DRAFT

72215

Aphanitic Impact Melt Breccia

379.2 grams

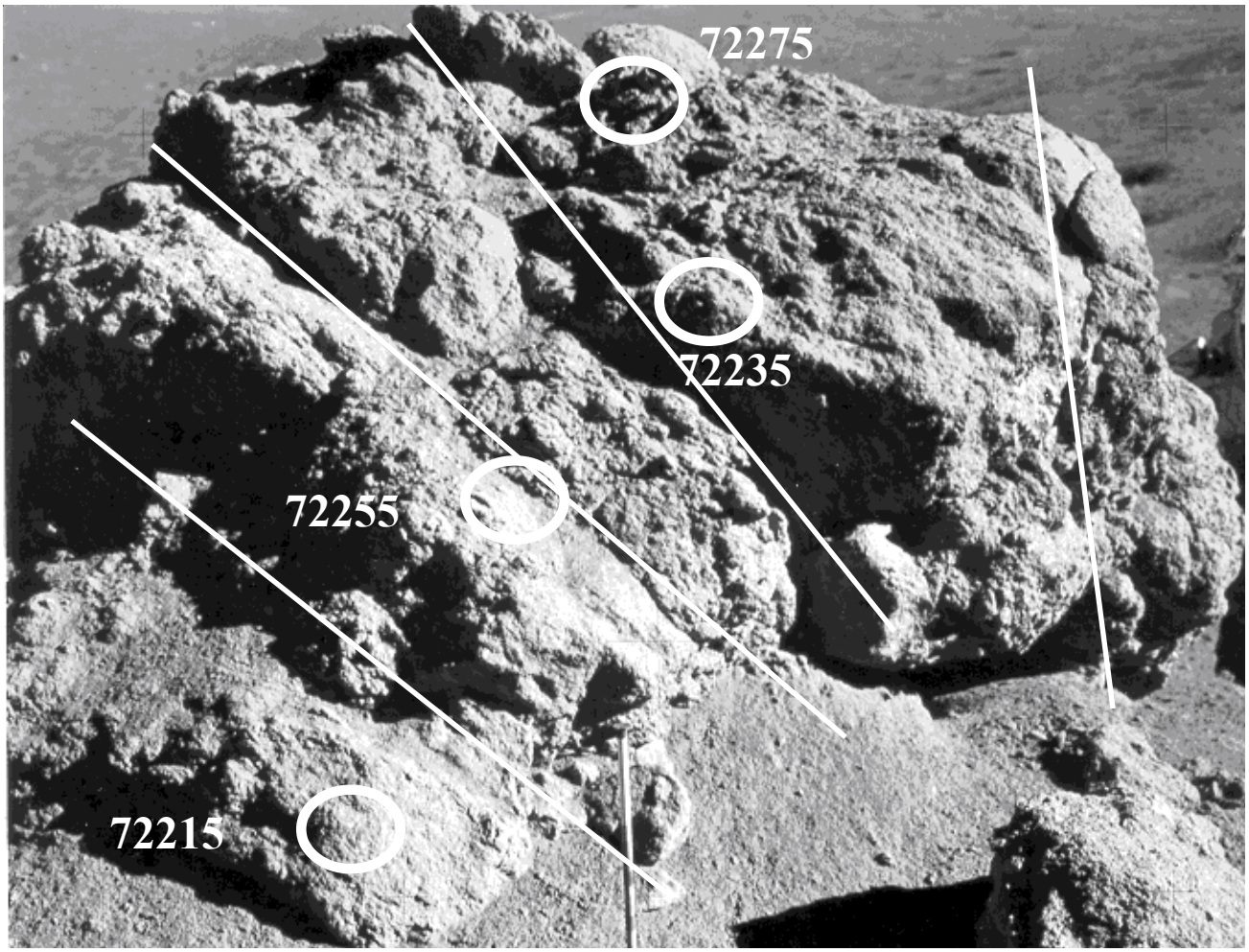


Figure 1: Boulder #1 at station #2 on the slope of South Massif, Apollo 17. AS17-137-20900. Boulder is ~2 meters across. Lines roughly indicate apparent layering in boulder (Wolfe et al. 1981).

Introduction

Lunar sample 72215 was collected from the side of a layered boulder #1 at station 2 located on the bottom slope of the South Massif and within the landslide material at Apollo 17 Taurus-Littrow (Schmitt 1973, Wolfe et al. 1981). Samples 72235, 72255 and 72275 are from other layers in this boulder and soils 72220, 72240 and 72260 are from the fillet surrounding the boulder. The boulder had a prominent layering with multi-layered clasts weathering out as "knobs" (figure 1). 72215 was sampled as one of the largest of these "knobs" (~10 cm).

