12005

Ilmenite Basalt

482 grams

Figure 1: Photo of top surface of 12005. Note the zap pits on rounded top surface. The bottom surface was flat. Cube is 1 cm. NASA# S76-23966

Introduction

12005 is one of the most Mg rich (and has the highest Mg/Fe ratio) of the lunar basalts. It contains a high percentage of olivine and is said to have a "cumulate texture" (Rhodes et al. 1977). It might be considered a "picritic" basalt. Although it is grouped with "ilmenite basalts" (Rhodes et al. 1977, Neal et al. 1994), it has relatively low TiO_2 (2.8 wt %) and, perhaps, belongs in a group by itself!

The top surface of 12005 was covered with micrometeorite craters and apparently rounded by the process (figure 1). The bottom surface was flat.

Petrography

According to Dungan and Brown (1977), 12005 has apparent "distinct textural regions". This is apparently caused by large pyroxene oikocrysts (2-6 mm) that enclose an early crystallizing assemblage of rounded and embayed olivine and glomerophyric aggregates of chrome spinel (figures 2a,b). The pyroxene oikocrysts have augite cores and distinct rims dominated by low-Ca pyroxene (figure 2). A mineral orientation fabric is imparted to 12005 by the alignment of elongate pyroxene oikocrysts.

Interstitial to the large pyroxene oikocrysts are bands of plagioclase poikilitically enclosing olivine and ilmenite. Ilmenite, in turn, poikilitially encloses olivine and pyroxene. Mesostasis is holocrystalline consisting of plagioclase, K-feldspar, phosphate, ilmenite, troilite and metal.

Subsolidus reduction of ilmenite and or ulvöspinel is common in 12005.

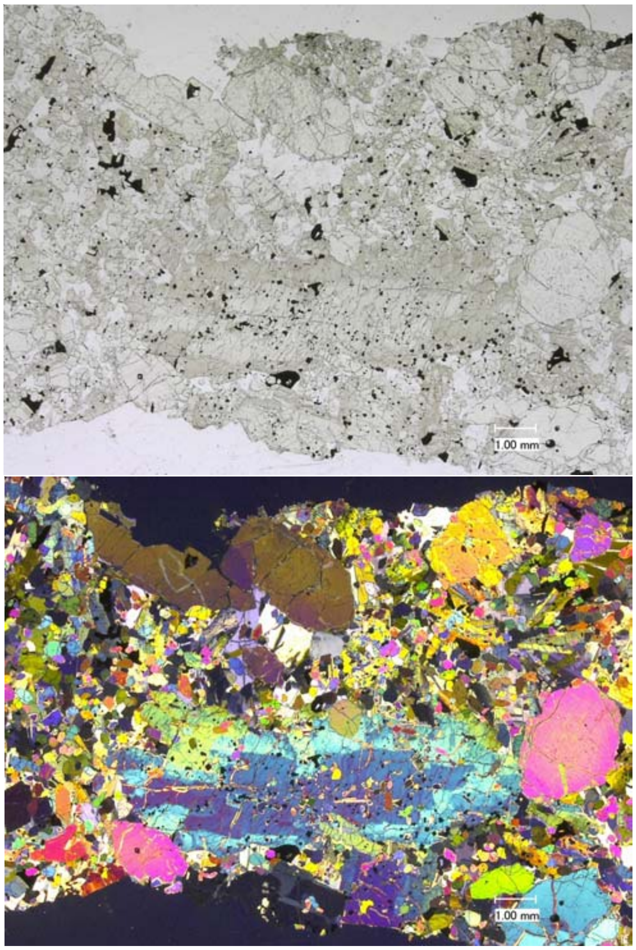

Figure 2a: Photomicrographs of thin section 12005,57 showing large zoned pyroxene.

