67435

Poymict Breccia

353 grams

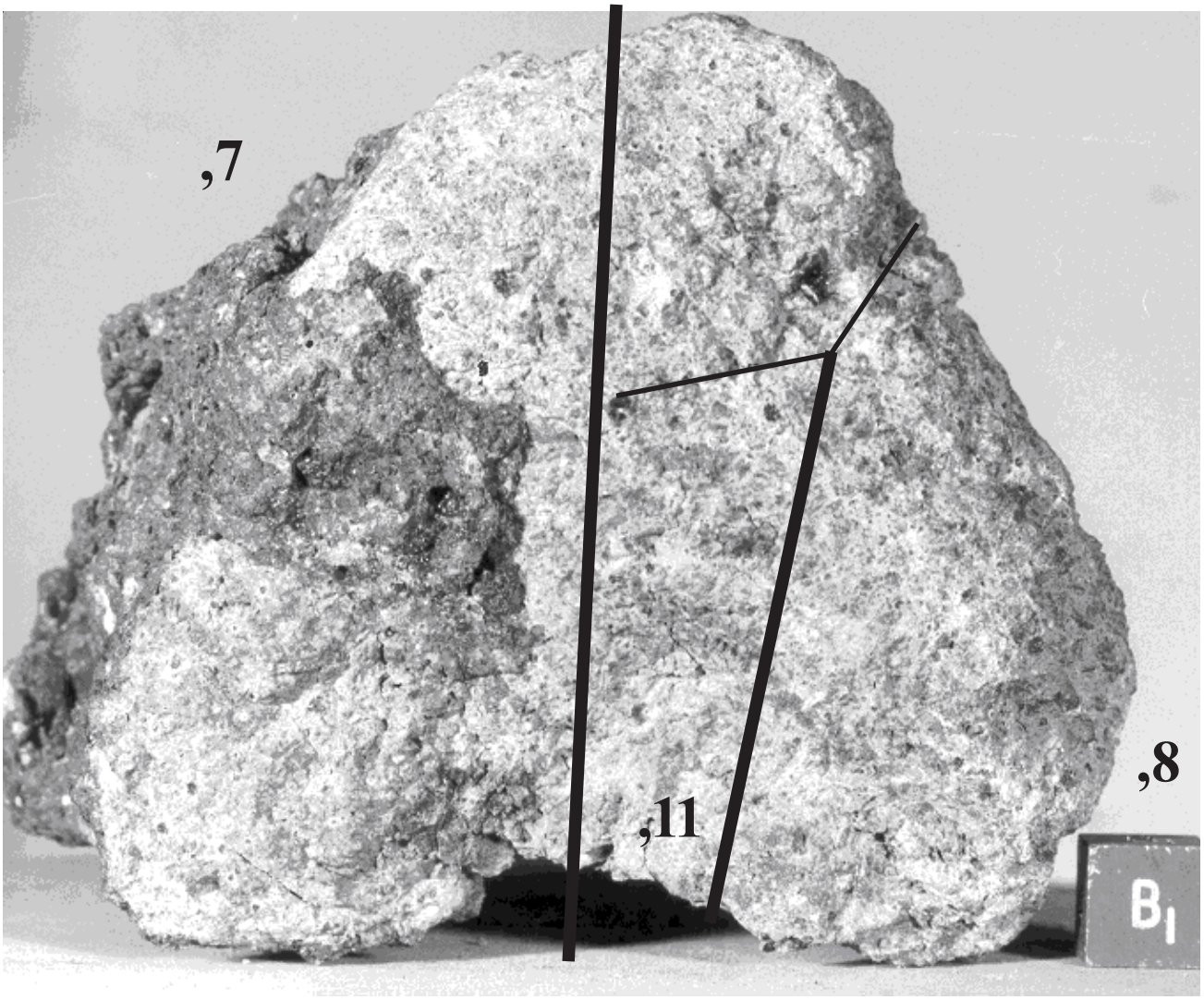


Figure 1: Photo of 67435 before processing. Cube is 1 cm. NASA SS72-43901.

Introduction

Ulrich (1973) and Wilshire et al. (1972) termed 67435 a "dark-matrix breccia", although it is not all that dark. It was found in the soil on the rim of North Ray Crater and had a prominent glass splash (figure 1). There are numerous micrometeorite craters on the surface including a fresh, glass-lined crater on ,7 (figure 1).

Clasts in this breccia have been dated at 4.42 b.y. The clasts appear to be of the anorthosite-norite-troctolite clan (ANT) including two clasts containing pleonaste spinel.

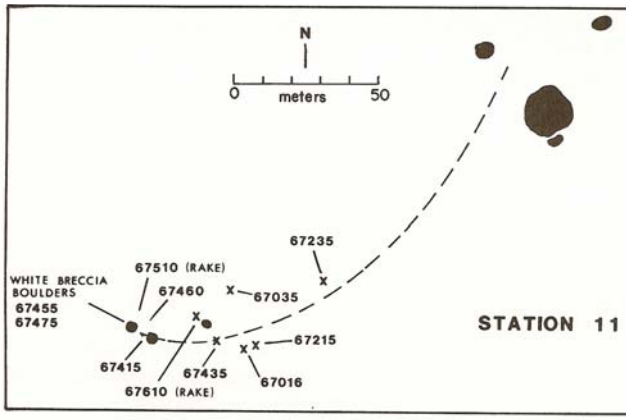


Figure 2: Map of southern rim of North Ray Crater showing location of 67435.

