

10072
Ilmenite Basalt (high K)
447 grams



Figure 1: Photo of freshly broken surface of basalt 10072,80 illustrating vesicles and vugs. Sample is about 5 cm across. NASA S76-22599.

Introduction

Lunar sample 10072 has been studied by a large number of people. It is a fine-grained, high-K, ilmenite basalt.

The crystallization age of this basalt is 3.6 b.y. with a cosmic ray exposure age of 235 m.y.

Petrography

Schmitt et al. (1970) termed 10072 as a “fine-grained, vesicular to vuggy, subophitic olivine basalt.” James

and Jackson (1970) described the texture as “intersertal”. McGee et al. (1977) described 10072 as a medium-grained intersertal basalt which consists of intergrown pyroxene, plagioclase and ilmenite with interstitial occurrences of cristobalite and glass. Numerous spherical vesicles and irregular vugs are 1 – 3 mm in size (figure 1). Chemically zoned pyroxene crystals (0.1-0.6 mm) are subhedral to anhedral and found to include rare rod-shaped tranquillityite. Plagioclase displays a variety of shapes ranging from

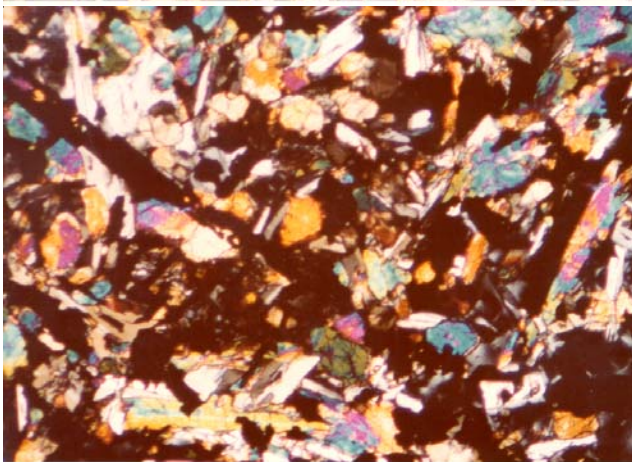
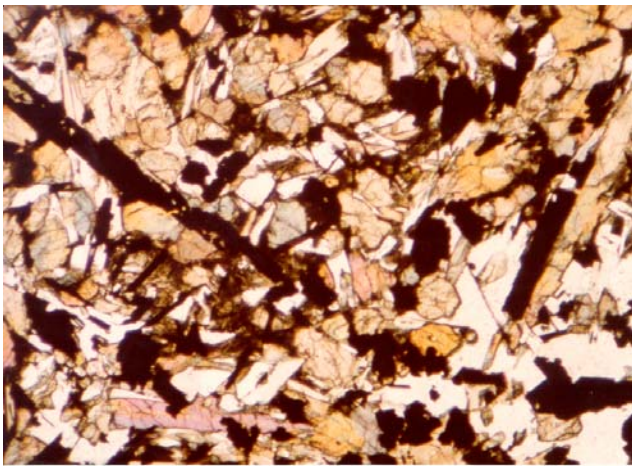


Figure 2: Photomicrographs of thin section 10072,53 (top: plane-polarized light, bottom: crossed Nicols). Scale is 0.69 mm. NASA S79-27091 and 092.

anhedral interstitial grains (0.1-0.6 mm) to hollow euhedral tablets (0.1-1.0 mm) intergrown with pyroxene (figure 2). Irregularly shaped ilmenite with arcuate boundaries and reentrants is 0.4-1.0 mm. Beaty and Albee (1978) list it as one of the coarsest of the fine grain basalts.

Walker et al. (1975) discuss the experimental results on Apollo 11 basalts.