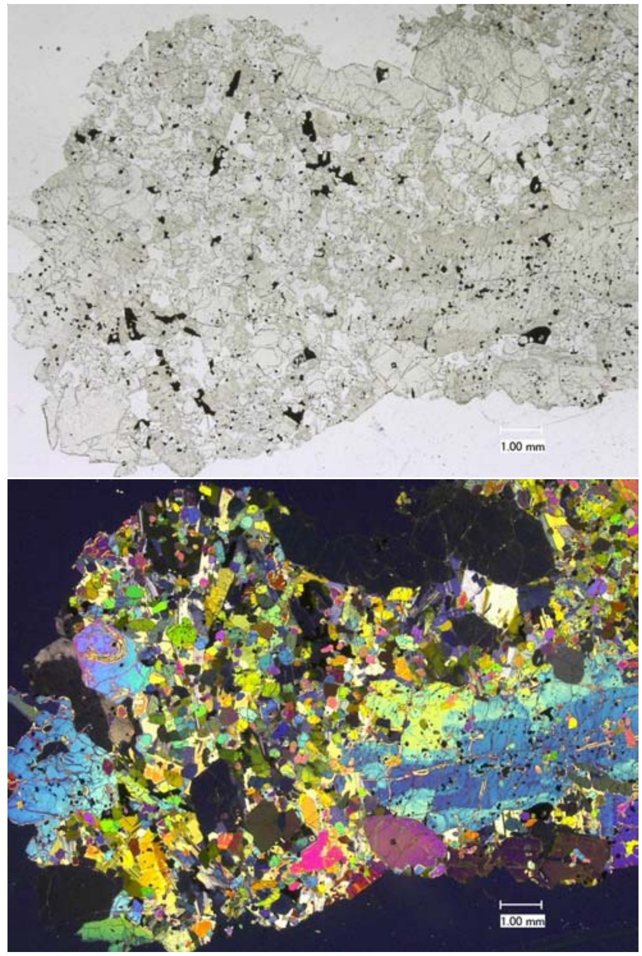

Figure 2b: Photomicrographs if thin section 12005,57 by C Meyer @ 20x. See also video file.

Mineralogy

Olivine: The cores of large olivine in 12005 are more magnesian than the rims of the same grains. The trace element content of the olivine is less than for that of other Apollo 12 rocks (when compared with equivalent Fo content, figure 4).

Spinel: Dungan and Brown (1977) have carefully studied the spinel in 12005. Chromite is common as inclusions in olivine and augite cores of pyroxene. Ulvöspinel is common in the interstitial areas and often has ilmenite exsolution (figure 5). One grain of Ti-poor Cr pleonaste was reported.

Pyroxene: Pyroxene compositions are given in figure 4 and are more restricted than for other mare basalts, apparently due to slow cooling. Augite cores are overgrown by low-Ca pyroxene with distinct boundaries. It is fair to say that the pyroxenes in 12005 deserve more study.

Metal grains: The Ni content of metal grains in 12005 is high (up to 18 wt. %, Dungan and Brown 1977, figure 6).

Ilmenite: Ilmenite analyses by Dungan and Brown have high Mg content (4.5 wt. %) compared with other Apollo 12 basalts

Chemistry

Rhodes et al. (1977) and Nyquist et al. (1977) give the composition (table 1, figure 8). 12005 has the highest

Mineralogical Mode

	Dungan and Brown 1977	Neal et al. 1994
Olivine	30 vol. %	30
Pyroxene	56.5	56.5
Plagioclase	11	11
Opaques	2.4	
Ilmenite		1.9
Chromite + usp.		0.5
Mesostasis	0.1	0.1

Mg content and is thus likely to be a cumulate (figure 7). Neal et al. (1994) group 12005 with ilmenite basalts, even though the TiO_2 content (2.76 wt. %) is low (there is also the possibility that the analysis by Rhodes et al. may not be representative).

Radiogenic age dating

12005 has not been dated, but Nyquist et al. (1977) have determined the isotopic composition of Sr and Unruh et al. (1984) determined the isotopic composition Nd and Hf.

Cosmogenic isotopes and exposure ages

Rancitelli et al. (1971) determined ^{22}Na (72 ± 2 dpm/kg), ^{26}Al (81 ± 2 dpm/kg), ^{46}Sc (5.5 ± 0.8 dpm/kg), ^{54}Mn (37 ± 4 dpm/kg), ^{56}Co (46 ± 6 dpm/kg) and ^{60}Co (0.5 ± 0.29 dpm/kg).

Processing

This sample is featured in the Lunar Petrographic Educational Thin Section Package (Meyer 2003). The largest remaining piece of 12005 is ~400 grams.

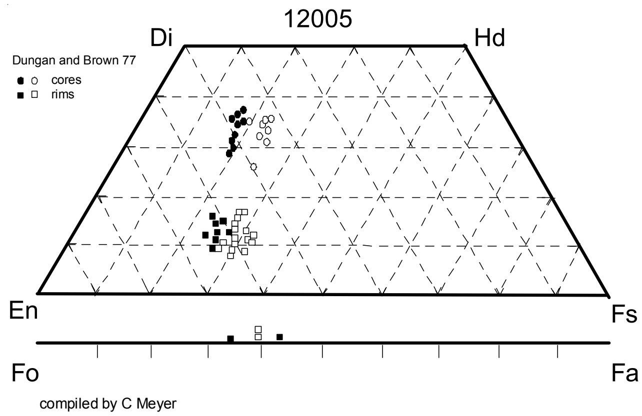

Figure 3: Pyroxene and olivine composition for 12005 (from Dungan and Brown 1977). Mafic minerals are relatively unzoned and there are two distinct pyroxenes.

