

71559 – 82.1 grams
71536 – 5.3 grams
71539 – 10.9 grams
71568 – 10 grams
 Ilmenite Basalt



Figure 1: Photo of 71559. Scale in cm and mm. S73-31335

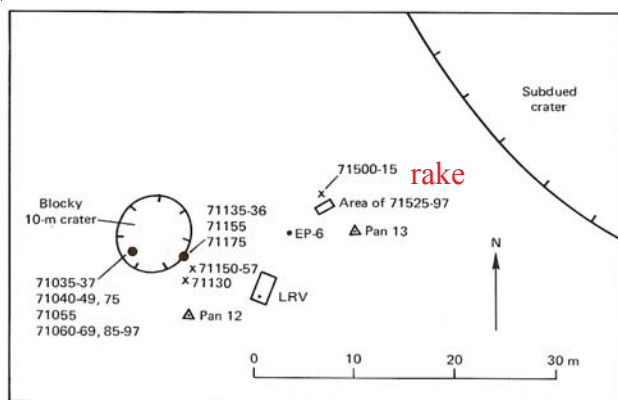


Figure 2: Location of rake sample 71525 - 71595 at station 1, Apollo 17.

Mineralogical Mode

	71559	71536	71539	71568
Olivine	- -	tr.	tr.	tr.
Pyroxene	50.2	49.5	50.2	49.1
Plagioclase	35.6	35.6	32.2	34.7
Opakes	10.6	10.9	12.2	12.1
Silica	2.4	2.7	4.5	3.3
Meostasis	0.6	1	0.8	0.9

Introduction

71559, 71536, 71539 and 71568 are coarse-grain ilmenite basalts with salt and pepper texture (figure 1). They are unusual in that they have only moderate Ti contents.

71525 - 71596 etc. are rake samples collected as part of a comprehensive sample at station 1, taken near Steno Crater, Apollo 17 (figure 2). They include numerous small ilmenite basalts.