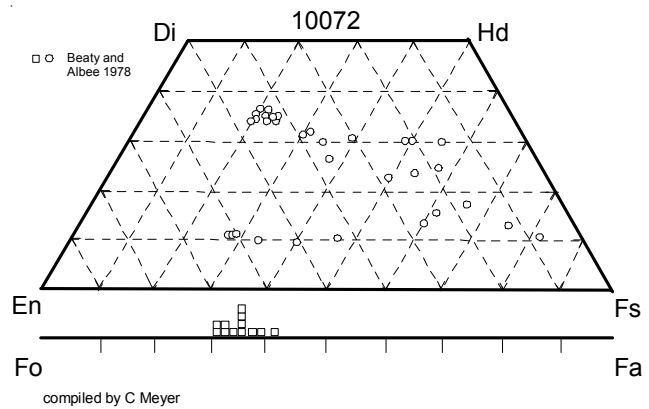


Figure 3: Pyroxene and olivine composition of 10072 (from Beaty and Albee 1978).

Roedder and Weiblen (1970) reported on silicate melt inclusions in olivine in 10072 as well as immiscible high-Fe, high-silica glass inclusions in pyroxene.

Mineralogy

Olivine: Beaty and Albee (1978) reported olivine with Fo₆₆.

Pyroxene: Pyroxene is chemically zoned (figure 3), but the Fe-enrichment does not extend all the way to pyroxferroite (Beaty and Albee 1978).

Plagioclase: Beaty and Albee (1978) reported plagioclase as An₆₉. Stewart et al. (1970) determined the cell size of plagioclase An₇₅.

Ilmenite: Jebwab (1970) studied growth steps on “free-growing” ilmenite from vugs in 10072.

Armalcolite: Kushiro and Nakamura (1970) show picture of magnesian armalcolite with ilmenite overgrowth in 10072 and give an analysis. Beaty and Albee (1978) also give an analysis (table 2).

Mineralogical Mode 10072

	James and Jackson 70	Kushiro and Nakamura 70	Haggerty et al. 1970	Beaty and Albee 1978	McGee et al. 1977
Olivine	0.7	0.1		0.4	tr. - 1
Pyroxene	49.3	52.0	59.4	51	49 - 59
Plagioclase	21.4	18.5	20.4	22.5	18 - 21
Ilmenite	15	22.1	14.8	13.2	13 - 22
mesostasis	8	7.3	3.7	10.8	7 - 9
silica	2.4		0.2	1.34	0.2 - 2.0
troilite	0.7			0.62	0.2 - 0.7
phosphate	0.1			0.15	tr.

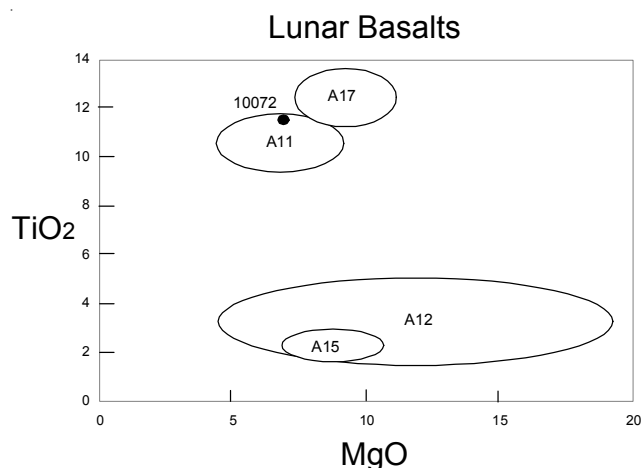


Figure 4: Composition of 10072 compared with that of other Apollo lunar samples.

