15614, 15616, 15620, 15622, 15623 and 15630

Vesicular Olivine-normative Basalt

9.7, 8.0, 6.6, 29.5, 3,and 23.2 grams

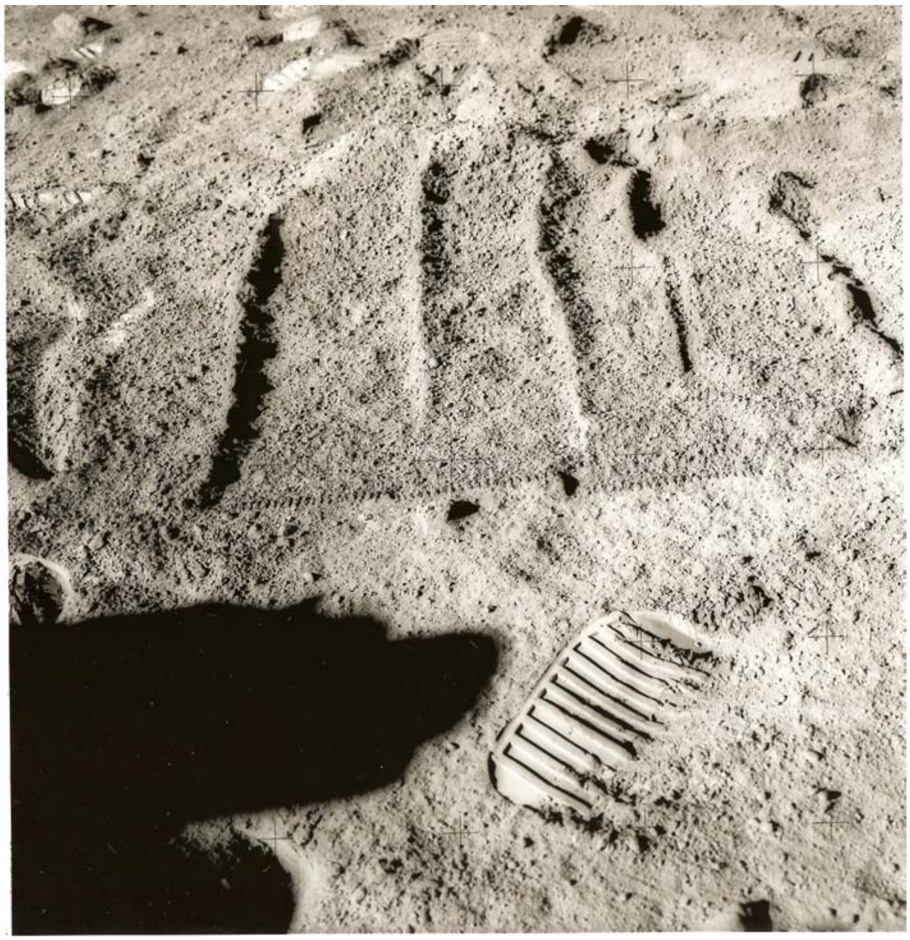


Figure 1: Surface photo of raked area at station 9a, about 20 meters from Hadley Rille. See section on 15600. AS15-82-11155.

Introduction

These small fragments of vesicular mare basalt were collected as part of the rake sample at station 9a, about 20 meters from the rim of Hadley Rille (figure 1). Their chemical composition is that of an olivine-normative basalt, but olivine does not form obvious phenocrysts.

Petrography

Dowty et al. (1973 and 1974) and Nehru et al (1974) described 15620 and 15623. Pyroxene, olivine and plagioclase form an interlocking network that is "peppered" by minute opaque minerals; ilmenite and spinel (figures 2-7). Small grains of metallic Ni-Co-Fe are also present. Vesicles are less than 1 mm. Pyroxene is red-brown (Ryder 1985) and chemically zoned (figures 8 and 9).

Chemistry

Apollo 15 basalts have broadly similar composition (figures 10 and 11). Trace elements (inc. REE) are very similar to that of 15555 (Ma et al. 1986, 1988; Fruchter et al. 1973). However, two groups can be distinguished: olivine-normative and pyroxene-phyric (figure 12). 15614, 15616, 15620, 15622, 15623 and 15630 all olivine-normative and have identical trace element content. However, there is evidence of olivine addition or subtraction (figure 10).

Figure 2a: Photo of 15614. Scale in cm. S71-49070.

