72435

Impact melt Breccia

160.6 grams

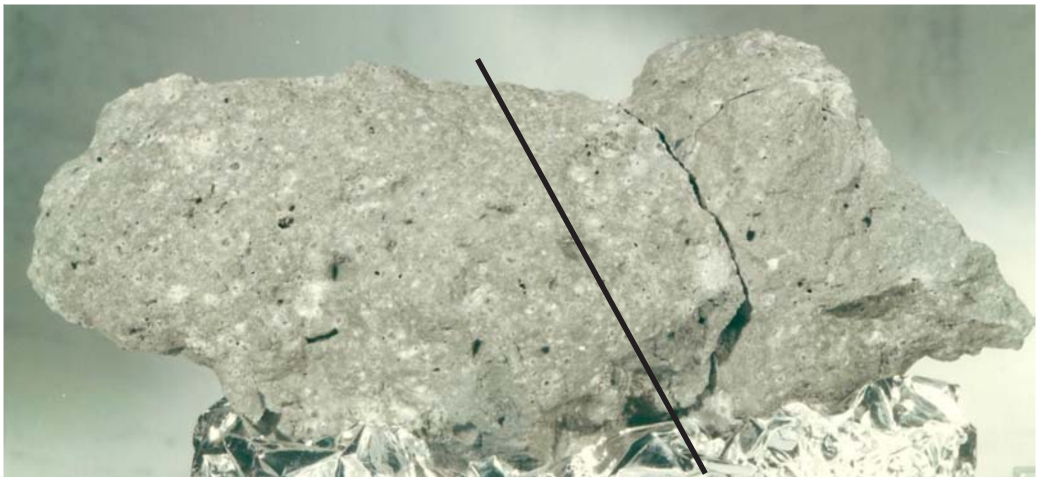

Figure 1: Exterior surface of 72435. It is about 6 cm long, in two pieces. Photo #S73-16188. The line indicates where the saw cut was made.

Figure 2: B/W photo of freshly-broken side of 72435 illustrating clasts. Sample is 6 cm across. NASA#S73-19653B

Introduction

72435 is a very fine-grained, clast-bearing impact melt with a micropoikilitic texture (typical of breccias from the large impact craters). The small boulder from which this sample was chipped is illustrated in the section on 72415. The sample was returned in two pieces, which could be fit together (figure 1).

Clasts up to 1 cm in size are visible in the sample (figure 2), while larger clasts are abundant in the boulder (e.g. 72415). The matrix contains about 1 % vesicles – often aligned (figure 3). Geochronology experiments found that the clasts were not in isotopic equilibration with the matrix.

Figure 3: Photo of broken surface between two large pieces of 72435. Scale is in cm. NASA#S73-16194

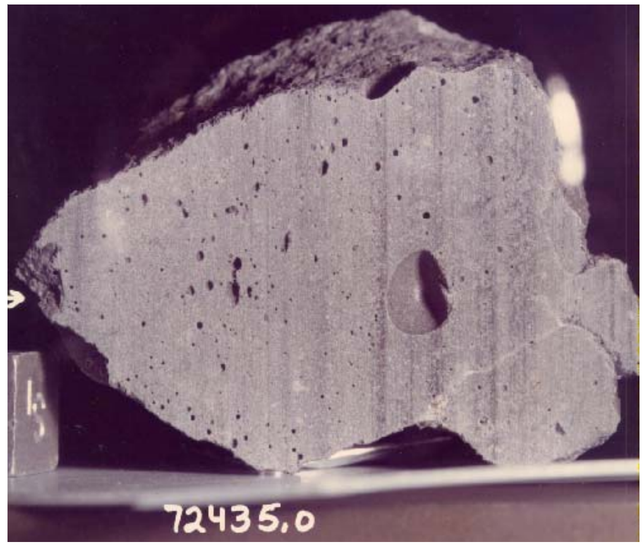

Figure 4: Photo illustrating saw cut through largest piece of 72435 illustrating vesicles. Cube is 1 cm. Photo#S74-22076

The research conducted on 72435 is reviewed in Ryder (1992). Most of the petrography has been reported by Dymek et al. (1976). In spite of this documentation, the data collected on the various clasts is difficult to correlate with the petrography and/or clasts seen in photos.