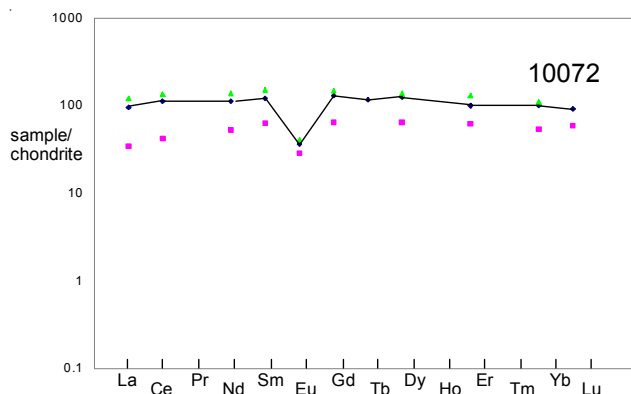


Figure 5: Normalized rare-earth-element composition for high-K basalt 10072 (the line) compared with that of low-K basalt 10020 and high-K basalt 10049 (the dots) (data from Wiesmann et al. 1975).

Troilite: Simpson and Bowie (1970) illustrated troilite with native iron blebs. Skinner (1970) also studied the metallic iron/troilite ratio and calculated the temperature of the volcanic liquid.

Chemistry

The composition of 10072 has been determined by a number of people (table 1, figures 4 and 5). Reed and Jovanovic (1970) reported concentrations for F, Cl, Br, I, Hg and Os.

Radiogenic age dating

Papanastassiou et al. (1977) and Guggisberg et al. (1979) showed that there are two distinct ages for mare basalts collected by Apollo 11 (figures 6, 7, 8). 10072 belongs to the younger age group. The old age reported by Compston et al. (1970) was revised downward by DeLaeter et al. (1973) to be just barely within error of the younger ages obtained by others. Hurley and Pinson (1970) reported Rb and Sr isotopes and placed 10072 on their “whole rock” isochron (3850 ± 50 m.y.).

Summary of Age Data for 10072

	Rb/Sr	Nd/Sm	Ar/Ar
Papanastassiou et al. 1977	3.64 ± 0.05 b.y.		
Papanastassiou et al. 1977		3.57 ± 0.03	
Turner 1970			3.52 ± 0.05
Compston et al. 1970	3.78 ± 0.1		
DeLaeter et al. 1973	3.71 ± 0.11		
Guggisberg et al. 1979			3.62 ± 0.05
Geiss et al. 1977			3.57 ± 0.04

Caution: Ages not corrected for new decay constants.

Cosmogenic isotopes and exposure ages

The radioactivity of 10072 that was induced by solar and cosmic ray irradiation was $^{22}\text{Na} = 46$ dpm/kg., $^{26}\text{Al} = 73$ dpm/kg., $^{46}\text{Sc} = 8$ dpm/kg., $^{54}\text{Mn} = 20$ dpm/kg. and $^{56}\text{Co} = 40$ dpm/kg. (O’Kelley et al. 1970).

Turner et al. (1970) and Guggisberg et al. (1979) determined ^{38}Ar exposure ages of 220 m.y. and 235 m.y., respectively. Eberhardt et al. (1970) calculated 240 m.y. from the data by Funkhouser et al. (1970) and others. Pepin et al. (1970) reported ^{83}Kr .

Other Studies

The concentrations of Sm, Nd, Lu and Hf and the isotopic ratios of $^{143}\text{Nd}/^{144}\text{Nd}$ and $^{176}\text{Hf}/^{177}\text{Hf}$ were determined by Unruh et al. (1984).

Pepin et al. (1970), Funkhouser et al. (1970) and Bogard et al. (1971) reported the abundance and isotopic composition of rare gasses from 10072. D’Amico et al. (1970) determined tritium, hydrogen, He and Ar.

Processing

Apollo 11 samples were originally described and cataloged in 1969 and “re-cataloged” by Kramer et al. (1977). There are 10 thin sections.

This is a public display sample in Canberra, Australia.

