12008

Olivine Vitrophyre Basalt

58.4 grams

Figure 1: Photo of 12008,0 after dusting. NASA photo # S70-47882. Sample is 2 cm across.

Introduction

12008 is an olivine vitrophyre very similar to 12009 and 12015, but with slightly higher TiO_2 content. The age has been determined to be about 3.2 b.y.

Petrography

Dungan and Brown (1977) describe 12008 as ~15-20% equant subhedral to euhedaral phenocrysts of olivine (0.2 -0.5 mm) heterogeneously distributed in the opaque groundmass as glomerophyric aggregates (Fo_{72}). Small chromite grains with attached metallic iron grains are found in the groundmass or attached to the rims of the olivine phenocrysts. Olivine includes spherical melt inclusions. A second generation of olivine occurs as chains of skeletal microphenocrysts (Donaldson et al. 1975). The fine-grained opaque matrix is made of microlites of aluminous titanaugite, ilmenite and plagioclase (?).

Figure 2: Photomicrograph of thin section 12008,20 showing olivine phenocrysts in nearly opaque groundmass. NASA # S76-29979. Length about 3 mm.

Mineralogy

Olivine: Olivine in 12008 is mostly Fo_{72} (Dungan and Brown 1977). Butler (1973) determined the minor element content of olivine.

Pyroxene: Dungan and Brown (1977) reported the composition of dendrites of pyroxene in 12008 (figure 3).

Metal: Brett et al. (1971) determined the Ni content of minute metallic iron grains in 12008 (figure 4).

Mineralogical Mode for 12008

	Neal et al. 1994
Olivine	38.2
Pyroxene	20.4
Plagioclase	2
Ilmenite	4.7
Chromite +Usp	0.6
Mesostasis	33.9
"silica"	

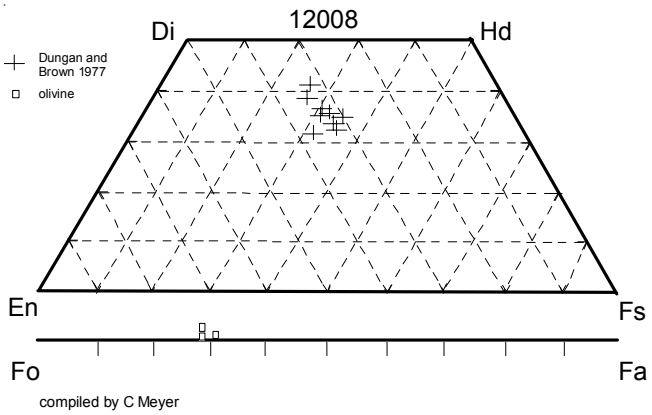


Figure 3: Olivine and pyroxene composition of 12008 (from Dungan and Brown 1977).

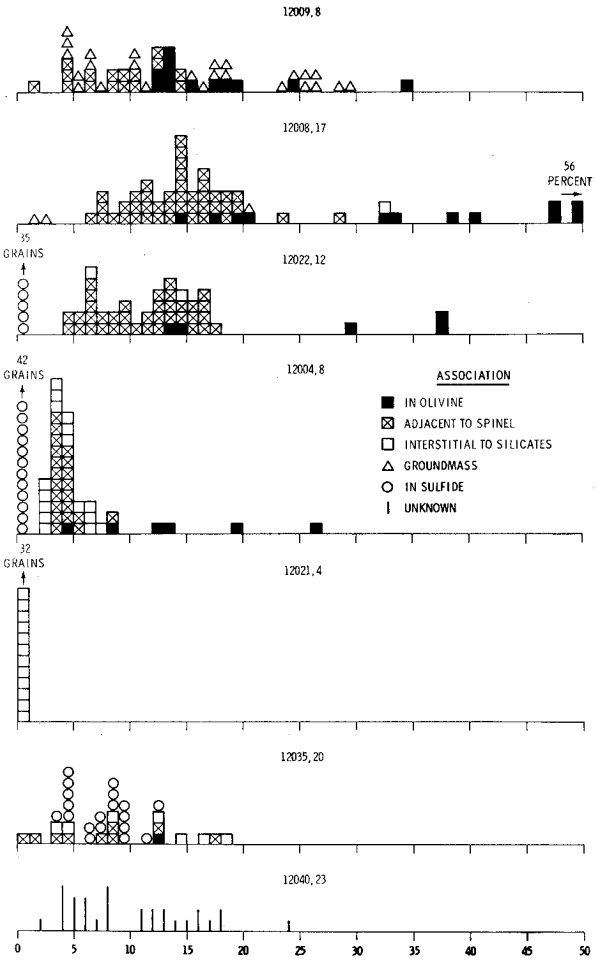


Figure 4: Histogram of Ni conentrations of metal grains in 7 lunar samples (lifted from Brett et al. 1971).

