# 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). 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 2, 3). The pyroxene oikocrysts have augite cores and distinct rims dominated by low-Ca pyroxene (figure 4). 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.

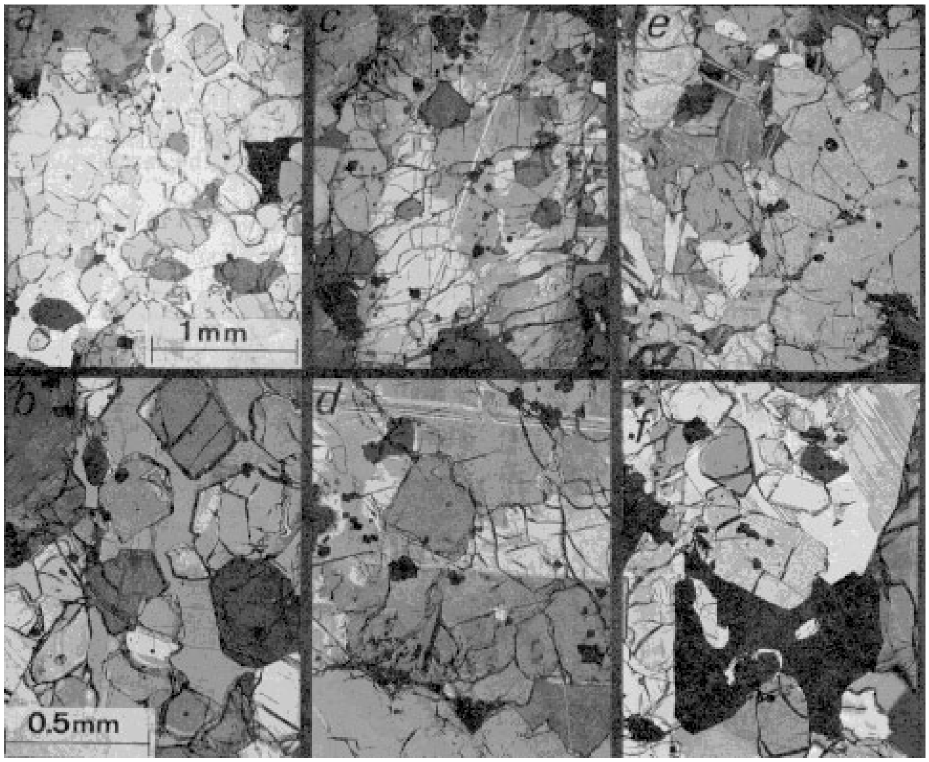



*Figure 2: Photomicrographs of thin sections of 12005 (from Dungan and Brown 1977).*

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

## 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 5).

***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 6). 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 7).

***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 9). 12005 has the highest Mg content and is thus likely to be a cumulate (figure 8). 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.

**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 |

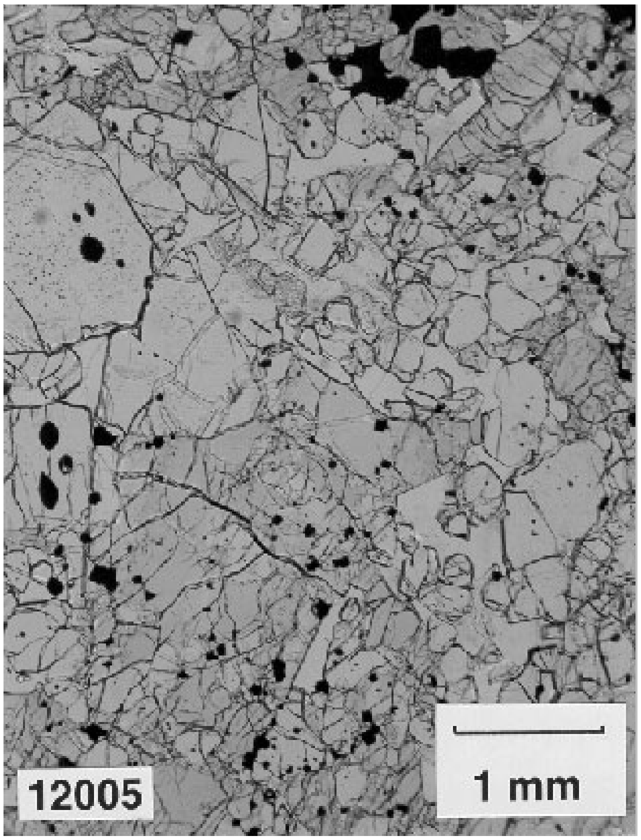



*Figure 3: Thin section photomicrograph of 12005. Olivine phenocrysts containing chromite and melt inclusions are surrounded by pyroxene. Large oikocrysts of plagioclase enclose olivine crystals.*

