10072

DRAFT

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

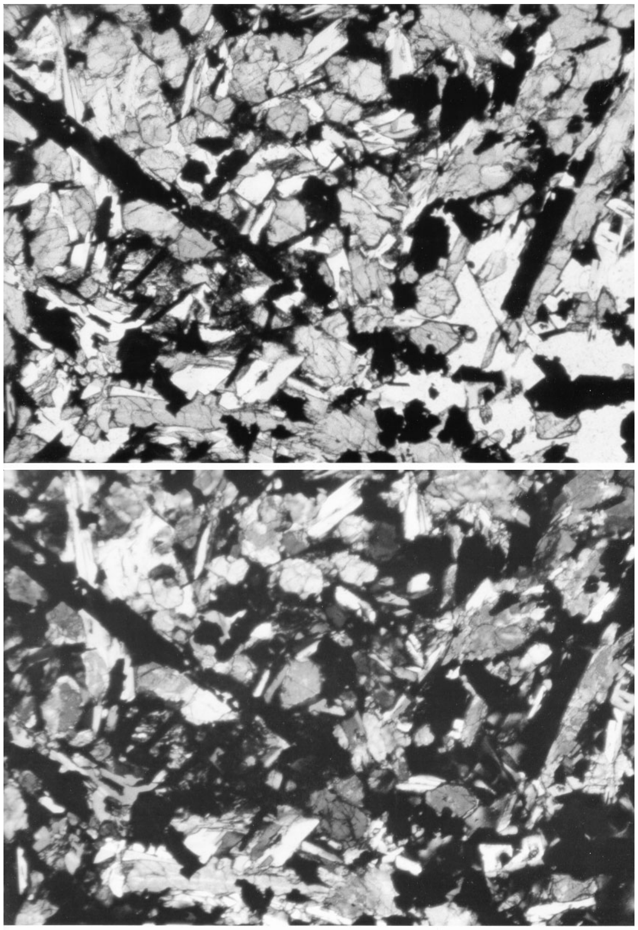

Figure 2: Photomicrographs of thin section 10072,53 (top: plane-polarized light, bottom: crossed Nicols). Scale is 0.69 mm. NASA S79-27091 and 092.

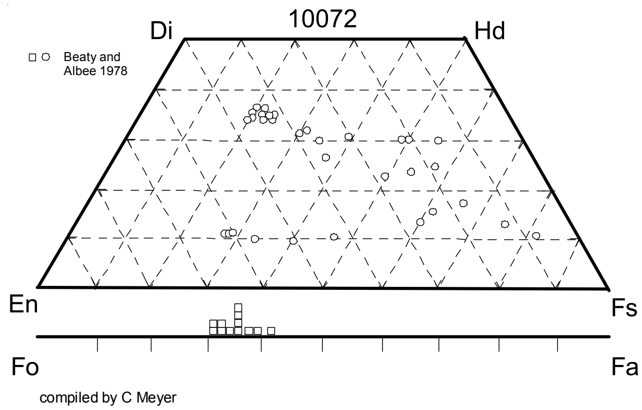

Figure 3: Pyroxene and olivine composition of 10072 (from Beaty and Albee 1978).

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.

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 Fo_{66}.

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 An_{69}. Stewart et al. (1970) determined the cell size of plagioclase An_{75}.

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

Armalcolite: Kushiro and Nakamura (1970) show picture of magnesian armacolite 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.

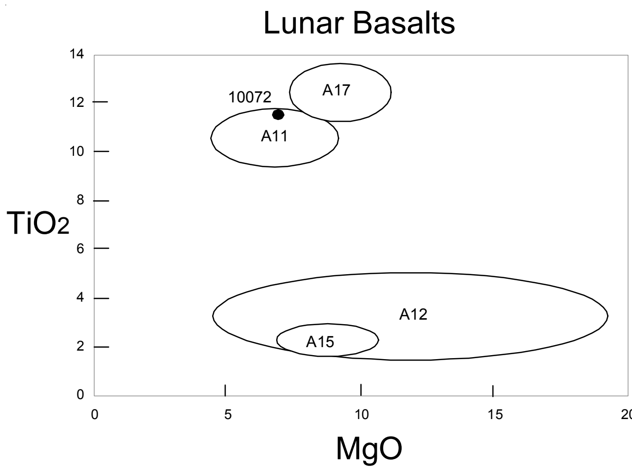

Figure 4: Composition of 10072 compared with that of other Apollo lunar samples.