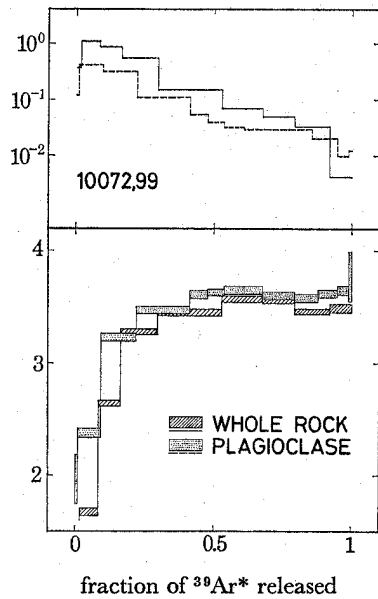


Figure 6: Ar-Ar plateau age for plagioclase and whole rock 10072 (from Geiss 1970).

List of Photo #s for 10072

- S69-47364
- S69-47381 - 88
- S69-47494 - 503
- S69-47610 - 13
- S70-48983 - 7 TS
- S70-49194 TS
- S70-49228 TS
- S76-21145 - 6
- S76-22596 - 99
- S76-23371 - 4
- S76-26285 - 6 TS B&W
- S79-27091 - 2 TS
- S79-27125 TS
- S83-25888 - 90

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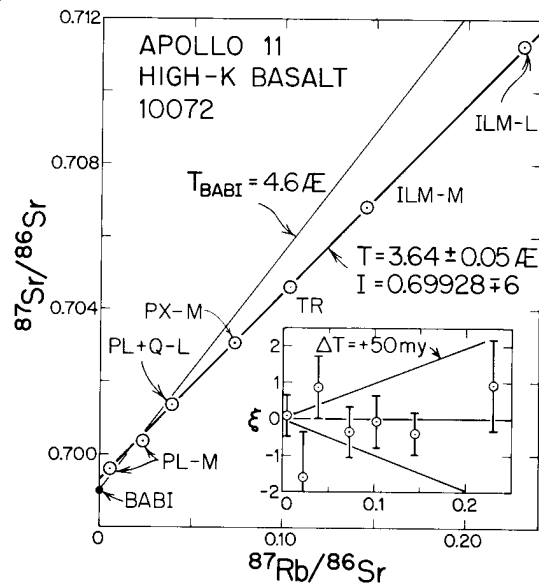


Figure 7: Rb-Sr isochron for 10072 (Papanastassiou et al. 1977).

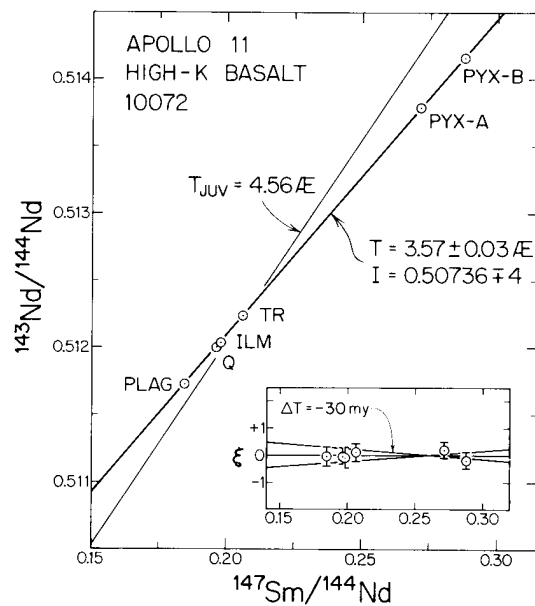


Figure 8: Sm-Nd isochron for 10072 (Papanastassiou et al. 1977).

Bogard D.D., Funkhouser J.G., Schaeffer O.A. and Zahringer J. (1971) Noble gas abundances in lunar material-cosmic ray spallation products and radiation ages from the Sea of Tranquillity and the Ocean of Storms. *J. Geophys. Res.* **76**, 2757-2779.

Compston W., Arriens P.A., Vernon M.J. and Chappell B.W. (1970a) Rubidium-strontium chronology and chemistry of lunar material. *Science* **167**, 474-476.

