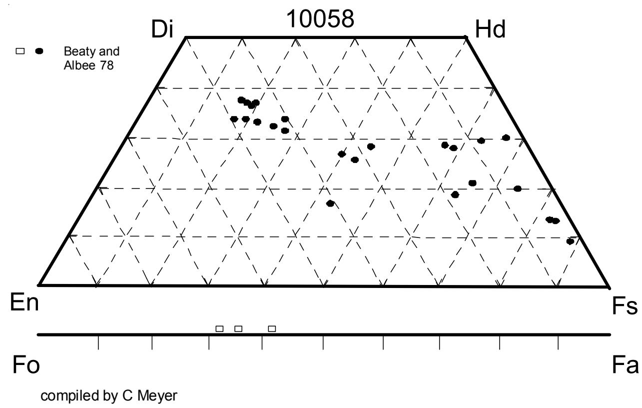


Figure 3: Pyroxene and olivine composition of 10058 (from Beaty and Albee 1978).

Plagioclase: Beaty and Albee (1978) found plagioclase was An_{94-70}, while Brown et al. (1970) reported An_{92-82}.

Ilmenite: Simpson and Bowie (1970) studied the complex intergrowth of ilmenite with ulvospinel in 10058 and give an analysis of ilmenite.

Y, Zr silicate: Cameron (1970) reported a new mineral – probably tranquilltyite.

Troilite: Simpson and Bowie (1970) give an analysis.

Phosphate: Brown et al. reported trace apatitie.

Cristobalite: Silica in 10058 has a distinctive cracking pattern, due to inversion of high to low cristobalite structure (Nord et al. 1974).

Chemistry

The chemical composition of 10058 is tabulated in table 1 and figures 4 and 5.

Radiogenic age dating

Papanastassiou et al. (1970) determined the Rb/Sr isochron age for 10058. Guggisberg et al. (1979) determined the age by the Ar/Ar plateau technique (figure 6).

Cosmogenic isotopes and exposure ages

Guggisberg et al. (1979) determined an $^{37}Ar/^{38}Ar$ exposure age of 71 m.y. Eberhardt et al. (1970) calculated an exposure age of 65 m.y. from the Ar data by Funkhouser et al. (1970) and Pepin et al. (1970).

Other Studies

Oxygen isotopes were reported for mineral separates of 10058 by Onuma et al. (1970) and Taylor and Epstein (1970).

Mineralogical Mode

	Beaty and Albee 1978	Brown et al. 1970
Olivine		
Pyroxene	47	45.7
Plagioclase	34	37.1
Ilmenite	13	10.5
Glass	0.05	
silica	4.8	5.1
troilite	0.43	.27
phosphate	0.42	

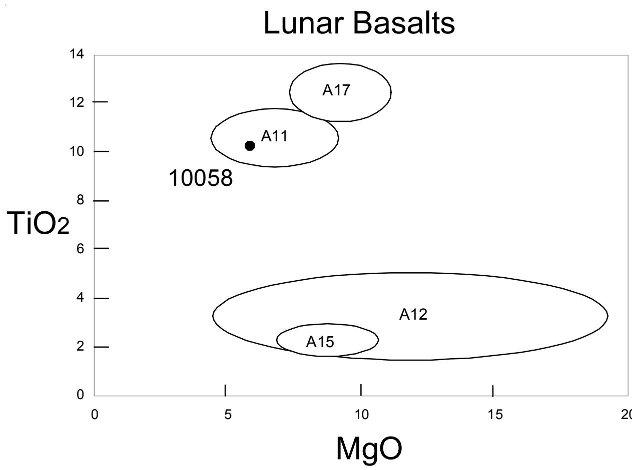


Figure 4: Composition of 10058 compared with that of other Apollo lunar samples.

