12039

Pigeonite Basalt

255 grams

Figure 1: Photo of sawn surface of 12039,18 showing coarse-grained, basaltic textures. Ruler is marked in cm. NASA #S75-34141.

Introduction

12039 was termed a graphic ilmenite-bearing gabbro by James and Wright (1972) and pigeonite basalt by Rhodes et al. (1977) and Neal et al. (1994). The sampling location of 12039 is not known. It is rounded and has zap pits that are hard to see. It has been dated at 3.2 b.y.

Petrography

McGee et al. (1977) describe 12039 as "a coarse grained porphyritic basalt which consists of pyroxene phenocrysts (0.8 to 4 mm), some of which are mantled by pyroxferroite, set in a matrix of intergrown plagioclase tablets (0.8 - 2 mm), anhedral pyroxene, rounded laths of ilmenite (0.8 – 2 mm) and euhedral laths of tridymite (0.05 to 1 mm)". Bunch et al. (1972) describe 12039 as a "micrograbbro, with variable texture ranging from subophitic to granular, and occasionally clinopyroxene grains are poikilitically enclosed by plagioclase".

Long needles of ilmenite and tridymite cut across plagioclase and pyroxene (figure 2).

Figure 2: Reflected light photo of thin section 12039,5 showing abundant long needles of ilmenite (light, highy reflective) and tridymite (dark, low reflectivity, low relief). Scale is 3 cm. NASA #S70-16111.

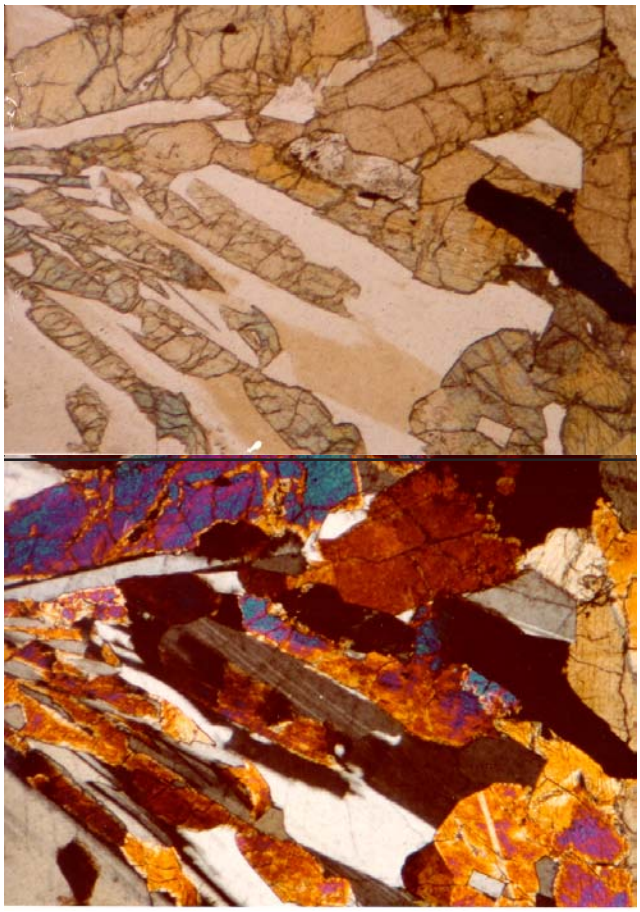


Figure 3: Photomicrographs of thin section 12039,6 (plane-polarized and crossed-nicols). Scale is 2.6 mm. NASA #S79-27116.

Mineralogy

Olivine: none

Pyroxene: Pyroxene analyses for 12039 are given by Bunch et al. (1972) and McGee et al. (1977) (figure 4). According to Bunch et al. (1972), many of the clinopyroxene crystals show optical zonation from very light tan interiors (augite) to dark tan (ferroaugite) to redish-brown (ferrohedenbergite) with an abrupt change to light yellow-green borders (pyroxferroite).

Plagioclase: Plagioclase is An_{93} to An_{82} (Bunch et al. 1972).