The "knobs" are intricate swirls of light and dark, interlayerd, crushed highland materials produced in some, as yet, unexplained fluidized impact mechanism. The dark portions are finer-grained and the lighter are coarser-grained – but both portions are found to have similar bulk composition. Two of these "knobs" were given special names: Marble Cake (72275) and Dying Dog (72235) by the Consortium Indomitable who first studied them. Aspects of 72215 are similar.

The sample is a coherent, clast-rich, impact melt breccia. It is aluminous and feldspathic and contains

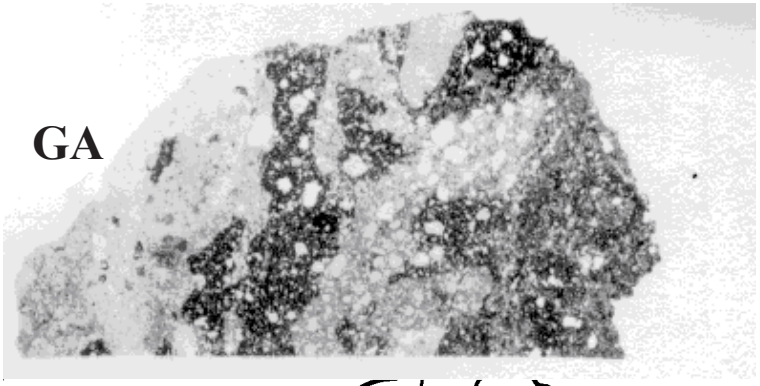
Figure 2: Exterior surface of 72215 showing patina and zap pits. Cube is 1 cm. NASA S73-23569.

numerous small patches of "granitic" material. It has been preliminary dated at 3.83 b.y. and has an exposure age of 42 m.y.

Petrography

Ryder (1993) provides a complete review of the work accomplished on 72215. Briefly, 72215 has a prominent layering that has been described by Ryder et al. (1974) and Stoeser et al. (1975) as separate "domains" – seen in figure 3 and 4.

Domains 1, 2 and 3 are similar in chemical composition, but differ in color and average



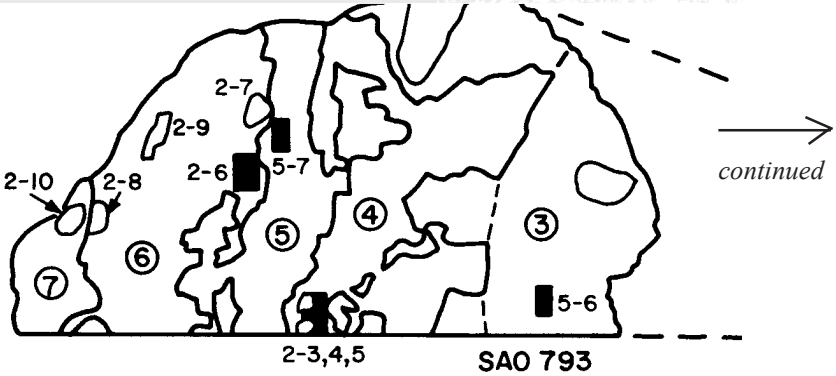
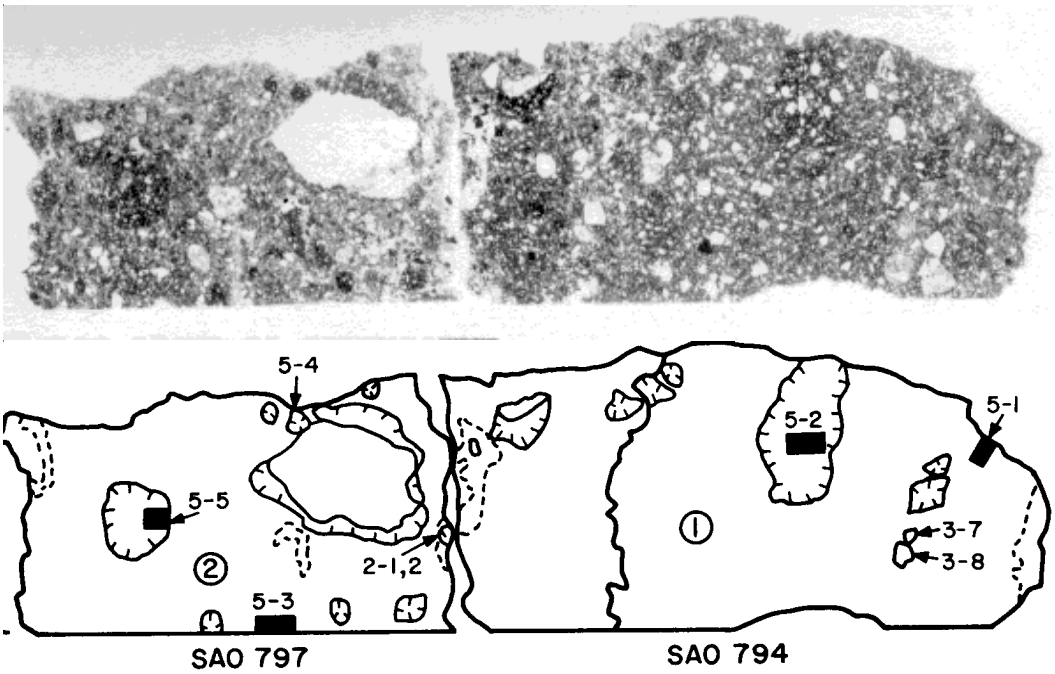