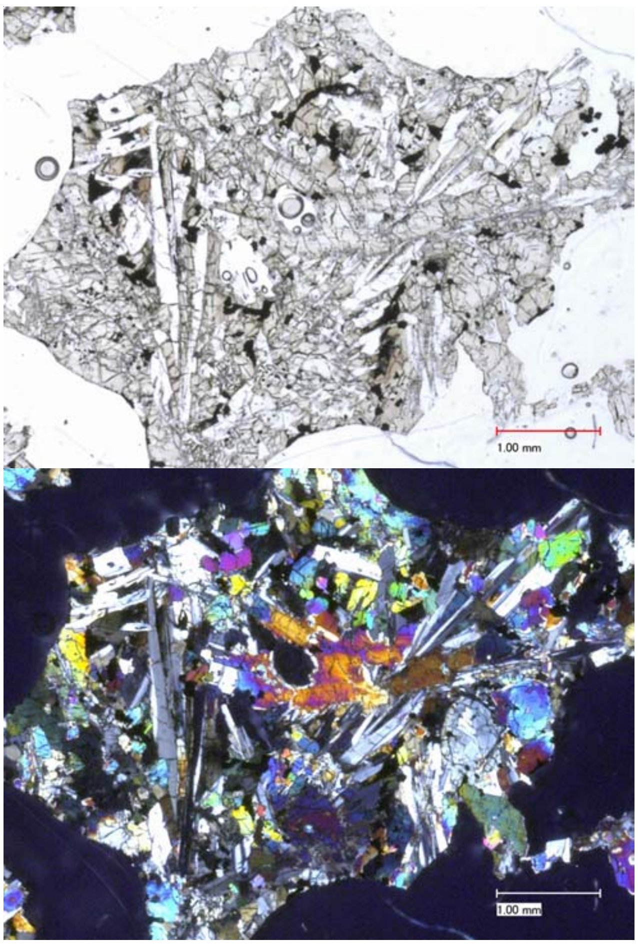


Figure 2b: Photomicrograph of thin section 15614,5 by C Meyer @ 50x.

Chappel and Green (1973) analyzed 15622 by XRF and finding very low silica content. Ryder and Schuraytz (2001) and Neal (2001) analyzed relatively large splits of 15622 and 15630.

Figure 3a: Photo of 15616. Scale in cm. S71-49120.

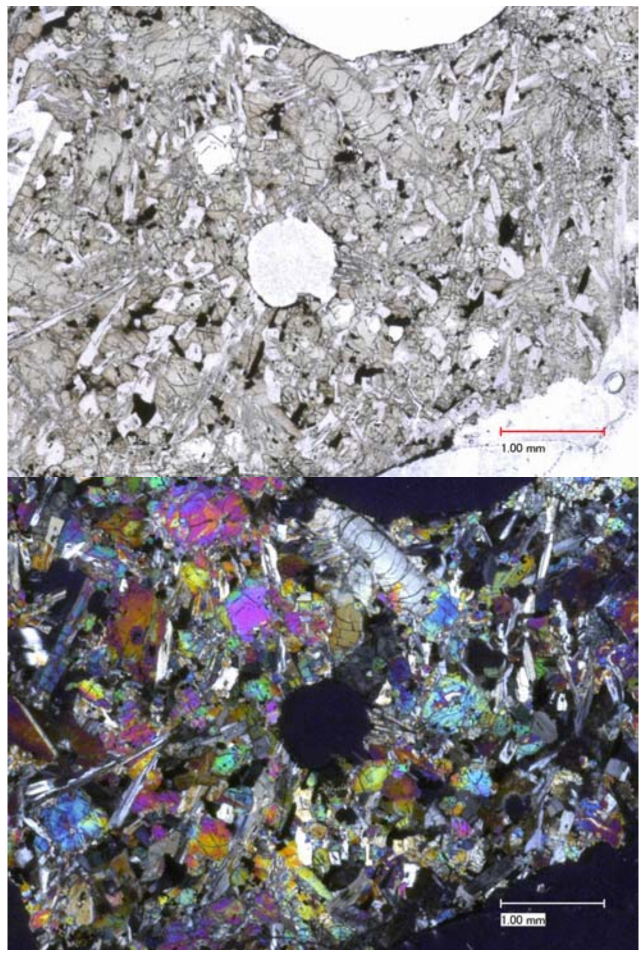


Figure 3b: Photomicrographs of thin section 15616,11 by C Meyer @ 50x.

Radiogenic age dating

Compston et al. (1972) reported Rb and Sr isotopic data for 15622.

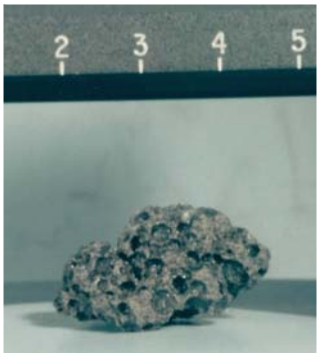


Figure 4a: Photo of 15620. Scale in cm. S71-49118.

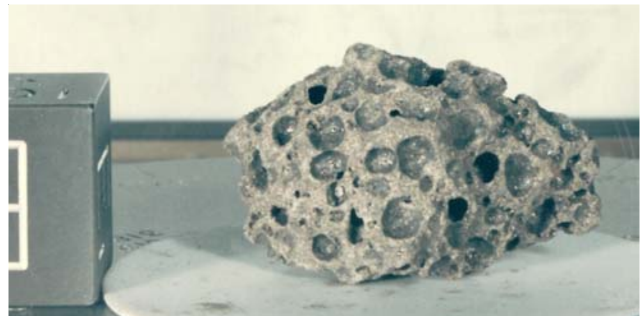


Figure 5a: Photo of 15622 with portion of 1 inch cube for scale. S71-49107.

