

**12016**  
Ilmenite Basalt  
2028.3 grams



*Figure 1: Photo of 12016,0 showing vesicles and zap pits on surface. Cube is 1 in. NASA# S75-33942.*

**Introduction**

12016 is rounded on all sides with abundant micrometeorite pits. Remnants of glass linings from large zap pits are present. Neal et al. (1994) classify it as an ilmenite basalt. It has not been dated.

**Petrography**

Dungan and Brown (1977) report that 12016 “is an equigranular, medium-grained microgabbro” somewhat similar to 12056. Olivine in 12016 is resorbed and often included within pyroxene grains. Pyroxenes tend

to be elongate (0.5 to 1 mm) and occur as complex intergrowths of augite and pigeonite. Plagioclase occurs interstitially, and is sometimes “subpoikilitic”. The mesostasis of 12016 includes grains of fayalite, silica and phosphate in a cryptocrystalline matrix of devitrified glass.

Neal et al. (1994) found identical mode to that determined by Dungan and Brown (1977).

**Mineralogy**

**Olivine:** The core of a large olivine phenocryst is Fo<sub>67</sub> but olivine apparently re-equilibrated.

**Pyroxene:** The composition of pyroxene in 12016 is given in figure 3. The cores of pyroxene are a complex mixture of augite and low-Ca pyroxene (not understood).

**Plagioclase:** Feldspar is normally zoned An<sub>90-80</sub> with significant Or content at rim adjacent to mesostasis (Dungan and Brown).

**Opakes:** Ulvöspinel and ilmenite in 12016 were analyzed by Dungan and Brown.

**Metal:** Metal grains with up to 10 wt % Ni are reported (figure 4).

**Chemistry**

The chemical composition of 12016 has been determined by Rancitelli et al. (1971), Rhodes et al. (1977) and Neal et al. (1994) (Table 1 and figures 2,5).

**Radiogenic age dating**

12016 has not been dated.

**Cosmogenic isotopes and exposure ages**

Rancitelli et al. (1971) determined the cosmic ray induced activity of <sup>22</sup>Na (44 dpm/kg), <sup>26</sup>Al (75 dpm/kg), <sup>46</sup>Sc (5.6 dpm/kg), <sup>54</sup>Mn (36 dpm/kg) and <sup>56</sup>Co (14 dpm/kg).

**Processing**

A large piece (,7) was cut off of 12016 in 1976 (no slab).

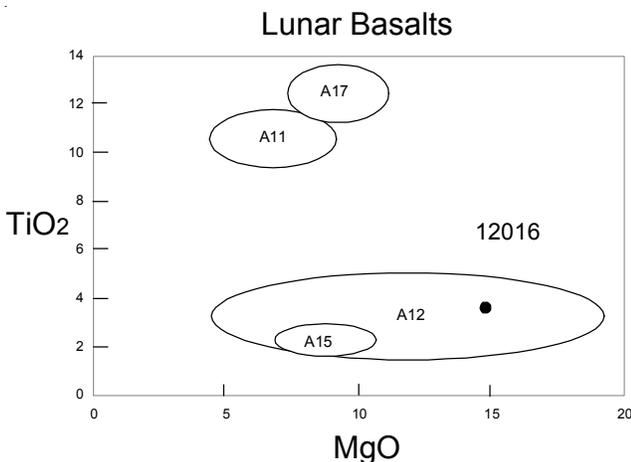


Figure 2: Composition of 12016 compared with that of other lunar basalts.

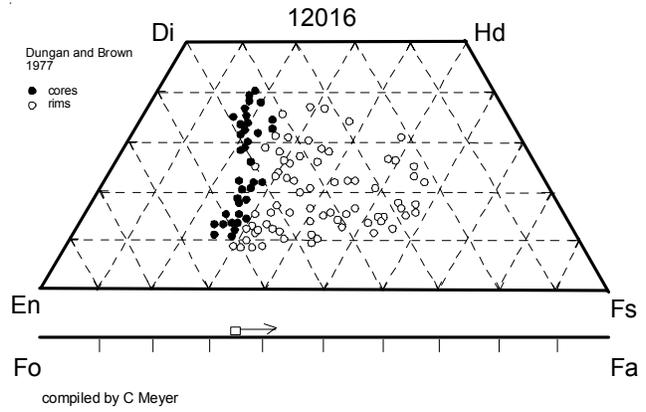


Figure 3: Pyroxene composition of 12016 (adapted from Dungan and Brown 1977).

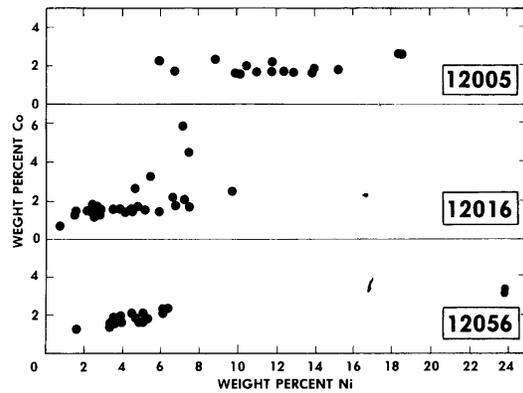


Figure 4: Compositions of metal grains in 12016 (from Dungan and Brown 1977).