Figure 4: Photographs of thin sections 72215,180, 183 and ,190, along with sketch maps (continued on next page). Together these sections provide an almost complete microscopic view across the whole sample (about 6 cm). The "knob" is the portion the left (see figure 14). The different "domains" are given numbers (circled). From Stoeser et al. 1974.

Figure 3: Freshly broken surface of 72215, illustrating banding and clastic nature. Cube is 1 cm. NASA S73-23569. GA is the position of the "knob".

grain size. They are composed of angular and rounded mineral grains and small clasts with a seriate grain size down to about 20 microns – in areas, the matrix is less than 1 micron. Analyses show it is feldspathic.

Domain 4 consists of crushed, fine-grained feldspathic granulite strung out in lenses and mixed with matrix for other domains. Following cataclasis, annealing was sufficient to eliminate porosity.



ure 4 continued

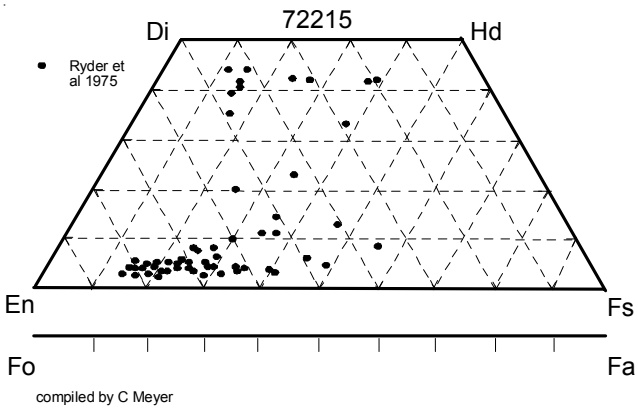


Figure 5: Composition of pyroxene in matrix 72215 (Ryder et al. 1975).

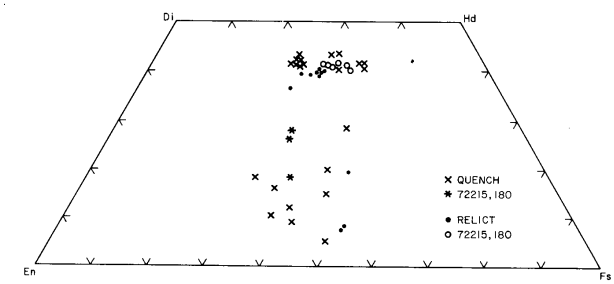


Figure 6: Chemical composition of pyroxene in granite clasts in 72215 (Ryder et al. 1975).

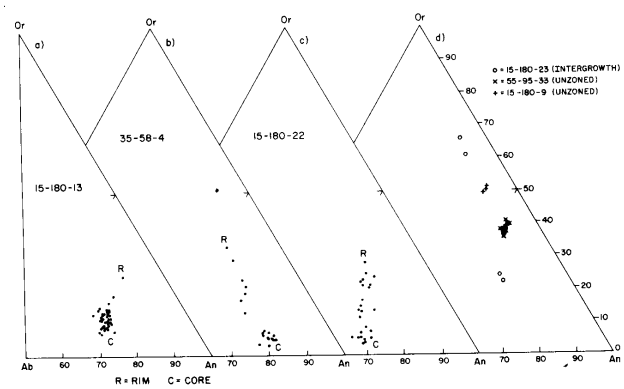


Figure 7: K, Na, Ca diagram for feldspar grains found in "granitic" patches in 72215, 72235 and 72255 (Ryder et al. 1975).