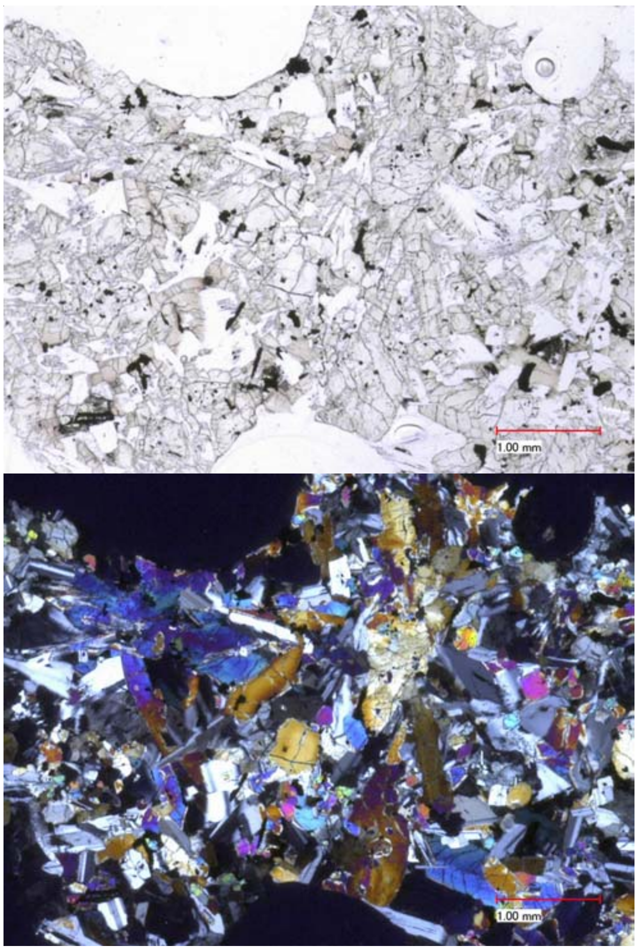


Figure 4b: Photomicrographs of thin section 15620,3 by C Meyer @ 50x.

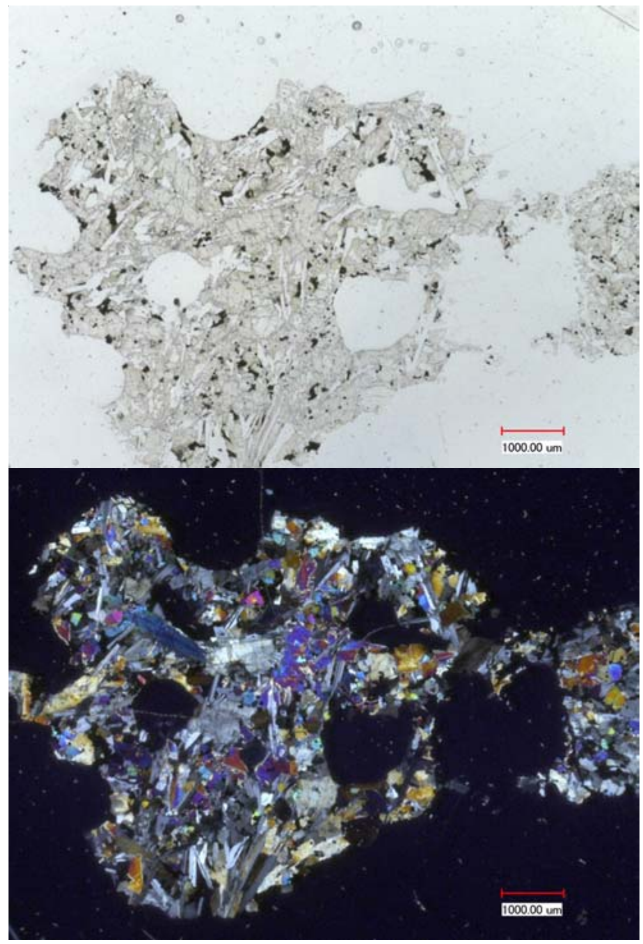


Figure 5b: Photomicrographs of thin section of 15622,20 by C Meyer @ 30x.

Mineralogical Mode

Olivine	8
Pyroxene	63
Plagioclase	24
Opaques	4
Silica	0.2
Meostasis	0.8
Dowty et al. 1973	

Other Studies

Gose et al. (1972) and Pearce et al. (1973) determined the magnetic remenance of 15614 and 15630.

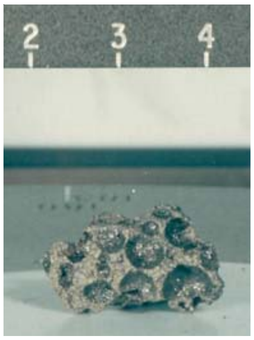


Figure 6a: Photo of 15623. Scale in cm. S71-49-313.

