10050

Ilmenite Basalt (low K)

114.5 grams

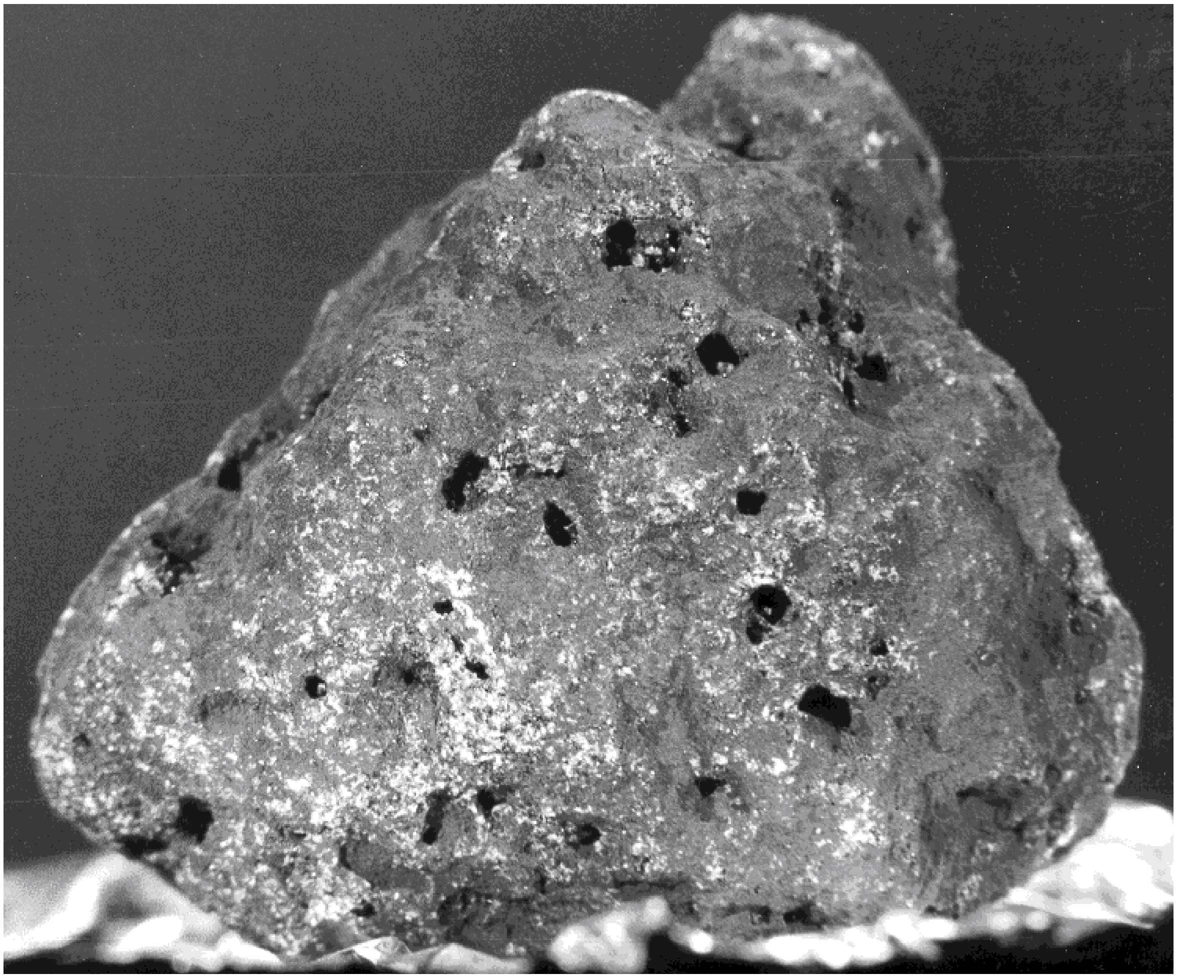


Figure 1: Photo of 10050 illustrating vesicles and eroded surface. NASA S69-45731. Sample is 6 cm across.