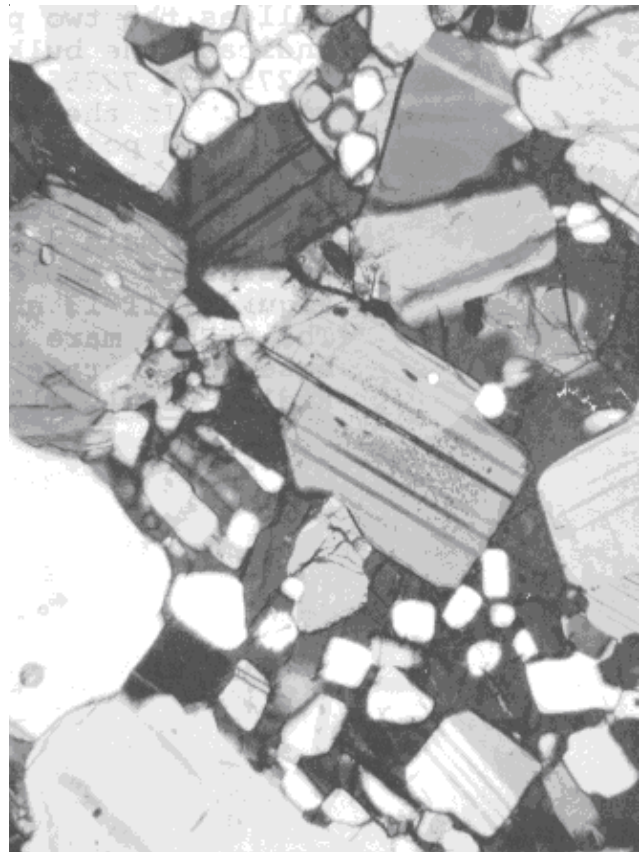


Figure 8: Poikilitic ANT clast in 72215,108. Plagioclase and olivine chadocrysts enclosed in a large orthopyroxene oikocryst. Field of view is about 700 microns. From Stoeser et al. 1974.

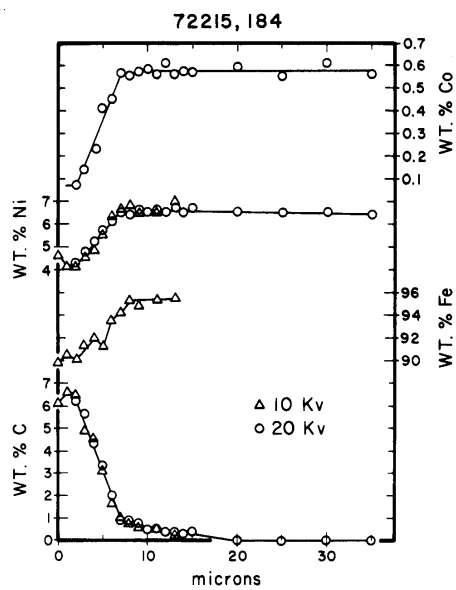


Figure 9: Evidence of cohenite at boundary of Ni, Co, Fe grain in 72215 (Goldstein et al. 1976).

Composition of ternary feldspar in 72215.

(from Ryder et al. 1975)

SiO2	53.28	53.14	53.04	51.09	52.85	54.37
Al2O3	30.1	30.02	28.77	29.97	28.05	28.89
FeO	0.2	0.22	0.23	0.21		
MgO	0.04	0.02	0.05	0.04		
CaO	13.82	13.78	12.97	13.98	13.36	13.51
Na2O	2.91	2.66	2.67	2.38	2.17	1.27
K2O	1.21	1.53	1.57	2.09	2.43	4.44
BaO	0.13	0.12	0.07	0.13		0.08
total	101.7	101.5	99.39	99.88	98.87	102.57

electron microporbe

Domain 5 is darker than the others and more vesicular. It has an abundance of granitic patches or clasts (up to 23%!). Broad beam analyses show it has higher K_2O.

Domain 6 (GA) is white, coarse-grained and cataclasized. It is made up of relic areas of poikilitic granulite and crushed equivalent. Equidimentional chadocrysts of plagioclase (An_{90-96}) are embedded in large pyroxene oikocrysts ($En_{75}Wo_4$).

Significant Clasts

Granite

The "granitic" clasts in boulder 1, including those in 72215, were analyzed and described by Ryder et al. (1975) and Stoeser et al. (1995). They have high silica (>75%) and high K_2O contents (~6%)(table 1). They are made of various intergrowths of silica, Ba,K feldspar, ternary feldspar (figure 7) and Fe-rich pyroxene (figure 6). Compston et al. (1975) determined a "mixing line" with apparent age of ~ 4 b.y. for these Rb-rich "granitic" assemblages (figure 11).

GA ,76

The white clast marked as GA in the figures 3, 4 and 14 is a cataclastic, poikilitic anorthositic norite. The analysis show that it is low in trace elements and high in alumina (Blanchard et al. 1974). It is also known as "domain 6".

Pink Spinel, Troctolite basalt

Small clasts of basalt containing Mg-spinel and/or olivine have been reported (Table 3).

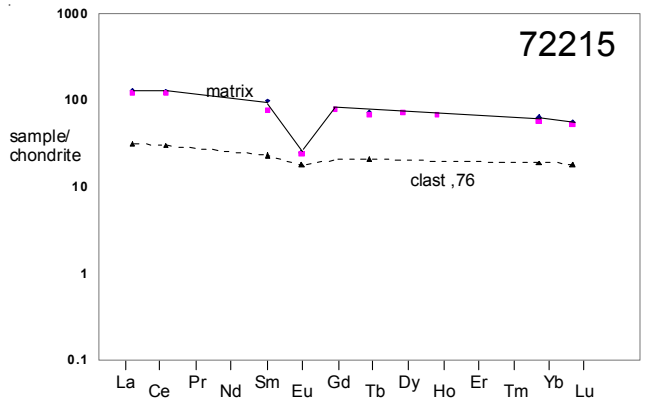


Figure 10: Normalized rare-earth-element diagram for 72215 (data from Blanchard et al. 1975 and Palme et al. 1978).