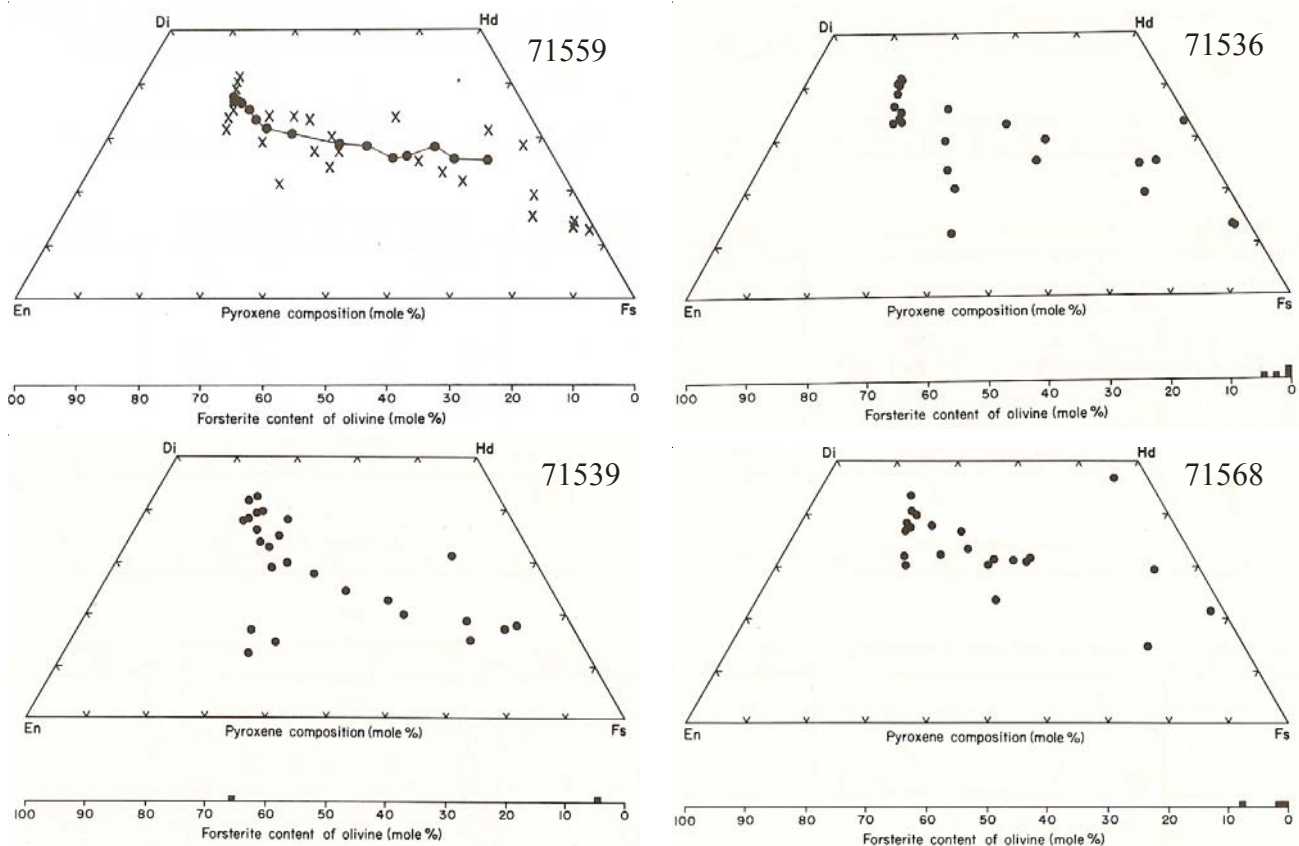


Figure 3: Composition of pyroxene in 71559 and associated rocks (Warner et al. 1978).

Petrography

71559 has a subophitic-granular texture with blocky ilmenite and little or no olivine (Warner et al. 1978). Grain size is 1 – 2 mm. Pyroxene has extreme iron enrichment (figure 3) and there is trace fayalite. Ilmenite in 71559 is blocky while it is bladed in 71539 (figure 4). These samples are somewhat like Apollo 11 high-Ti basalts from “a thousand miles away”!

Warner et al. (1978) reported armalcolite, tranquillityite, barian K-feldspar, zirconolite, and baddeleyite in these coarse-grain Apollo 17 basalts. Warner et al. (1976) gives the composition of armalcolite (table 5) and tranquillityite (table 6).