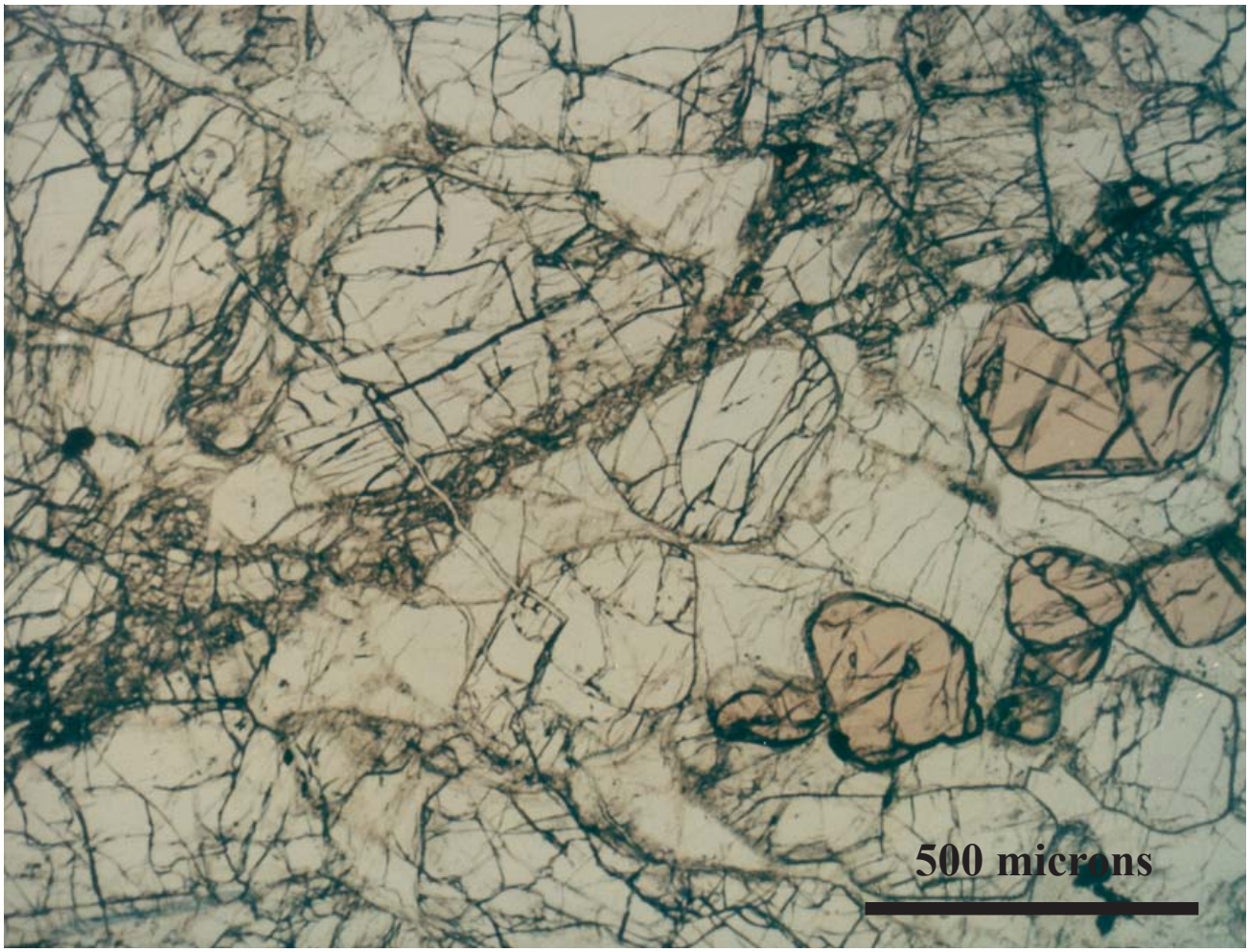


Figure 3: Thin section photomicrograph of pink spinel troctolite clast in 67435,14. NASA S72-42391.

Petrography

R. Warner et al. (1976) produced the consortium report for 67435 and Ryder and Norman (1980) summarized the results.

67435 is a grey matrix breccias with both dark and light clasts (figures 1 and 5). The fine-grained matrix is feldspathic, porous, friable and fractured. The matrix encloses numerous grey aphanitic clasts and rare white (ANT) clasts. The dark aphanitic clasts have a poikilitic texture indicating that they are impact melt breccias (Warner et al. 1976). One large (1.5 cm) white clast is 88% plagioclase with minor olivine (Fo_{50}). Two clasts of pink spinel troctolite (PST) have been found, but the pretty one (figure 3) was used to make two thin sections.

Metallic Iron: Prinz et al. (1972) found high Ni in iron in the PST, Mehta and Goldstein (1980) found meteoritic levels of Ni and Co in iron in the glass and Hunter and Taylor (1981) reported on rust.

Glass: Warner et al. (1976), See et al. (1986) and Morris et al. (1986) studied the glass coat. It is devitrified and has a composition about that of the underlying breccia.

