

10022

Ilmenite Basalt (high K)

95.6 grams

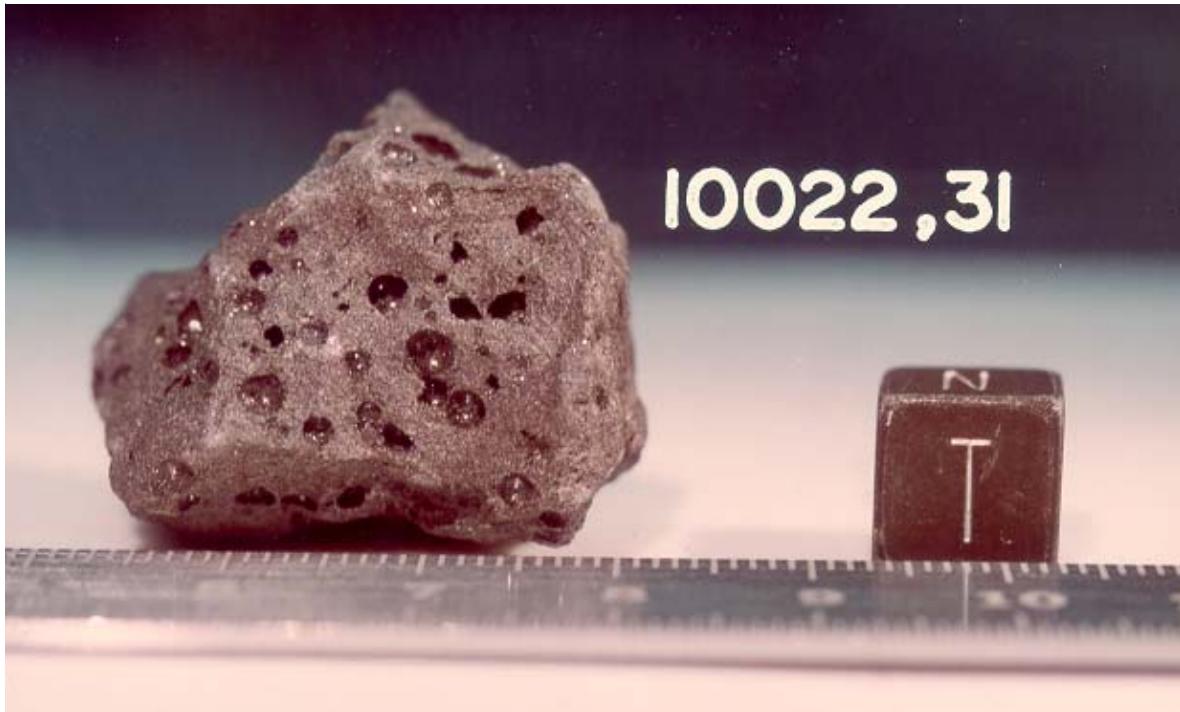


Figure 1: Photo of 10022,31 showing vesicles (~2 mm). Cube is 1 cm. NASA S76-25940..

Introduction

Lunar sample 10022 is a fine-grained, vesicular, high-K ilmenite basalt (figure 1). 10022 was 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”. Beatty 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 Beatty 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 coexisting 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.

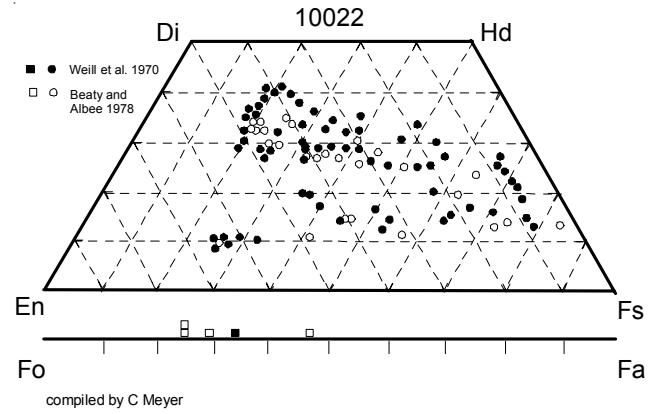


Figure 3: Pyroxene and olivine composition of 10022 (data replotted from Weill et al. 1970 and Beatty and Albee 1978).

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 Beatty (1980) performed experiments related to high-K Apollo 11 basalts.