Opaques: Ilmenite is the major opaque phase and is intergrown with ulvöspinel. Tranquillityite, troilite and native iron blebs are present in the mesostasis.

Silica: Bunch et al. (1972) analyzed both tridymite and cristobalite in 12039.

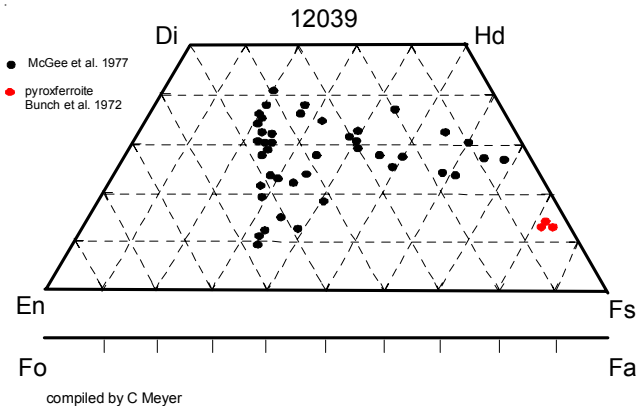


Figure 4: Pyroxene composition in 12039 (from McGee et al. 1977, Bunch et al. 1972).

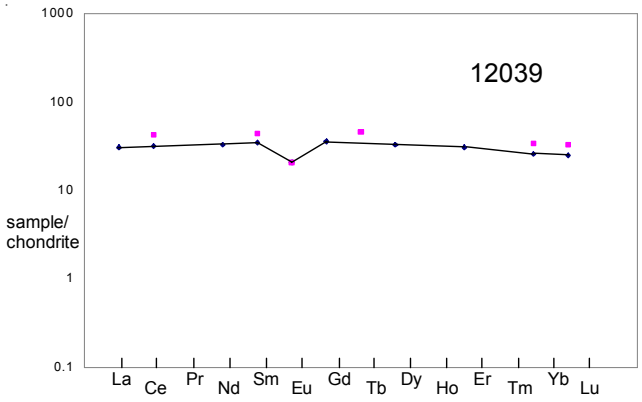


Figure 5: Normalized rare-earth-element diagram (isotope dilution data connected).

Tranquillityite: Lovering et al. (1971) give the analysis of tranquillityite in 12039.

Chemistry

Rhodes et al. (1977) and Nyquist et al. (1977) determined the composition of 12039 (figures 5 and 6). It has the highest Fe/Mg ratio of the Apollo 12 basalts.

Radiogenic age dating

Nyquist et al. (1977, 1979) determined the Rb-Sr age as 3.19 ± 0.06 b.y. (figure 8) and a concordant age of 3.2 ± 0.05 b.y. by Nd-Sm (figure 7).

Cosmogenic isotopes and exposure ages

O'Kelly et al. (1971) reported the cosmic-ray induced activity to be ^{22}Na = 43 dpm/kg, ^{26}Al = 95 dpm/kg, ^{54}Mn = 37 dpm/kg and ^{56}Co = 40 dpm/kg.

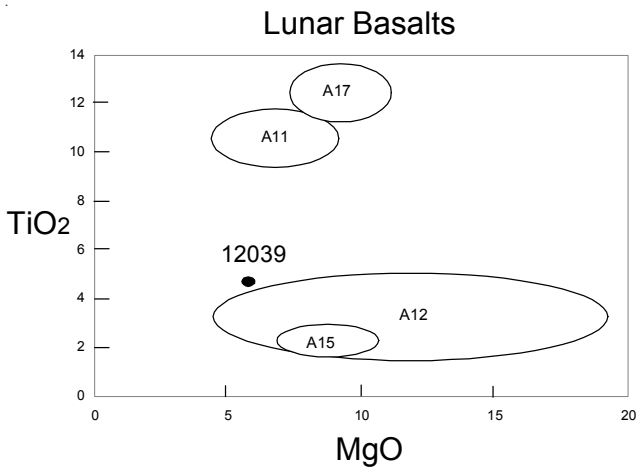


Figure 6: Composition of 12039 compared with that of other luanr basalts.