Significant Clasts:

Pink Spinel Troctolite:

Prinz et al. (1973) reported on a unique plutonic igneous clast with pink spinel ($MgAl_2O_4$) (figures 3 and 4). This clast was reported to be 4 by 4.5 mm in size in thin section 67435,14. The cumulous phases are subhedral to euhedral olivine (Fo_{92}) and pink spinel poikilitically included in coarse plagioclase (An_{97})(no pyroxene). There is trace metallic iron with very high Ni content. The composition was determined by broad beam

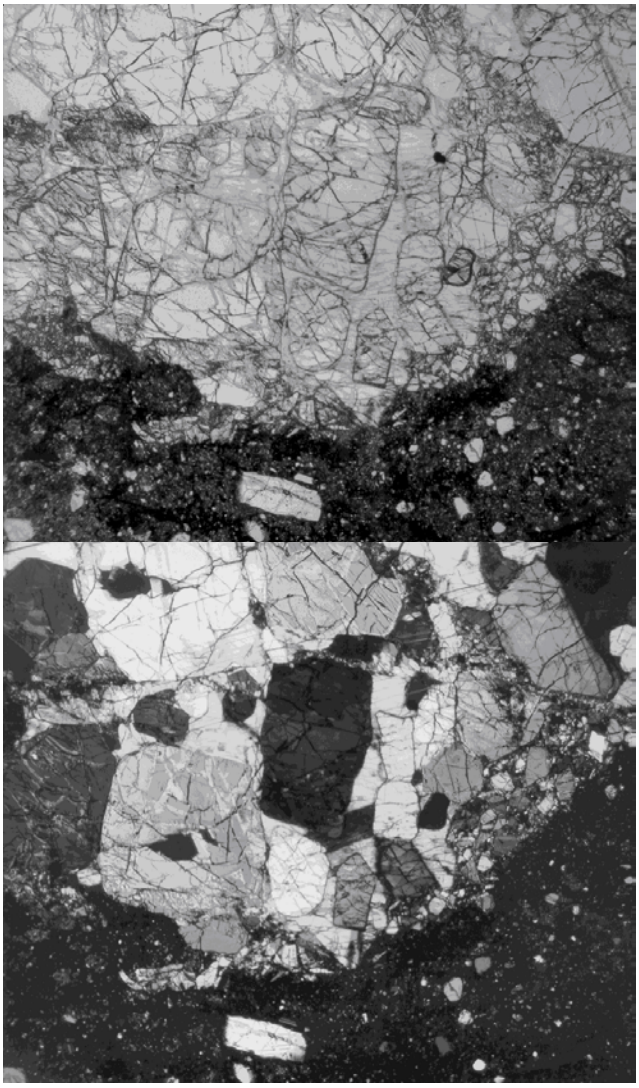


Figure 4: Photomicrographs of thin section 67435,14 with a portion of the pink spinel troctolite. Top is NASA S72-43653 transmitted light; bottom is NASA S71-43656 crossed polarizers. Scale is 2.5 x.

electron probe, because the material was all used up to make the thin sections!

Chemistry

Wanke et al. (1976), Warner et al. (1976), (Ma et al. 1981) and Lindstrom et al. (1977) determined the composition of the matrix. Ebihara et al. (1992) studied the dark clasts.

Radiogenic age dating

Dominik and Jessberger (1978) found the plagioclase clasts were 4.4 b.y. old (figure 9). Dark clasts were about 4.0 b.y. and the matrix was younger.

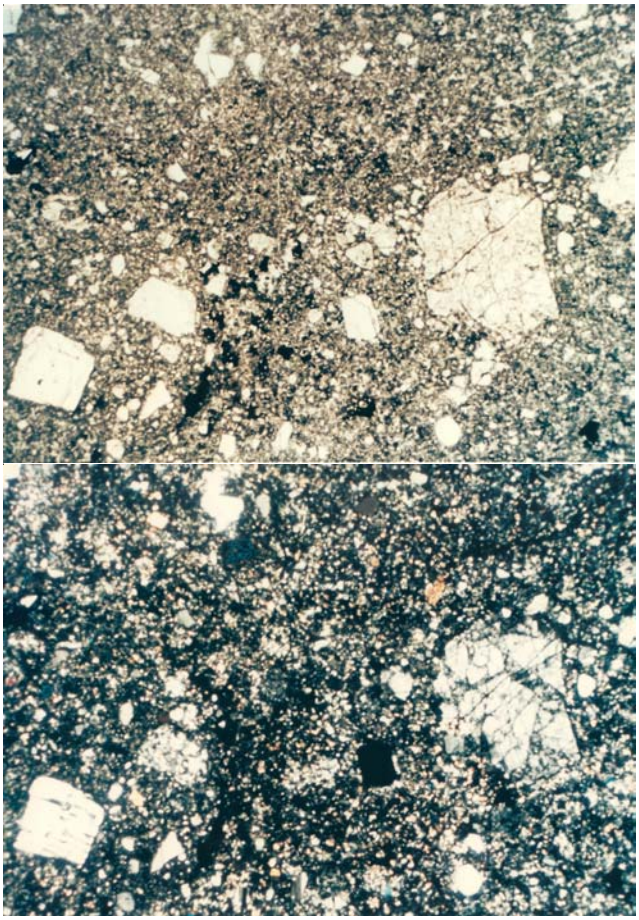


Figure 5: Photomicrographs of thin section of 67435. Scale unknown. S72-42380-81.

Cosmogenic isotopes and exposure ages

Ckark and Keith (1973) reported the cosmic-ray-induced activity of ^{22}Na = 45 dpm/kg and ^{26}Al = 161 dpm/kg.

Dominik and Jessberger (1978) determined the exposure age by ^{38}Ar and Eugster and Niedermann (1986) refined the exposure age for 67435 by ^{3}He, ^{21}Ne, ^{38}Ar, ^{83}Kr, ^{128}Xe and ^{81}Kr – averaging 48 ± 6 m.y. It was concluded that this sample had no prior exposure, and that its 'shielding depth' was about 12 ± 2 g/cm^2.