Introduction

Lunar Sample 10050 is a low-K, ilmenite basalt with a 3.75 b.y. crystallization age and 480 m.y. exposure age (longer than the others). Although, 10050 has been well studied, but the apparent cognate, mafic inclusions require more study.

Petrography

Schmitt et al. (1970) termed 10050 as a "coarse-grained, vuggy, ophitic cristobalite basalt." James and Jackson (1970) grouped it with medium-grained ophitic basalts (figure 2). Frondel et al. (1970) termed 10050 a "microgabbro". Beaty and Albee (1978) found that 10050 was unlike the other Apollo 11 basalts and deserved a category all by itself.

Beaty and Albee (1978) found that 10050,31 contains a "xenolith" whose minerals were "out of equilibrium" with the rest of the sample. The pyroxene crystals in this inclusion were more mafic $Wo_3En_{73}Fs_{21}$.

Mineralogy

Olivine: Frondel et al. (1970) and Beaty and Albee (1978) found a range in olivine composition Fo_{70-40}. Fayalite is also reported.

Pyroxene: Ross et al. (1970), Frondel et al. (1970) and Beaty and Albee (1978) reported pyroxene composition and studied chemical zoning from center

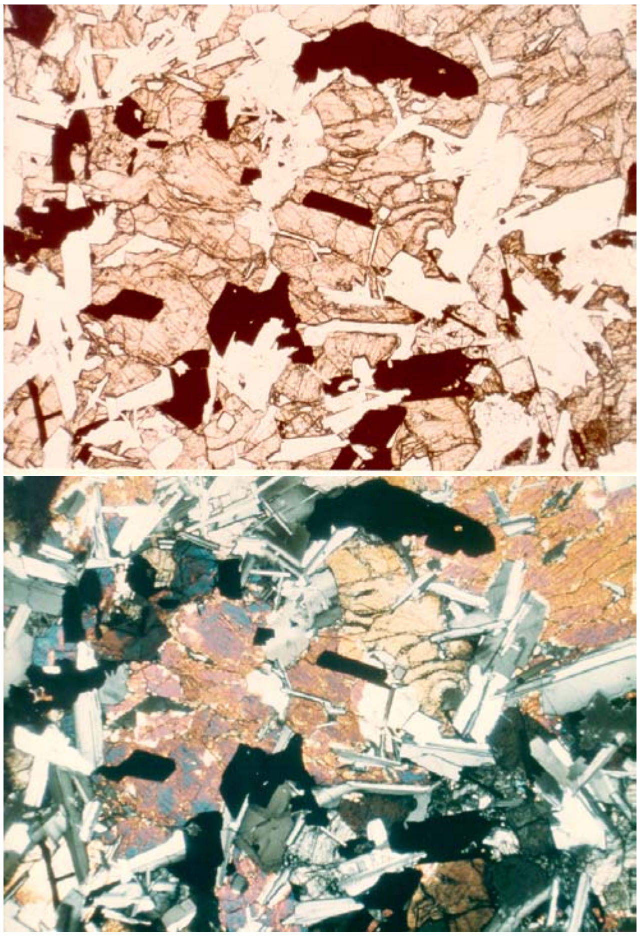


Figure 2: Photomicrograph of thin section 10050 (top: plane polarized, bottom: crossed polarized). NASA S70-49003 and 4. Scale is 2.5 mm.

to edge (figure 3). An unusual feature of the pyroxene in 10050 is that the most Fe-rich is lower in Ca than in other lunar basalts.

Plagioclase: Frondel et al. (1970) and Beaty and Albee (1978) reported the average plagioclase analysis was An_{90} and An_{92-70}, respectively (figure 4). Appleman et al. (1971) determined the cell dimensions of plagioclase from 10050 and other samples.

Ilmenite: Frondel et al. (1970) reported a "wet chemical" analysis of ilmenite from 10050.