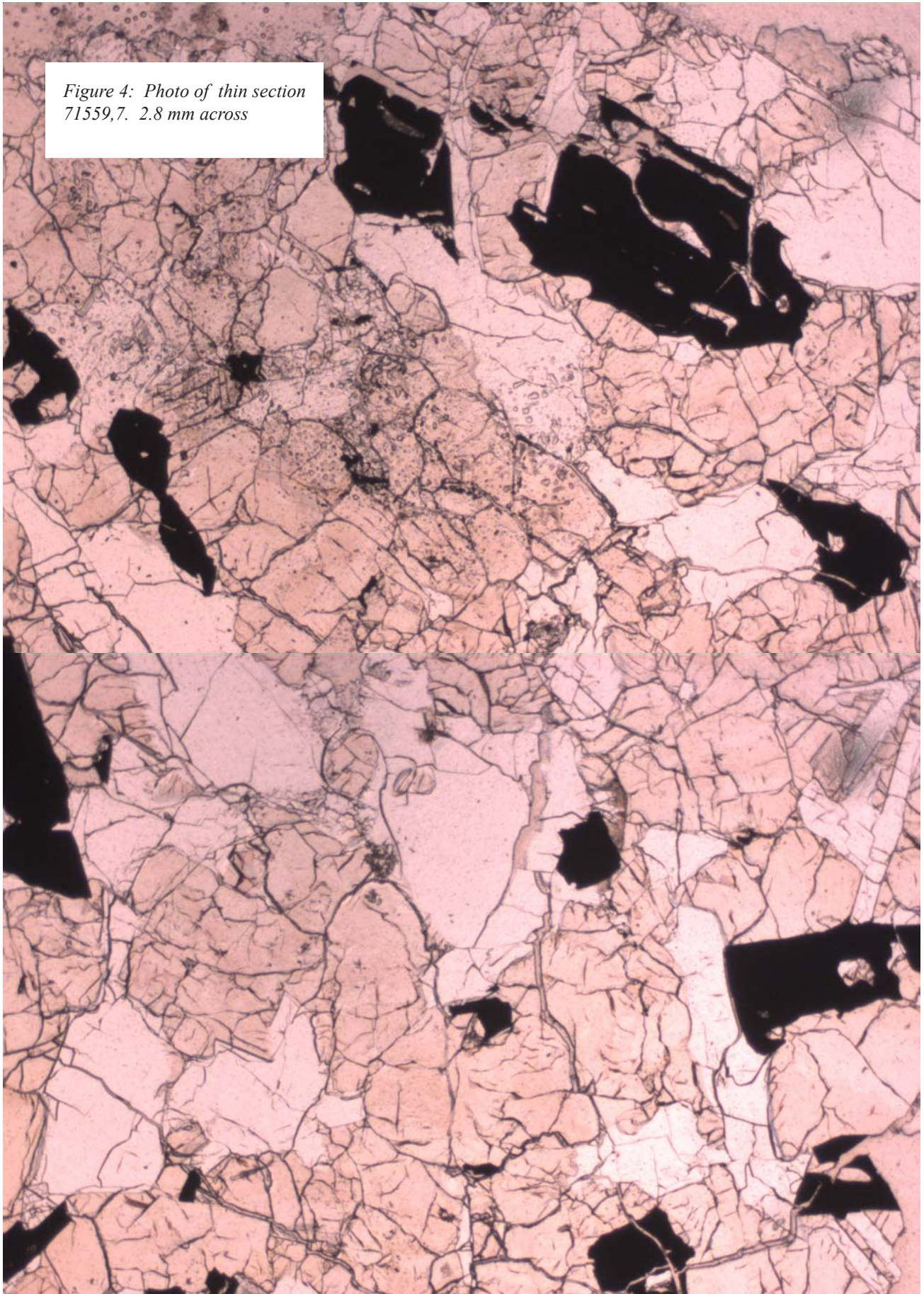
Chemistry

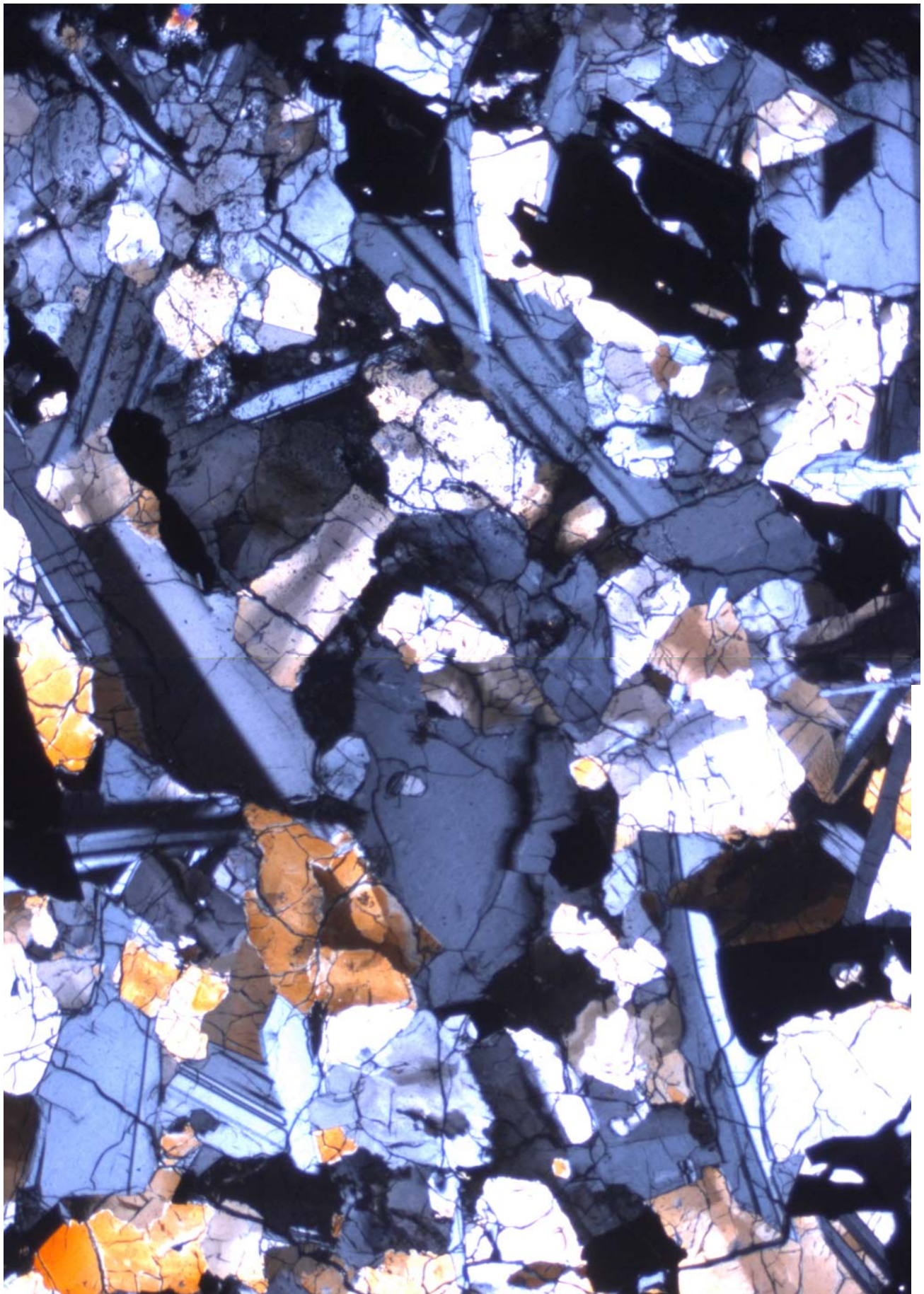
Warner et al. (1975) and Murali et al. (1977) reported the composition, finding that these coarse-grain rocks have lower Ti than for other Apollo 17 (figure 5). The REE pattern is like that of type A Apollo 17 basalt (figure 6).

Radiogenic age dating

Of these samples, only 71539 has been dated. Paces et al. (1991) determined a Rb/Sr isochron of 3.67 ± 0.1 b.y. and a Nd/Sm isochron of 3.75 ± 0.067 b.y. (*3.75 is typical of type A basalts*)

*Figure 4: Photo of thin section
71559,7. 2.8 mm across*





Lunar Sample Compendium
C Meyer 2011