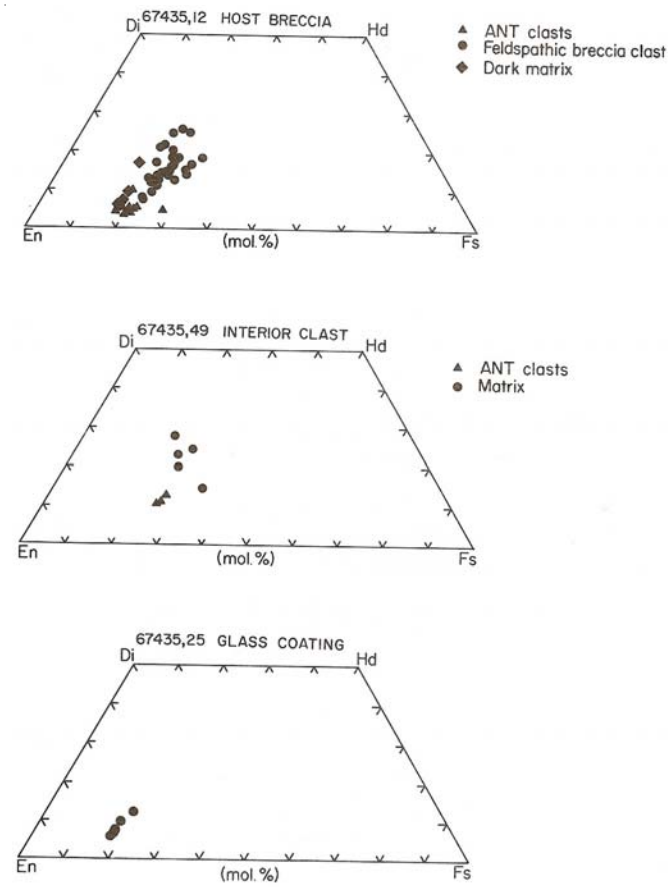


Figure 6: Pyroxene composition in 67435 (Warner et al. 1976).

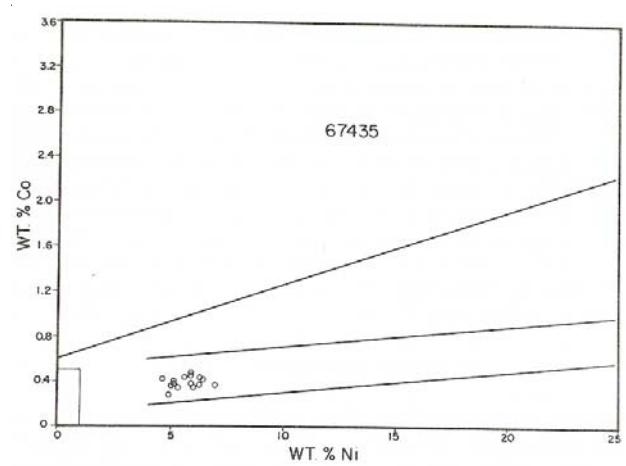


Figure 7: Ni and Co content of metallic iron grains in matrix of 67435 (Mehta and Goldstein 1980).

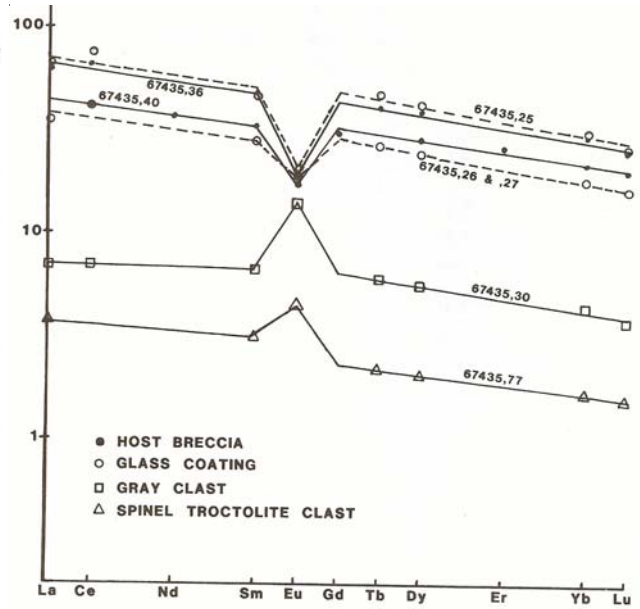


Figure 8: Normalized rare-earth-element diagram for 67435 - see table.

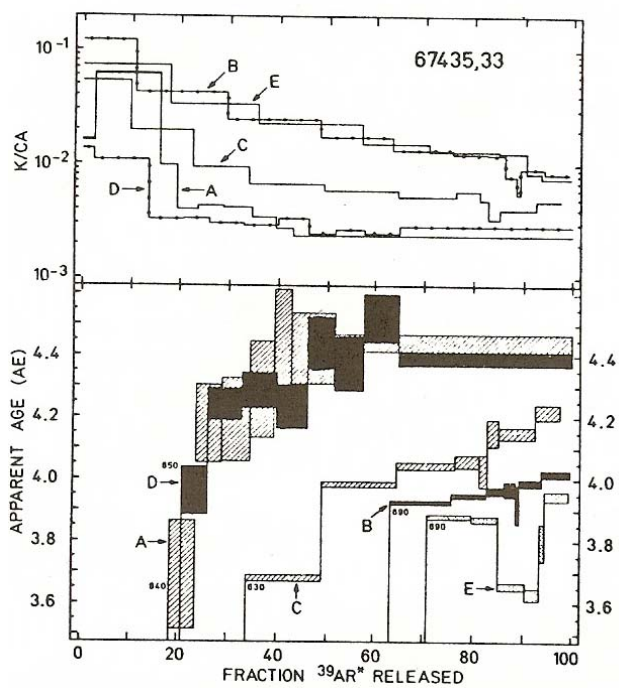


Figure 9: Ar/Ar plateau diagram for 67435 from Dominik and Jessberger (1978).

