# 71569

Ilmenite Basalt

289.6 grams

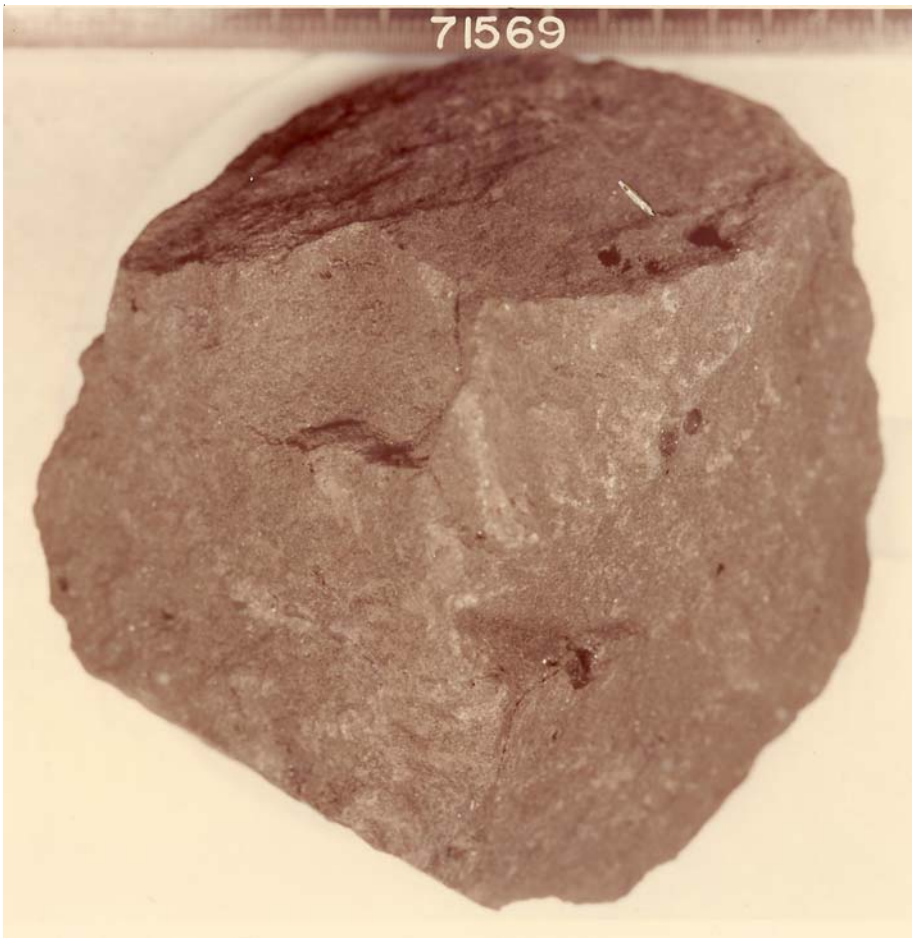


*Figure 1: Photo of 71569 with mm scale. S73- 31337. Sample is 7 cm across*

## Introduction

According to Warner et al. (1978), 71569 is an olivine-microporphritc ilmenite basalt similar to 71577 and 71578. According to Longhi et al. (1974), 71569 is nearly identical to 70215, but that is debatable – see below. Both the textures and the compositions are the same for these, rather large, samples.

71525 - 71596 etc. are rake samples collected as part of a comprehensive sample at station 1, taken near Steno Crater, in the middle of the Taurus-Littrow valley, Apollo 17. They include numerous ilmenite basalts – all with similar compositions.

## Petrography

There is apparently some variability to the texture of 71569, but generally groundmass is variolitic. Olivine phenocrysts are skeletal, often partially resorbed. Ilmenite is irregular or bladed in shape, often broken and sometimes acicular (figure 3).

71569 and its related rocks are fine-grained and the minerals are interpenetrating. Brown et al. (1975) reported too high a proportion of ilmenite. Warner et al. (1975, 1976 a, b), Longhi et al. (1975) and Neal and Taylor (1993) reported mineral compositions (figure 2). Warner et al. (1976) determined the composition of armalcolite in 71569 (table 2).

