12031

Pigeonite Basalt

185 grams

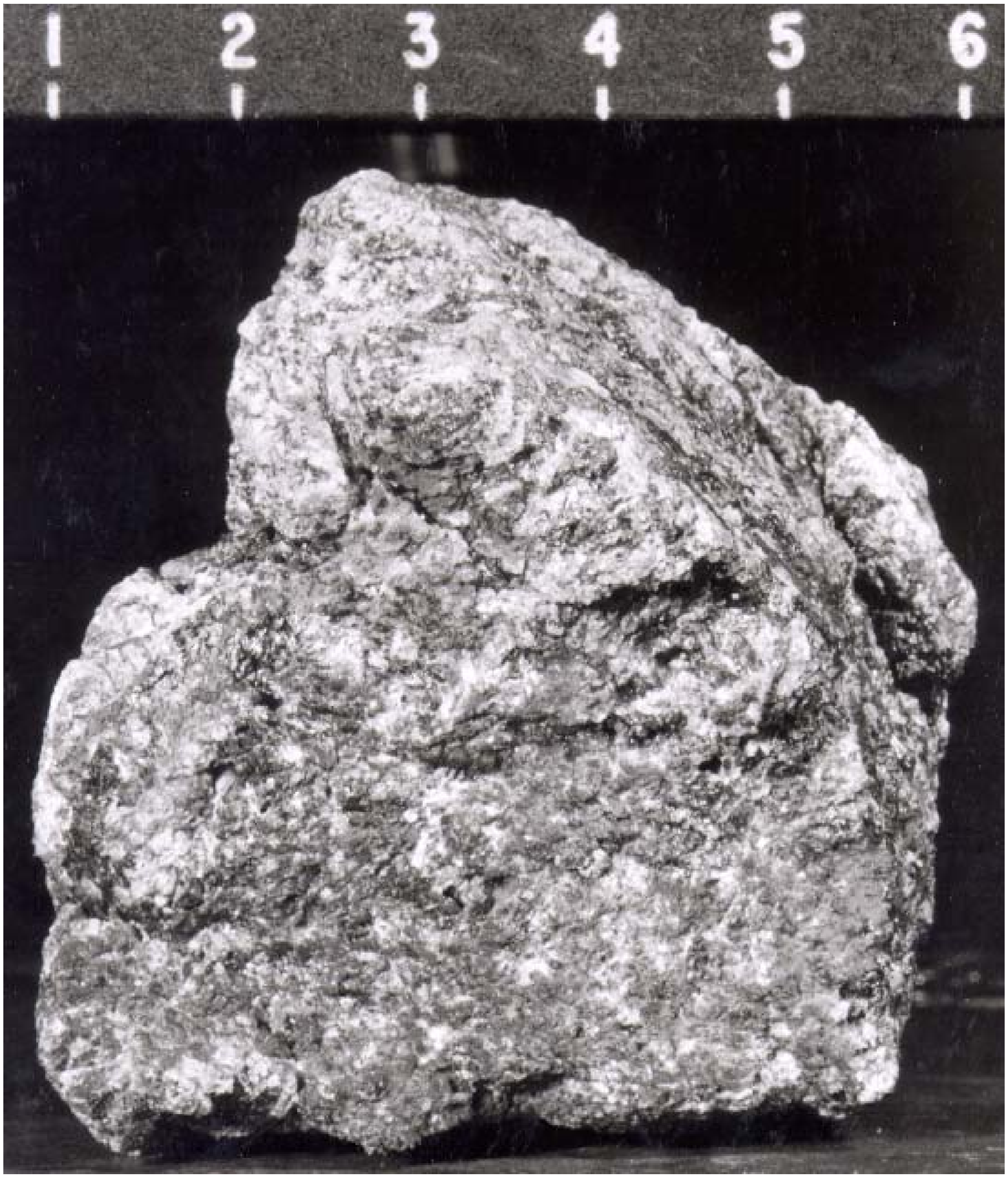


Figure 1: Photo of 12031. NASA #S69-63652.

Introduction

This interesting rock is not well studied, nor characterized. It has a remarkably coarse-grained mesostasis, thus allowing accurate analysis of minor minerals (not accomplished). It has been dated at 3.2 b.y.