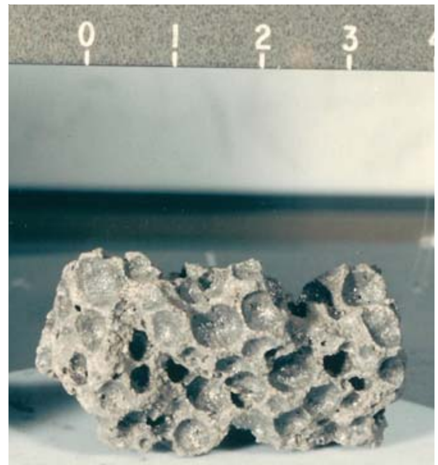


Figure 7a: Photo of rake sample 15630. Scale in cm. S71-49270

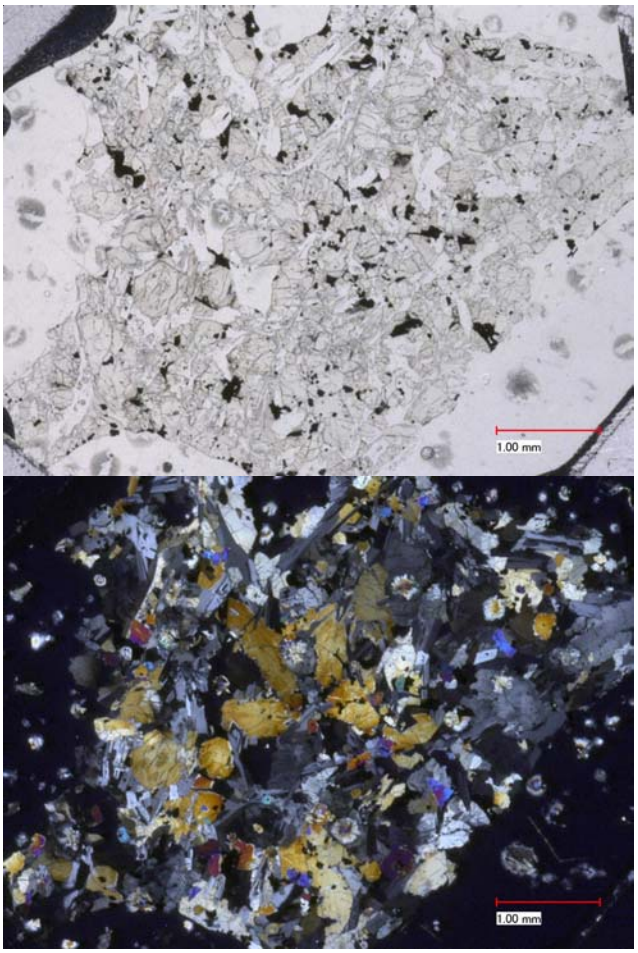


Figure 6b: Photomicrographs of thin section 15623,3 by C Meyer @ 50x.

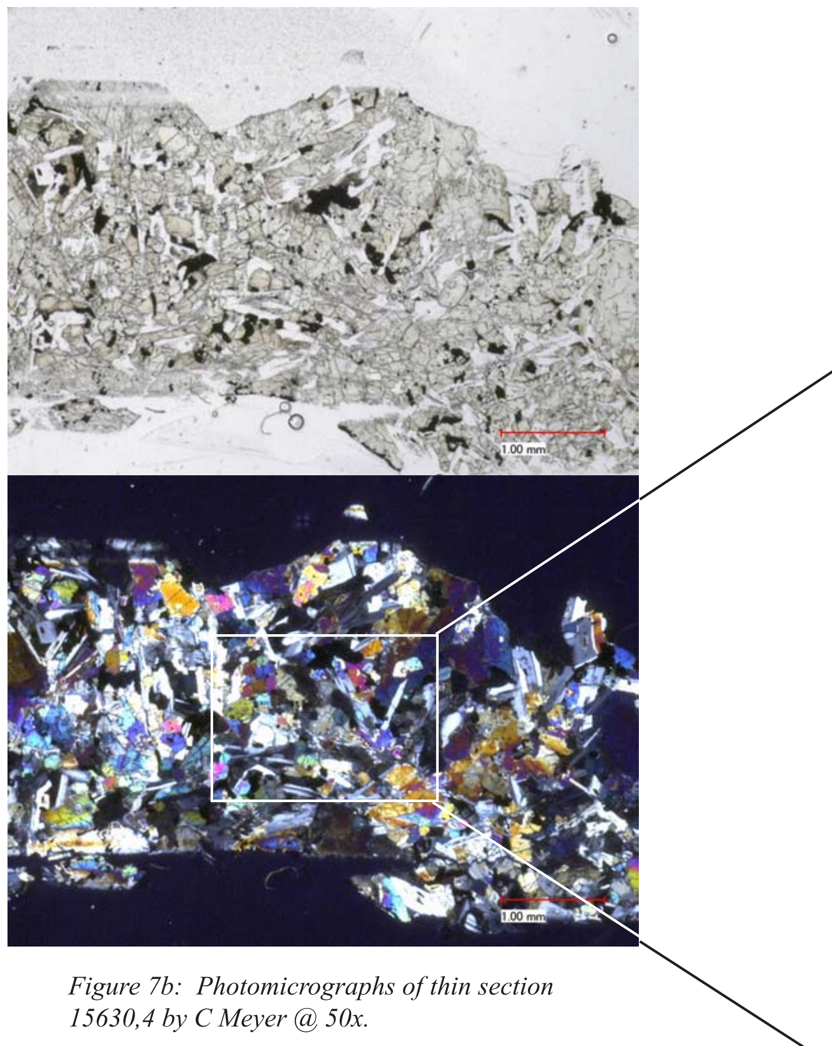


Figure 7b: Photomicrographs of thin section 15630,4 by C Meyer @ 50x.

Mineralogical Mode

Olivine	9
Pyroxene	61
Plagioclase	24
Opaques	6
Silica	
Meostasis	

Dowty et al. 1973

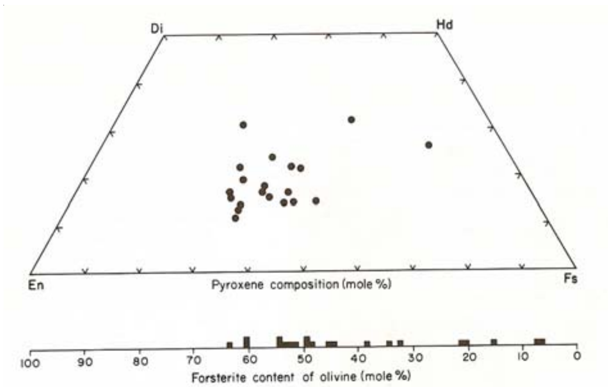


Figure 8: Pyroxene and olivine composition of 15620 (Dowty et al. 1973).