Chemistry

Palme et al. (1978), Blanchard et al. (1975), Morgan et al. (1975) have analyzed 72215 (table 1, figure 10). In addition, Stoeser used the broad beam electron probe to obtain the composition of the various domains (table 3). Eveyrthing is high alumina and there is not much different about the various domains – other than grain size and appearance.

Morgan et al. (1975) found that meteoritic siderophiles (Ir, Re, Os etc.) have different ratios (figure 11) from other lunar breccias and discuss this in context to the Serenitatis ejecta.

Radiogenic age dating

Schaeffer et al. (1982) dated the matrix and various clasts using the Ar/Ar laser technique.
Compston et al. (1975) reported data for an anorthosite clast, the matrix and various granitic clasts (figure 12).

Mineralogical Mode for 72215

From Stoeser et al. 1974

	Domains 1 + 2	Domain 3	Domain 5
ANT breccias	8.2 %	6.7	7.8
Granulitic ANT	19.8	23.5	25
Poikilitic ANT	2.2	6.3	2.6
Coarse ANT	4.5	5.3	3.4
Ultramafic	2.4	1.4	1.7
Basalts	3.6	1.4	0.9
Granite	4.2	11	23.2
Maskelynite	14	10	2.6
Glass	0.4		
Plagioclase	24.3	17.7	21.6
Olivine	5.1	6.7	1.7
Pyroxene	10.6	9.1	9.5
Chromite	0.2		
Silica		0.5	

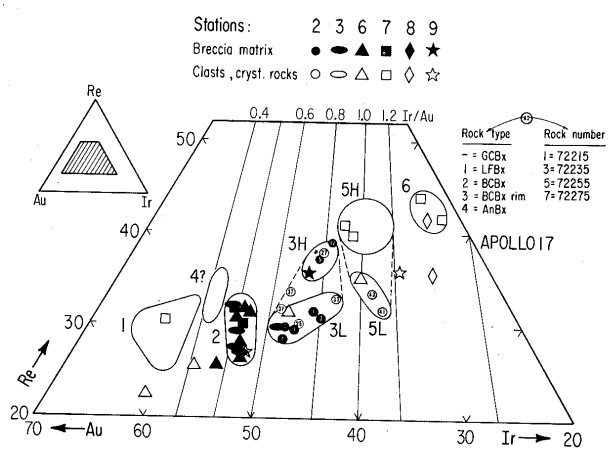


Figure 11: Chopped 3-element diagram for Ir, Re and Au used by Morgan et al. (1975) to show that station 2 boulder samples at Apollo 17 were different in trace siderophile element content from other Apollo 17 samples.

Nunes and Tatsumoto (1975) studied the U-Th-Pb systematics, but could not obtain an age.

Summary of Age Data for 72215

	Ar/Ar	Rb/Sr
Schaeffer et al.	3.83 – 4.02 b.y	
Compston et al.		~ 4 b.y.

Cosmogenic isotopes and exposure ages

The cosmic-ray exposure age of 72215 was determined as 41.4 m.y. by ^{81}Kr and 41 m.y. by ^{38}Ar methods (Leich et al. 1975). This is less than the exposure age of samples form the top of the boulder (e.g. 72275), probably because of shielding or erosion effects. Arvidson et al. (1976) have proposed that this is the age of Tyco!

Other Studies

Rare gas contents	Leich et al. 1975
Reflectance spectra figure 13	Adams and Charette 1975
Pb isotopes	Nunes and Tatsumoto 1975
Magnetics	Banerjee et al. 1975
Cohenite figure 9	Goldstein et al. 1976

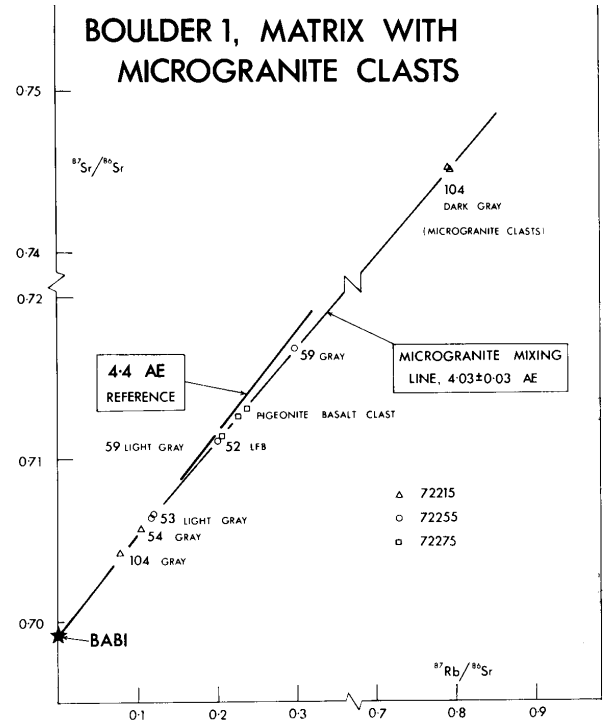


Figure 12: Rb-Sr diagram for "granite" clasts in boulder samples 72215, 72255 and 72275 (Compston et al. 1975).

