10022

Ilmenite Basalt (high K)

95.6 grams

Figure 1: Photo of 10022,31 showing vesicles (~2 mm). Cube is 1 cm. NASA S76-25940..

Introduction

Lunar sample 10022 is a fine-grained, vesicular, high-K ilmenite basalt (figure 1). 10022 as collected as part of the contingency sample collected from the area between the LM and the flag. It was photographed before collection on the lunar surface and the lunar orientation is known (see Schmitt et al. 1970). An age of 3.6 b.y has been determined and it has been exposed to cosmic rays for ~500 m.y.

Petrography

Schmitt et al. (1970) termed 10022 a "fine-grained, vesicular, plumose, subophitic, olivine basalt." Weill et al. (1970) described it as "fine-grained, holocrystalline, vesicular basalt". Beaty and Albee (1978) termed the texture "microporphyritic", because the pyroxene grains were about twice that of the groundmass minerals (average grain size ~150 microns). The texture of 10022 is different from that of any of the other Apollo 11 basalt. It is not clear whether the large pyroxene grains are true phenocrysts are not (figure 2).

Vesicles (gas bubbles) in 10022 are perfectly round; 1 - 3 mm in size.

Mineralogy

Olivine: Weill et al. (1970), Kushiro and Nakamura (1970) and Beaty and Albee (1978) reported minute olivine grains included within augite. Olivine in 10022 is chemically zoned (Fo_{71-41}).

Pyroxene: Large augite grains have pigeonite cores (figure 3). Kushiro and Nakamura (1970) determined the composition of coexisiting augite-pigeonite pairs.

Plagioclase: Smith et al. (1970) determined the composition of plagioclase An_{77-71}. Kushiro and Nakamura (1970) found a range An_{81-73}. Weill et al. (1970) remarked on the apparent non-stoichiometry of lunar plagioclase.

Ilmenite: Ilmenite in 10022 has both a tabular and "thin platy" habit as though there were two generations

Figure 2: Photomicrographs of thin section 10022,40. Top is plane polarized light, bottom is crossed nicols. NASA S70-49196-197. Field of view is 2.5 mm.

(Cameron 1970). Smith et al. (1970) found that ilmenite had variable MgO content (0.1 to 3.4%).

Armalcolite: Anderson et al. (1970) and Smith et al. (1970) reported the chemical composition of armalcolite in 10022.

Chemistry

Figures 4 and 5 and table 1 give the composition of 10022. It has a high content of trace elements.

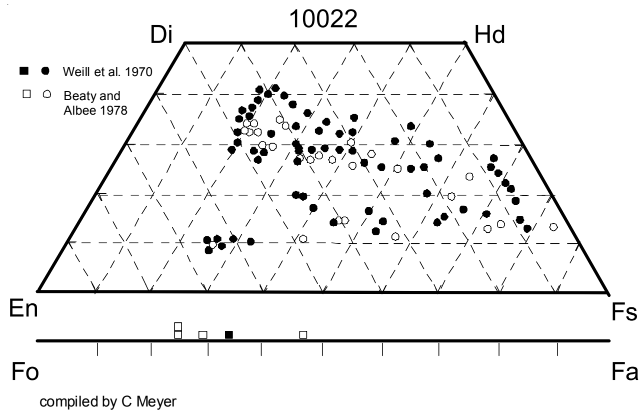

Figure 3: Pyroxene and olivine composition of 10022 (data replotted from Weill et al. 1970 and Beaty and Albee 1978).

Radiogenic age dating

Turner (1970) dated 10022 by Ar/Ar plateau technique at 3.59 ± 0.06 b.y. (figure 6) and Geiss et al. (1977) also obtained a low temperature plateau of 3.58 b.y.

Cosmogenic isotopes and exposure ages

Turner et al. (1970) and Guggisberg et al. (1979) determined ^{38}Ar exposure ages 380 m.y. and 520 m.y., respectively. Eberhardt et al. (1970) calculated 420 m.y. from data by Funkhouser et al. (1970).

Other Studies

Oxygen isotopes were reported for mineral separates of 10022 by Onuma et al. (1970).

Funkhouser et al. (1970) and Bogard et al. (1971) reported the abundance and isotopic composition of rare gasses from 10022.

Helsley (1970) reported magnetic properties.