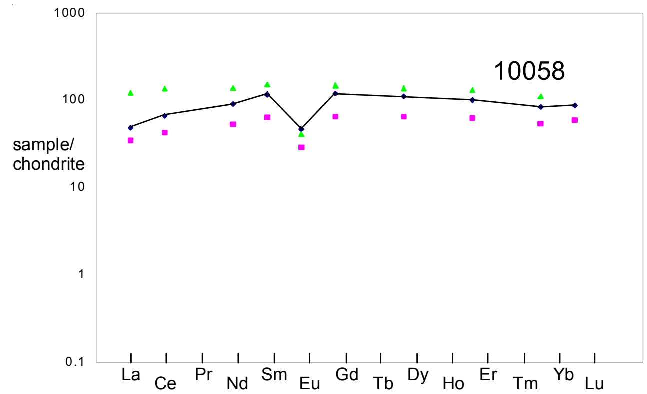


Figure 5: Normalized rare-earth-element composition for low-K basalt 10058 (the line) compared with that of low-K basalt 10020 and high-K basalt 10049 (the dots) (data from Wiesmann et al. 1975).

Pepin et al. (1970), Funkouser et al. (1970) and Bogard et al. (1971) reported the abundance and isotopic composition of rare gasses from 10058.

Crozaz et al. (1970) studied the cosmic ray tracks as a function of depth in plagioclase crystals for 10058 (figure 7) and determined the "erosion rate" by micrometeorite bombardment by comparing the apparent exposure age by tracks with the exposure age determined by ^{81}Kr and ^{38}Ar.

Housley et al. (1970) determined the Mossbauer spectra.

Processing

Apollo 11 samples were originally described and cataloged in 1969 and "re-cataloged" by Kramer et al. (1977). There are 12 thin sections.

List of Photo #s for 10058

S69-46297 – 320	B&W mug
S69-47473 – 6	
S69-47485 – 6	
S70-49009 – 12	TS color
S70-49967 – 8	TS
S70-49874 – 5	TS
S74-27032	,34
S76-21354 – 5	
S76-26326 – 7	TS
S76-23295 – 6	,109

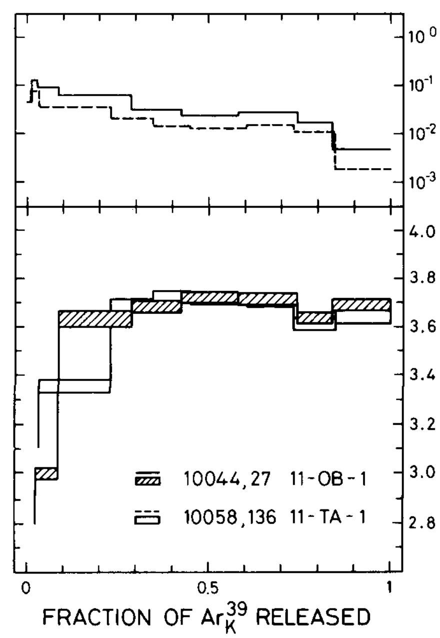


Figure 6: Argon release pattern for 10044 and 10058 (Guggisberg et al. 1979).

Summary of Age Data for 10058

	Rb/Sr	Ar/Ar plateau
Papanastassiou et al. 1970	3.63 ± 0.20 b.y.	
Guggisberg et al. 1979		3.71 ± 0.04

Caution: Change in Rb decay constant.

Table 1. Chemical composition of 10058.