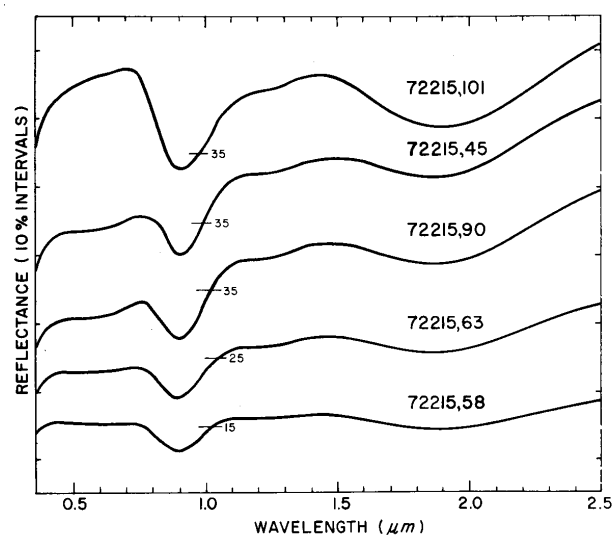


Figure 13: Reflectance spectra of chips of different lithologies from 72215 (Adams and Charette 1975).

Table 1. Chemical composition of 72215.

				Higuchi75													
reference	Blanchard75			Morgan75						Palme78		Ryder75						
weight	*matrix*	clast,76		grey matrix				clast4				granite clasts					glass	
SiO2 %	45.2	44.7	(b)							46.68	(d)	79.13	78.05	79.58	71.14	74.25	81.49	(e)
TiO2	0.9	0.5	(b)							0.7	(d)	0.1	0.14	0.14	0.31	0.31	0.07	(e)
Al2O3	21.1	27.3	(b)							20.33	(d)	9.44	10.59	10.89	12.48	11.81	9.43	(e)
FeO	8.43	4.8	(a)							7.81	(d)	0.63	0.17	0.17	0.68	2.01	0.3	(e)
MnO	0.128	0.067	(b)							0.12	(d)	0.02		0.01	0.02	0.01	0.04	(e)
MgO	10.7	7.19	(b)							10.33	(d)	0.07			0.12	0.12	0.01	(e)
CaO	12.1	14.9	(b)							12.5	(d)	1.27	1.39	2.25	3.22	0.53	0.64	(e)
Na2O	0.52	0.48	(a)							0.47	(d)	0.19	0.16	0.26	0.42	0.03	0.01	(e)
K2O	0.25	0.11	(b)							0.21	(d)	6	6.66	5.75	6.34	9.55	7.06	(e)
P2O5										0.24	(d)	0.05	0.02	0.02	0.64	0.1	0.02	(e)
S %										0.032	(d)							
sum																		
Sc ppm	18.6	7.68	(a)							18.5	(d)							
V																		
Cr										1665	(d)							
Co	27	11.9	(a)							26.9	(d)							
Ni	160	50	(a)	154	146	158	136	56	(c)	170	(d)							
Cu																		
Zn				1.8	1.7	1.6	1.8	1.3	(c)									
Ga										3.9	(d)							
Ge ppb				141	117	144	124	42	(c)									
As																		
Se				68	49	72	71	15	(c)									
Rb				4.88	2.83	6.65	3.88	1.48	(c)									
Sr										160	(d)							
Y										90	(d)							
Zr										360	(d)							
Nb										25	(d)							
Mo																		
Ru																		
Rh																		
Pd ppb																		
Ag ppb				0.46	0.56	0.46	0.47	0.5	(c)									
Cd ppb				3.6	3.8	3	5.3	6.7	(c)									
In ppb																		
Sn ppb																		
Sb ppb				0.66	0.64	0.92	0.71	0.31	(c)									
Te ppb				3.3	2.4	2.5	4.9	<5.4	(c)									
Cs ppm				0.16	0.12	0.216	0.2	0.05	(c)	0.18	(d)							
Ba										299	(d)							
La	30	7.3	(a)							28.1	(d)							
Ce	77	18.3	(a)							72	(d)							
Pr																		
Nd										45	(d)							
Sm	14.5	3.36	(a)							11.2	(d)							
Eu	1.38	1	(a)							1.34	(d)							
Gd										15.5	(d)							
Tb	2.6	0.75	(a)							2.47	(d)							
Dy										17.2	(d)							
Ho										3.77	(d)							
Er																		
Tm										1.56	(d)							
Yb	10.3	3.1	(a)							9.29	(d)							
Lu	1.37	0.44	(a)							1.26	(d)							
Hf	9.7	2.4	(a)							9.11	(d)							
Ta	1.4	0.3	(a)							1.14	(d)							
W ppb																		
Re ppb				0.37	0.4	0.38	0.28	0.19	(c)									
Os ppb																		
Ir ppb				5.2	5.4	5	4	3	(c)	6.1	(d)							
Pt ppb																		
Au ppb				2.2	2.1	2.3	1.8	0.8	(c)	4	(d)							
Th ppm	5	1.3	(a)							3.94	(d)							
U ppm				1.36	1.32	1.52	1.62	0.52	(c)	1.16	(d)							