Table 1. Chemical composition of 71559.

<i>reference weight</i>	Warner75 Warner78	
SiO ₂ %		
TiO ₂	8.3	(a)
Al ₂ O ₃	10.3	(a)
FeO	17.8	(a)
MnO	0.226	(a)
MgO	6.3	(a)
CaO	12.2	(a)
Na ₂ O	0.48	(a)
K ₂ O	0.068	(a)
P ₂ O ₅		
S %		
<i>sum</i>		
Sc ppm	72	(a)
V	30	(a)
Cr	1577	(a)
Co	14.4	(a)
Ni		
Cu		
Zn		
Ga		
Ge ppb		
As		
Se		
Rb		
Sr		
Y		
Zr		
Nb		
Mo		
Ru		
Rh		
Pd ppb		
Ag ppb		
Cd ppb		
In ppb		
Sn ppb		
Sb ppb		
Te ppb		
Cs ppm		
Ba		
La	6.6	(a)
Ce	26	(a)
Pr		
Nd	24	(a)
Sm	10.4	(a)
Eu	2.2	(a)
Gd		
Tb	2.6	(a)
Dy	17	(a)
Ho		
Er		
Tm		
Yb	9.2	(a)
Lu	1.4	(a)
Hf	8.8	(a)
Ta	1.5	(a)
W ppb		
Re ppb		
Os ppb		
Ir ppb		
Pt ppb		
Au ppb		
Th ppm		
U ppm		