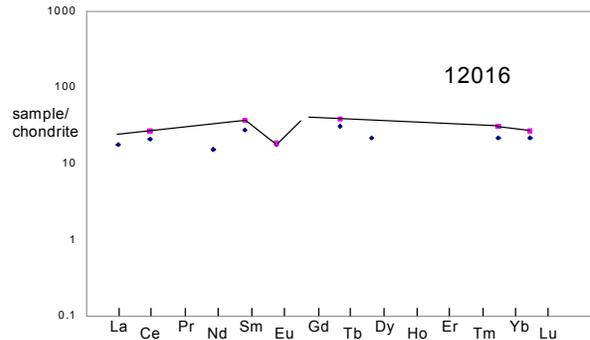


Figure 5: Normalized rare-earth-element diagram for 12016 (data from Neal et al. 1994 and Rhodes et al. 1977).

**Mineralogical Mode for 12016**

	Neal et al. 1994	Dungan and Brown 1977
Olivine	12	12
Pyroxene	52.1	52.1
Plagioclase	29.1	29.1
Ilmenite	4.8	4.8
Chromite +Usp	1.6	1.6
mesostasis	0.6	0.6
“silica”		

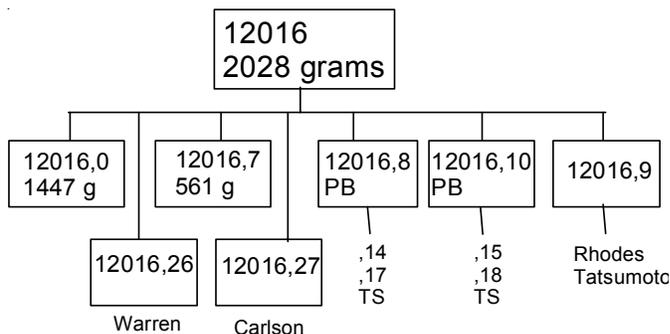
**Table 1. Chemical composition of 12016.**

reference weight	Neal94 .666 g	Rhodes77	Rancitelli71 2028 g	
SiO <sub>2</sub> %		42.78	(c)	
TiO <sub>2</sub>	3.5	(a) 4.02	(c)	
Al <sub>2</sub> O <sub>3</sub>	8.2	(a) 7.23	(c)	
FeO	22.2	(a) 22.64	(c)	
MnO	0.252	(a) 0.3	(c)	
MgO	15.1	(a) 12.65	(c)	
CaO	8.2	(a) 8.42	(c)	
Na <sub>2</sub> O	0.258	(a) 0.22	(a)	
K <sub>2</sub> O	0.049	(a) 0.06	(c)	0.053 (d)
P <sub>2</sub> O <sub>5</sub>		0.08	(c)	
S %		0.08	(c)	
sum				
Sc ppm	49	(a) 49.4	(a)	
V	153	(a)		
Cr	3790	(a) 3950	(a)	
Co	54.3	(a) 54	(a)	
Ni	78	(a) 25	(a)	
Cu				
Zn				
Ga				
Ge ppb				
As				
Se				
Rb				
Sr	85	(a) 126	(c)	
Y		45	(c)	
Zr		117	(c)	
Nb		6.1	(c)	
Mo				
Ru				
Rh				
Pd ppb				
Ag ppb				
Cd ppb				
In ppb				
Sn ppb				
Sb ppb				
Te ppb				
Cs ppm				
Ba		59	(b)	
La	4.3	(a)		
Ce	12.7	(a) 16.2	(a)	
Pr				
Nd	7	(a)		
Sm	4.1	(a) 5.5	(a)	
Eu	1.04	(a) 1.06	(a)	
Gd				
Tb	1.13	(a) 1.42	(a)	
Dy	5.5	(a)		
Ho				
Er				
Tm				
Yb	3.6	(a) 5	(a)	
Lu	0.53	(a) 0.67	(a)	
Hf	3	(a) 6.3	(a)	
Ta	0.26	(a)		
W ppb				
Re ppb				
Os ppb				
Ir ppb				
Pt ppb				
Au ppb				
Th ppm	0.47	(a)		0.57 (d)
U ppm				0.157 (d)

technique (a) INAA, (b) IDMS, (c) XRF, (d) radiation counting.

**List of Photo #s for 12016**

S69-60718 – 60726 B & W mug  
 S69-64081 color  
 S75-33937 – 33941 color  
 S75-33965 sawn surface



**References for 12016**

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

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

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.

Rancitelli L.A., Perkins R.W., Felix W.D. and Wogman N.A. (1971) Erosion and mixing of the lunar surface from cosmogenic and primordial radionuclide measurement in Apollo 12 lunar samples. *Proc. 2<sup>nd</sup> Lunar Sci. Conf.* 1757-1772.

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. 8<sup>th</sup> Lunar Sci. Conf.* 1305-1338.