Summary of Age Data for 67435

	Ar/Ar
Dominik and Jessberger 1978	3.82 ± 0.09 b.y. (no plateau)
	3.955 ± 0.013 b.y.
	4.044 ± 0.029 b.y.
	4.427 ± 0.05 b.y.

Table 1. Chemical composition of 67435.

reference	Lindstrom 77		Morris 86		Ebihara P22				Wanke 76		Clark 73		Ma 81		Dowty
weight	matrix		glass		dark clast										pink
SiO2 %	45.2		45.54						45.3	(a)					Ma 81
TiO2	0.66		0.65						0.85	(a)			0.2	(c)	0.05
Al2O3	25.71		26.08						22.1	(a)			20.6	(c)	15.9
FeO	5.03		4.93						6.87	(a)			5.3	(c)	5.8
MnO	0.07								0.083	(a)			0.05	(c)	0.16
MgO	6.75		6.66						9.4	(a)			29.6	(c)	33.7
CaO	15.16		14.78						13.3	(a)			7.1	(c)	6.2
Na2O	0.52		0.53						0.49	(a)			0.14	(c)	0.14
K2O	0.13		0.09						0.15	(a)	0.177	(d)	0.013	(c)	0.04
P2O5	0.11								0.19	(a)					
S %									0.11	(a)					
sum															
Sc ppm			9	(c)					11.6	(a)			1.9	(c)	
V													101	(c)	
Cr	684		790	(c)					1060	(a)			690	(c)	335
Co			13	(c)					45	(a)			57	(c)	
Ni			226	(c)	1525	27.2	455	(e)	730	(a)			1230	(c)	
Cu									5.46	(a)					
Zn					3.38	0.89	5.72	(e)	7.73	(a)					
Ga									4.04	(a)					
Ge ppb					2170	16.1	1180	(e)	1300	(a)					
As									220	(a)					
Se					114.6	46.1	124.8	(e)	240	(a)					
Rb	4.5	(b)			7.69	4.7	12.7	(e)	4.3	(a)					
Sr	170	(b)							176	(a)					
Y									69	(a)					
Zr									331	(a)					
Nb									16	(a)					
Mo									0.265	(a)					
Ru															
Rh															
Pd ppb					51.3	0.68	25.6	(e)							
Ag ppb					1.99	1630	4.52	(e)							
Cd ppb					45.9	5.74	424	(e)							
In ppb															
Sn ppb															
Sb ppb					10.2	0.47	9.38	(e)							
Te ppb					28.5	1.62	13	(e)							
Cs ppm					0.177	0.075	0.346	(e)							
Ba	163	(b)	164	(c)					231	(a)			18	(c)	
La			15	(c)					24.2	(a)			1.3	(c)	
Ce	35.7	(b)	46.4	(c)					63.9	(a)					
Pr									8.4	(a)					
Nd	23.8	(b)							39	(a)					
Sm	6.61	(b)	6.96	(c)					10.3	(a)			0.63	(c)	
Eu	1.31	(b)	1.3	(c)					1.39	(a)			0.33	(c)	
Gd	8.14								12.2	(a)					
Tb			1.09	(c)					2.24	(a)			0.1	(c)	
Dy	8.85	(b)							13.8	(a)			0.6	(c)	
Ho									2.7	(a)					
Er	5.41	(b)							8.6	(a)					
Tm															
Yb	4.87	(b)	4.71	(c)					8.04	(a)			0.38	(c)	
Lu	0.7	(b)	0.65	(c)					1.16	(a)			0.053	(c)	
Hf			4.42	(c)					7.46	(a)			0.37	(c)	
Ta			0.58	(c)					0.97	(a)			0.04	(c)	
W ppb									410	(a)					
Re ppb					4.29	0.047	1.24	(e)	1.6	(a)					
Os ppb					43.6	1.14	11.7	(e)							
Ir ppb					42	1.07	10.9	(e)	23	(a)					
Pt ppb															
Au ppb					25.1	0.275	12.3	(e)	15.7	(a)			5	(c)	
Th ppm			1.87	(c)					3.3	(a)	3.6	(d)			
U ppm			0.5	(c)	0.522	0.103	0.999	(e)	0.97	(a)	1.09	(d)			

technique: (a) mixed, (b) IDMS, (c) INAA, (d) radiation counting, (e) RNAA

Table 2. Chemical composition of 67435.

reference	Warner 76					
weight	,25	,26	,27	,30	,36	
SiO2 %						
TiO2	0.96	0.92	0.84	0.34	0.81	(a)
Al2O3	22.3	26.4	26.6	30.1	23.4	(a)
FeO	7.7	5.4	6.1	3.8	6.9	(a)
MnO	0.077	0.065	0.059	0.048	0.076	(a)
MgO	10.5	8.2	7.5	3.6	9.3	(a)
CaO	13.1	15.2	15.3	17.9	13.5	(a)
Na2O	0.52	0.57	0.57	0.51	0.5	(a)
K2O	0.2	0.23	0.11	0.056	0.16	(a)
P2O5						
S %						
sum						
Sc ppm	10.7	9.1	8.8	7.7	11	(a)
V	26	60	26	18	30	(a)
Cr	1450	1590	691	458	958	(a)
Co	59	17	41	6	39	(a)
Ni	1080	400	760	31	620	(a)
Cu						
Zn						
Ga						
Ge ppb						
As						
Se						
Rb						
Sr						
Y						
Zr	361	103	201		279	(a)
Nb						
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb						
In ppb						
Sn ppb						
Sb ppb						
Te ppb						
Cs ppm						
Ba					170	(a)
La	23	12.2	11.8	2.4	21.2	(a)
Ce	64	37	33	6	57	(a)
Pr						
Nd						
Sm	9.5	5.7	5.5	1.3	9.6	(a)
Eu	1.52	1.44	1.34	1.03	1.4	(a)
Gd						
Tb	2.2	1.2	1.3	0.28	1.9	(a)
Dy	13	8	7	1.7	12	(a)
Ho						
Er						
Tm						
Yb	6.7	4.2	3.8	0.98	6.7	(a)
Lu	0.89	0.58	0.52	0.13	0.88	(a)
Hf	7.9	4.1	4.3	0.85	6.8	(a)
Ta	0.8	0.5	0.62	0.12	0.88	(a)
W ppb						
Re ppb						
Os ppb						
Ir ppb	41	10	24		12	(a)
Pt ppb						
Au ppb	32	43	19		13	(a)
Th ppm	1.8	1.7	1.6	0.3	2	(a)
U ppm						