Petrography

Beaty et al. (1979) describe 12031 as a "coarse-grained (~2 mm), equigranular rock with a variable texture. On the thin section they studied, graphic intergrowths of pyroxene and plagioclase on one side give way to a more granular, gabbroic texture on the other side (figure

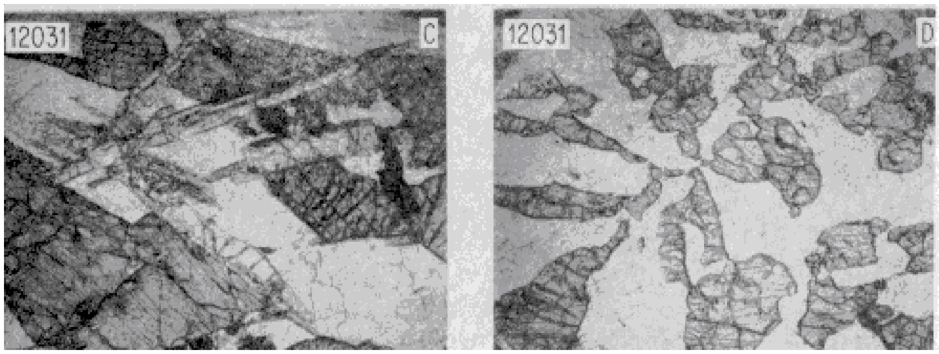


Figure 2: Two different textures of 12031 (from Beaty et al. 1977). Scale about 1.5 mm.

Mineralogical Mode of 12031

	Beaty et al. 1979	Neal et al. 1994
Olivine	- -	- -
Pyroxene	49.2	49.2
Plagioclase	40.2	40.2
Ilmenite	3.77	3.9
Chromite	0.05	0.1
"silica"	4.9	4.9
mesostasis	0.36	0.9

2). Elongated and externally skeletal ilmenite, tridymite laths and interstitial cristobalite constitute the rest of the rock. Magnesian olivine and Cr-spinel are absent and pyroxenes are neither lath-shaped nor porphritic. Plagioclase occurs as large, anhedral, poikilitic grains with prominent and complicated twinning."

Mesostasis phases are remarkably coarse-grained. Troilite is associated with phosphate at the junction of pyroxene and pyroxferroite. At the junction, pyroxferroite breaks down to fayalite, cristobalite and Fe-rich pyroxene in wormy intergrowths.

Although Beaty et al. grouped 12031 with 12038 (feldspathic basalt), on the basis of Sr isotopic analysis, Nyquist et al. (1981) showed convincingly that 12031 was instead a pigeonite basalt. Neal et al. (1994) found that it grouped instead with the ilmenite basalts.

Mineralogy

Olivine: Minor fayalite.

Pyroxene: Figure 7 shows large pyroxene crystals up to 3 cm long radiating outward from a common point. Beaty et al. (1979) show a scatter diagram for pyroxene with many points at ferroheddenbergite and "discontinuous" pyroxferroite. Complete pyroxene analyses are replotted in figure 3.

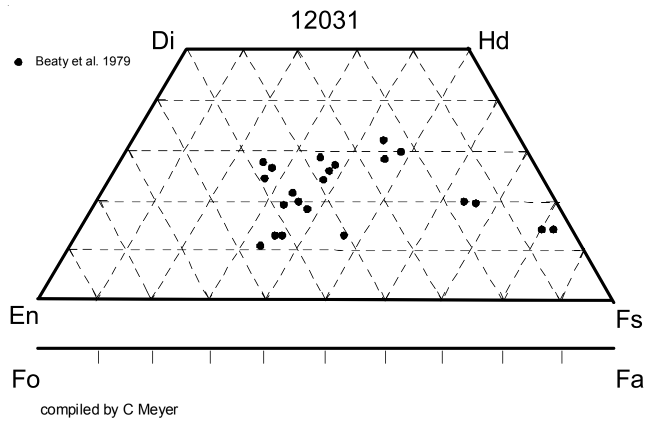


Figure 3: Pyroxene composition for 12031 (adapted from Beaty et al. 1979).

Pyroxferroite: Beaty et al. (1979) reported pyroxferroite up to 3 mm.

Plagioclase: Beaty et al. (1979) found a wide range of plagioclase composition An_{98-48}, with significant Or content and silica deficiency. However, the average plagioclase composition is $An_{90.6}$.

Ilmenite: Ilmenite is low MgO.

Tridymite: Tridymite laths are up to 1 mm in length.

Chemistry

The chemical composition was determined by Rhodes et al. (1977) and Nyquist et al. (1977 and 1979).