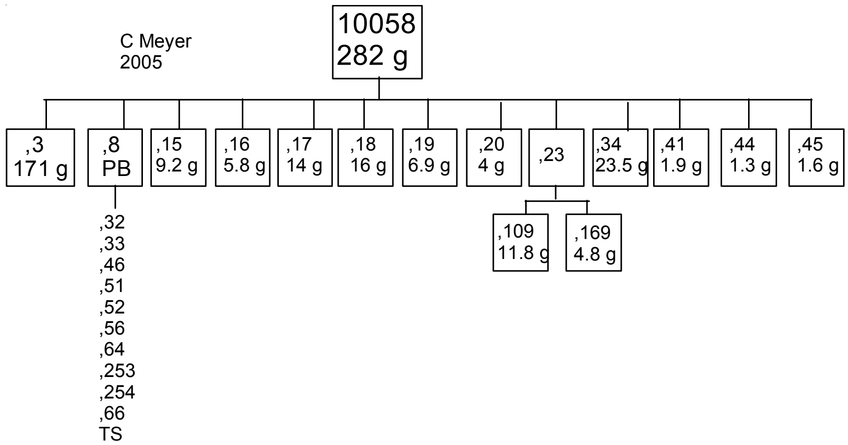
reference	LSPET69		Tera70		Dickinson89		Rose70			Gast70		Wiesmann75		Goles70		Rhodes80	
weight																1.51 g	
SiO2 %	43	(a)					41.4	41.7	(d)					40.6	(c)	42.18	(e)
TiO2	9	(a)					11.1	9.55	(d)					10.2	(c)	9.37	(e)
Al2O3	13	(a)					10.7	11.8	(d)					11.1	(c)	10.45	(e)
FeO	17	(a)			15.2	(c)	17.3	18.2	(d)					19.2	(c)	18.96	(e)
MnO	*0.55*	(a)					0.27	0.27	(d)					0.24	(c)	0.3	(e)
MgO	6.5	(a)					6.25	6.3	(d)					6.3	(c)	5.91	(e)
CaO	10.5	(a)	12	(b)	8.4	(c)	12.1	11	(d)					11.3	(c)	12.28	(e)
Na2O	0.56	(a)	0.44		0.4		0.79	0.68	(d)	0.39		39		0.41	(c)	0.39	(c)
K2O	0.11	(a)	0.1	(b)			0.07	0.09	(d)	0.1	(b)	0.1	(b)			0.11	(e)
P2O5																0.13	(e)
S %																	
sum																	
Sc ppm					76	(c)								80.8	(c)	88	(c)
V	32	(a)												78	(c)		
Cr	3700	(a)			1400	(c)	1437	1642	(d)					1800	(c)	1390	(c)
Co	7	(a)			10	(c)								14.4	(c)	11	(c)
Ni																	
Cu																	
Zn																	
Ga					12	(c)										8.4	(e)
Ge ppb					2.7	(c)											
As																	
Se																	
Rb	1.6	(a)	1.02	(b)						0.98	(b)	0.98	(b)			1.2	(e)
Sr	190	(a)			186	(c)				218	(b)	218	(b)			224	(e)
Y	230	(a)														141	(e)
Zr	250	(a)												190	(c)		
Nb																	
Mo																	
Ru																	
Rh																	
Pd ppb																	
Ag ppb																	
Cd ppb																	
In ppb																	
Sn ppb																	
Sb ppb																	
Te ppb																	
Cs ppm			0.04	(b)						0.03	(b)	0.027	(b)				
Ba	85	(a)	113	(b)	122	(c)				117	(b)	117	(b)	140	(c)		
La					9.7	(c)				11.5	(b)	11.5	(b)	11.8	(c)	10.3	(c)
Ce					33	(c)				40.2	(b)	40.2	(b)	39	(c)	40	(c)
Pr																	
Nd					20	(c)				41.2	(b)	41.2	(b)				
Sm					41	(c)				17.2	(b)	17.2	(b)	14	(c)	16.4	(c)
Eu					2.3	(c)				2.64	(b)	2.64	(b)	2.14	(c)	2.42	(c)
Gd										23.6	(b)	23.6	(b)				
Tb					4.3	(c)								3.5	(c)	3.4	(c)
Dy										27	(b)	27	(b)				
Ho														5.5	(c)		
Er					0.57	(c)				16.3	(b)	16.3	(b)				
Tm					0.71	(c)											
Yb	5	(a)			13.5	(c)				15.5	(b)	13.8		14	(c)	13.3	(c)
Lu					2.1	(c)				2.14	(b)	2.14	(b)	1.94	(c)	1.9	(c)
Hf					10.8	(c)								11.2	(c)	12.1	(c)
Ta					1.9	(c)								1.6	(c)	2.5	(c)
W ppb																	
Re ppb																	
Os ppb																	
Ir ppb																	
Pt ppb																	
Au ppb																	
Th ppm					0.84	(c)										1.2	(c)
U ppm														0.18	(c)		

technique: (a) OES, (b) IDMS, (c) INAA, (d) semimicro XRF, (e) XRF

Table 1b. Chemical composition of 10058.