Grove and Beaty (1980) performed experiments related to high-K Apollo 11 basalts.

Mineralogical Mode for 12022

	Kushiro and Nakamura 70	Beaty and Albee 78	Weill et al. 1970
Olivine		0.1	tr.
Pyroxene	48.9	52.6	55
Plagioclase	15.6	21.6	29
Ilmenite	26.3	14.1	15
mesostasis	8.6		
silica	0.6	0.8	
troilite		0.6	1
phosphate		0.2	

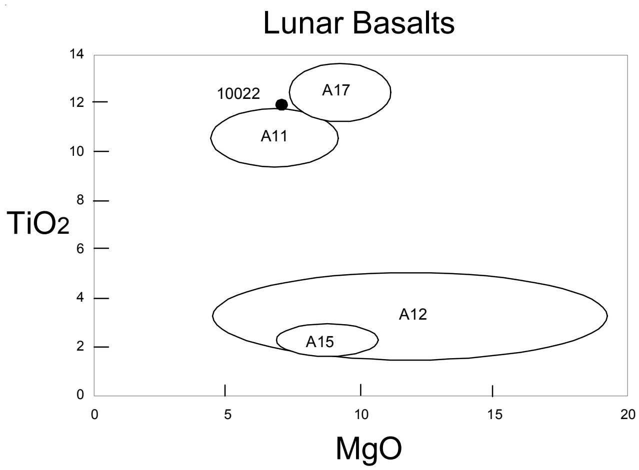

Figure 4: Composition of 10022 compared with that of other Apollo lunar samples.

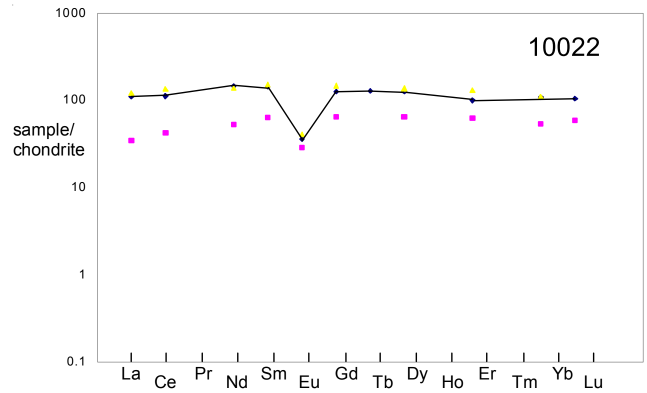

Figure 5: Normalized rare-earth-element composition for high-K basalt 10022 (the line) compared with that of low-K basalt 10020 and high-K basalt 10049 (the dots) (data from Haskin et al. 1970).

Processing

Apollo 11 samples were originally described and cataloged in 1969 and "re-cataloged" by Kramer et al. (1977). There are 9 thin sections.

List of Photo #s for 10022

S69-47623 – 47624 TS B&W
S69-45210 – 213 mug
S69-45523 – 527
S69-45380
S69-45560
S69-46328
S70-48942 – 944 TS
S70-49196 – 197 TS color
S74-27029 ,108 display
S76-25426 – 430 ,108
S76-25938 – 943 ,31
S76-26297 reflected TS
S76-26311 ,57

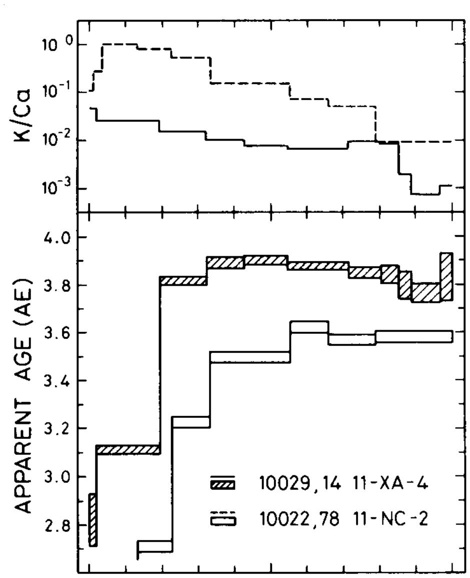

Figure 6: Ar/Ar age of high K vrs low K Apollo 11 basalts (Guggisberg et al. 1979).