Radiogenic age dating

Nyquist et al. (1979) determined a Rb-Sr mineral isochron of 3.23 ± 0.07 b.y. (figure 6).

Processing

12031 was not sawn. When chipped, it crumbled (figure 7). There are 8 thin sections.

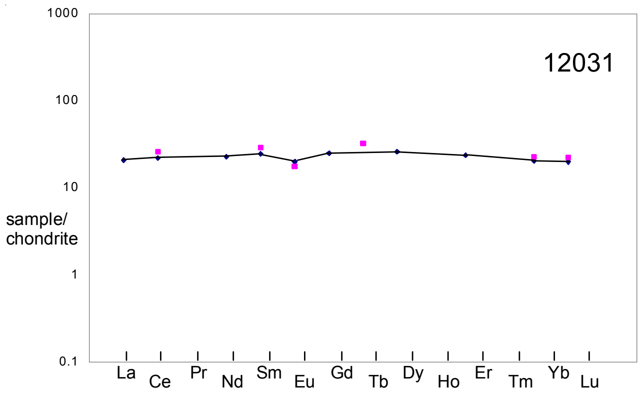


Figure 4: Normalized rare-earth-element composition diagram for basalt 12031 (data from

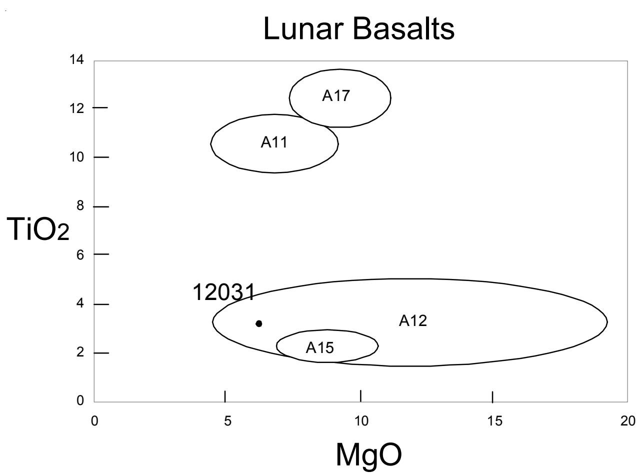


Figure 5: Composition of 12031 compared with that of other lunar basalts.

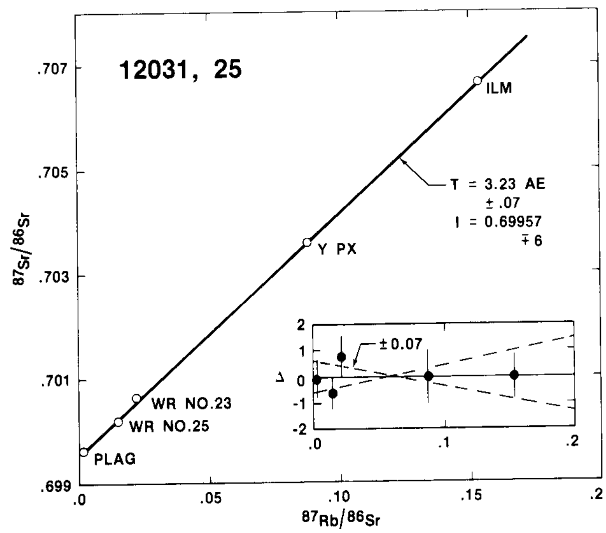


Figure 6: Rb-Sr mineral isochron for basalt 12031 (from Nyquist et al. 1979).

List of Photo #s for 12031

S69-61811 – 61834	B & W mug
S69-63635 – 63654	B & W mug
S69-63062 – 63084	color mug
S70-18937	processing
S70-24366	

Summary of Age Data for 12031

	Ar/Ar	Rb/Sr
Nyquist et al. 1979		3.23 ± 0.07 b.y.

Caution: Change in Rb decay constant.