Petrography

Sample 72435 is comprised of 5-10 % clasts (1 mm to 2 cm) set in an extremely fine-grained, partially-clastic, crystalline matrix (Dymek et al. 1976). The average grain size of the matrix is less than 50 microns with a micropoikilitic texture of intergrown pyroxene oikocyrsts and lath-like plagioclase and ilmenite (figure 5). Olivine and ilmenite occur around the rims of the pyroxene oikocrysts.

Dymek et al. (1976) studied the small clasts in 13 thin sections of 72435. Of special interest were two pink-spinel-bearing, troctolite clasts, one of which also had a small grain of cordierite present. The mineral modes for these plagioclase-rich clasts are given in the table. They appear to be related to the suite of plutonic rocks known as ferroan anorthosites (figure 9). The data on these clasts is confusing. However, Herzberg (1978), Herzberg and Baker (1980) and Baker and Herzberg (1980) have derived the temperature-pressure relationship from the mineral chemistry.

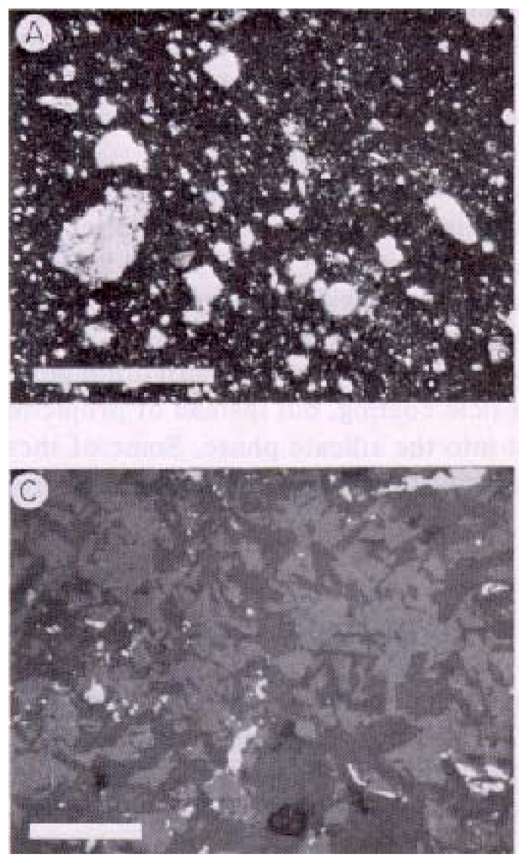

Figure 5: Photomicrographs of thin sections of 72435 (from Dymek et al. 1976). A) transmitted light photograph illustrating fine grain size of matrix. Scale 1 mm. C) reflected light photograph illustrating micropoikilitic texture. Scale 50 microns.

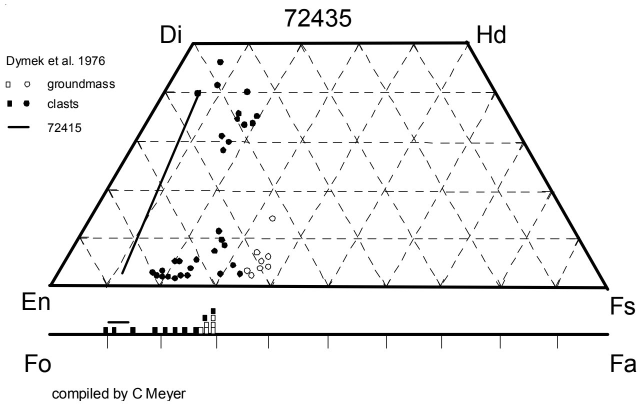

Figure 6: Pyroxene and olivine composition of groundmass and mineral clast in 72435. Line represents data from 72415. Data from Dymek et al. 1976.