Usselman et al. (1975) experimentally reproduced textures and mineral chemistries of high-titanium mare basalts of this composition and calculated a cooling rate of 5-15 deg./hr. for 71569. Walker et al. (1975) and O'Hara and Humphries (1975) used a synthetic major element composition similar to 71569 to determined the phase diagram and sequence of crystallization and Longhi et al. (1978) studied the distribution of Fe and Mg between olivine and melt.

## Chemistry

The chemical analyses by Wanke et al. (1974), Rhodes et al. (1976) and Warner et al. (1975, 1978) are in close agreement and the composition closely matches that of 71577, 71578. This is classified as a type A, Apollo 17 basalt (figure 5).

*Note: 70215, which has been compared with 71569, is type B.*

## Radiogenic age dating

none

## Cosmogenic isotopes and exposure ages

Niemeyer et al. (1977a) determined a cosmic-ray exposure age of 134 m.y. by the $^{81}Kr$ method for 71569. This is typical of the ages of the craters of the central cluster at Taurus-Littrow (Drozd et al. 1977).

## Other Studies

Simmons et al. (1975) studied the microcracks in 71569.

The abundance and isotopic composition of rare gases in 71569 was reported by Niemeyer et al. (1977).

The isotopic systematics of Rb/Sr and U/Th/Pb were studied by Nyquist et al. (1976) and Nunes et al. (1974).

## Processing

71569 was sawn with a band saw to make a slab from the middle (figure 7). There were numerous allocations of this basalt. There are 14 thin sections.

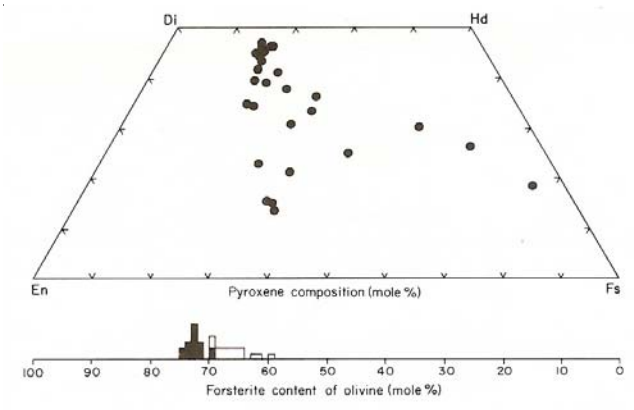


*Figure 2: Pyroxene and olivine composition of 71569 (Warner et al. 1978).*

## Mineralogical Mode

| | Warner | Brown |
|---|---|---|
| Olivine | 6.3 | 7.8 |
| Pyroxene | 43.7 | 28.9 |
| Plagioclase | 26.8 | 10.8 |
| Opaques | 17 | 38.6 |
| Silica | 5.4 | |
| Meostasis | 0.9 | |