Processing

12039 was cut with a band saw (figure 10). It has been used for public display (figure 9). There are 8 thin sections.

Mineralogical Mode of 12039

	McGee et al. 1977	Neal et al. 1994	Bunch et al. 1972
olivine	- -	- -	
pyroxene	50-56	55	49.7
pyroxferroite			6.7
plagioclase	27-34	39.5	27.5
ilmenite	8-10	2.8	7.8
chromite + usp.		1.5	0.7
"silica"	7	0.5	7.3
mesostasis		0.5	0.3

Table 1. Chemical composition of 12039.

reference	Rhodes77		Nyquist77		LSPET70		O'Kelly71		Bunch72
weight					255 g		255 g		
SiO2 %	46.09	(c)							47.3
TiO2	4.46	(c)							3.04
Al2O3	10.52	(c)							10.7
FeO	20.32	(c)							21.1
MnO	0.29	(c)							0.19
MgO	5.75	(c)							5.3
CaO	11.67	(c)							12.1
Na2O	0.29	(a)							0.36
K2O	0.1	(c)	0.07	(b)	0.073	(d)	0.081	(d)	0.09
P2O5	0.09	(c)							0.09
S %	0.11	(c)							
sum									
Sc ppm	56	(a)							
V									
Cr	2500	(a)							
Co	28	(a)							
Ni									
Cu									
Zn									
Ga									
Ge ppb									
As									
Se									
Rb			1.29	(b)					
Sr	122	(c)	138	(b)					
Y	52	(c)							
Zr	156	(c)							
Nb	10.7	(c)							
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb									
In ppb									
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm									
Ba	88	(b)	74.4	(b)					
La			7.25	(b)					
Ce	25.7	(a)	19.5	(b)					
Pr									
Nd			15	(b)					
Sm	6.55	(a)	5.1	(b)					
Eu	1.18	(a)	1.17	(b)					
Gd			7.01	(b)					
Tb	1.66	(a)							
Dy			8.17	(b)					
Ho									
Er			4.92	(b)					
Tm									
Yb	5.5	(a)	4.31	(b)					
Lu	0.81	(a)	0.604	(b)					
Hf	4.7	(a)							
Ta									
W ppb									
Re ppb									
Os ppb									
Ir ppb									
Pt ppb									
Au ppb									
Th ppm					1.2	(d)	1.2	(d)	
U ppm					0.31	(d)	0.31	(d)	

technique: (a) INAA, (b) IDMS, (c) XRF, (d) radiation counting, (e) electron microprobe

List of Photo #s for 12039

S69-61466 – 61489	
S69-63859 – 63861	
S70-16111	TS B & W
S70-17703	display
S70-17962 – 17965	
S70-19137 – 19147	
S70-22440 – 22451	color mug
S70-48847 – 48855	
S70-49963 – 49966	TS color
S70-50030 – 50031	
S72-32868	
S75-34141	processing
S76-21578	sawing
S79-27116 – 27117	

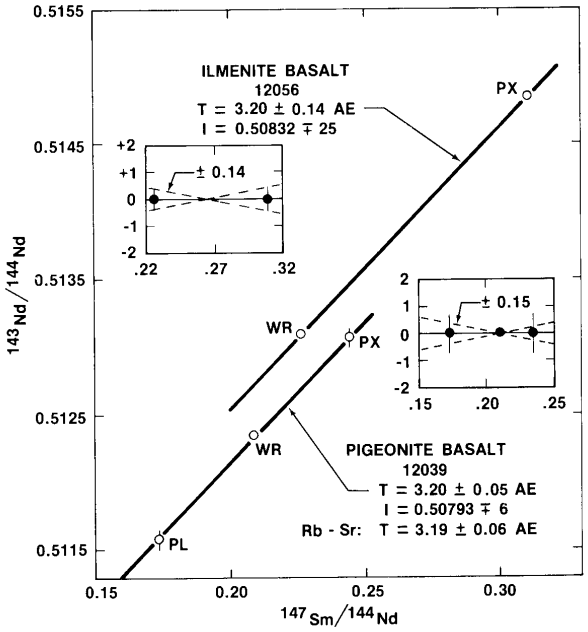


Figure 7: Sm-Nd mineral isochron diagrams for 12039 and 12056 (Nyquist et al. 1979).