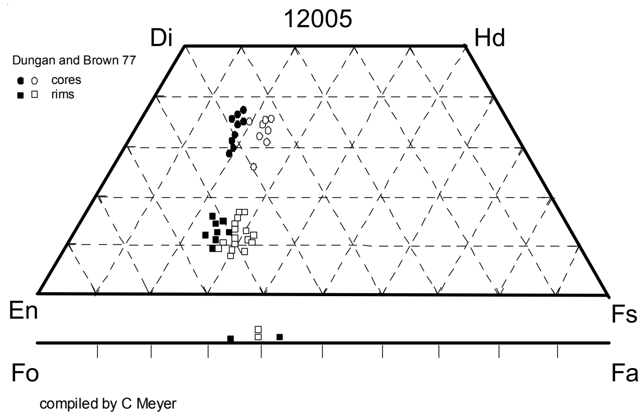



*Figure 4: Pyroxene and olivine composition for 12005 (from Dungan and Brown 1977). Mafic minerals are relatively unzoned and there are two distinct pyroxenes.*

## 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.

### List of Photo #s for 12005

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

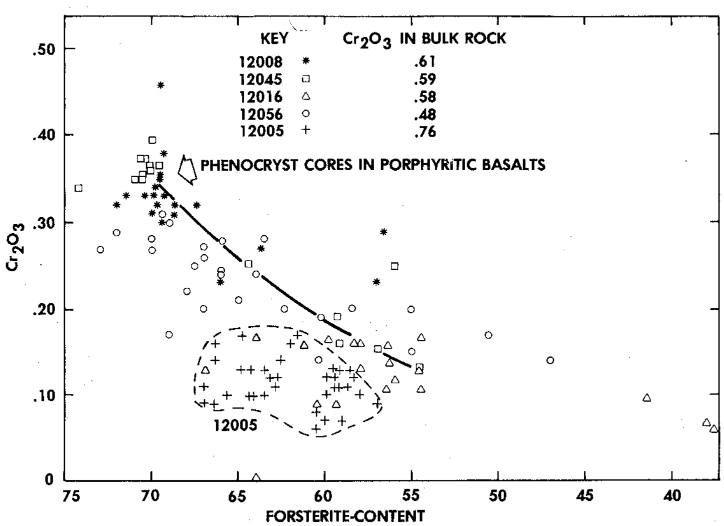



*Figure 5: Trace element content of olivine in Apollo 12 samples (by Dungan and Brown 1976).*