Mineralogical Mode for 12022

	Kushiro and Nakamura 70	Beatty 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	

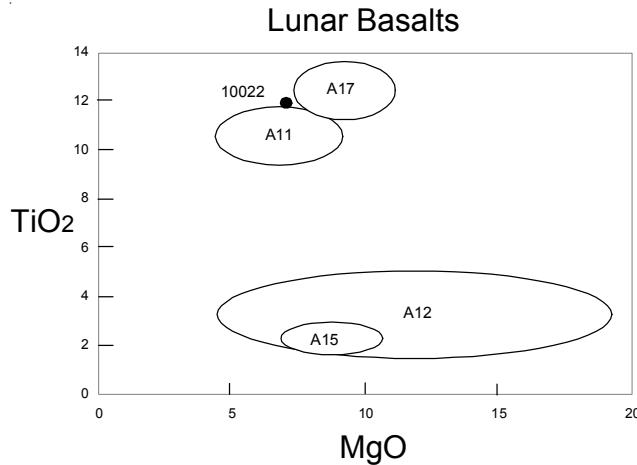


Figure 4: Composition of 10022 compared with that of other Apollo lunar samples.

Processing

Apollo 11 samples were originally described and catalogued in 1969 and “re-catalogued” 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

References for 10022

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Beaty D.W. and Albee A.L. (1978) Comparative petrology and possible genetic relations among the Apollo 11 basalts. *Proc. 9th Lunar Planet. Sci. Conf.* 359-463.

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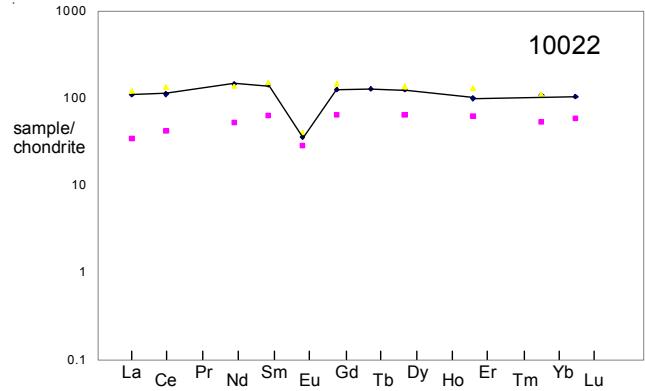


Figure 5: Normalized rare-earth-element composition for high-K basalt 10022 (the line) compared with that of low-K basalt 10020 and high-K basalt 10049 (the dots) (data from Haskin et al. 1970).

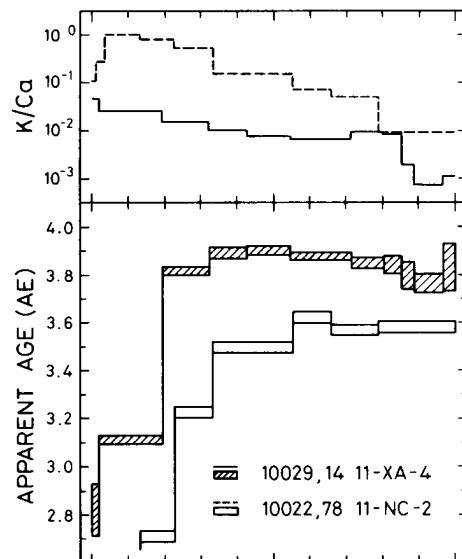


Figure 6: Ar/Ar age of high K vs low K Apollo 11 basalts (Guggisberg et al. 1979).

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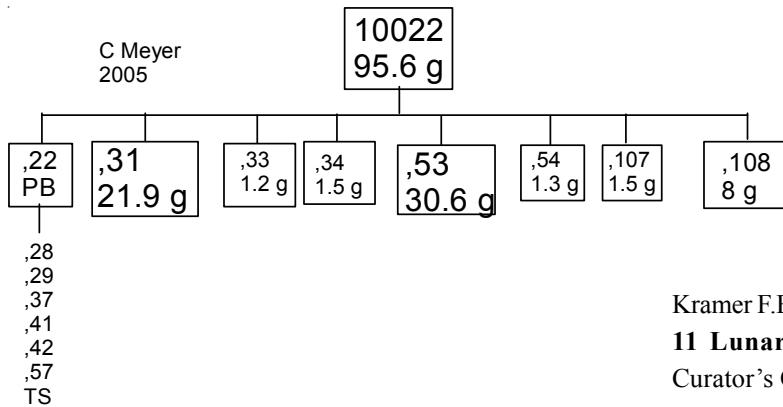
Summary of Age Data for 10022

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 weight	LSPET69	Rose70	Goles70	Haskin70	Beaty78	Gopalan70	Hurley70	Murthy70
SiO ₂ %	43	(a) 40.1	(b) 41.5	(c)	40.93	(d)		
TiO ₂	11	(a) 12.2	(b) 11.8	(c)	11.72	(d)		
Al ₂ O ₃	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)		
Na ₂ O	0.4	(a) 0.91	(b) 0.48	(c)	0.48	(d)		
K ₂ O	0.21	(a) 0.3	(b)	0.26	(c) 0.22	(d)	0.27	(e)
P ₂ O ₅					0.1	(d)		
S %					0.31	(d)		
<i>sum</i>								
Sc ppm			76.6	(c) 76	(c)	(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
Sr	110			164	(c)	165.9	173	163
Y	230							(e)
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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