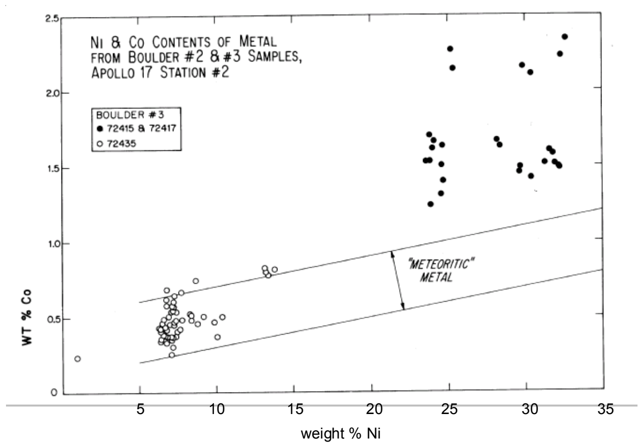

Figure 7: Ni and Co composition of Fe metal grains in 72435 compared with that of 72415. Range for "meteoritic" metal shown. From Dymek et al. 1976.

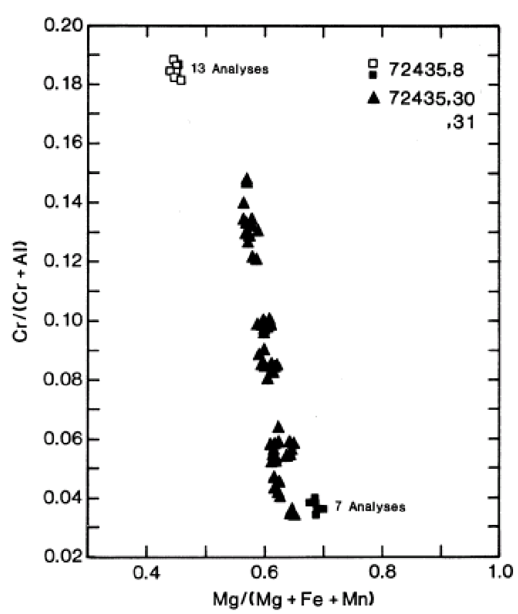

Figure 8: Composition of spinel in 72435 clasts 1 and 2 (from Baker and Herzberg 1980).

Significant Clasts

Clast 1 Cordierite-spinel-bearing: 72435,8

Dymek et al. (1976) and Baker and Herzberg (1980) give the composition of a 30 micron-sized grain of cordierite (see table), Al-rich spinel (figure 8) and other minerals in this clast. Mineral compositions are: olivine (Fo_{73}), orthopyroxene ($En_{65-87}Wo_2Fs_{20-33}$). A few micron-sized grains of ilmenite are included.

Clast 2 Spinel-bearing: 72435,30 and ,31

Dymek et al. (1976) describe this clast as "highly fiable". Baker and Herzberg (1980) give the mineral data.

Clast A:

Papanastassiou and Wasserburg (1975) excavated a "leucocratic igneous clast" with plagioclase (An_{95}), pyroxene ($En_{77}Wo_4Fs_{19}$ and $En_{49}Wo_{39}Fs_{12}$) and olivine (Fo_{77}).

Clast E: Plagioclase

Papanastassiou and Wasserburg (1975) describe and analyzed this large clast (0.5 by 1.0 cm). It is mostly plagioclase (An_{92-87}), but with minor olivine and some K-rich regions ($An_{54}Ab_4Or_{42}$). This clast was dated by Rb-Sr (figure 12).

Granite (?):

Dymek et al. (1976) report small "aggregates of plagioclase, K-rich glass, SiO_2, ilmenite, troilite and metal (and one zircon)".

Mineralogy

Olivine: Olivine oikocyrsts range from Fo_{70-72}. Small olivine clasts were zoned (Fo_{84-90}).

Pyroxene: The composition of pyroxene in 72435 is summarized in figure 6.

Plagioclase: Plagioclase chadocrysts (An_{85-91}) are included in the pyroxene oikocrysts.