References for 10022

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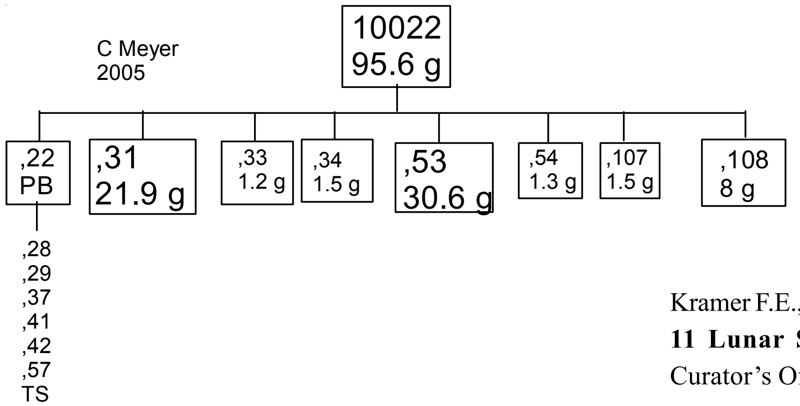
Summary of Age Data for 10022

	Rb/Sr	Ar/Ar
Turner 1970		3.59 ± 0.06 b.y.
Geiss et al. 1977		(3.58 ± 0.04)

Table 1. Chemical composition of 10022.

reference	LSPET69		Rose70		Goles70		Haskin70			Beaty78		Gopalan70	Hurley70	Murthy70	
weight															
SiO2 %	43	(a)	40.1	(b)	41.5	(c)				40.93	(d)				
TiO2	11	(a)	12.2	(b)	11.8	(c)				11.72	(d)				
Al2O3	7.7	(a)	8.6	(b)	8.5	(c)				8.01	(d)				
FeO	21	(a)	18.9	(b)	20.2	(c)	18.6		(c)	18.66	(d)				
MnO	0.26	(a)	0.25	(b)	0.23	(c)	0.22		(c)	0.23	(d)				
MgO	6.5	(a)	7.74	(b)	6.8	(c)				8.29	(d)				
CaO	9	(a)	10.7	(b)	10.4	(c)				11.36	(d)				
Na2O	0.4	(a)	0.91	(b)	0.48	(c)				0.48	(d)				
K2O	0.21	(a)	0.3	(b)			0.26		(c)	0.22	(d)			0.27	(e)
P2O5										0.1	(d)				
S %										0.31	(d)				
sum															
									(c)						
Sc ppm					76.6	(c)	76		(c)						
V	36	(a)			89	(c)									
Cr	2800	(a)	2531	(b)	2250	(c)	2254		(c)						
Co	15	(a)			29.8	(c)	29		(c)						
Ni	320	(a)													
Cu							5.1		(c)						
Zn							2.9		(c)						
Ga							2.9		(c)						
Ge ppb															
As							0.063		(c)						
Se							0.7		(c)						
Rb							5.7		(c)			5.66	6	5.57	(e)
Sr	110						164		(c)			165.9	173	163	(e)
Y	230														
Zr	1000		300	(b)											
Nb															
Mo															
Ru															
Rh															
Pd ppb															
Ag ppb							2.3		(c)						
Cd ppb															
In ppb							7.8		(c)						
Sn ppb															
Sb ppb							5.6		(c)						
Te ppb															
Cs ppm							0.2		(c)						
Ba	100				220	(c)	228		(c)					277	(e)
La					25.9	(c)	26.4	26.4	(c)						
Ce					81	(c)	68	69	(c)						
Pr															
Nd							66	64	(c)						
Sm					20.3	(c)	21.2	21.2	(c)						
Eu					2.15	(c)	2.04	1.98	(c)						
Gd							25	22.9	(c)						
Tb					5.7	(c)	4.7	4.31	(c)						
Dy							31.2	29	(c)						
Ho					8.2	(c)									
Er							16	15.6	(c)						
Tm															
Yb	7				21	(c)	17.7	17.3	(c)						
Lu					2.69	(c)	2.55	2.39	(c)						
Hf					19.6	(c)	21.5		(c)						
Ta					1.8	(c)	1		(c)						
W ppb															
Re ppb															
Os ppb															
Ir ppb															
Pt ppb															
Au ppb							0.1		(c)						
Th ppm															
U ppm					0.67	(c)									

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



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