Summary of Age Data for 12008

	Ar/Ar	Rb/Sr
Stettler et al. 1973	3.18 ± 0.07 b.y	
	3.09 ± 0.07	

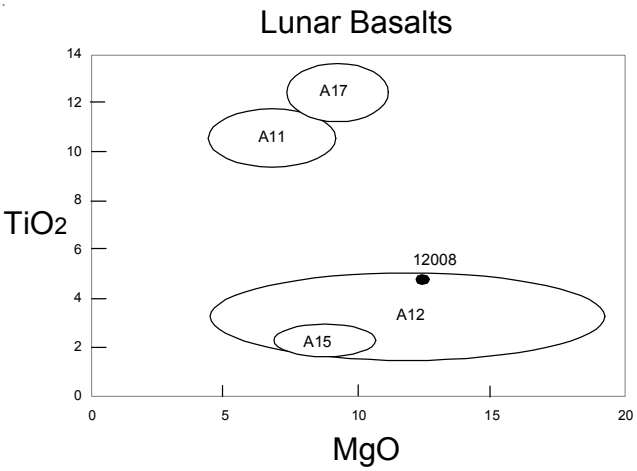


Figure 5: Composition of 12008 compared with other lunar basalts.

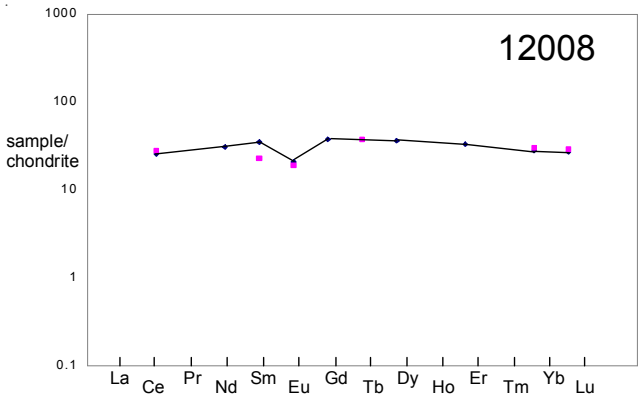


Figure 6: Rare-earth-element data for 12008 normalized by chondritic abundance (from Nyquist et al. 1977).

Chemistry

The chemical composition of 12008 was determined by Rhodes et al. (1977), Jarosowich et al. (1977) (figure 5). Trace elements were determined by Nyquist et al. (1977) and Anders et al. (1971) (figure 6).

Radiogenic age dating

Stettler et al. (1973) determined an age for 12008 by total Argon 39/40 (see table). The high temperature release represented a lower age (see figure in 12051).

Cosmogenic isotopes and exposure ages

Stettler et al. (1973) determined an ^{38}Ar exposure age of 50 m.y.

Other Studies

Clayton et al. (1971) reported oxygen isotope analysis of olivine and matrix of 12008.

Processing

There ar 10 thin sections.

List of Photo #s of 12008

S69-63190 – 63213	color mug
S70-47876 – 47833	B & W mug
S70-44092	color
S70-49238 – 49243	TS color
S70-46343	reflected TS ,17
S70-46567	reflected TS ,19
S70-44557	reflected TS, 14
S70-44572	reflected TS, 15
S70-46349	reflected TS ,20
S76-29979	TS ,20
S70-47875 – 47878	processing
S94-035798	processing

References for 12008

Anders E., Ganapathy R., Keays R.R., Laul J.C., and Morgan J.W. (1971) Volatile and siderophile elements in lunar rocks: Comparsion with terrestrial and meteoritic basalts. *Proc. 2nd Lunar Sci. Conf.* 1021-1036.

Anders E., Ganapathy R., Krahenbuhl U. and Morgan J.W. (1973) Meteoritic material on the Moon. *The Moon* **8**, 3-24.

Brett R., Butler P., Meyer C., Reid A.M., Takeda H. and Williams R. (1971) Apollo 12 igneous rocks 12004, 12008, 12009 and 12022: A mineralogical and petrological study. *Proc. 2nd Lunar Sci. Conf.* 301-317.

Butler P. (1972b) Compositional characteristics of olivines from Apollo 12 samples. *Geochim. Cosmochim. Acta* **36**, 773-785.

Clayton R.N., Onuma N. and Mayeda T.K. (1971) Oxygen isotope fractionation in Apollo 12 rocks and soils. *Proc. Second Lunar Sci. Conf.* 1417-1420.

Donaldson C.H., Drever H.I. and Johnston R. (1977) Supercooling on the lunar surface: a review of analogue information. *Phil. Trans. Roy. Soc. London* **A285**, 207-218.