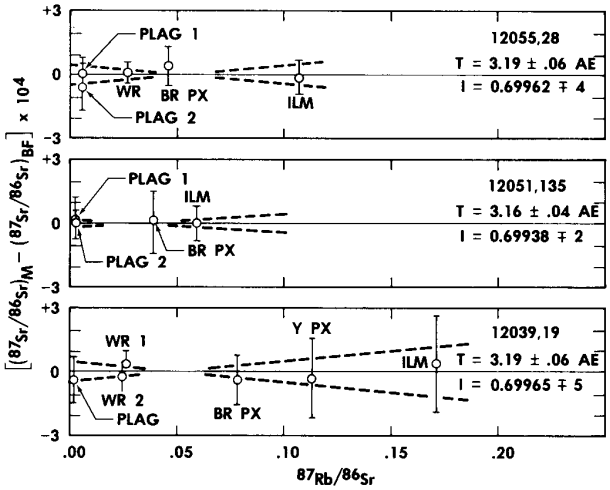


Figure 8: Rb/Sr isochron diagrams for selected Apollo 12 samples inc. 12039 (Nyquist et al. 1977).

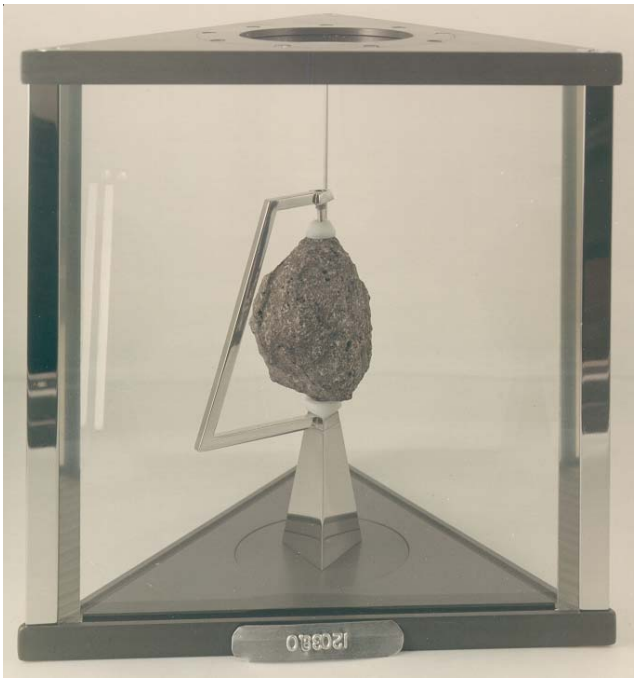


Figure 9: 12038,0 on display. NASA #S70-17703.

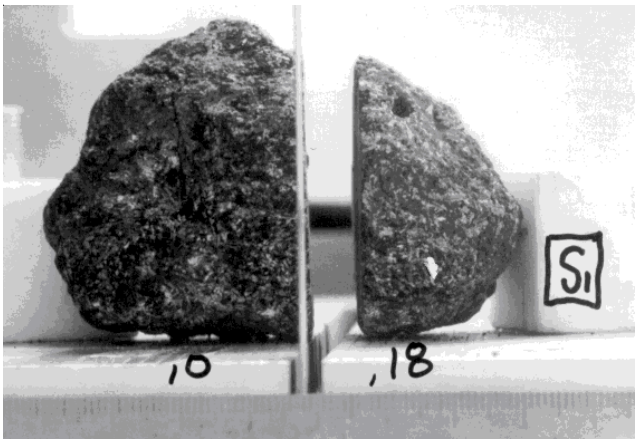
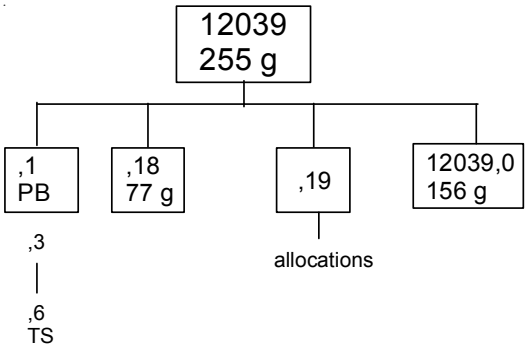