technique: (a) INAA

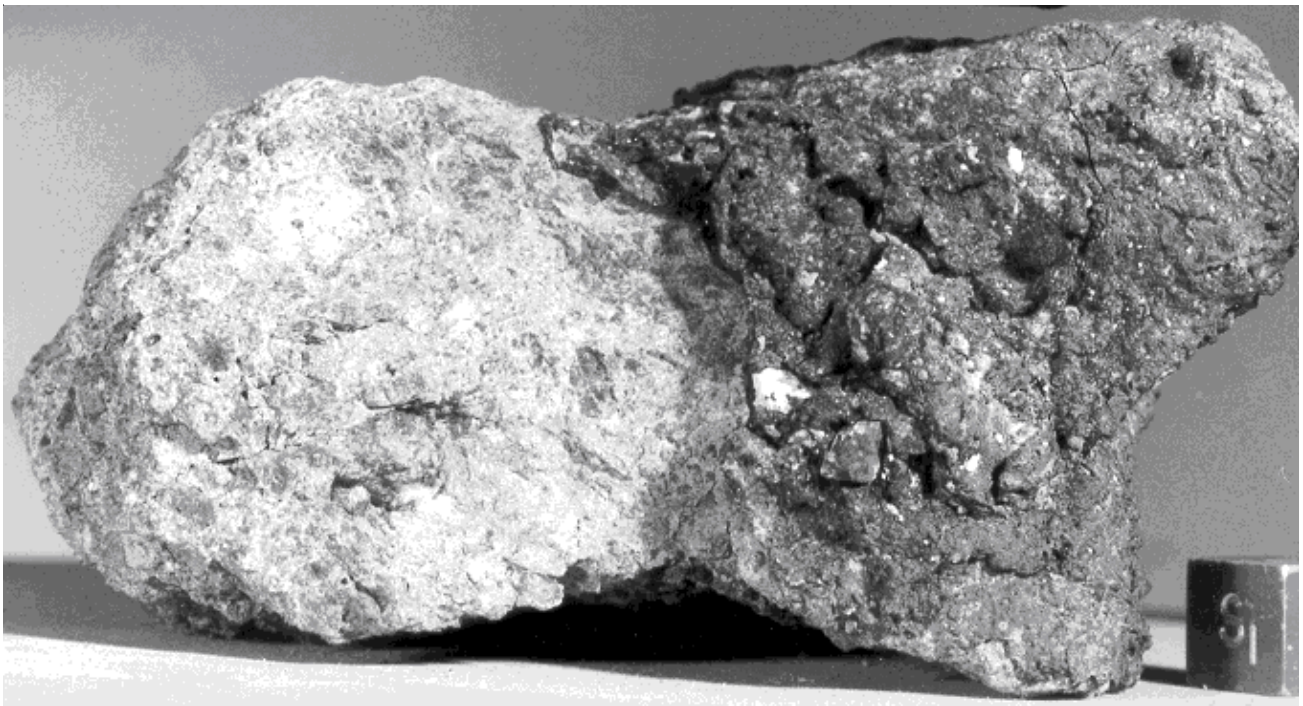
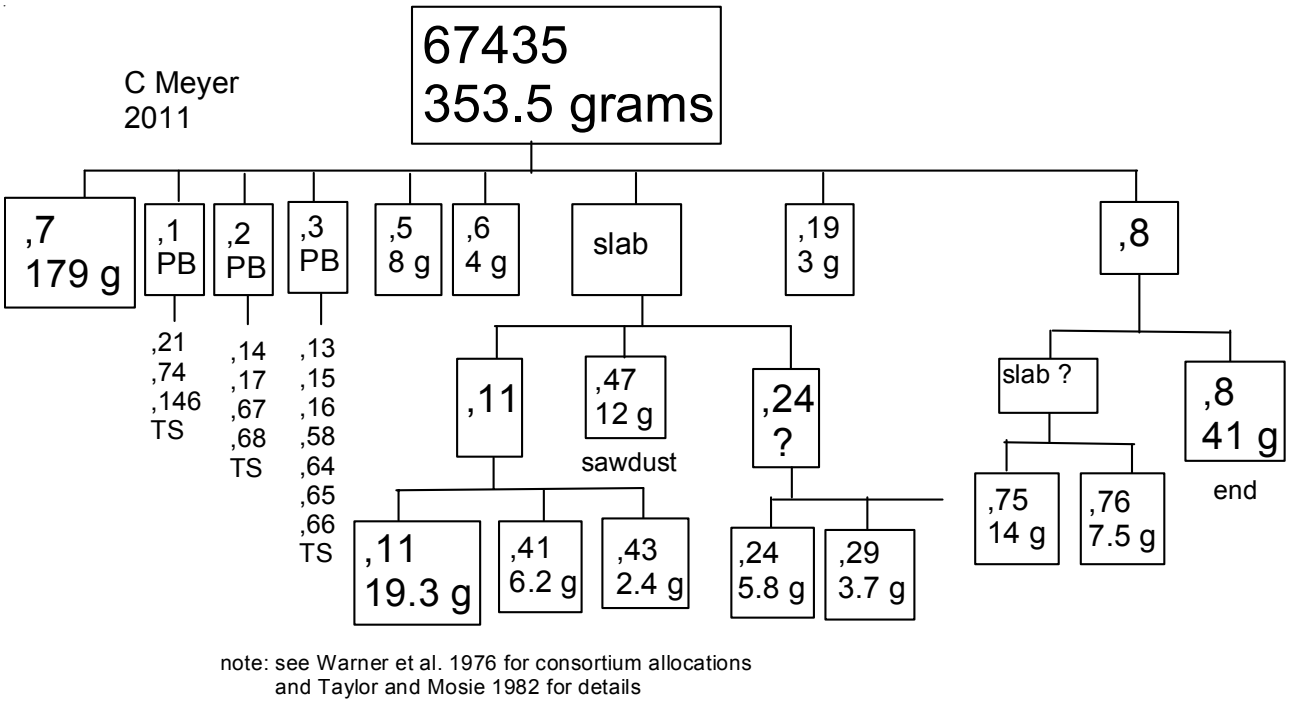