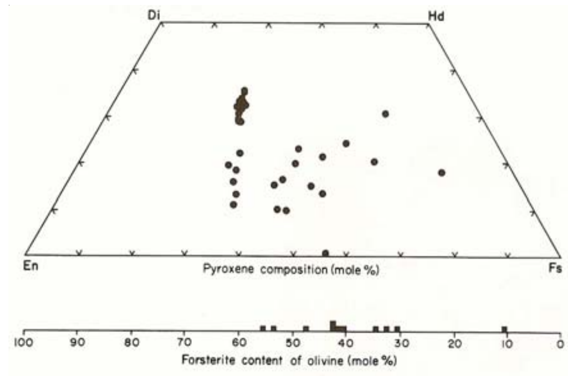


Figure 9: Pyroxene and olivine composition of 15623 (Dowty et al. 1973).

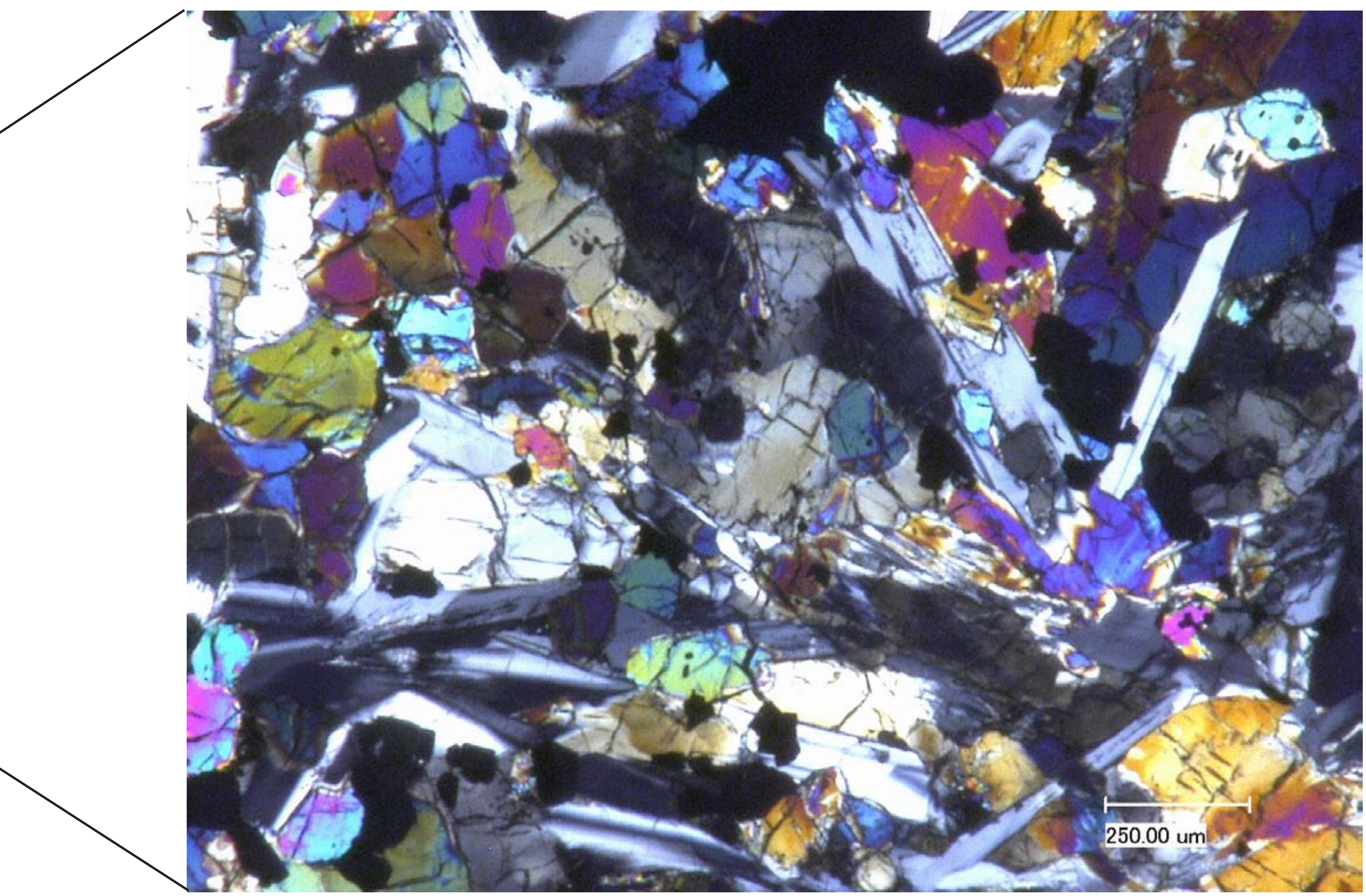


Figure 7c: Enlargement of figure 7b.

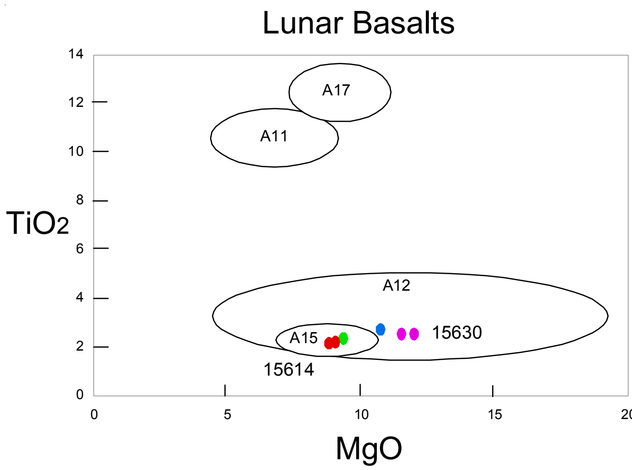


Figure 10: Composition of small rake samples compared with Apollo basalts.