reference	Duncan76		Morrison70		Beaty78			Murthy70		Hurley70		Neal2001	
weight													
SiO2 %	41.78	(e)	39.4	(f)	40.24	39.76	(g)						
TiO2	9.07	(e)	9.7	(f)	10.6	10.52	(g)						
Al2O3	10.44	(e)	10.2	(f)	10.34	10.54	(g)						
FeO	18.68	(e)	19.6	(f)	19.6	19.36	(g)						
MnO	0.266	(e)	0.25	(f)	0.29	0.28	(g)						
MgO	5.96	(e)	5.6	(f)	5.8	6.22	(g)						
CaO	12.34	(e)	15.4	(f)	12.18	12.53	(g)						
Na2O	0.48	(e)	0.43	(f)	0.42	0.42	(g)						
K2O	0.085	(e)	0.11	(f)	0.06	0.02	(g)	0.098	(b)				
P2O5	0.132	(e)	0.055	(f)	0.16	0.09	(g)						
S %	0.19	(e)			0.2	0.22	(g)						
sum	99.423												
Sc ppm			87	(f)								88.6	(h)
V	46	(e)	41	(f)								65.3	(h)
Cr	1402	(e)	1500	(f)								1201	(h)
Co	12	(e)	14	(f)								15.5	(h)
Ni	<2	(e)										1.15	(h)
Cu			7.1	(f)								37.6	(h)
Zn			9.3	(f)								88	(h)
Ga			4.3	(f)								4.5	(h)
Ge ppb													
As			70	(f)									
Se													
Rb	1.5	(e)	1.2	(f)				1.15	(b)	0.68	(b)	0.88	(h)
Sr	208	(e)	180	(f)				224	(b)	172	(b)	217	(h)
Y	147	(e)	150	(f)								111	(h)
Zr	376	(e)	380	(f)								300	(h)
Nb	28.4	(e)	47	(f)								25	(h)
Mo			0.4	(f)								0.19	(h)
Ru													
Rh													
Pd ppb			200	(f)									
Ag ppb			70	(f)									
Cd ppb			700	(f)									
In ppb			600	(f)									
Sn ppb			1200	(f)									
Sb ppb			10	(f)									
Te ppb													
Cs ppm			0.3	(f)								0.05	(h)
Ba	136	(e)	140	(f)				128	(b)			108	(h)
La			16	(f)								11.5	(h)
Ce			45	(f)								45.4	(h)
Pr			13	(f)								7.33	(h)
Nd			72	(f)								42.9	(h)
Sm			22	(f)								18.2	(h)
Eu			3	(f)								2.4	(h)
Gd			22	(f)								23.3	(h)
Tb			5.4	(f)								4.5	(h)
Dy			39	(f)								28.1	(h)
Ho			9	(f)								5.56	(h)
Er			36	(f)								16.1	(h)
Tm			2	(f)								2.25	(h)
Yb			22	(f)								15.3	(h)
Lu			2.3	(f)								2.07	(h)
Hf			13	(f)								11.2	(h)
Ta			1	(f)								1.82	(h)
W ppb			360	(f)								160	(h)
Re ppb													
Os ppb													
Ir ppb													
Pt ppb													
Au ppb													
Th ppm			1.1	(f)								0.74	(h)
U ppm			0.2	(f)								0.23	(h)

technique: (e) XRF, (f) various, (g) elec. Probe, (h) ICP-MS



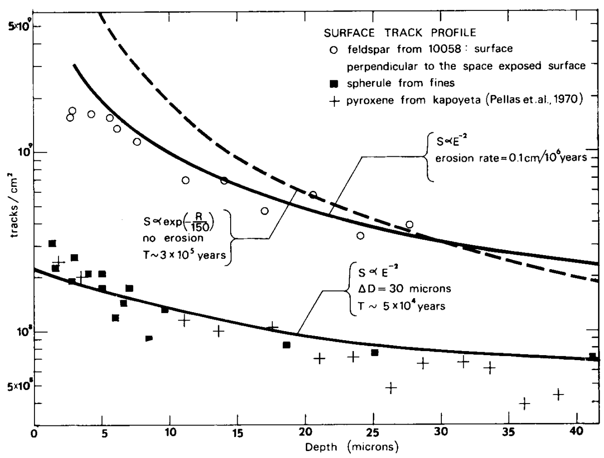


Figure 7: Etched cosmic ray track profile with depth for plagioclase (circles) from 10058 (Crozaz et al. 1970).

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