Figure 10: Another view of 67435 showint the extent of glass coating. Cube is 1 cm. NASA S72-43896.



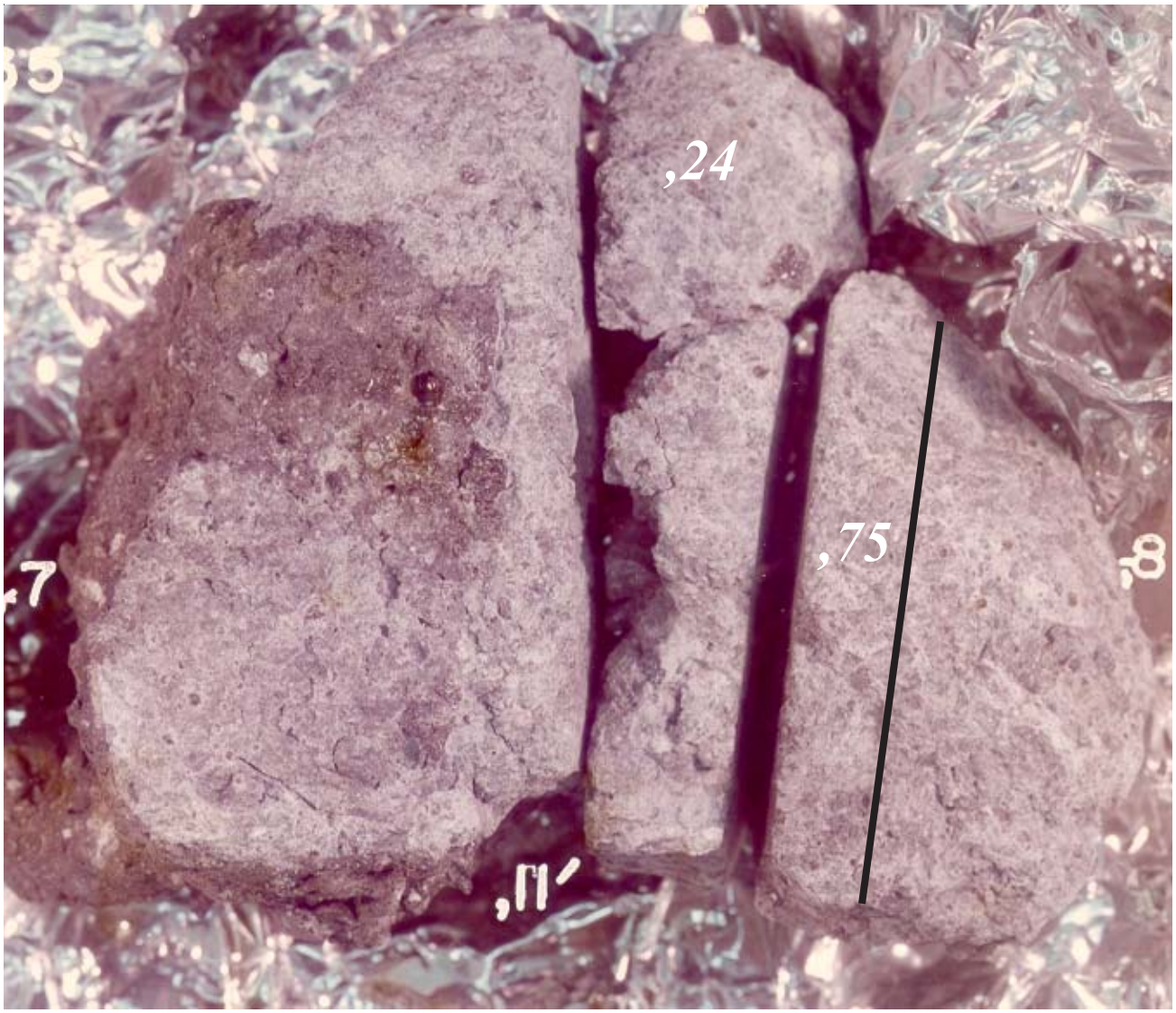


Figure 11: Processing photo of slab cut from 67435 - compare with figure 1. NASA S75-21532.