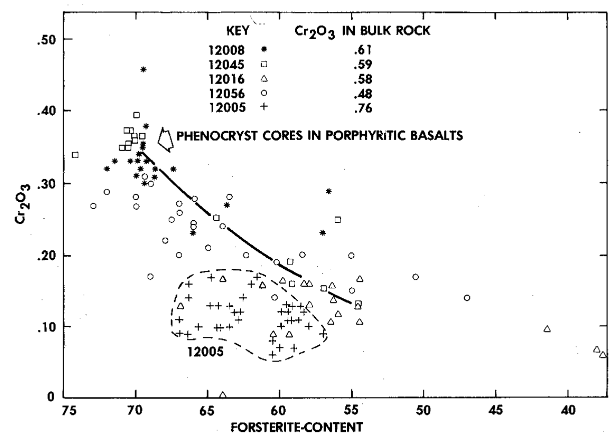

Figure 4: Trace element content of olivine in Apollo 12 samples (by Dungan and Brown 1976).

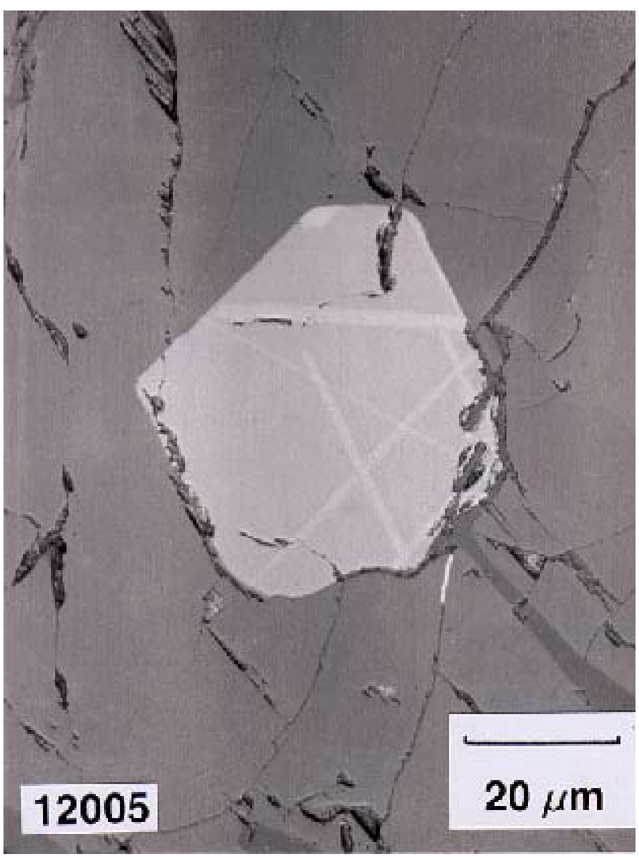

Figure 5: Ulvospinel with exsolved ilmenite in 12005.

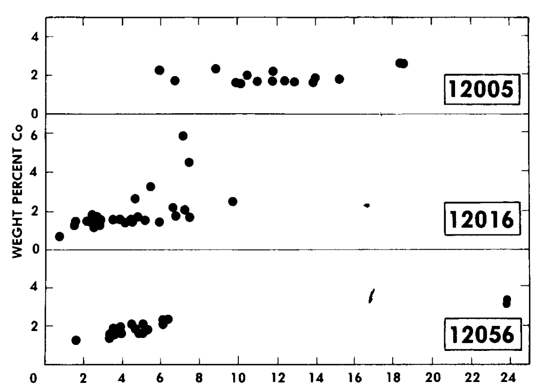

Figure 6: Composition of metal grains in lunar samples (from Dungan and Brown 1977).

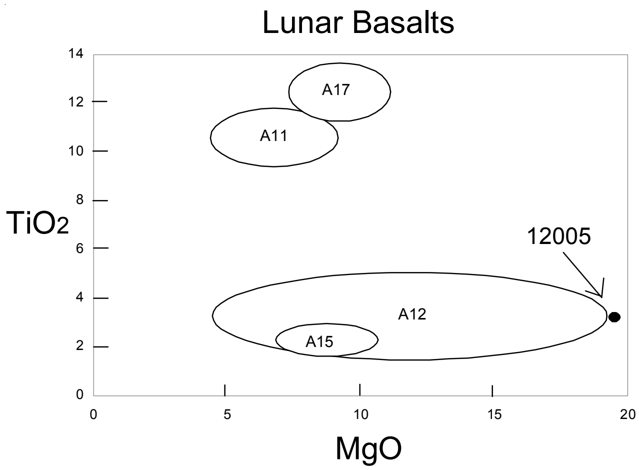

Figure 7: Composition of lunar basalts showing relative position of 12005.