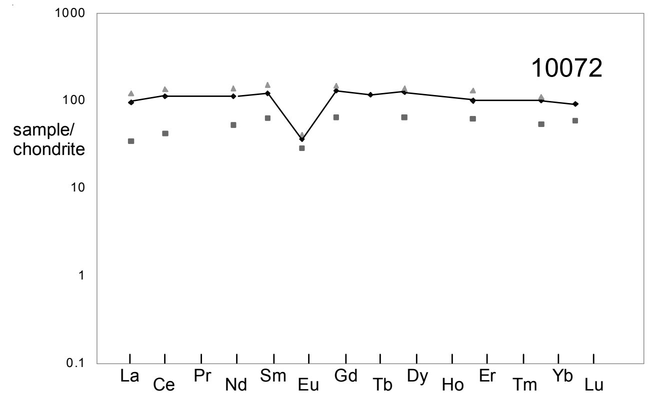

Figure 5: Normalized rare-earth-element composition for high-K basalt 10072 (the line) compared with that of low-K basalt 10020 and high-K basalt 10049 (the dots) (data from Wiesmann et al. 1975).

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}Na = 46 dpm/kg., ^{26}Al= 73 dpm/kg., ^{46}Sc= 8 dpm/kg., ^{54}Mn= 20 dpm/kg. and ^{56}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}Nd/^{144}Nd and ^{176}Hf/^{177}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). This is a public display sample in Canberra, Australia.

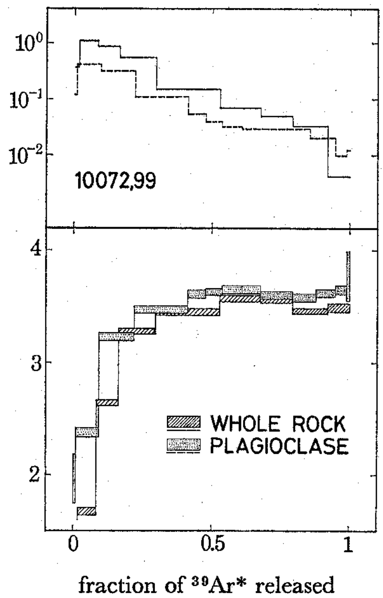

Figure 6: Ar-Ar plateau age for plagioclase and whole rock 10072 (from Geiss 1970).

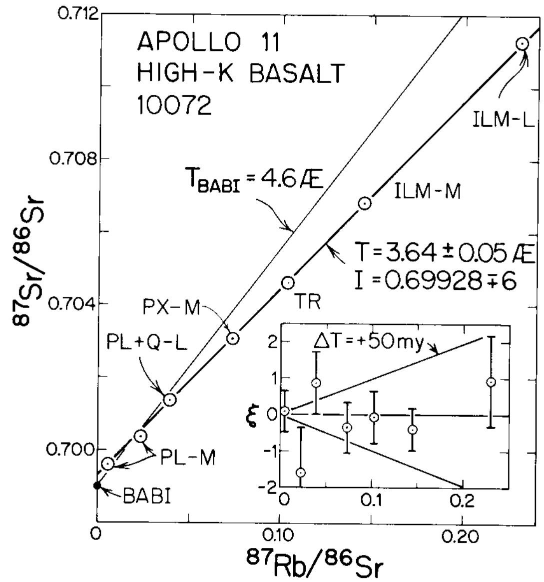

Figure 7: Rb-Sr isochron for 10072 (Papanastassiou et al. 1977).