technique: (a) INAA, (b) AA, (c) RNAA, (d) INAA, RNAA, XRF, (e) broad-beam e-probe

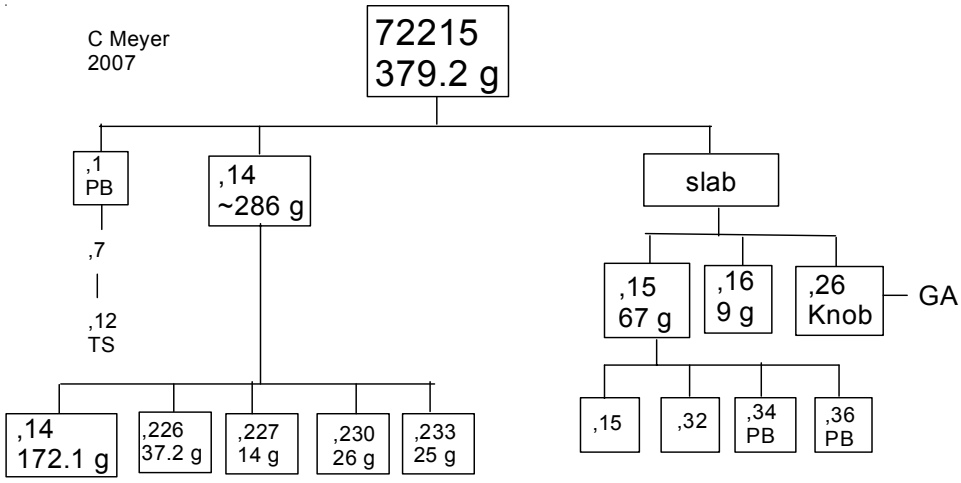
Table 2: 72215	U ppm	Th ppm	K ppm	Rb ppm	Sr ppm
Nunes et al. 1975	1.408	4.633			
	1.369	5.084			
	1.29	4.635			
	1.179	4.327			
	1.185	4.298			
	1.023	3.768			
Compston et al. 1975				5.02	139.1
				0.86	164.6
				4.05	149.7
				44.19	162.2
				43.98	161

Table 3: Broad beam electron probe analyses of domains in 72215.

by Stoeser et al. 1974							clast	clast
	domain 1	domain 2	domain 3	domain 4	domain 5	domain 6	PST basalt	olivine basalt
SiO2	46.2	45.05	46.75	47.48	48.02	45.81	48.17	43.67
TiO2	0.56	0.6	0.68	0.79	0.66	0.61	0.36	0.2
Al2O3	18.3	19.81	19.64	23.14	18.79	23.93	22.3	18.86
FeO	8.39	7.32	8.2	6.63	8	5.83	4.73	6.73
MnO	0.12	0.12	0.11	0.05	0.12	0.05	0.07	0.07
MgO	11.04	9.71	10.54	6.37	7.32	7.09	9.07	17.24
CaO	12.01	12.62	12.73	14.76	11.81	14.72	14.44	11.31
Na2O	0.51	0.56	0.49	0.58	0.77	0.46	0.51	0.39
K2O	0.21	0.18	0.22	0.34	1.02	0.28	0.35	0.09

Processing

The original processing of 72215 was documented by Marvin (1974). A sawcut lengthwise through the sample produced a slab (,15) with one side sawn and the other original surface (figure 13). At a later time additional material was provided to Ryder. There are 30 thin sections. The main mass is still intact (as of 2007).