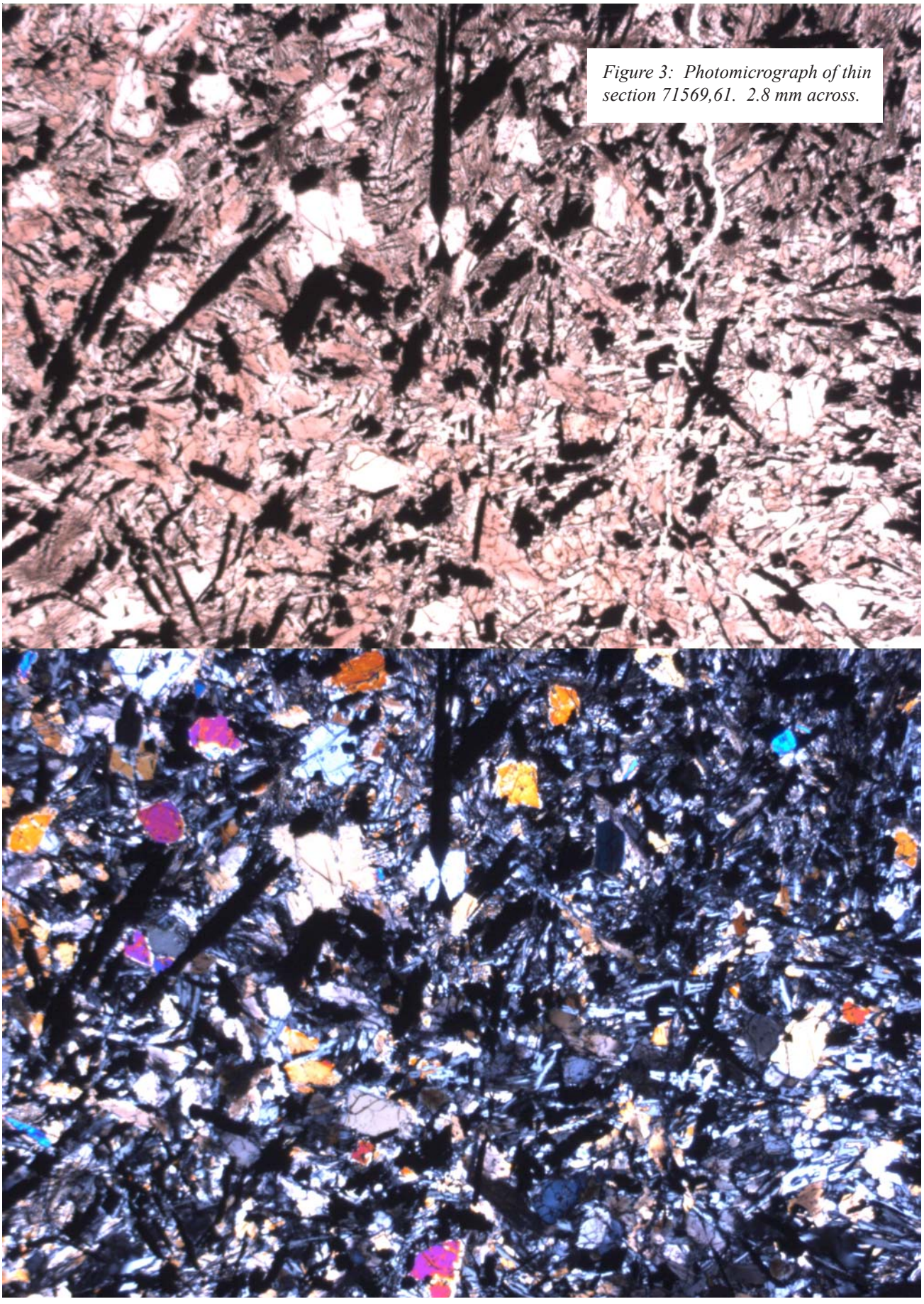

*Figure 3: Photomicrograph of thin section 71569,61. 2.8 mm across.*

## Table 1. Chemical composition of 71569.

| *reference* | Wanke74 | | Warner78 | | Rhodes76 | |
|---|---|---|---|---|---|---|
| *weight* | | | Warner75 | | Nyquist76 | |
| SiO2 % | 39.4 | (a) | | | 39.97 | (d) |
| TiO2 | 12.2 | (a) | 13.2 | (b) | 11.57 | (d) |
| Al2O3 | 8.6 | (a) | 8.5 | (b) | 9.08 | (d) |
| FeO | 18.9 | (a) | 17.9 | (b) | 18.85 | (d) |
| MnO | 0.245 | (a) | 0.22 | (b) | 0.28 | (d) |
| MgO | 8.47 | (a) | 9.2 | (b) | 7.66 | (d) |
| CaO | 10.6 | (a) | 9.6 | (b) | 11.27 | (d) |
| Na2O | 0.39 | (a) | 0.37 | (b) | 0.41 | (d) |
| K2O | 0.067 | (a) | 0.07 | (b) | 0.06 | (d) |
| P2O5 | 0.066 | (a) | | | 0.06 | (d) |
| S % | 0.16 | (a) | | | 0.19 | (d) |
| *sum* | | | | | | |
| | | | | | | |
| Sc ppm | 82.4 | (b) | 73 | (b) | 81 | (b) |
| V | | | 100 | (b) | | |
| Cr | 3180 | (a) | | | 2463 | (d) |
| Co | 18.6 | (b) | 17.5 | (b) | 18 | (b) |
| Ni | | | | | | |
| Cu | 4 | (b) | | | | |
| Zn | | | | | | |
| Ga | 2.15 | (b) | | | | |
| Ge ppb | | | | | | |
| As | 0.012 | (b) | | | | |
| Se | 0.11 | (b) | | | | |
| Rb | 0.74 | (b) | | | 0.64 | (e) |
| Sr | 170 | (b) | | | 195 | (e) |