Cordierite: Dymek et al. (1976) and Baker and Herzberg (1980) give the composition of cordierite (see table).

Spinel: The composition of pink-spinel found in 72435 was determined by Baker and Herzberg (1980) (figure 8).

Composition of Cordierite in 72435

	Dymek et al. 1976	Baker and Herzberg 1980
SiO2	50.74	49.57
Al2O3	34.73	34.5
TiO2	0.12	0.06
FeO	3.94	3.86
MnO	0.05	0.08
MgO	12.11	11.41
CaO	0.06	0.05
K2O	0.06	0.18
Na2O	0.08	0.2

Metal: The composition of metallic iron in 72435 is given in figure 7. It is within the range of meteoritic iron, and not as Ni and Co rich as the iron in the dunite clast (72415) in same boulder.

Footballs*: "Isolated footballs of troilite and iron metal up to 300 microns in size"* were described in Papanastassiou and Wasserburg (1976).

Chemistry

The chemical composition of 72435 is generally similar to that of many other breccia samples, including the large boulders at Apollo 17 (table 1 and figure 10). Murali et al. (1977) reported high Ir and Au.

Radiogenic age dating

The matrix of 72435 proved difficult to date (Papanastassiou and Wasserburg 1975), because of intermixed small calcic plagioclase fragments (figure 11). This breccia has instead been dated by carefully dating the youngest clasts found within it (see table). *Note: The plagioclase clasts labeled 1 and 2 by Huneke are not be the spinel-bearing clasts 1 and 2 of Dymek.*

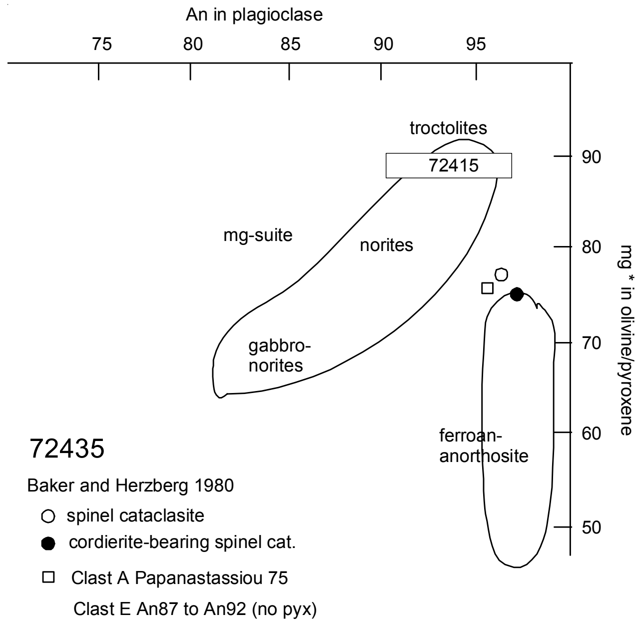

Figure 9: An content of plagioclase plotted vrs. En or Fo content of mafic minerals for clasts (1 and 2) in 72435 compared with 72415 dunite clast from same boulder. Data from Dymek et al. 1976, Papanastassiou and Wasserburg 1975 and Baker and Herzberg 1980. Dymek et al. also report small clasts in 72435 that plot all over this diagram!

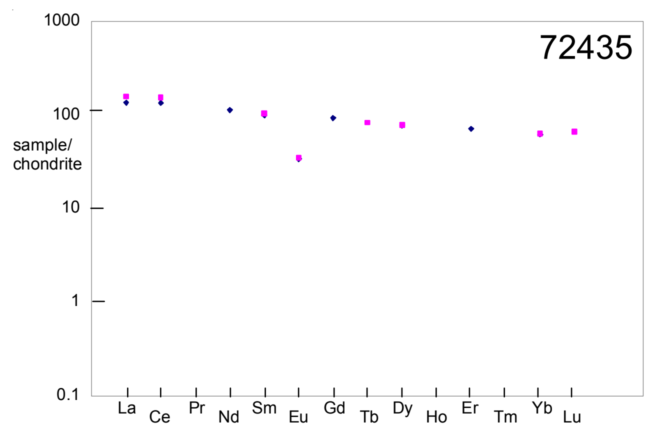

Figure 10: Normalized rare-earth-element diagram for 72435 (data from Hubbard et al. 1974 and Murali et al. 1977).