Processing

67435 was a consortium sample issued to Klaus Keil (see Warner et al. 1976). A slab was cut, but the sample broke before the 2nd cut was complete (figure 11). Many small pieces resulted. End piece ,8 was also cut to make a second, smaller slab (figure 14.). Taylor and Mosie (1982) produced a "Breccia Guidebook" (#6) documenting many of the subsamples. There are about 15 thin sections and a bunch of grain mounts. A really large piece (,7) remains undisturbed.

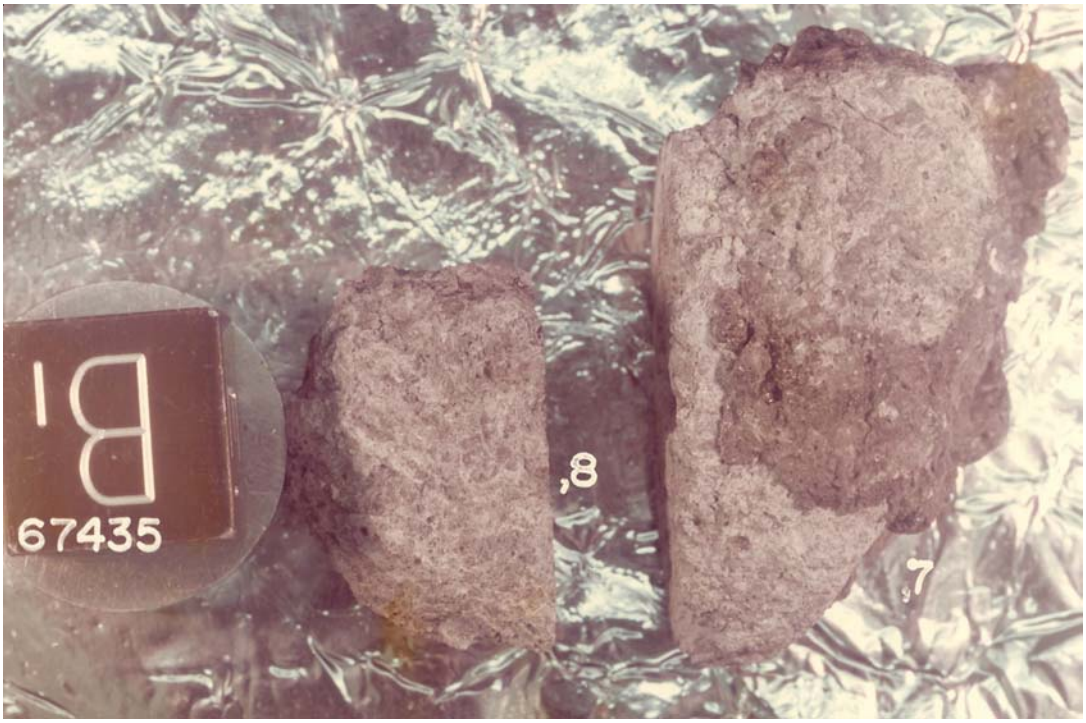


Figure 12: First saw cut of 67435. Compare with figures 1 and 11. Cube is 1 inch. S75-21525

Figure 13: Sawn surfaces of 67435 after second cut. Cube is 1 inch. S75-21524.

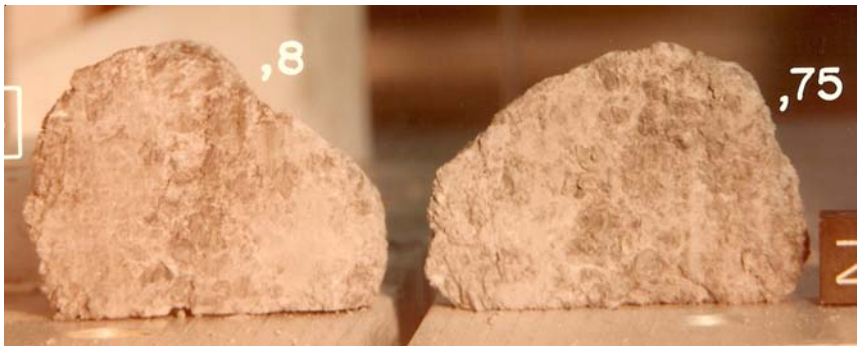


Figure 14: Sawn surfaces of 67435 after third cut. S80-27373.

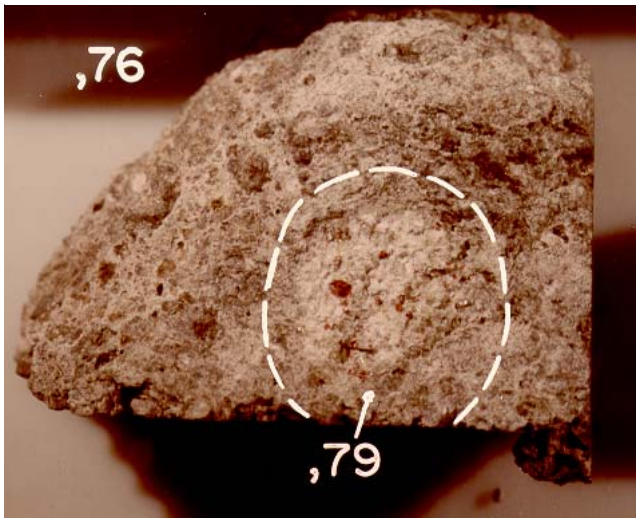


Figure 15: NASA S80-27372. Sample is about 2 cm. This piece is from 67435,8.

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