| Y | 91 | (b) | | | | |
| Zr | 258 | (b) | | | | |
| Nb | 24 | (b) | | | | |
| Mo | | | | | | |
| Ru | | | | | | |
| Rh | | | | | | |
| Pd ppb | | | | | | |
| Ag ppb | | | | | | |
| Cd ppb | | | | | | |
| In ppb | | | | | | |
| Sn ppb | | | | | | |
| Sb ppb | | | | | | |
| Te ppb | | | | | | |
| Cs ppm | 0.041 | (b) | | | | |
| Ba | 88 | (b) | | | 84 | (e) |
| La | 6.82 | (b) | 6.1 | (b) | 6.74 | (e) |
| Ce | 23 | (b) | 22 | (b) | 23.8 | (e) |
| Pr | 4.3 | (b) | | | | |
| Nd | 26 | (b) | | | 26.3 | (e) |
| Sm | 10.4 | (b) | 11.1 | (b) | 10.9 | (e) |
| Eu | 2.03 | (b) | 1.97 | (b) | 2.19 | (e) |
| Gd | 15.1 | (b) | | | 17.1 | (e) |
| Tb | 2.7 | (b) | 2.4 | (b) | | |
| Dy | 17.1 | (b) | 15 | (b) | 19 | (e) |
| Ho | 3.7 | (b) | | | | |
| Er | 11 | (b) | | | 11.6 | (e) |
| Tm | | (b) | | | | |
| Yb | 10.1 | (b) | 9.8 | (b) | 10.5 | (e) |
| Lu | 1.42 | (b) | 1.4 | (b) | 1.5 | (b) |
| Hf | 8.7 | (b) | 8.4 | (b) | 9.7 | (b) |
| Ta | 1.75 | (b) | 1.7 | (b) | | |
| W ppb | 79 | (b) | | | | |
| Re ppb | | | | | | |
| Os ppb | | | | | | |
| Ir ppb | 4.8 | (b) | | | | |
| Pt ppb | | | | | | |
| Au ppb | 0.25 | (b) | | | | |
| Th ppm | | | | | | |
| U ppm | 0.147 | (b) | | | | |

