

10047

Ilmenite Basalt (low K)

138 grams



Figure 1: Photo of 10047 showing interior basaltic texture. NASA S75-26513. Cube is 1 cm.

### **Introduction**

Lunar sample 10047 is a low-K, ilmenite basalt with a relatively coarse texture (figure 1). It has been extensively studied. The crystallization age of 10047 is 3.74 b.y. and it has a cosmic ray exposure age of 80 m.y.

### **Petrography**

Schmitt et al. (1970) termed 10047 as a “coarse-grained, vuggy, ophitic, cristobalite basalt.” James and Jackson (1970) termed it a “medium grained ophitic basalt”. 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.” Smith et al. (1970) and others refer to this rock as a “microgabbro”.

Lovering and Ware (1970) and Beaty and Albee (1978) give a complete description of the mineral chemistry of 10047. Dence et al. (1970) reported pyroxene and plagioclase up to 2 mm in size. The residual mesostasis between the major minerals contains residual glass with fine-grained intergrowth of several minor phases.

### **Mineralogy**

***Olivine:*** Lovering and Ware (1970) reported fayalite in an “intergrowth region” and give an analysis. Beaty and Albee (1978) give an analysis (Fa<sub>99.5</sub>).

***Pyroxene:*** Lovering and Ware (1970), Mason et al. (1970) and Beaty and Albee (1978) determined the composition of pyroxene in 10047 (figure 3). Ross et



Figure 2: Photomicrograph of thin section of 10047. NASA S69-54011. Scale unknown (about 1 cm).

al. (1970) and Essene et al. (1970) determined the abundance and zoning in trace elements (Cr, Mn, Ti and Al) in pyroxene from 10047. They found the cores of the large pyroxenes were highly aluminous with coupled substitution by Ti etc.

**Pyroxferroite:** Frondel et al. (1970) and Chao et al. (1970) give the optical, chemical and crystallographic data for pyroxferroite in 10047. Mason et al. (1970) give the composition as  $Wo_{28}En_4Fs_{78}$ . Burnham (1971) determined the crystal structure.

**Plagioclase:** Lovering and Ware report plagioclase cores with  $An_{90}$  and rims  $An_{75}$  with elevated  $K_2O$ .

### Mineralogical Mode for 10047

	James and Jackson 70	Beaty and Albee 1978	Lovering and Ware 1970
Olivine			
Pyroxene	44.8	46.53	45
Plagioclase	37.8	34.91	30
Ilmenite	10.1	11.2	17
mesostasis	1.9	0.1	
silica	4.5	6.22	
troilite	0.5	0.43	1
phosphate	0.1	0.36	

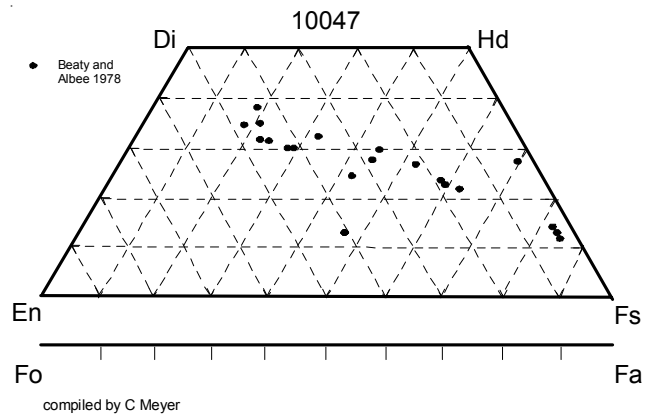


Figure 3: Pyroxene composition of 10047 (data from Beaty and Albee 1978).

Essene et al. (1970) determined zoning from  $An_{90}Ab_{9.8}Or_{0.2}$  to  $An_{75}Ab_{21}Or_4$ . Stewart et al. (1970) determined crystal structure and cell size.

**Ilmenite:** Lovering and Ware determined the composition of ilmenite, while Stewart et al. (1970) determined cell size.

**Ulvospinel:** Smith et al. (1970) report that small subhedra of ulvospinel are found intergrown with ilmenite in the finely intergrown residuum.

**Troilite:** Lovering and Ware determined the composition of troilite ( $Fe:S = 1.0087$ ). It contains blebs of Ni-free iron metal.

**Cristobalite:** Lovering and Ware determined the composition of silica and Dence et al. (1970) determined the cell dimensions.

**K-rich Glass:** Lovering and Ware (1970) and Beaty and Albee (1978) reported the composition of the residual glass ( $K_2O = 7-10\%$ ). Dence et al. (1970) and Beaty and Albee found needles of Ba,K feldspar in the glass (6.7% Ba).