Troilite: Evans (1970) determined the crystal structure of a euhedral troilite crystal found growing in a vug of 10050.

Chemistry

The original analyses of 10050 were by LSPET (1969), Rose et al. (1970), Goles et al. (1970), Wakita et al.

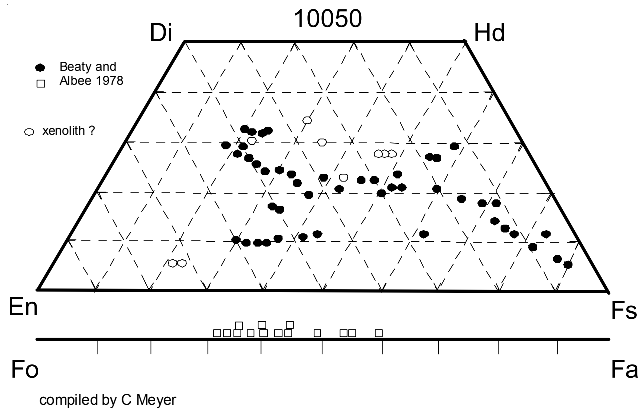


Figure 3: Composition of olivine and pyroxene in 10050.

Figure 4: Large plagioclase grain in 10050. Scale 80x

(1970), Ganapathy et al. (1970), Tera et al. (1970) and others (table 1). Rhodes and Blanchard (1980) reanalyzed the sample with similar results. It is a low K variety of Apollo 11 basalt (figures 5 and 6). Moore et al. (1970) reported an average of 64 ppm carbon and 30 ppm nitrogen.

Mineralogical Mode for 10050

	James and Jackson 70	Beaty and Albee 1978
Olivine	1.2	0.73
Pyroxene	50.2	48.8
Plagioclase	29.5	33.6
Ilmenite	14.4	14.2
Glass	0.6	0.07
silica	2.8	2.3
troilite	0.4	0.23
phosphate	0.4	0.05

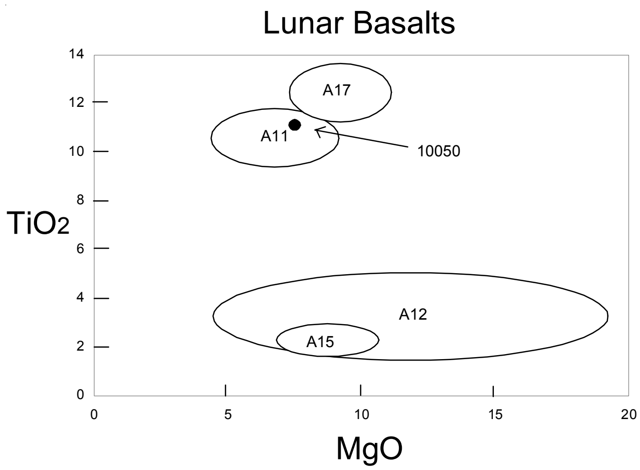


Figure 5: Composition of 10050 compared with that of other Apollo lunar samples.

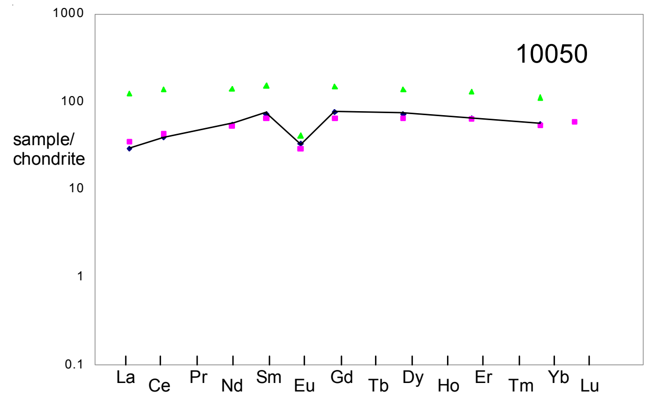


Figure 6: Normalized rare-earth-element composition for low-K basalt 10050 (the line) compared with that of low-K basalt 10020 and high-K basalt 10049 (the dots) (data from Wiesmann et al. 1975).