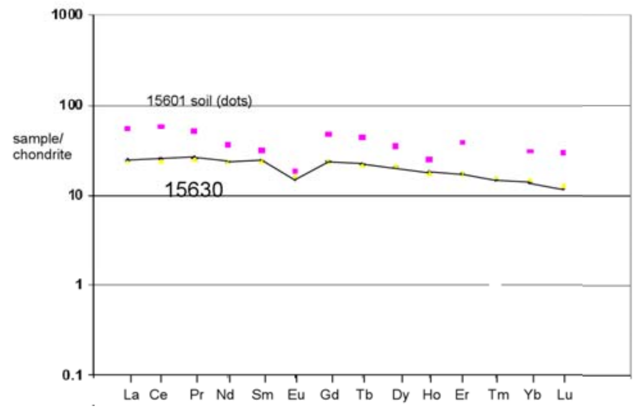


Figure 11: Normalized rare-earth-element diagram for 15630, with 15601 soil for comparison.

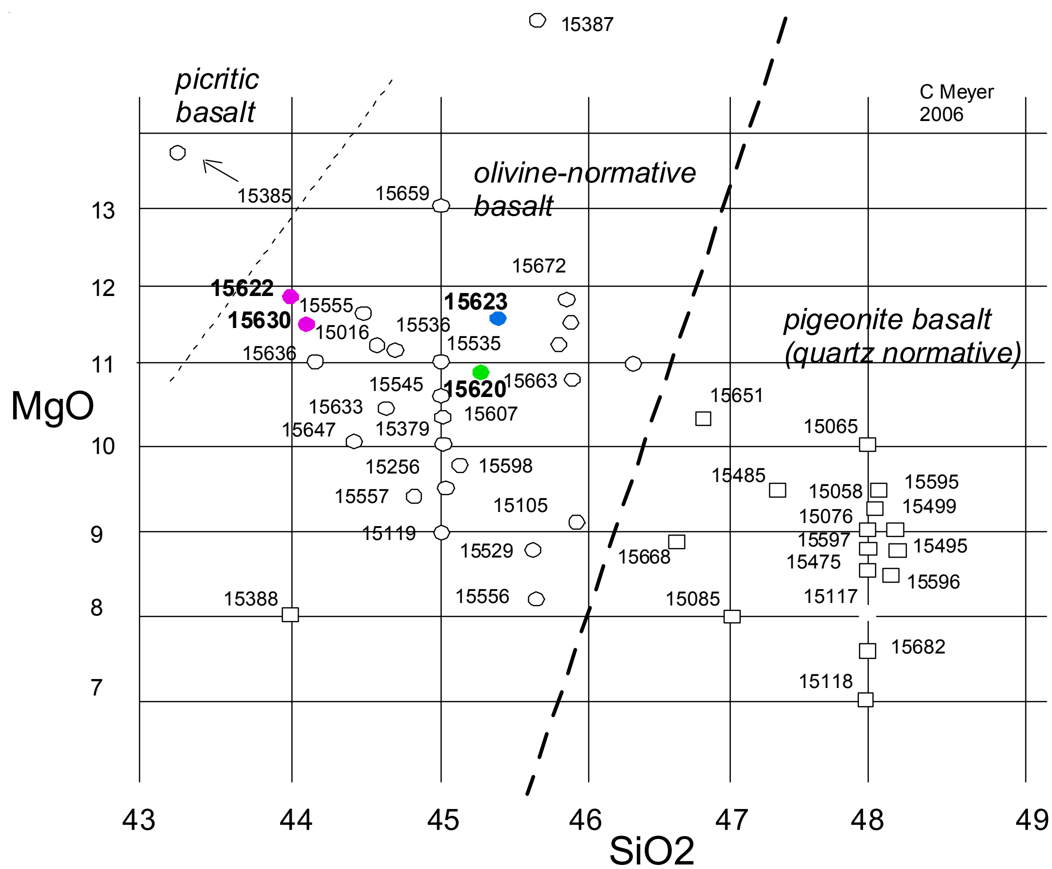


Figure 12: The Apollo 15 basalts can be divided into two groups based on silica content.

Table 1: Chemical composition of 15614, 15616, 15620 and 15622.