### Summary of Age Data for 10047

	Ar/Ar plateau
Stettler et al. 1974	$3.74 \pm 0.03$ b.y.
Guggisberg et al. 1979	$3.71 \pm 0.03$

Note: Not corrected for new decay constants.

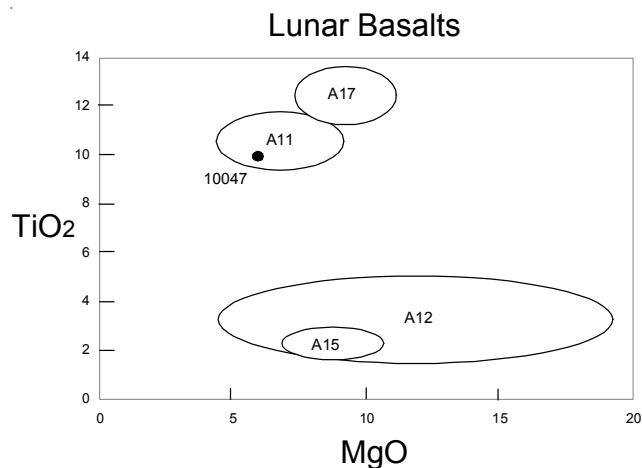


Figure 4: Composition of 10047 compared with that of other Apollo lunar samples.

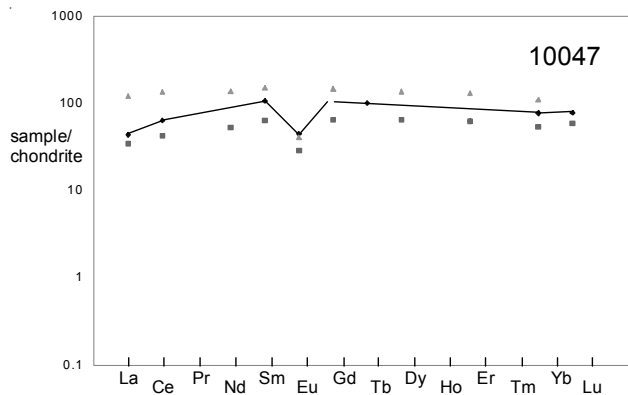


Figure 5: Normalized rare-earth-element composition for low-K basalt 10047 (the line) compared with that of low-K basalt 10020 and high-K basalt 10049 (the dots) (data from Wiesmann et al. 1975).

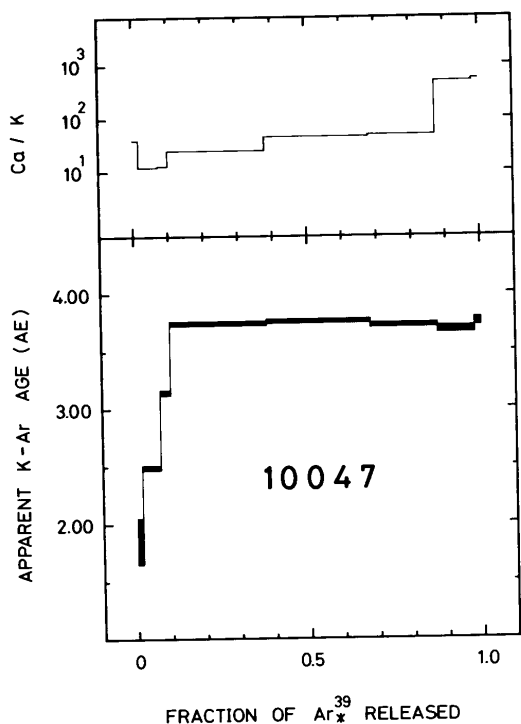


Figure 6: Argon plateau by Stettler et al. (1974).

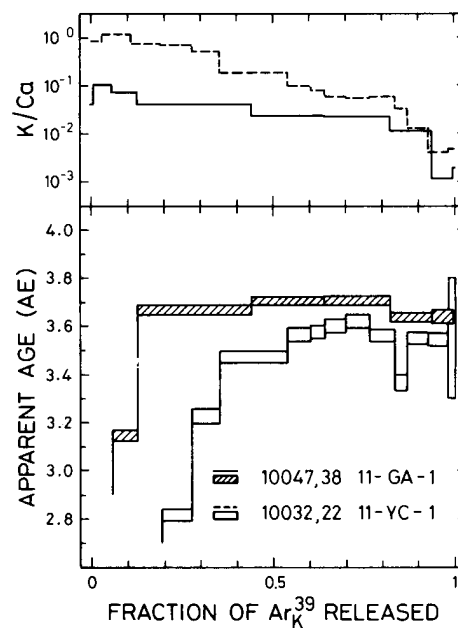


Figure 7: Argon plateau age by Guggisberg et al. (1979).