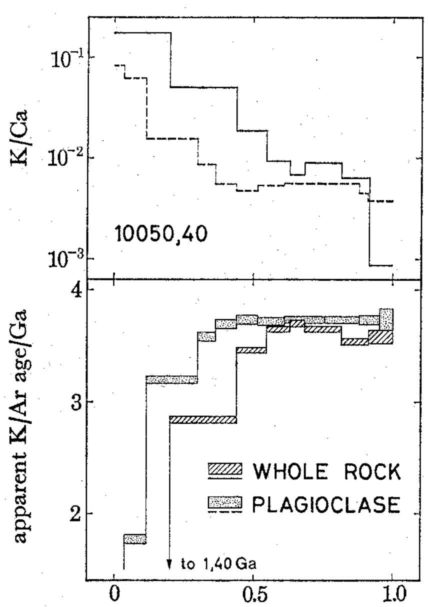


Figure 7: Argon release pattern for 10050 whole rock and plagioclase (from Geiss et al. 1977).

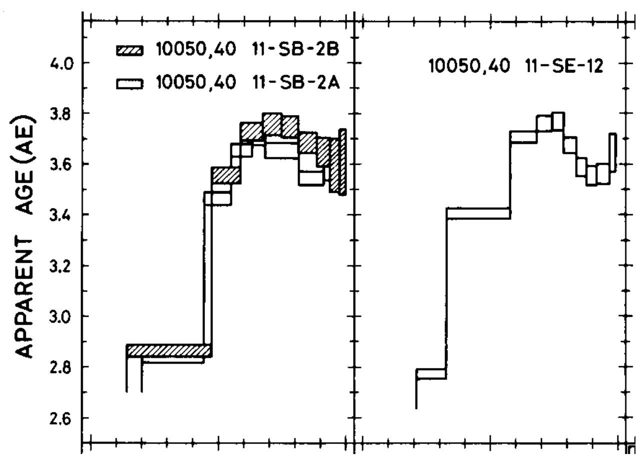


Figure 8: Argon release patterns for 10050 from Guggisberg et al. (1979).

Radiogenic age dating

Geiss et al. (1977) and Guggisberg et al. (1979) determined the age of 10050 by the Ar/Ar plateau method for whole rock and plagioclase. Plagioclase gives the better plateau and more precise age (figures 7 and 8). Gopalan et al. (1970) determined Rb/Sr and $^{87}Sr/^{86}Sr$ for "whole rock".

Summary of Age Data for 10050

	Ar/Ar (plagioclase)
Geiss et al. 1977	3.75 ± 0.03 b.y.
Guggisberg et al. 1979	3.75 ± 0.03

Cosmogenic isotopes and exposure ages

Geiss et al. (1977) found that 10050 had a long exposure history compared with other low K basalts. Guggisberg et al. (1979) reported an $^{37}Ar/^{38}Ar$ cosmic ray exposure age of 480 m.y.

Other Studies

The total organic carbon content of 10050 was determined by hydrogen flame ionization pyrolysis (Ponnamperuma et al. 1970).

Funkhouser et al. (1970) and Bogard et al. (1971) reported the abundance and isotopic composition of rare gasses from 10050.

Tatsumoto et al. (1970) determined the concentration of U and Th and isotopic composition of Pb.

Table 1. Chemical composition of 10050.