technique: (a) INAA

Table 2. Chemical composition of 71536.

<i>reference weight</i>	Murali77	
SiO ₂ %		
TiO ₂	7.8	(a)
Al ₂ O ₃	11.7	(a)
FeO	16.1	(a)
MnO	0.223	(a)
MgO	7.3	(a)
CaO	13.6	(a)
Na ₂ O	0.5	(a)
K ₂ O	0.071	(a)
P ₂ O ₅		
S %		
<i>sum</i>		
Sc ppm	73	(a)
V	39	(a)
Cr	2313	(a)
Co	13	(a)
Ni		
Cu		
Zn		
Ga		
Ge ppb		
As		
Se		
Rb		
Sr		
Y		
Zr		
Nb		
Mo		
Ru		
Rh		
Pd ppb		
Ag ppb		
Cd ppb		
In ppb		
Sn ppb		
Sb ppb		
Te ppb		
Cs ppm		
Ba		
La	6.2	(a)
Ce	29	(a)
Pr		
Nd		
Sm	9.6	(a)
Eu	2.17	(a)
Gd		
Tb	2.4	(a)
Dy	14	(a)
Ho		
Er		
Tm		
Yb	9	(a)
Lu	1.4	(a)
Hf	7.2	(a)
Ta	1.4	(a)
W ppb		
Re ppb		
Os ppb		
Ir ppb		
Pt ppb		
Au ppb	1.4	(a)
Th ppm		
U ppm		

technique: (a) INAA

Table 3. Chemical composition of 71539.

reference weight	Murali77	Paces91
SiO2 %		
TiO2	8.6 (a)	
Al2O3	9.8 (a)	
FeO	19.1 (a)	
MnO	0.258 (a)	
MgO	5.4 (a)	
CaO	12.1 (a)	
Na2O	0.47 (a)	
K2O	0.081 (a)	
P2O5		
S %		
sum		
Sc ppm	73 (a)	
V	36 (a)	
Cr	1273 (a)	
Co	13.5 (a)	
Ni		
Cu		
Zn		
Ga		
Ge ppb		
As		
Se		
Rb		0.787 (b)
Sr		229 (b)
Y		
Zr		
Nb		
Mo		
Ru		
Rh		
Pd ppb		
Ag ppb		
Cd ppb		
In ppb		
Sn ppb		
Sb ppb		
Te ppb		
Cs ppm		
Ba		
La	8 (a)	
Ce	30 (a)	
Pr		
Nd		32.5 (b)
Sm	12.1 (a)	13.4 (b)
Eu	2.44 (a)	
Gd		
Tb	3.3 (a)	
Dy	21 (a)	
Ho		
Er		
Tm		
Yb	11.5 (a)	
Lu	1.52 (a)	
Hf	9.9 (a)	
Ta	1.8 (a)	
W ppb		
Re ppb		
Os ppb		
Ir ppb		
Pt ppb		
Au ppb		
Th ppm		
U ppm		

technique: (a) INAA, (b) IDMS.