Table 1. Chemical composition of 10072.

reference weight	LSPET69	Maxwell70 GSF	USGS	Compston70	Dickinson89	Haskin70	Ganapathy70	Anders71	Annell70
SiO ₂ %	45	(a) 40.2	40.53	(b) 40.49	(c)				
TiO ₂	10	(a) 12.28	11.74	(b) 11.99	(c)				
Al ₂ O ₃	9	(a) 7.78	8.52	(b) 7.74	(c)				
FeO	17	(a) 19.77	19.76	(b) 19.38	(c)	17.2	(d)		
MnO	0.36	(a) 0.22	0.24	(b) 0.24	(c)				0.29 (f)
MgO	8	(a) 8.06	7.68	(b) 7.45	(c)				
CaO	9.5	(a) 10.27	10.42	(b) 10.56	(c)	7	(d)		
Na ₂ O	0.6	(a) 0.52	0.54	(b) 0.5	(c)	0.44	(d)		
K ₂ O	0.2	(a) 0.29	0.27	(b) 0.29	(c)				
P ₂ O ₅		0.18	0.14	(b) 0.19	(c)				
S %			0.24	(b) 0.23	(c)				
sum									
Sc ppm	45	(a) 77		(b)		69	(d)		96 (f)
V	30	(a) 82		(b) 22					76 (f)
Cr	4700	(a) 2460		(b) 2280		2600	(d)		2860 (f)
Co	12	(a) 30		(b) 34		23	(d)	27.2 (e)	50 (e) 30 (f)
Ni				<20					6.6 (f)
Cu	5	(a) 21		(b) 22			4.94	(e)	6.7 (f)
Zn		24		(b) 34			1.81	(e) 1.72 (e)	
Ga				4		15	(d)	4.73 (e)	4.5 (f)
Ge ppb						4.9	(d)		
As									
Se								0.188 (e)	
Rb	6.5	(a)		5.61	(c)		5.98	(e)	5 (f)
Sr	130	(a)		168	(c)	144	(d)		130 (f)
Y	210	(a) 175		(b) 162	(c)				155 (f)
Zr	850	(a) 460		(b) 497	(c)				530 (f)
Nb				25					23 (f)
Mo									
Ru									
Rh									
Pd ppb							3	(e)	
Ag ppb							17.3	(e)	
Cd ppb							6.47	(e) 14 (e)	
In ppb							179	(e)	
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm							0.159	(e)	
Ba	130	(a)		300		296	(d)		430 (f)
La				43		24	(d) 22.7 (d)		25 (f)
Ce				94		68	(d) 69 (d)		
Pr				16					
Nd				49		56	(d) 51 (d)		
Sm		21		(b)		64	(d) 17.9 (d)		
Eu		2		(b)		2	(d) 2.07 (d)		
Gd						26	(d)		
Tb		3		(b)		5.4	(d) 4.3 (d)		
Dy							31.2 (d)		
Ho									
Er						0.93	(d) 16 (d)		
Tm						0.86	(d)		
Yb	2	(a) 19		(b)		16.8	(d) 16.6 (d)		
Lu		5		(b)		2.6	(d) 2.24 (d)		
Hf		12		(b)		14.8	(d)		
Ta		5		(b)		2.1	(d)		
W ppb									
Re ppb									
Os ppb									
Ir ppb							4	(e) 0.022 (e)	
Pt ppb									
Au ppb							0.14	(e) 0.1 (e)	
Th ppm		4		(b) 3.5	(c)	3.8	(d)		
U ppm									

technique: (a) OES, (b) mixed, (c) XRF, (d) INAA, (e) RNAA, (f) emission spec.