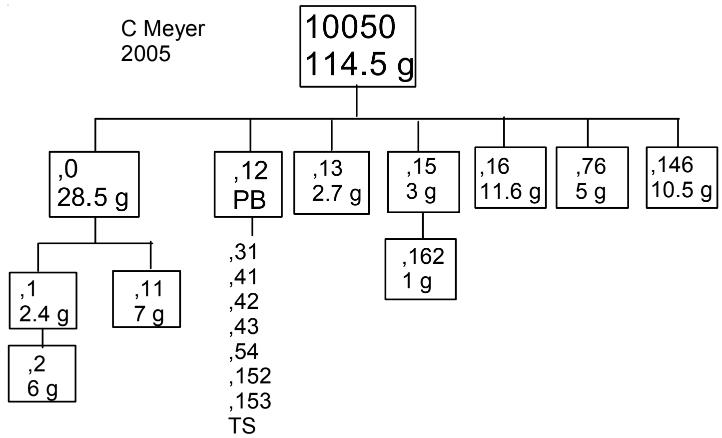
reference	LSPET69		Wiesmann75		Tera70		Rose70		Goles70		Rhodes80			Wakita70			Ganapathy70	
weight			67 mg								1.2 g	0.31 g		600 mg	575 mg			
SiO2 %	*38*	(a)					40.9	(c)	39.4	(d)	39.25	40.62	(e)	42.1	43.6	(d)		
TiO2	*9*	(a)	11	(b)			12.6	(c)	11	(d)	11.79	9.61	(e)	12.8		(d)		
Al2O3	*11*	(a)					8.9	(c)	10.4	(d)	9.64	10.87	(e)	10.4	10.8	(d)		
FeO	*20*	(a)					17.3	(c)	17.5	(d)	19.29	16.51	(e)	20	19	(d)		
MnO	*0.5*	(a)					0.27	(c)	0.26	(d)	0.3	0.26	(e)	0.3	0.28	(d)		
MgO	*10*	(a)					8	(c)	10.8	(d)	7.86	7.82	(e)	7.3	6.96	(d)		
CaO	*10*	(a)			11.4	(b)	11.3	(c)	11.5	(d)	11.28	12.65	(e)	11.2		(d)		
Na2O	*0.51*	(a)	0.35		0.37		0.66	(c)	0.35	(d)	0.36	0.35	(d)	0.39	0.41	(d)		
K2O	*0.06*	(a)	0.065	(b)	0.08	(b)	0.05	(c)			0.08	0.06	(e)	0.05	0.06	(d)		
P2O5											0.08	0.07	(e)					
S %																		
sum																		
Sc ppm									88.9	(d)	91		(d)	96	89	(d)		
V	*80*	(a)							117	(d)				99	97	(d)		
Cr	*4800*	(a)					2400	(c)	2120	(d)	2415		(d)	2410	2230	(d)		
Co	*10*	(a)							13.6	(d)	13.9		(d)	19	19	(d)	15.2	(f)
Ni	*55*	(a)																
Cu	*10*	(a)															15.2	(f)
Zn																	1.75	(f)
Ga	*8*	(a)									8.8		(e)				4.41	(f)
Ge ppb																		
As																		
Se																		
Rb	*0.8*	(a)	0.567	(b)	0.75	(b)					0.6		(e)				0.6	(f)
Sr	*140*	(a)	165	(b)	171	(b)					183		(e)					
Y	*130*	(a)									103		(e)		104	(f)		
Zr	*700*	(a)	300	(b)										650	390	(d)		
Nb																		
Mo																		
Ru																		
Rh																		
Pd ppb																	1.4	(f)
Ag ppb																	1.42	(f)
Cd ppb																	2.56	(f)
In ppb																	4.4	(f)
Sn ppb																		
Sb ppb																		
Te ppb																	11	(f)
Cs ppm					0.03	(b)											0.026	(f)
Ba	*60*	(a)	63.5	(b)	92	(b)								70	68	(f)		
La			6.77	(b)					7.2	(d)	7.6		(d)	8.9	8	(f)		
Ce			23.4	(b)					34	(d)	29		(d)		37	(f)		
Pr															6.2	(f)		
Nd			24.8	(b)											36	(f)		
Sm			10.6	(b)					11.9	(d)	12.2		(d)	16.2	12.9	(f)		
Eu			1.84	(b)					2	(d)	1.92		(d)	2.2	2.2	(f)		
Gd			14.9	(b)											19.9	(f)		
Tb									2.1	(d)	2.5		(d)		4.3	(f)		
Dy			17.6	(b)											28	(f)		
Ho									4.6	(d)					4.9	(f)		
Er			10.2	(b)														
Tm																		
Yb	*2.7*	(a)	9.17	(b)					11.1	(d)	10		(d)	13.6	12.2	(d)		
Lu									1.96	(d)	1.52		(d)	1.9	1.7	(d)		
Hf									8.6	(d)	9.3		(d)	15	12	(d)		
Ta									2.2	(d)	2.1		(d)					
W ppb																		
Re ppb																		
Os ppb																		
Ir ppb																	0.24	(f)
Pt ppb																		
Au ppb																	0.33	(f)
Th ppm											0.7		(d)	2	1.6	(d)		
U ppm			0.2	(b)														