Table 4. Chemical composition of 71568.

reference weight	Murali77
SiO2 %	
TiO2	9.8 (a)
Al2O3	10.1 (a)
FeO	19.4 (a)
MnO	0.249 (a)
MgO	7.9 (a)
CaO	13.4 (a)
Na2O	0.46 (a)
K2O	0.058 (a)
P2O5	
S %	
sum	
Sc ppm	79 (a)
V	27 (a)
Cr	1690 (a)
Co	15 (a)
Ni	
Cu	
Zn	
Ga	
Ge ppb	
As	
Se	
Rb	
Sr	
Y	
Zr	
Nb	
Mo	
Ru	
Rh	
Pd ppb	
Ag ppb	
Cd ppb	
In ppb	
Sn ppb	
Sb ppb	
Te ppb	
Cs ppm	
Ba	
La	5.3 (a)
Ce	29 (a)
Pr	
Nd	
Sm	8.5 (a)
Eu	1.91 (a)
Gd	
Tb	2.4 (a)
Dy	14 (a)
Ho	
Er	
Tm	
Yb	8.1 (a)
Lu	1.36 (a)
Hf	8.6 (a)
Ta	1.6 (a)
W ppb	
Re ppb	
Os ppb	
Ir ppb	
Pt ppb	
Au ppb	
Th ppm	
U ppm	

technique: (a) INAA

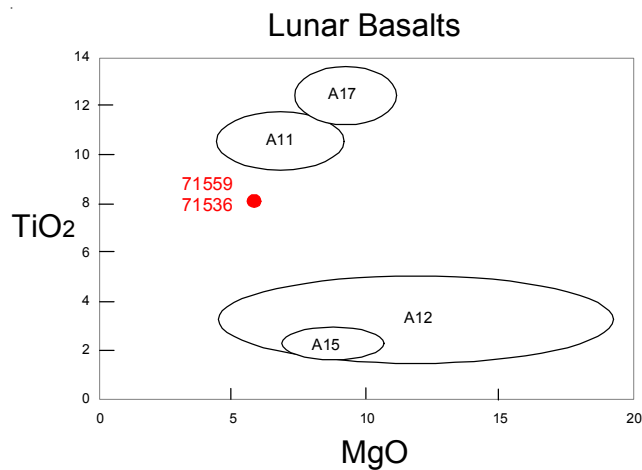


Figure 5: Composition of 71559 compared with other Apollo basalts.

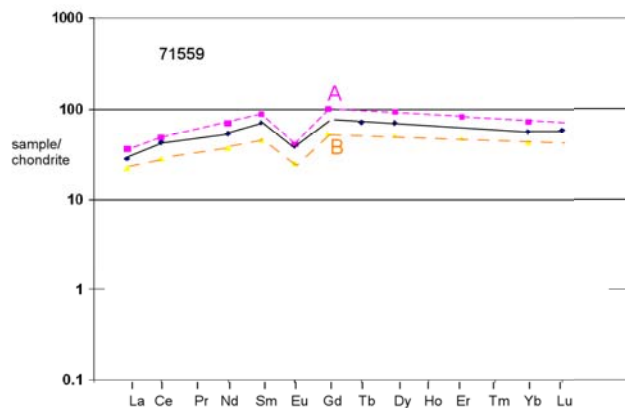


Figure 6: Normalized rare-earth-element diagram for 71559 and type A and B basalts.

References for 71559, 71536, 71539 and 71568.

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.

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.

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.