**Fe, Ti, Zr- silicate:** Dence et al. (1970) and other reported the analysis of a new mineral in 10047. Lovering et al. (1971) defined it as “tranquillityite”, giving it a full analysis.

**Phosphate:** Beatty and Albee (1978) give an analysis of apatite. Lovering et al. (1974) reported the composition of a 15 micron grain of rare earth element phosphate (monazite?) they found included in heddenberrigite in the mesostasis of 10047.

**Chemistry**

Numerous labs analyzed 10047 in 1970 (table 1, figure 4 and 5). Rhodes and Blanchard (1980) reanalyzed the sample with the same result. Essene et al. (1970) and Beatty and Albee (1978) determined the composition of thin sections by measuring the mode and combining with average mineral compositions (table 1b).

**Table 1a. Chemical composition of 10047.**

reference weight	Compston70	Rose70	Goles70	Rhodes80	Wakita70		Ganapathy70	Anders71
					351 mg	563 mg		
SiO2 %	42.16	(a) 41.3	(b) 43	(c) 41.6	(a) 44.5	46	(c)	
TiO2	9.43	(a) 10.2	(b) 10	(c) 10.02	(a) 10.8	9.5	(c)	
Al2O3	9.89	(a) 9.8	(b) 10.6	(c) 10.27	(a) 7.4	11.1	(c)	
FeO	19.11	(a) 19	(b) 19.4	(c) 19.09	(a) 21.9	19.8	(c)	
MnO	0.28	(a) 0.29	(b) 0.27	(c) 0.3	(a) 0.35	0.29	(c)	
MgO	5.67	(a) 6.1	(b) 5.8	(c) 5.99	(a) 6.8	4.8	(c)	
CaO	12.15	(a) 12.2	(b) 12.2	(c) 12.16	(a) 13.6	12.6	(c)	
Na2O	0.45	0.65	(b) 0.47	(c) 0.44	(c) 0.35	0.49	(c)	
K2O	0.11	(a) 0.11	(b)	0.1	(a) 0.082	0.06	(c)	
P2O5	0.11	(a)		0.11	(a)			
S %	0.18	(a)						
sum								
Sc ppm			92	(c) 92	(c) 120	90	(c)	
V	13	(a)	63	(c)	73	57	(c)	
Cr	1220	(a) 1505	(b) 1250	(c) 1480	(c) 1810	1380	(c)	
Co	16	(a)	12.2	(c) 11.3	(c) 15	19	(c)	14.4 (d) 12 (d)
Ni	<20	(a)						
Cu	16	(a)					13.3	(d)
Zn	13	(a)					5.76	(d) 1.8 (d)
Ga	4	(a)		8.9	(a)		5.35	(d)
Ge ppb								
As								
Se								0.25 (d)
Rb	1.11	(a)		1.3	(a)		1.25	(d) 1.54 (d)
Sr	209	(a)		219	(a)			
Y	134	(a)		128	(a)			
Zr	334	(a)				70	800	(c)
Nb	23	(a)						
Mo								
Ru								
Rh								
Pd ppb							2	(d)
Ag ppb							25	(d) 1.89 (d)
Cd ppb							255	(d)
In ppb							109	(d) 2.8 (d)
Sn ppb								
Sb ppb								
Te ppb							13	(d)
Cs ppm							0.045	(d) 0.06 (d)
Ba	88	(a)			250	290	(c)	
La	20	(a)	11.3	(c) 10.4	(c) 8.5	12.2	(c)	
Ce	48	(a)	46	(c) 39	(c)			
Pr	13	(a)						
Nd	36	(a)						
Sm			18.9	(c) 15.8	(c) 16.1	20.2	(c)	
Eu			2.71	(c) 2.51	(c) 2.2	2.9	(c)	
Gd								
Tb			4.1	(c) 3.7	(c)			
Dy								
Ho			7.9	(c)				
Er								
Tm								
Yb			18.2	(c) 12.6	(c) 18	18	(c)	
Lu			2.88	(c) 1.93	(c) 2.3	2.3	(c)	
Hf			13.2	(c) 11.3	(c) 15	16	(c)	
Ta			2.6	(c) 2.2	(c)			
W ppb								
Re ppb								
Os ppb								
Ir ppb							0.24	(d) 0.005 (d)
Pt ppb								
Au ppb							0.33	(d) 0.029 (d)
Th ppm	0.6	(a)		0.8	(c) 2.4	1.6	(c)	
U ppm			0.16	(c)				