*technique: (a) mixed, (b) INAA, (c ) broad beam e probe. (d) XRF, (e) IDMS*

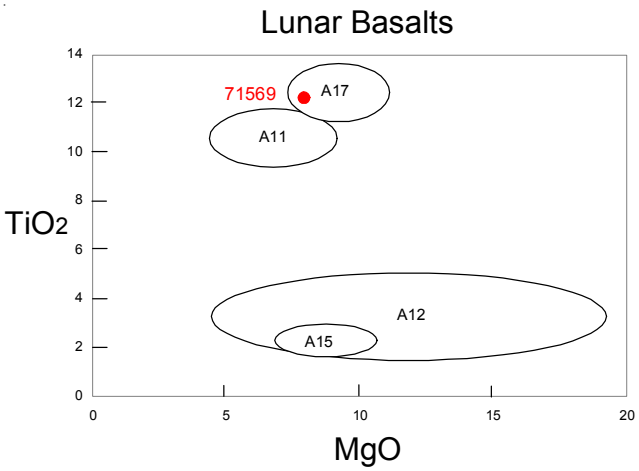


*Figure 4: Composition of 71569 compared with that of Apollo basalts.*

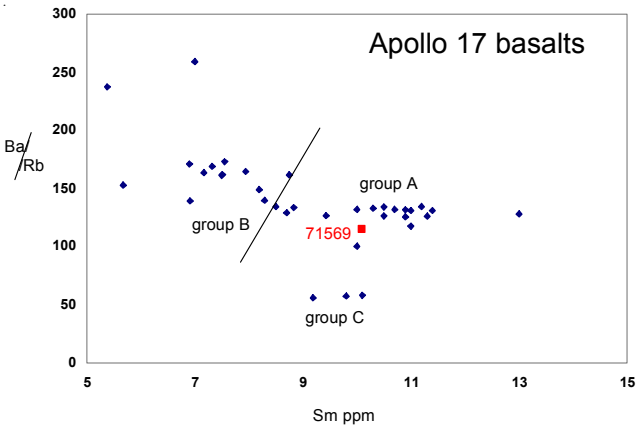


*Figure 5: Trace element composition of Apollo 17 basalts.*

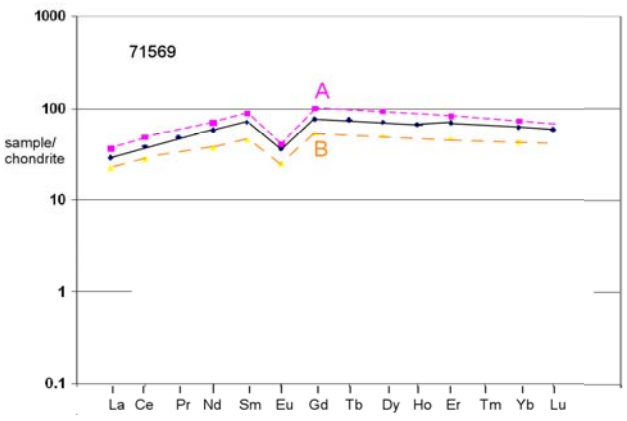


*Figure 6: Normalized rare-earth-element diagram for 71569 and type A and B basalts.*