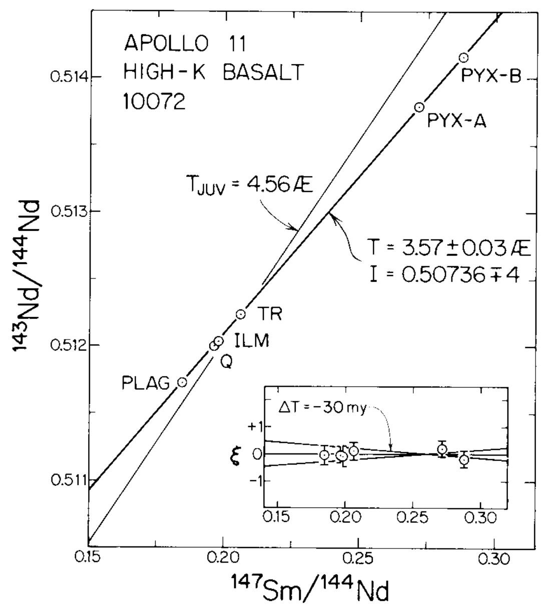

Figure 8: Sm-Nd isochron for 10072 (Papanastassiou et al. 1977).

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	

Table 1. Chemical composition of 10072.

reference	LSPET69		Maxwell70			Compston70		Dickinson89		Haskin70		Ganapathy70		Anders71		Annell70	
weight			GSF	USGS													
SiO2 %	45	(a)	40.2	40.53	(b)	40.49	(c)										
TiO2	10	(a)	12.28	11.74	(b)	11.99	(c)										
Al2O3	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)								
Na2O	0.6	(a)	0.52	0.54	(b)	0.5		0.44	(d)								
K2O	0.2	(a)	0.29	0.27	(b)	0.29	(c)										
P2O5			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	Duncan 76		Morrison 70	Silver70		Beaty78		O'Kelley70		Wasson70		Gopalan 70	
weight								399 g					
SiO2 %	39.81	(c)	41.1			41.62	(h)						
TiO2	12.27	(c)	11.2			11.02	(h)						
Al2O3	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)						
Na2O	0.55	(c)	0.43			0.55	(h)						
K2O	0.269	(c)	0.35			0.26	(h)	0.28	(g)			0.306	(f)
P2O5	0.192	(c)	0.16			0.07	(h)						
S %	0.254	(c)				0.31	(h)						
sum													
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

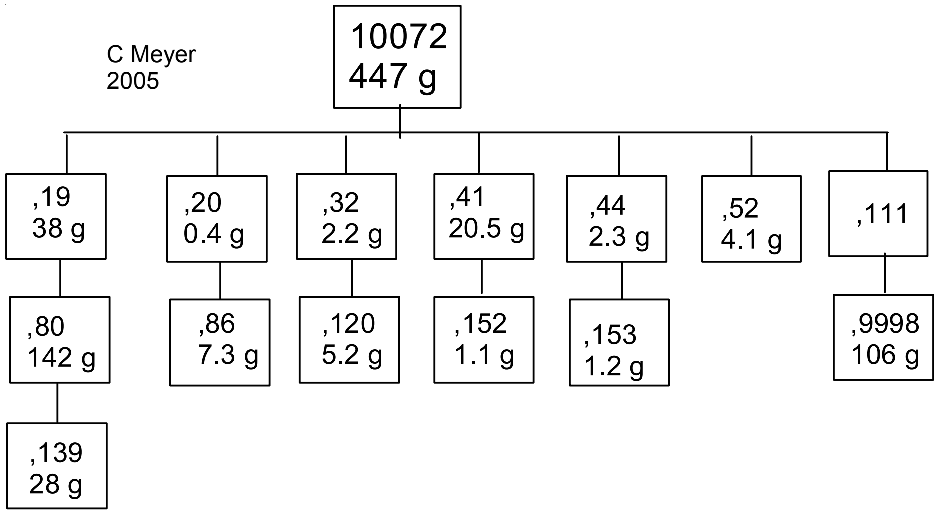

Table 2: Armalcolite

	core	rim	
SiO2	0.09	0.08	0.07
Al2O3	1.62	1.53	1.56
TiO2	74	73	72.32
Cr2O3	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