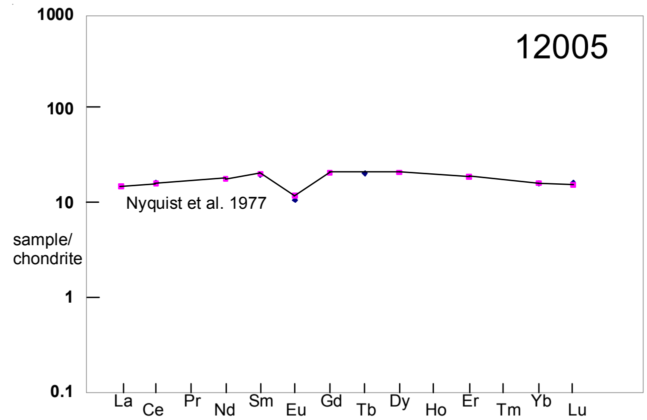

Figure 8: Normalized rare-earth-element composition diagram (data from Rhodes et al. 1977 and Nyquist et al. 1977).

List of Photo #s for 12005

S69-62294-298	B&W
S69-64089	
S69-64114	
S76-23960-968	color

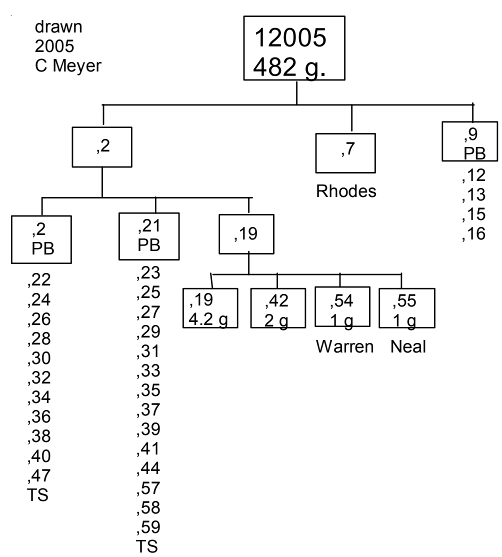

Table 1. Chemical composition of 12005.

reference	Rhodes 77		Nyquist 77		Rancitelli 71		Unruh 84	
weight								
SiO2 %	41.56	(a)						
TiO2	2.76	(a)						
Al2O3	5.3	(a)						
FeO	22.27	(a)						
MnO	0.3	(a)						
MgO	19.97	(a)						
CaO	6.31	(a)						
Na2O	0.16	(a)						
K2O	0.04	(a)	0.033	(c)	0.031	(d)		
P2O5	0.04	(a)						
S %	0.04	(a)						
sum								
Sc ppm	37.1	(b)						
V								
Cr	5200	(b)						
Co	71	(b)						
Ni	90	(b)						
Cu								
Zn								
Ga								
Ge ppb								
As								
Se								
Rb			0.501	(c)				
Sr	83	(b)	78.2	(c)				
Y	28	(b)						
Zr	66	(b)						
Nb	4.3	(b)						
Mo								
Ru								
Rh								
Pd ppb								
Ag ppb								
Cd ppb								
In ppb								
Sn ppb								
Sb ppb								
Te ppb								
Cs ppm								
Ba	35	(b)	34.5	(c)				
La			3.62	(c)				
Ce	10.2	(b)	9.87	(c)				
Pr								
Nd			8.38	(c)			7.97	(c)
Sm	2.99	(b)	3.07	(c)			2.86	(c)
Eu	0.62	(b)	0.687	(c)				
Gd			4.23	(c)				
Tb	0.77	(b)						
Dy			5.25	(c)				
Ho								
Er			3.1	(c)				
Tm								
Yb	2.7	(b)	2.69	(c)				
Lu	0.41	(b)	0.39	(c)	0.28	(c)	0.363	(c)
Hf	2.4	(b)			2.4	(c)	2.14	(c)
Ta								
W ppb								
Re ppb								
Os ppb								
Ir ppb								
Pt ppb								
Au ppb								
Th ppm					0.403	(d)		
U ppm					0.106	(d)		

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

References for 12005

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