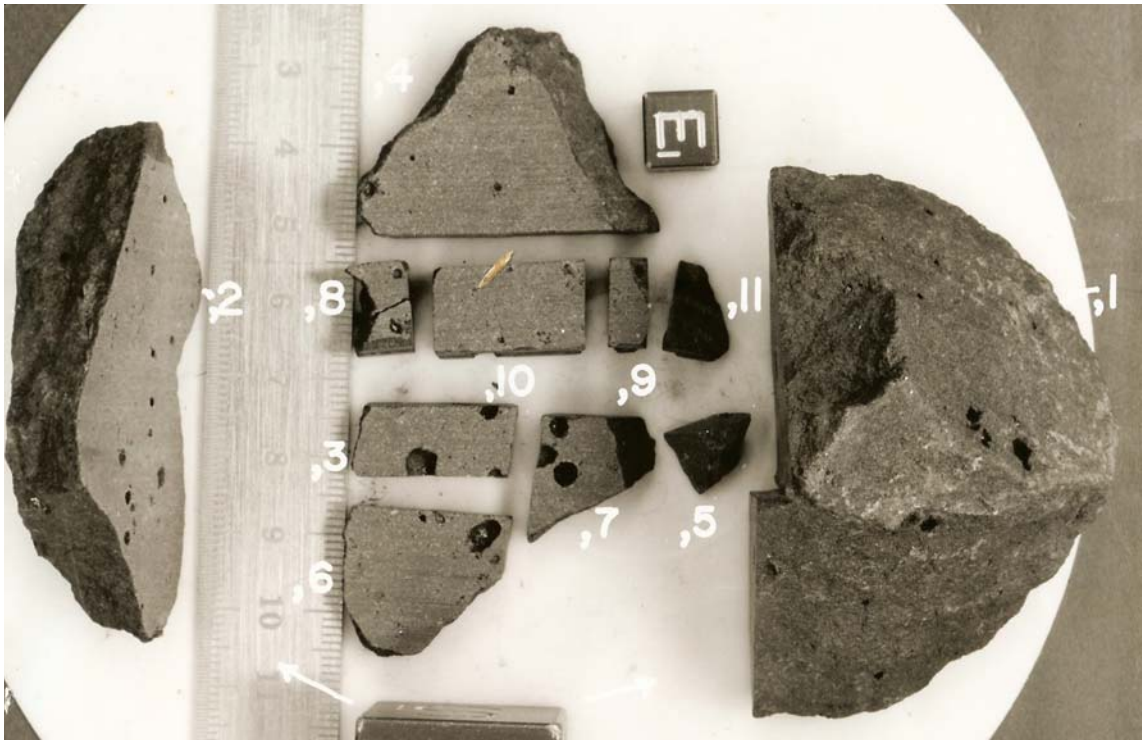


*Figure 7: Slab cut from 71569. Small cube is 1 cm. S74-17828.*

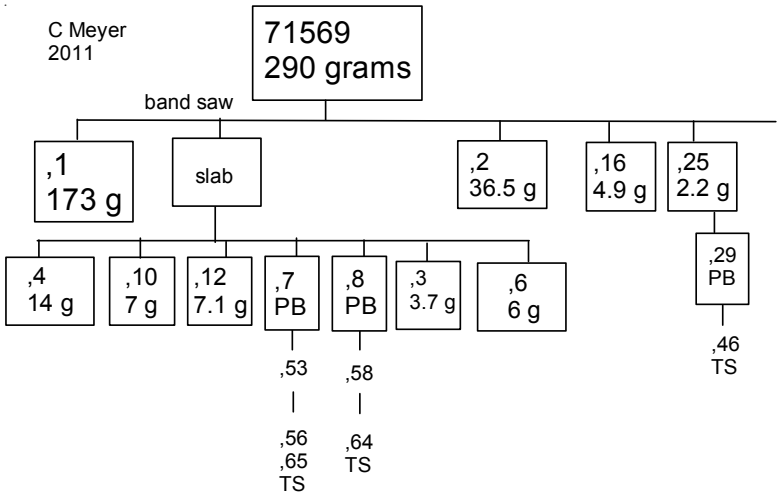


Table 2: Armalcolite in 71569 (Warner et al. 1976).
(traverse across one grain)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TiO2 | 70.8 | 71.7 | 72.3 | 72.3 | 72.3 | 72.2 | 72.6 | 72 | 71.7 | 71.5 |
| Al2O3 | 1.79 | 1.86 | 2.05 | 1.76 | 1.87 | 1.8 | 1.51 | 1.6 | 1.85 | 1.87 |
| Cr2O3 | 1.28 | 1.4 | 1.38 | 1.48 | 1.38 | 1.59 | 1.6 | 1.33 | 1.27 | 1.12 |
| FeO | 19.1 | 17.1 | 16.9 | 16.4 | 15.9 | 16.1 | 16.6 | 16.9 | 17.9 | 18.7 |
| MgO | 5.6 | 6.4 | 6.7 | 6.7 | 7 | 7.2 | 6.8 | 6.5 | 5.9 | 5.2 |
| CaO | 0.31 | 0.25 | 0.3 | 0.26 | 0.26 | 0.26 | 0.26 | 0.27 | 0.29 | 0.29 |
| ZrO2 | 0.09 | 0.09 | 0.05 | 0.03 | 0.01 | 0.06 | 0.01 | 0.03 | 0.05 | 0.06 |

## References for 71569


Brown G.M., Peckett A., Emeleus C.H., Phillips R. and Pinsent R.H. (1975a) Petrology and mineralogy of Apollo 17 mare basalts. *Proc. 6th Lunar Sci. Conf.* 1-13.

Butler P. (1973) **Lunar Sample Information Catalog Apollo 17.** Lunar Receiving Laboratory. MSC 03211 Curator's Catalog. pp. 447.

Drozd R.J., Hohenberg C.M., Morgan C.J., Podosek F.A. and Wroge M.L. (1977) Cosmic-ray exposure history at Taurus-Littrow. *Proc. 8th Lunar Sci. Conf.* 3027-3043.

Laul J.C., Hill D.W. and Schmitt R.A. (1974d) Chemical studies of Apollo 16 and 17 samples. *Proc. 5th Lunar Sci. Conf.* 1047-1066.

Longhi J., Walker D., Grove T.L., Stolper E.M. and Hays J.F. (1974) The petrology of the Apollo 17 mare basalts. *Proc. 5th Lunar Sci. Conf.* 447-469.

Longhi J., Walker D. and Hays J.F. (1978) The distribution of Fe and Mg between olivine and lunar basaltic liquids. *Geochim. Cosmochim. Acta* **42**, 1545-1558.