Table 1. Chemical composition of 12031.

reference	Rhodes77		Nyquist77		Nyquist79		Neal2001	
weight								
SiO2 %	46.97	(c)						
TiO2	2.88	(c)						
Al2O3	12.63	(c)						
FeO	16.78	(c)						
MnO	0.26	(c)						
MgO	7.13	(c)						
CaO	12.25	(c)						
Na2O	0.33	(a)						
K2O	0.05	(c)	0.05	(b)	0.0554	(b)		
P2O5	0.05	(c)						
S %	0.05	(c)						
sum								
Sc ppm	48.9	(a)					49.5	(d)
V							128	(d)
Cr	2460	(a)					1934	(d)
Co	26	(a)					28	(d)
Ni							4.21	(d)
Cu							14	(d)
Zn							16.9	(d)
Ga							3.43	(d)
Ge ppb								
As								
Se								
Rb			0.797	(b)	0.966	(b)	1.09	(d)
Sr	136	(c)	153	(b)	128	(b)	127	(d)
Y	35	(c)					36	(d)
Zr	100	(c)					92	(d)
Nb							6.5	(d)
Mo								
Ru								
Rh								
Pd ppb								
Ag ppb								
Cd ppb								
In ppb								
Sn ppb								
Sb ppb								
Te ppb								
Cs ppm							0.05	(d)
Ba	60	(b)	49.6	(b)	59.8	(b)	58.5	(d)
La			5.01	(b)			5.22	(d)
Ce	15.6	(a)	13.5	(b)	15.5	(b)	15.6	(d)
Pr							2.4	(d)
Nd			10.5	(b)	11.9	(b)	11.4	(d)
Sm	4.23	(a)	3.62	(b)	4.07	(b)	3.93	(d)
Eu	1	(a)	1.14	(b)	1.03	(b)	1.04	(d)
Gd			4.96	(b)	5.53	(b)	5.4	(d)
Tb	1.19	(a)					0.94	(d)
Dy			6.22	(b)	6.72	(b)	6.35	(d)
Ho							1.33	(d)
Er			3.77	(b)	3.96	(b)	3.88	(d)
Tm							0.53	(d)
Yb	3.7	(a)	3.35	(b)	3.45	(b)	3.48	(d)
Lu	0.55	(a)	0.486	(b)	0.493	(b)	0.48	(d)
Hf	3.3	(a)					2.87	(d)
Ta							0.39	(d)
W ppb							110	(d)
Re ppb								
Os ppb								
Ir ppb								
Pt ppb								
Au ppb								
Th ppm							0.82	(d)
U ppm							0.22	(d)

technique (a) INAA, (b) IDMS, (c) XRF, (d) ICP-MS

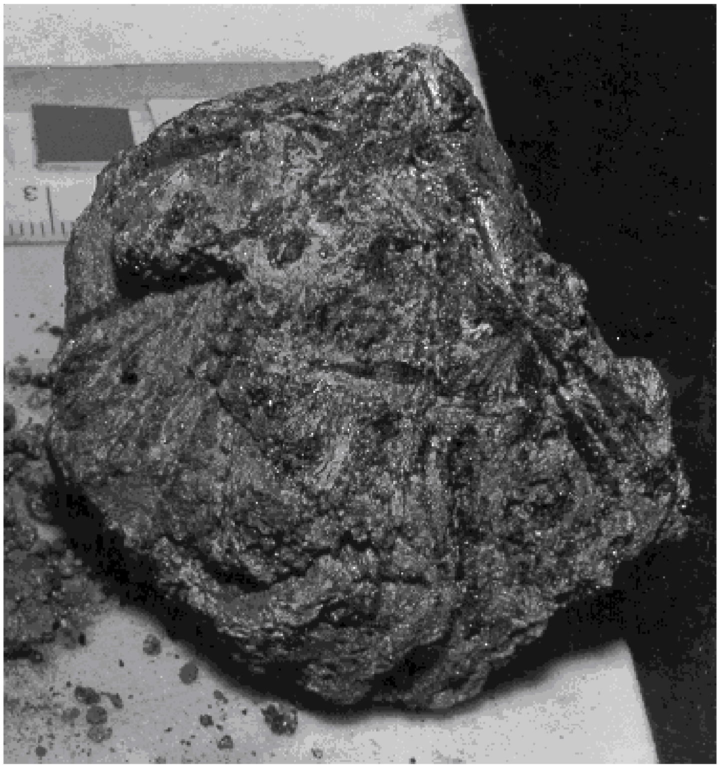
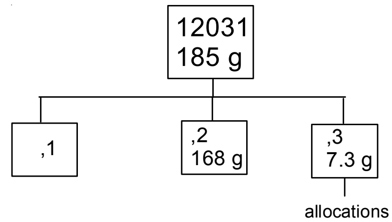


Figure 7: 12031,0 after subdivision. NASA S70-18937. Sample is 5 - 6 cm across.



References for 12031

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