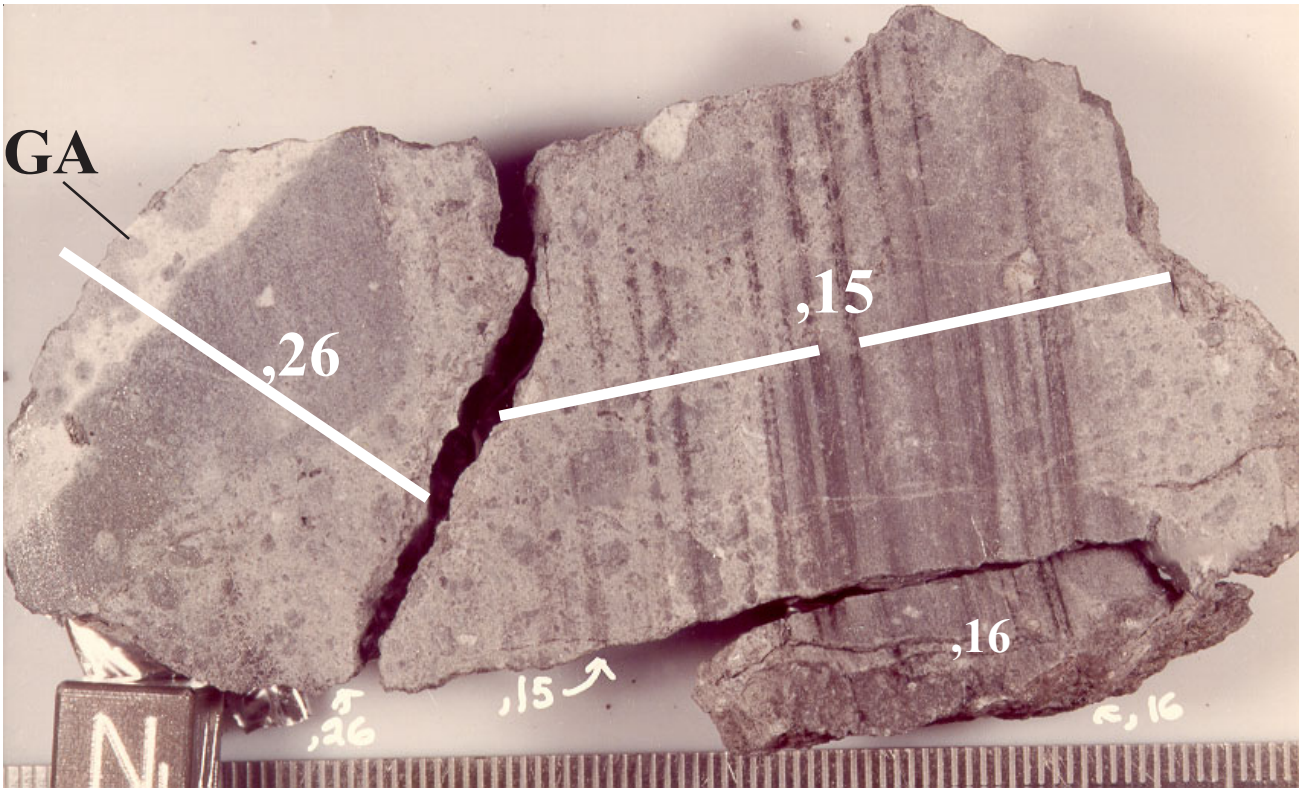
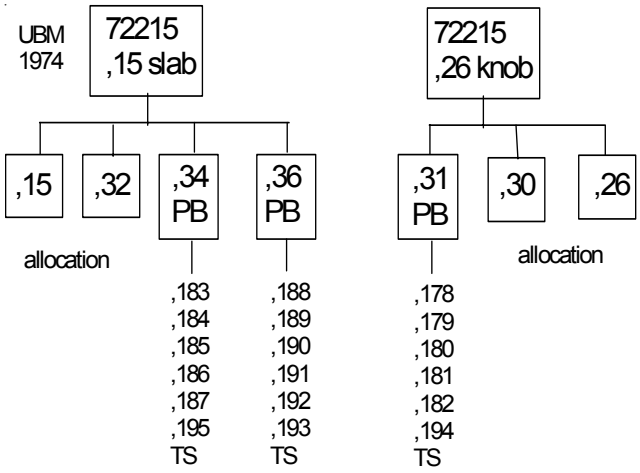


Figure 14: Sawn surface of 72215. Note white cataclastic gabbroic anorthosite (GA) with black rind (the knob). Cube is 1 cm; scale is in mm.. NASA S74-20753. Saw marks obscure texture. Approximate postion of set of continuous thin sections (figure 4) is shown.



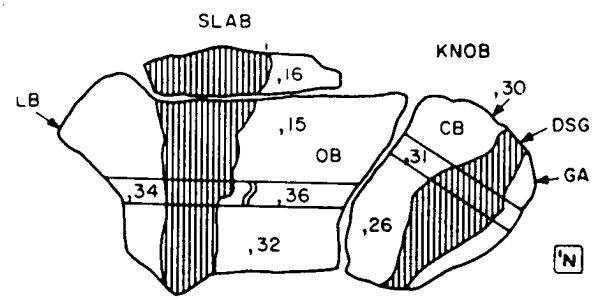


Figure 15: Map of slab of 72215 - reverse side of figure 14. Position of thin section set (figure 4) is also in reverse order. From Marvin (1974).

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