Table 1b. Chemical composition of 10072.

reference weight	Duncan 76	Morrison 70	Silver70	Beaty78	O'Kelley70 399 g	Wasson70	Gopalan 70
SiO ₂ %	39.81	(c) 41.1		41.62	(h)		
TiO ₂	12.27	(c) 11.2		11.02	(h)		
Al ₂ O ₃	7.66	(c) 7.56		8.25	(h)		
FeO	19.41	(c) 19.8		18.53	(h)		
MnO	0.233	(c) 0.22		0.17	(h)		
MgO	8.01	(c) 7.13		8.06	(h)		
CaO	10.4	(c) 14.4		11.04	(h)		
Na ₂ O	0.55	(c) 0.43		0.55	(h)		
K ₂ O	0.269	(c) 0.35		0.26	(h)	0.28 (g)	0.306 (f)
P ₂ O ₅	0.192	(c) 0.16		0.07	(h)		
S %	0.254	(c)		0.31	(h)		
<i>sum</i>							
Sc ppm		86					
V	62	(c) 62					
Cr	2655	(c) 2400					
Co	25	(c) 28					
Ni	3	(c)					
Cu		18					
Zn		7					
Ga		4.3				4.9 (d)	
Ge ppb						60 (d)	
As		50					
Se							
Rb	6	(c) 5.7					5.72 (f)
Sr	160	(c) 140					168.2 (f)
Y	161	(c) 250					
Zr	504	(c) 720					
Nb	27.8	(c) 45					
Mo		0.4					
Ru							
Rh							
Pd ppb		100					
Ag ppb		600					
Cd ppb		1000					
In ppb		2000				52 (d)	
Sn ppb		400					
Sb ppb		10					
Te ppb							
Cs ppm		0.3					
Ba	294	(c) 300					
La		35					
Ce		96					
Pr		20					
Nd		88					
Sm		28					
Eu		2.2					
Gd		31					
Tb		6.8					
Dy		45					
Ho		10					
Er		35					
Tm		2.8					
Yb		28					
Lu		2.6					
Hf		18					
Ta		1.8					
W ppb		420					
Re ppb							
Os ppb							
Ir ppb						0.46 (d)	
Pt ppb							
Au ppb						0.16 (d)	
Th ppm		4.8	3.348	2.935	2.8 (g)		
U ppm		0.5	0.884	0.831	0.76 (g)		

technique: (c) XRF, (f) IDMS, (g) radiation counting, (h) elec. Probe

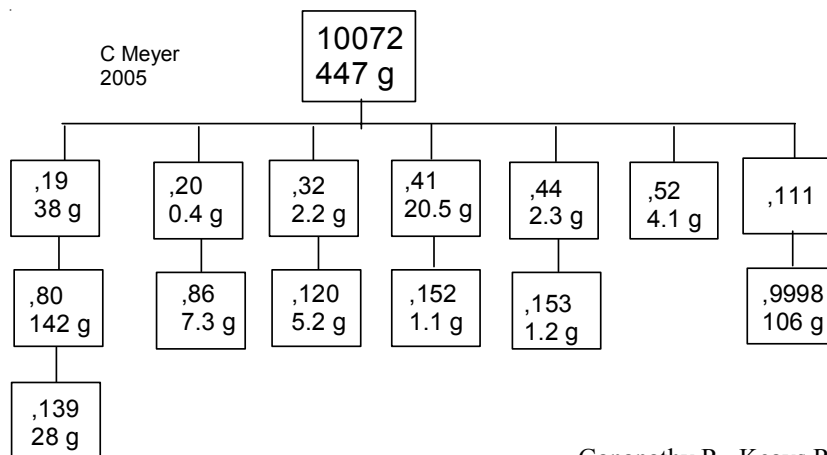


Table 2: Armalcolite

	core	rim	
SiO ₂	0.09	0.08	0.07
Al ₂ O ₃	1.62	1.53	1.56
TiO ₂	74	73	72.32
Cr ₂ O ₃	1.94	1.4	1.4
FeO	16.2	19.5	19.4
MnO	0.11	0.13	0.05
MgO	6.84	5.07	5.54
CaO	0.02	0.03	
	Kushiro 1970		Beaty and Albee 1978

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