LSPET (1973) Apollo 17 lunar samples: Chemical and petrographic description. *Science* **182**, 659-672.

LSPET (1973) Preliminary Examination of lunar samples. Apollo 17 Preliminary Science Rpt. NASA SP-330. 7-1 – 7-46.

Muehlberger et al. (1973) Documentation and environment of the Apollo 17 samples: A preliminary report. Astrogeology 71 322 pp superceeded by Astrogeolgy 73 (1975) and by Wolfe et al. (1981)

Muehlberger W.R. and many others (1973) Preliminary Geological Investigation of the Apollo 17 Landing Site. *In* **Apollo 17 Preliminary Science Report.** NASA SP-330.

Neal C.R. and Taylor L.A. (1993) Catalog of Apollo 17 rocks. Vol. 3 Central Valley

Niemeyer S. (1977a) Exposure histories of lunar rocks 71135 and 71569. *Proc. 8th Lunar Sci. Conf.* 3083-3093.

Nyquist L.E., Bansal B.M. and Wiesmann H. (1976a) Sr isotopic constraints on the petrogenesis of Apollo 17 mare basalts. *Proc. 7th Lunar Sci. Conf.* 1507-1528.

Rhodes J.M., Hubbard N.J., Wiesmann H., Rodgers K.V., Brannon J.C. and Bansal B.M. (1976a) Chemistry, classification, and petrogenesis of Apollo 17 mare basalts. *Proc. 7th Lunar Sci. Conf.* 1467-1489.

Shih C.-Y., Haskin L.A., Wiesmann H., Bansal B.M. and Brannon J.C. (1975a) On the origin of high-Ti mare basalts. Proc. 6th Lunar Sci. Conf. 1255-1285.

Simmons G., Siegfried R. and Richter Dorthy (1975a) Characteristics of microcracks in lunar samples. *Proc. 6th Lunar Sci. Conf.* 3227-3254.

Usselman T.M., Lofgren G.E., Donaldson C.H. and Williams R.J. (1975) Experimentally reproduced textures and mineral chemistries of high-titanium mare basalts. *Proc. 6th Lunar Sci. Conf.* 997-1020.

Wänke H., Palme H., Baddenhausen H., Dreibus G., Jagoutz E., Kruse H., Palme C., Spettel B., Teschke F. and Thacker R. (1975a) New data on the chemistry of lunar samples: Primary matter in the lunar highlands and the bulk composition of the moon. *Proc. 6th Lunar Sci. Conf.* 1313-1340.

Warner R.D., Keil K., Prinz M., Laul J.C., Murali A.V. and Schmitt R.A. (1975b) Mineralogy, petrology, and chemistry of mare basalts from Apollo 17 rake samples. *Proc. 6th Lunar Sci. Conf.* 193-220.

Warner R.D., Warren R.G., Mansker W.L., Berkley J.L. and Keil K. (1976a) Electron microprobe analyses of olivine, pyroxene and plagioclase from Apollo 17 rake sample mare basalts. Spec. Publ. # 15, UNM Institute of Meteoritics, Albuquerque. 158 pp.

Warner R.D., Berkley J.L., Mansker W.L., Warren R.G. and Keil K. (1976b) Electron microprobe analyses of spinel, Fe-Ti oxides and metal from Apollo 17 rake sample mare basalts. Spec. Publ. #16, UNM Institute of Meteoritics, Albuquerque. 114 pp.

Warner R.D., Keil K., Nehru C.E. and Taylor G.J. (1978) Catalogue of Apollo 17 rake samples from Stations la, 2, 7, and 8. Spec. Publ. #18, UNM Institute of Meteoritics, Albuquerque. 88 pp.

Warner R.D., Nehru C.E. and Keil K. (1978g) Opaque oxide mineral crystallization in lunar high-titanium basalts. *Am. Mineral.* **68**, 1209-1224.

Wolfe E.W., Bailey N.G., Lucchitta B.K., Muehlberger W.R., Scott D.H., Sutton R.L and Wilshire H.G. (1981) The geologic investigation of the Taurus-Littrow Valley: Apollo 17 Landing Site. US Geol. Survey Prof. Paper, 1080, pp. 280.