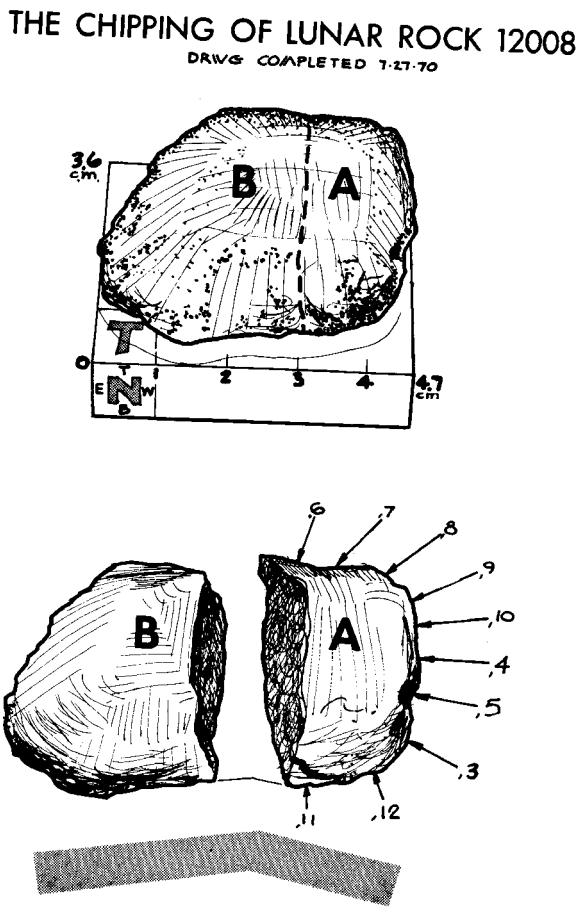
Dungan M.A. and Brown R.W. (1977) The petrology of the Apollo 12 basalt suite. *Proc. 8th Lunar Sci. Conf.* 1339-1381.

James O.B. and Wright T.L. (1972) Apollo 11 and 12 mare basalts and gabbros: Classification, compositional variations

Table 1. Chemical composition of 12008

reference	Rhodes77		Jarosowich77		Nyquist77		Anders71		Neal2001	
weight			.5 g		38 mg					
SiO2 %	42.75	(a)	42.58	(b)						
TiO2	4.45	(a)	4.82	(b)						
Al2O3	7.98	(a)	8.49	(b)						
FeO	21.94	(a)	22.4	(b)						
MnO	0.3	(a)	0.28	(b)						
MgO	12.33	(a)	11.99	(b)						
CaO	8.97	(a)	9.1	(b)						
Na2O	0.25	(d)	0.24	(b)						
K2O	0.05	(a)	0.14	(b)	0.054	(c)				
P2O5	0.07	(a)	0.05	(b)						
S %	0.08	(a)								
sum										
Sc ppm	52.4	(d)							56	(f)
V									164	(f)
Cr	4200	(d)							3908	(f)
Co	51	(d)					60	(e)	63.2	(f)
Ni									64	(f)
Cu									20.8	(f)
Zn							1.04	(e)	28.5	(f)
Ga							3.2	(e)	3.44	(f)
Ge ppb										
As										
Se							0.139	(e)		
Rb					0.681	(c)	0.62	(e)	0.9	(f)
Sr	130	(a)			133	(c)			144	(f)
Y	45	(a)							55	(f)
Zr	117	(a)							118	(f)
Nb	5.9	(a)							6.7	(f)
Mo									0.22	(f)
Ru										
Rh										
Pd ppb										
Ag ppb							1.17	(e)		
Cd ppb							1.3	(e)		
In ppb										
Sn ppb										
Sb ppb										
Te ppb							50	(e)		
Cs ppm							0.028	(e)	0.01	(f)
Ba	51	(c)			49.6	(c)			59	(f)
La									5.8	(f)
Ce	16.9	(d)			15.4	(c)			15.7	(f)
Pr									2.62	(f)
Nd					13.9	(c)			13.6	(f)
Sm	3.35	(d)			5.14	(c)			5.11	(f)
Eu	1.06	(d)			1.17	(c)			1.17	(f)
Gd					7.39	(c)			7.23	(f)
Tb	1.39	(d)							1.28	(f)
Dy					8.88	(c)			8.68	(f)
Ho									1.79	(f)
Er					5.27	(c)			5.27	(f)
Tm									0.71	(f)
Yb	4.9	(d)			4.55	(c)			4.68	(f)
Lu	0.71	(d)			0.657	(c)			0.61	(f)
Hf	3.8	(d)							3.62	(f)
Ta									0.34	(f)
W ppb									40	(f)
Re ppb										
Os ppb										
Ir ppb							0.06	(e)		
Pt ppb										
Au ppb							0.074	(e)		
Th ppm									0.59	(f)
U ppm									0.15	(f)

technique: (a) XRF, (b) wet, (c) IDMS, (d) INAA, (e) RNAA, (f) ICP-MS



and possible petrogenetic relations. *Geol. Soc. Am. Bull.* **83**, 2357-2382.

Jarosewich E. and Mason B. (1977) Compositions of lunar basalts 10069, 10071 and 12008. *In* **Lunar Sample Studies**. (ed. W. Phinney) NASA SP-418

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

Neal C.R. (2001) Interior of the moon: The presence of garnet in the primitive deep lunar mantle. *J. Geophys. Res.* **106**, 27865-27885.

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.

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.

Stettler A., Eberhardt Peter, Geiss J., Grogler N. and Maurer P. (1973) Ar^{39}-Ar^{40} ages and Ar^{37}-Ar^{38} exposure ages of lunar rocks. *Proc. 4th Lunar Sci. Conf.* 1865-1888.