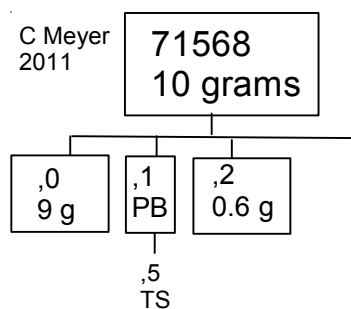
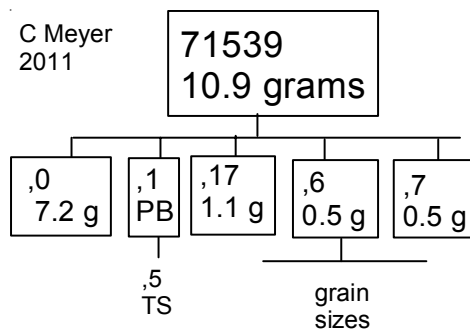
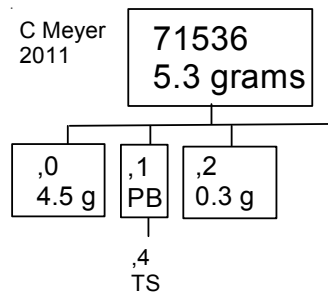
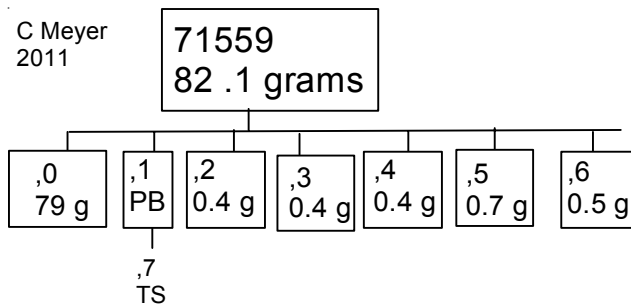


Table 5: Armalcolite in 71559.*(Warner et al. 1976)*

TiO ₂	70.7
Al ₂ O ₃	2.75
Cr ₂ O ₃	1.07
FeO	14.6
MgO	0.9
CaO	6.1
ZrO ₂	0.9
Y ₂ O ₃	0.2

Table 6: Tranquillityite in 71559.*(Warner et al. 1976)*

SiO ₂	15.1	14.3	14.4	14.6	14.4
TiO ₂	19.5	13.9	19.5	17.7	19.8
Al ₂ O ₃	1.63	1.59	1.5	1.73	1.62
Cr ₂ O ₃	0.4	0.11	0.04	0.05	
FeO	40.8	41	42.3	42.7	42.8
MnO	0.86	0.43	0.36	0.43	0.31
MgO	0.86	0.49	0.22	0.06	0.15
CaO	1.13	1.34	1.25	1.1.34	1.06
ZrO ₂	14.5	16.5	12.6	18.5	14.4
HfO ₂	0.37	0.64	0.4	0.51	0.51
Nb ₂ O ₅	0.8	0.91	0.76	0.29	0.8
Y ₂ O ₃	2.73	2.77	3.7	3.3	2.96
REE	tr.	tr.	high	tr.	tr.

Muehlberger et al. (1973) Documentation and environment of the Apollo 17 samples: A preliminary report. *Astrogeology* 71 322 pp superceded by *Astrogeology* 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.

Murali A.V., Ma M.-S., Schmitt R.A., Warner R.D., Keil K. and Taylor G.J. (1977b) Chemistry of 30 Apollo 17 rake basalts; 71597 a product of partial olivine accumulation (abs). *Lunar Sci.* **VIII**, 703-705. Lunar Planetary Institute, Houston.

Neal C.R. and Taylor L.A. (1993) Catalog of Apollo 17 rocks. Vol. 2 Basalts

Neal C.R., Taylor L.A., Patchen A.D., Hughes S.S. and Schmitt R.A. (1990a) The significance of fractional crystallization in the petrogenesis of Apollo 17 Type A and B high-Ti basalts. *Geochim. Cosmochim. Acta* **54**, 1817-1833.

Paces J.B., Nakai S., Neal C.R., Taylor L.A., Halliday A.N. and Lee D.-C. (1991) A strontium and neodymium isotopic study of Apollo 17 high-Ti mare basalts: Resolution of ages, evolution of magmas, and origin of source heterogeneities. *Geochim. Cosmochim. Acta* **55**, 2025-2043.

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.

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 1a, 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.

Warner R.D., Taylor G.J., Conrad G.H., Northrop H.R., Barker S., Keil K., Ma M.-S. and Schmitt R. (1979a) Apollo 17 high-Ti mare basalts: New bulk compositional data, magma types, and petrogenesis. *Proc. 10th Lunar Planet. Sci. Conf.* 225-247.

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.