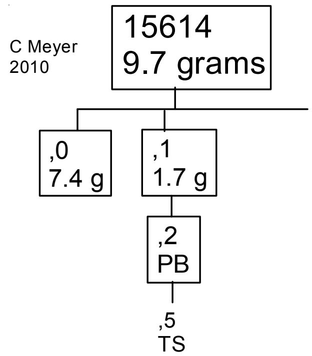
	15614		15616		15620		15620		15620		15622		15622		15622		15622	
reference	Ma78		Ma78		Ma76		Ryder88		Dowty73		Ryder2001		Neal2001		Chappell73		Fruchter73	
weight																		
SiO2 %							45.8	(b)	44.9	(c)	44.1	(b)			43.98	(e)		
TiO2	2	(a)	2	(a)	2.3	(a)	1.95	(b)	2.63	(c)	2.27	(b)			2.29	(e)	2.93	(a)
Al2O3	8.8	(a)	8.7	(a)	8.8	(a)	9.2	(b)	9.7	(c)	8.58	(b)			8.46	(e)	7.84	(a)
FeO	21.3	(a)	21.8	(a)	23.5	(a)	21.5	(b)	21.9	(c)	22.15	(b)			22.73	(e)	21.74	(a)
MnO	0.267	(a)	0.264	(a)			0.35	(b)	0.28	(c)	0.282	(b)			0.31	(e)		
MgO	11	(a)	12	(a)	11.1	(a)	11.3	(b)	10.9	(c)	11.75	(b)			11.64	(e)		
CaO	8.9	(a)	8.3	(a)	8.9	(a)	9.2	(b)	9.6	(c)	9.02	(b)			9.19	(e)		
Na2O	0.25	(a)	0.238	(a)	0.26	(a)	0.26	(a)	0.36	(c)	0.242	(a)			0.29	(e)	0.26	(a)
K2O	0.034	(a)	0.043	(a)	0.044	(a)			0.04	(c)	0.044	(b)			0.05	(e)		
P2O5							0.12	(b)	0.13	(c)	0.069	(b)			0.08	(e)		
S %															0.05	(e)		
sum																		
Sc ppm	38	(a)	38	(a)	41	(a)	39.1	(a)			39.6	(a)	49.6	(d)			40	(a)
V	218	(a)	248	(a)	225	(a)							330	(d)				
Cr	4680	(a)	6226	(a)	4420	(a)	4526	(a)	2737	(c)	6430	(a)	8046	(d)	5540	(e)	6060	(a)
Co	52	(a)	57	(a)	48	(a)	52.8	(a)			59.3	(a)	72.7	(d)			56	(a)
Ni	70	(a)	90	(a)	95	(a)					82	(a)	98.7	(d)				
Cu													14.6	(d)				
Zn													17.6	(d)				
Ga													3.99	(d)				
Ge ppb																		
As																		
Se																		
Rb													1.01	(d)				
Sr											102	(a)	111	(d)				
Y													34	(d)				
Zr													111	(d)				
Nb													7.6	(d)				
Mo													0.12	(d)				
Ru																		
Rh																		
Pd ppb																		
Ag ppb																		
Cd ppb																		
In ppb																		
Sn ppb																		
Sb ppb													10	(d)				
Te ppb																		
Cs ppm													0.03	(d)				
Ba	55	(a)	60	(a)	54	(a)					49	(a)	61.1	(d)				
La	5.2	(a)	5.3	(a)	5.4	(a)	4.92	(a)			5.08	(a)	6.29	(d)			5.5	(a)
Ce							13.2	(a)			15.5	(a)	14.6	(d)				
Pr													2.24	(d)				
Nd											11	(a)	10.4	(d)				
Sm	3.4	(a)	3.5	(a)	3.4	(a)	3.3	(a)			3.48	(a)	3.5	(d)			3.8	(a)
Eu	0.76	(a)	0.77	(a)	0.88	(a)	0.809	(a)			0.85	(a)	0.85	(d)			0.92	(a)
Gd													4.63	(d)				
Tb	0.6	(a)	0.7	(a)	0.69	(a)	0.81	(a)			0.76	(a)	0.8	(d)			0.7	(a)
Dy	4	(a)	3.8	(a)	4.4	(a)							4.91	(d)				
Ho													0.96	(d)				
Er													2.71	(d)				
Tm													0.36	(d)				
Yb	2	(a)	2.2	(a)	2.1	(a)	2.04	(a)			2.2	(a)	2.29	(d)			2.4	(a)
Lu	0.27	(a)	0.34	(a)	0.36	(a)	0.324	(a)			0.3	(a)	0.29	(d)			0.38	(a)
Hf	2.4	(a)	2.4	(a)	2.7	(a)	2.11	(a)			2.7	(a)	2.53	(d)			2.6	(a)
Ta	0.39	(a)	0.47	(a)	0.44	(a)					0.37	(a)	0.46	(d)			0.43	(a)
W ppb																		
Re ppb																		
Os ppb																		
Ir ppb																		
Pt ppb																		
Au ppb																		
Th ppm							0.629	(a)			0.36	(a)	0.52	(d)				
U ppm													0.14	(d)				

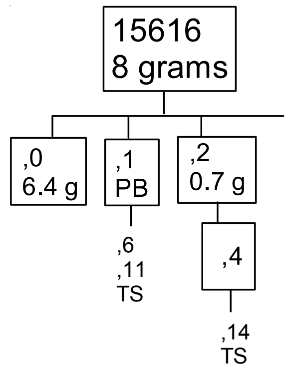
technique: (a) INAA, (b) fused-bead e-probe, (c) broad-beam e-probe, (d) ICP-MS, (e) XRF

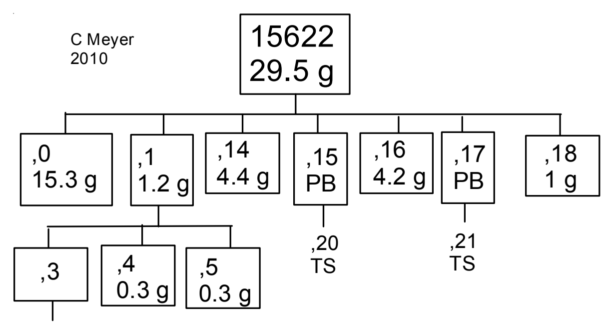
Table 2. Chemical composition of 15623 and 15630.