Mineralogical Mode for 72435 matrix and clasts

	Matrix	Spinel-bearing clasts	
	Dymek et al.	Dymek et al. 1976	Baker and Herzberg 1980
Plagioclase	63 vol. %	83-89	80
Olivine	8.1	2-7	10
Spinel		1-11	10
Pyroxene	24.8	2-6	1
Cordierite		tr.	tr.
Troilite	0		
Ilmenite	1.9		
Phosphate	0.3		
Mesostasis	0.9		

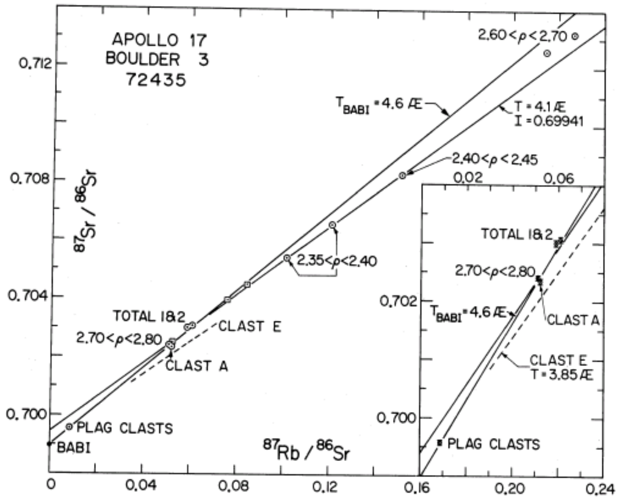

Figure 11: Rb-Sr diagram for 72435 (from Papanastassiou and Wasserburg 1974). Note that clast E is not isotopically equilibrated with the martix.

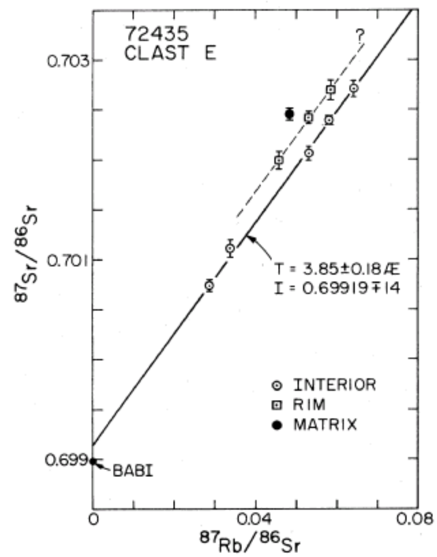

Figure 12: Rb-Sr isochron for 72435 clast E. (from Papanastassiou and Wasserburg 1975).

Cosmogenic isotopes and exposure ages

The exposure age of this boulder has not been reported. However, the surfaces of the samples are covered with zap pits and 72415 was saturated in ^{26}Al, indicating that the boulder has been exposed in its location some time.

Other Studies

Goswami et al. (1976) reported track data for 72435 and Pearce et al. (1974) reported the magnetic properties.

Processing

72435 was studied by a consortium led by Gerry Wasserburg. A single saw cut was made through the largest piece of 72435 (figures 3 and 4) to produce a piece (,11) very like a slab. The careful dissection of 72435,11 is described in Papanastassiou and Wasserburg (1975). Two large notches were take out of it (figure 14). There are 24 thin sections of 72435. Ryder (1993) gives a rather lengthy review.