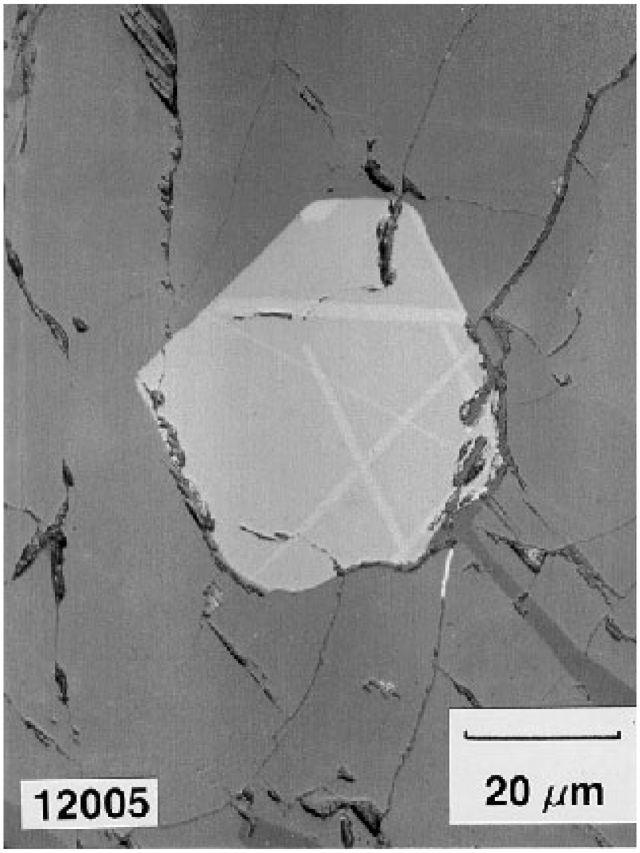



*Figure 6: Ulvospinel with exsolved ilmenite in 12005.*

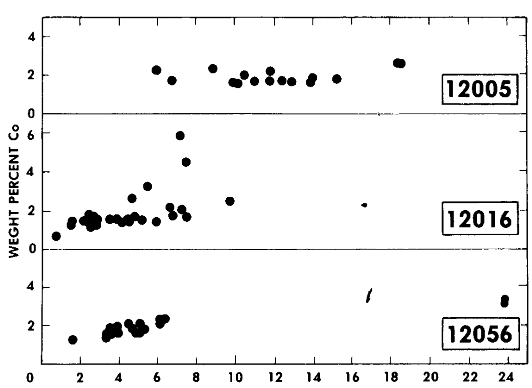



*Figure 7: Composition of metal grains in lunar samples (from Dungan and Brown 1977).*

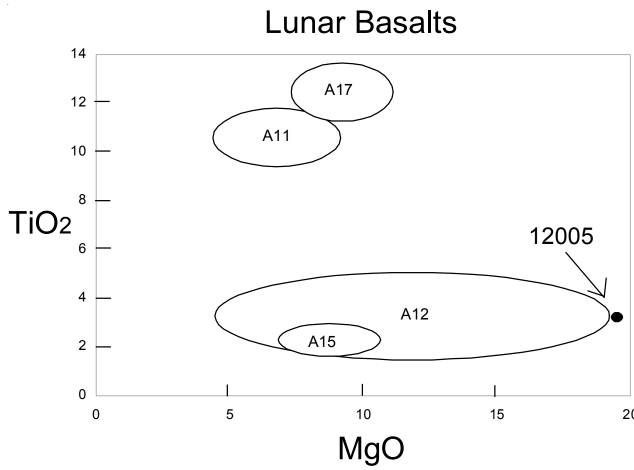



*Figure 8: Composition of lunar basalts showing relative position of 12005.*

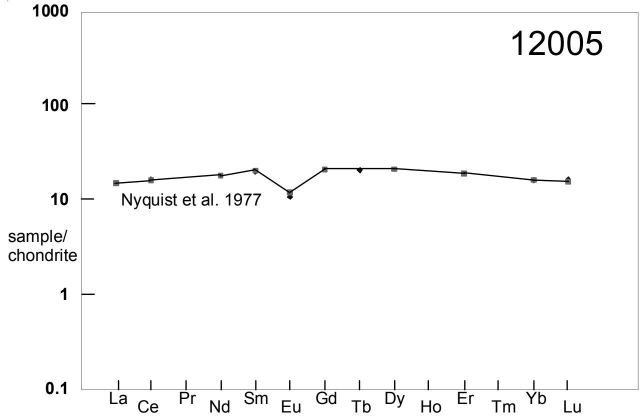
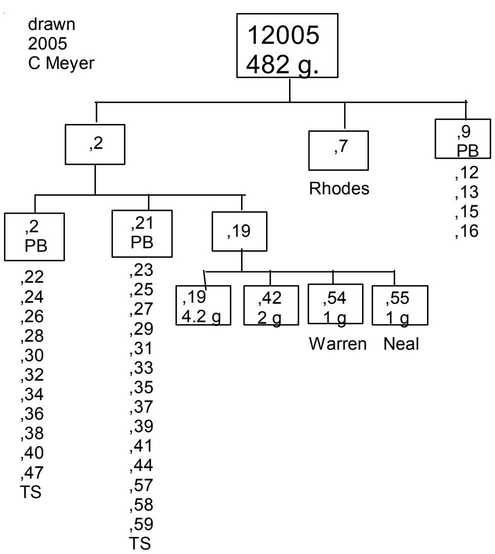



*Figure 9: Normalized rare-earth-element composition diagram (data from Rhodes et al. 1977 and Nyquist et al. 1977).*



## Table 1. Chemical composition of 12005.

| *reference* | Rhodes 77 | | Nyquist 77 | | Rancitelli 71 | |
|---|---|---|---|---|---|---|
| *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 ) | | |
| Sm | 2.99 | (b) | 3.07 | (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 ) | | |
| Hf | 2.4 | (b) | | | | |
| 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*