technique: (a) XRF, (b) micro XRF, (c) INAA, (d) RNAA

**Table 1b. Chemical composition of 10047.**

<i>reference weight</i>	Essene70	Beaty78	Hurley 70	Silver 70	
SiO2 %	41.8	42.51	(f)		
TiO2	9.6	9.21	(f)		
Al2O3	10.1	10.54	(f)		
FeO	18.6	19.31	(f)		
MnO	0.24	0.26	(f)		
MgO	5.7	5.51	(f)		
CaO	11.9	11.82	(f)		
Na2O	0.51	0.48	(f)		
K2O	0.08	0.02	(f)		
P2O5		0.13	(f)		
S %		0.22	(f)		
<i>sum</i>					
Sc ppm					
V					
Cr					
Co					
Ni					
Cu					
Zn					
Ga					
Ge ppb					
As					
Se					
Rb			0.93	(e)	
Sr			194	(e)	
Y					
Zr					
Nb					
Mo					
Ru					
Rh					
Pd ppb					
Ag ppb					
Cd ppb					
In ppb					
Sn ppb					
Sb ppb					
Te ppb					
Cs ppm					
Ba					
La					
Ce					
Pr					
Nd					
Sm					
Eu					
Gd					
Tb					
Dy					
Ho					
Er					
Tm					
Yb					
Lu					
Hf					
Ta					
W ppb					
Re ppb					
Os ppb					
Ir ppb					
Pt ppb					
Au ppb					
Th ppm			0.849	0.6	(e)
U ppm			0.246	0.203	(e)

*technique: (a) XRF, (b) micro XRF, (c) INAA, (d) RNAA, (e) IDMS, (f) elec. Probe*

Ganapathy et al. (1970) analyzed a powder prepared from 10047, but when Anders et al. (1971) analyzed a chip instead they obtained much lower values for trace elements. Reed and Jonvanovic (1970) reported Li, F, Cl, Br and I.

**Radiogenic age dating**

Stettler et al. (1974) and Guggisberg et al. (1979) determined crystallization ages of 3.74 and 3.71 b.y. by the Ar/Ar plateau technique (figure 6 and 7).

**Cosmogenic isotopes and exposure ages**

Marti et al. (1970), Arvidson et al. (1975) and Eugster et al. (1984) reported <sup>81</sup>Kr exposure ages of 86 m.y., 84 m.y. (determined by Schwaller 1971) and 87.4 m.y., respectively. Stettler et al. (1974) and Guggisberg et al. (1979) determined an <sup>37</sup>Ar/<sup>38</sup>Ar cosmic ray exposure age of 70 and 78 m.y. respectively. Eberhardt et al. (1970) calculated 110 m.y. from data by Funkhouser et al. (1970).

**Other Studies**

Oxygen isotopes were reported for mineral separates of 10047 by Onuma et al. (1970).

Rare gas abundance and isotopic ratios were reported by Eugster et al. (1984), Funkhouser et al. (1970) and Bogard et al. (1971).

Crozaz et al. (1970) studied the fossil comic ray track density as a function of depth in plagioclase and pyroxene crystals from 10047 (figure 8) and determined an exposure age of 16 m.y.

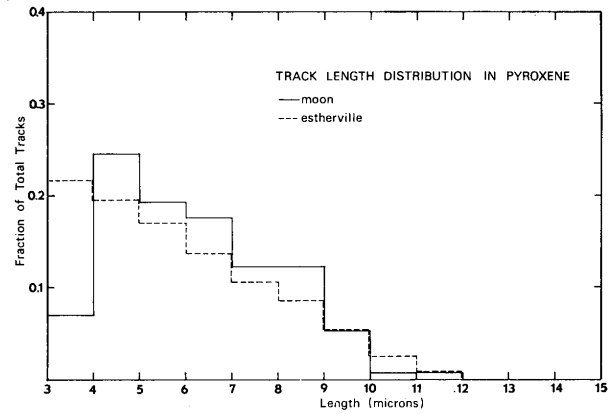


Figure 8: Track length in pyroxene from 10047 compared with Esterville meteorite (Crozaz et al. 1970).

**List of Photo #s for 10047**

- S69-53977 B&W TS
- S69-53980
- S69-54011 – 12
- S69-54044
- S69-54048
- S69-54064
- S69-59269
- S69-59277
- S69-59282
- S70-48962 – 3 color TS
- S70-49212 – 3
- S70-50541 – 2
- S76-26298 – 9 B&W TS
- S72-32082
- S75-25083 – 87 Processing
- S75-26511 – 14
- S76-25537
- S76-25542
- S82-27857

**Processing**

Apollo 11 samples were originally described and cataloged in 1969 and then “re-cataloged” by Kramer et al. in 1977.