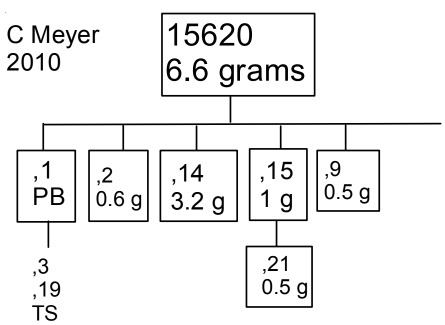
	15623		15623		15623		15630		15630		15630	
reference	Dowty73		Ryder88		Ma78		Neal2001		Ryder2001		Ma78	
weight												
SiO2 %	45.1	(c)	45.4	(b)					44.1	(b)		
TiO2	1.46	(c)	2.27	(b)	2	(a)			2.26	(b)	2	(a)
Al2O3	8.6	(c)	8.2	(b)	8.6	(a)			8.84	(b)	8.9	(a)
FeO	23.1	(c)	22.5	(b)	23.2	(a)			22.15	(b)	20.8	(a)
MnO	0.22	(c)	0.37	(b)	0.27	(a)			0.28	(b)	0.27	(a)
MgO	11.4	(c)	11.6	(b)	13	(a)			11.5	(b)	11	(a)
CaO	9.5	(c)	9.6	(b)	9.2	(a)			9.2	(b)	8.8	(a)
Na2O	0.3	(c)	0.24	(b)	0.24	(a)			0.23	(b)	0.25	(a)
K2O	0.02	(c)		(b)	0.043	(a)			0.042	(b)	0.044	(a)
P2O5	0.17	(c)	0.13	(b)					0.067	(b)		
S %												
sum												
Sc ppm			39	(a)	38	(a)	38.4	(d)	41.1	(a)	39	(a)
V					217	(a)	208	(d)			225	(a)
Cr	4105	(c)	5481	(a)	5843	(a)	5563	(d)	6010	(a)		(a)
Co			55	(a)	54	(a)	59.3	(d)	57	(a)	53	(a)
Ni					70	(a)	81.2	(d)	100	(a)	70	(a)
Cu							13.3	(d)				
Zn							15	(d)				
Ga							3.34	(d)				
Ge ppb												
As												
Se												
Rb							0.91	(d)				
Sr							96.5	(d)	82	(a)		
Y							28	(d)				
Zr							96.5	(d)				
Nb							6.36	(d)				
Mo							0.09	(d)				
Ru												
Rh												
Pd ppb												
Ag ppb												
Cd ppb												
In ppb												
Sn ppb												
Sb ppb							10	(d)				
Te ppb												
Cs ppm							0.02	(d)				
Ba					80	(a)	55.2	(d)	53	(a)	80	(a)
La			5.23	(a)	5.4	(a)	5.69	(d)	5.21	(a)	5.4	(a)
Ce			14.3	(a)			15.2	(d)	15.2	(a)		
Pr							2.29	(d)				
Nd							10.5	(d)	11	(a)		
Sm			3.5	(a)	3.5	(a)	3.56	(d)	3.66	(a)	3.5	(a)
Eu			0.826	(a)	0.79	(a)	0.86	(d)	0.84	(a)	0.79	(a)
Gd							4.62	(d)				
Tb			0.821	(a)	0.7	(a)	0.79	(d)	0.75	(a)	0.7	(a)
Dy					4.3	(a)	5	(d)			4.3	(a)
Ho							0.99	(d)				
Er							2.72	(d)				
Tm							0.36	(d)				
Yb			2.22	(a)	2.1	(a)	2.28	(d)	2.29	(a)	2.1	(a)
Lu			0.322	(a)	0.27	(a)	0.29	(d)	0.31	(a)	0.27	(a)
Hf			2.27	(a)	2.4	(a)	2.54	(d)	2.65	(a)	2.4	(a)
Ta					0.47	(a)	0.41	(d)	0.36	(a)	0.47	(a)
W ppb												
Re ppb												
Os ppb												
Ir ppb												
Pt ppb												
Au ppb												
Th ppm			0.667	(a)			0.59	(d)	0.46	(a)		
U ppm							0.16	(d)				

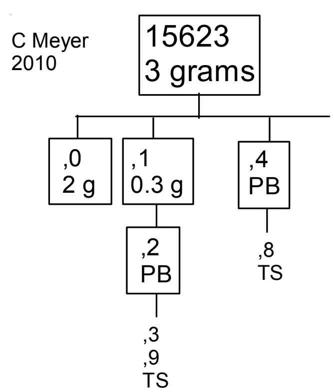
technique: (a) INAA, (b) fused-bead e-probe, (c) broad-beam e-probe, (d) ICP_MS.

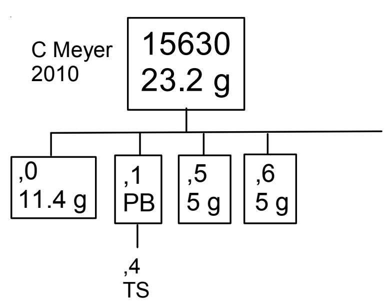

C Meyer
2010
15614
9.7 grams
,0
7.4 g
,1
1.7 g
,2
PB
,5
TS


15616
8 grams
,0
6.4 g
,1
PB
,2
0.7 g
,6
,11
TS
,4
,14
TS


C Meyer
2010
15622
29.5 g
,0
15.3 g
,1
1.2 g
,14
4.4 g
,15
PB
,16
4.2 g
,17
PB
,18
1 g
,3
,4
0.3 g
,5
0.3 g
,20
TS
,21
TS


C Meyer
2010
15620
6.6 grams
,1
PB
,2
0.6 g
,14
3.2 g
,15
1 g
,9
0.5 g
,3
,19
TS
,21
0.5 g


C Meyer
2010
15623
3 grams
,0
2 g
,1
0.3 g
,4
PB
,2
PB
,8
TS
,3
,9
TS


C Meyer
2010
15630
23.2 g
,0
11.4 g
,1
PB
,5
5 g
,6
5 g
,4
TS

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