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

Table 1b. Chemical composition of 10050.

reference	Duncan 76		Beaty 78		Tatsumoto70		Gopalan70		Neal2001	
weight										
SiO2 %	39.7	(e)	40.05	(g)						
TiO2	11.16	(e)	11.12	(g)						
Al2O3	10.21	(e)	10.49	(g)						
FeO	18.57	(e)	17.83	(g)						
MnO	0.262	(e)	0.28	(g)						
MgO	7.95	(e)	7.9	(g)						
CaO	11.91	(e)	11.67	(g)						
Na2O	0.44	(e)	0.36	(g)						
K2O	0.052	(e)	0.04	(g)			0.08	(b)		
P2O5	0.094	(e)	0.02	(g)						
S %	0.143	(e)	0.12	(g)						
sum										
Sc ppm									114	(h)
V	88	(e)							115	(h)
Cr	2484	(e)	2330	(g)					2445	(h)
Co	14	(e)							18	(h)
Ni	<2	(e)							2.2	(h)
Cu									56	(h)
Zn									99	(h)
Ga									5	(h)
Ge ppb										
As										
Se										
Rb	<1.4	(e)					0.788	(b)	1.11	(h)
Sr	172	(e)					189	(b)	216	(h)
Y	103	(e)							165	(h)
Zr	265	(e)							381	(h)
Nb	21	(e)							29.6	(h)
Mo									0.16	(h)
Ru										
Rh										
Pd ppb										
Ag ppb										
Cd ppb										
In ppb										
Sn ppb										
Sb ppb									60	(h)
Te ppb										
Cs ppm									0.01	(h)
Ba	98	(e)							118	(h)
La									11.9	(h)
Ce									38.4	(h)
Pr									7.19	(h)
Nd									40.5	(h)
Sm									16.1	(h)
Eu									2.37	(h)
Gd									22.8	(h)
Tb									4.04	(h)
Dy									26.6	(h)
Ho									5.33	(h)
Er									15.2	(h)
Tm									2.07	(h)
Yb									13.5	(h)
Lu									1.75	(h)
Hf									11.2	(h)
Ta									1.55	(h)
W ppb									130	(h)
Re ppb										
Os ppb										
Ir ppb										
Pt ppb										
Au ppb										
Th ppm					0.531	(b)			0.74	(h)
U ppm					0.156	(b)			0.22	(h)

technique: (b) IDMS, (e) XRF, (g) elec. Probe, (h) ICP-MS



Processing

Apollo 11 samples were originally described and cataloged in 1969 and "recataloged" by Kramer et al. (1977). There are 14 thin sections.

List of Photo #s for 10050

S69-45718 – 45	B&W mug
S69-57234	TS B&W
S70-49003 – 6	TS color
S70-50018 – 8	
S76-21738 – 9	color
S76-21349 – 51	
S76-26261	TS

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