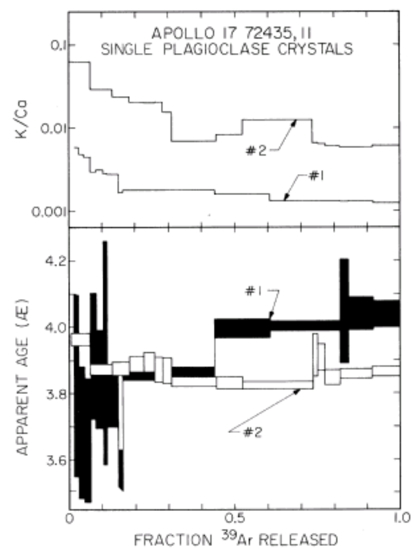

Figure 13: Ar-Ar release pattern for plagioclase from 72435 clasts (1 and 2) (from Huneke 1978).

Summary of Age Data for 72435

	Ar-Ar	Rb-Sr	
Papanastassiou and Wasserburg 1975		3.85 ± 0.18 b.y.	clast E
Huneke et al. 1977	3.87 ± 0.07		
Huneke 1978	3.86 ± 0.04		clast 2 (K-rich plag)
Huneke 1978	3.86-4.04		clast 1 (large plag)

Note: Not corrected for new decay constants.

Table 1. Chemical composition of 72435

reference	LSPET 73		Hubbard 74		Murali 77		Dymek 76	Dymek 76	
weight							calculated	measured	
SiO2 %	45.76	(b)					45.59	48.4	(d)
TiO2	1.54	(b)			1.5	(c)	1.85	1.43	(d)
Al2O3	19.23	(b)			17.8	(c)	20.71	16.6	(d)
FeO	8.7	(b)			10.4	(c)	8.01	8.48	(d)
MnO	0.11	(b)			0.112	(c)	0.09	0.11	(d)
MgO	11.63	(b)			12	(c)	10.49	11.8	(d)
CaO	11.72	(b)			10.4	(c)	12.51	11.6	(d)
Na2O	0.52	(b)			0.67	(c)	0.66	0.61	(d)
K2O	0.23	(b)	0.22	(a)	0.23	(c)	0.23	0.31	(d)
P2O5	0.27	(b)					0.15	0.56	(d)
S %	0.08						0.03	0.07	(d)
sum									
Sc ppm					17	(c)			
V					50	(c)			
Cr			1291	(a)	1485	(c)			
Co					31	(c)			
Ni	112	(b)			320	(c)			
Cu									
Zn	2	(b)							
Ga									
Ge ppb									
As									
Se									
Rb	3.8	(b)	3.93	(a)					
Sr	165	(b)	171.6	(a)					
Y	107	(b)							
Zr	450	(b)	473	(a)	430	(c)			
Nb	30	(b)							
Mo									
Ru									
Rh									
Pd ppb									
Ag ppb									
Cd ppb									
In ppb									
Sn ppb									
Sb ppb									
Te ppb									
Cs ppm									
Ba			334	(a)	310	(c)			
La			31.7	(a)	37	(c)			
Ce			80.6	(a)	92	(c)			
Pr									
Nd			51.3	(a)					
Sm			14.5	(a)	15.3	(c)			
Eu			1.88	(a)	1.98	(c)			
Gd			18.3	(a)					
Tb					3	(c)			
Dy			18.6	(a)	19	(c)			
Ho									
Er			11.3	(a)					
Tm									
Yb			10.1	(a)	10.2	(c)			
Lu					1.6	(c)			
Hf			12.7	(a)	11.5	(c)			
Ta					1.9	(c)			
W ppb									
Re ppb									
Os ppb									
Ir ppb					9	(c)			
Pt ppb									
Au ppb					6	(c)			
Th ppm					3	(c)			
U ppm			1.4	(a)					

technique (a) IDMS, (b) XRF, (c) INAA, (d) e. probe

Table 2: Composition of 72435.