Figure 10: Bandsawing 12039. NASA #S76-21578.



Summary of Age Data for 12039

	Ar/Ar	Rb/Sr	Sm/Nd
Nyquist et al. 1977		3.19 ± 0.06 b.y.	
Nyquist et al. 1979			3.2 ± 0.05

References for 12039

Bunch T.E., Keil K. and Prinz M. (1972c) Mineralogy, petrology and chemistry of lunar rock 12039. *Meteoritics* **7**, 245-255.

Bunch T.E., Prinz M. and Keil K. (1972d) Electron microprobe analyses of lithic fragments and glasses from Apollo 12 lunar samples. Special. Pub. #4, UNM Institute of Meteoritics, ABQ.

James O.B. and Wright T.L. (1972) Apollo 11 and 12 mare basalts and gabbros: Classification, compositional variations and possible petrogenetic relations. *Geol. Soc. Am. Bull*. **83**, 2357-2382.

Lovering J.F. and 14 authors (1971) Tranquillityite: A new silicate mineral from Apollo 11 and Apollo 12 basaltic rocks. *Proc. Second Lunar Science Conf.* 39-45.

LSPET (1970) Preliminary examination of lunar samples from Apollo 12. *Science* **167**, 1325-1339.

McGee P.E., Warner J.L. and Simonds C.H. (1977) Introduction to the Apollo Collections. Part I: Lunar Igneous Rocks. Curators Office, JSC.

Neal C.R., Hacker M.D., Snyder G.A., Taylor L.A., Liu Y.-G. and Schmitt R.A. (1994a) Basalt generation at the Apollo 12 site, Part 1: New data, classification and re-evaluation. *Meteoritics* **29**, 334-348.

Neal C.R., Hacker M.D., Snyder G.A., Taylor L.A., Liu Y.-G. and Schmitt R.A. (1994b) Basalt generation at the Apollo 12 site, Part 2: Source heterogeneity, multiple melts and crustal contamination. *Meteoritics* **29,** 349-361.

Nyquist L.E., Bansal B.M., Wooden J. and Wiesmann H. (1977) Sr-isotopic constraints on the peterogenesis of Apollo 12 mare basalts. *Proc. 8th Lunar Sci. Conf.* 1383-1415.

Nyquist L.E., Shih C.-Y., Wooden J.L., Bansal B.M. and Wiesmann H. (1979) The Sr and Nd isotopic record of Apollo 12 basalts: Implications for lunar geochemical evolution. *Proc. 10th Lunar Planet. Sci.* Conf. 77-114.

O'Kelley G.D., Eldridge J.S., Schonfeld E. and Bell P.R. (1971a) Abundances of the primordial radionuclides K, Th, and U in Apollo 12 luanr samples by nondestructive gamma-ray spectroscopy: implications for the origin of lunar soils. *Proc. Second Lunar Sci. Conf.* 1159-1168.

O'Kelley G.D., Eldridge J.S., Schonfeld E. and Bell P.R. (1971b) Cosmogenic radionuclide concentrations and exposure ages of lunar samples from Apollo 12. *Proc. Second Lunar Sci. Conf*. 1747-1755.

Rhodes J.M., Blanchard D.P., Dungan M.A., Brannon J.C., and Rodgers K.V. (1977) Chemistry of Apollo 12 mare basalts: Magma types and fractionation processes. *Proc. 8th Lunar Sci. Conf.* 1305-1338.