	U ppm	Th ppm	K2O %	Rb ppm	Sr ppm	Nd ppm	Sm ppm	technique
Papanastassiou + W 75			0.24	3.53	168			IDMS
			0.24	3.45	169			IDMS
			0.21	2.76	165			IDMS
Nyquist et al. 1974	1.4		0.22	3.93	172	51.3	14.5	IDMS
Murali et al. 1977		3					15.3	INAA

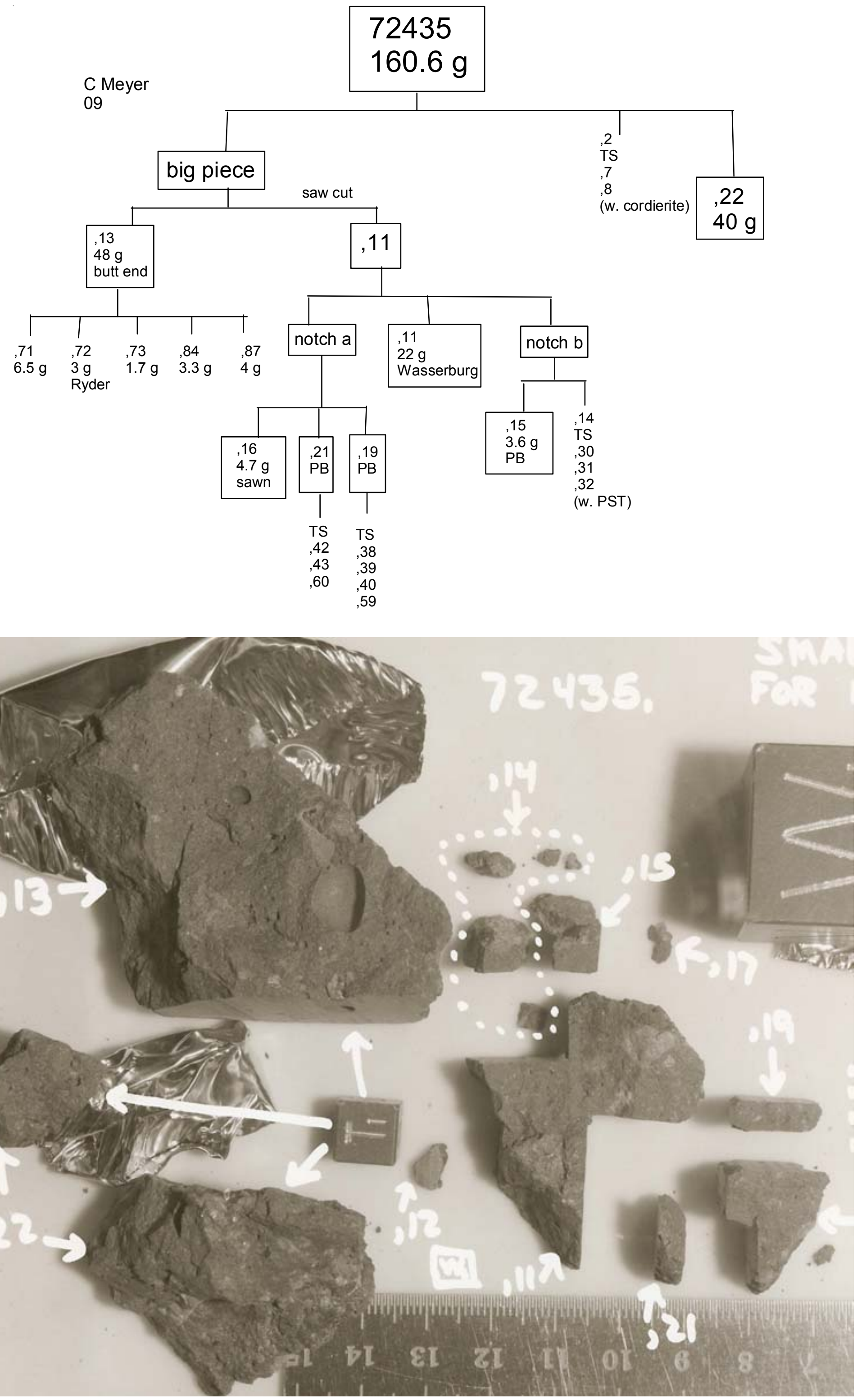

Figure 14: Cutting diagram for 74235. Large cube is 1 inch. Photo # S74-23146.

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