72315

Impact melt Breccia

131.4 grams

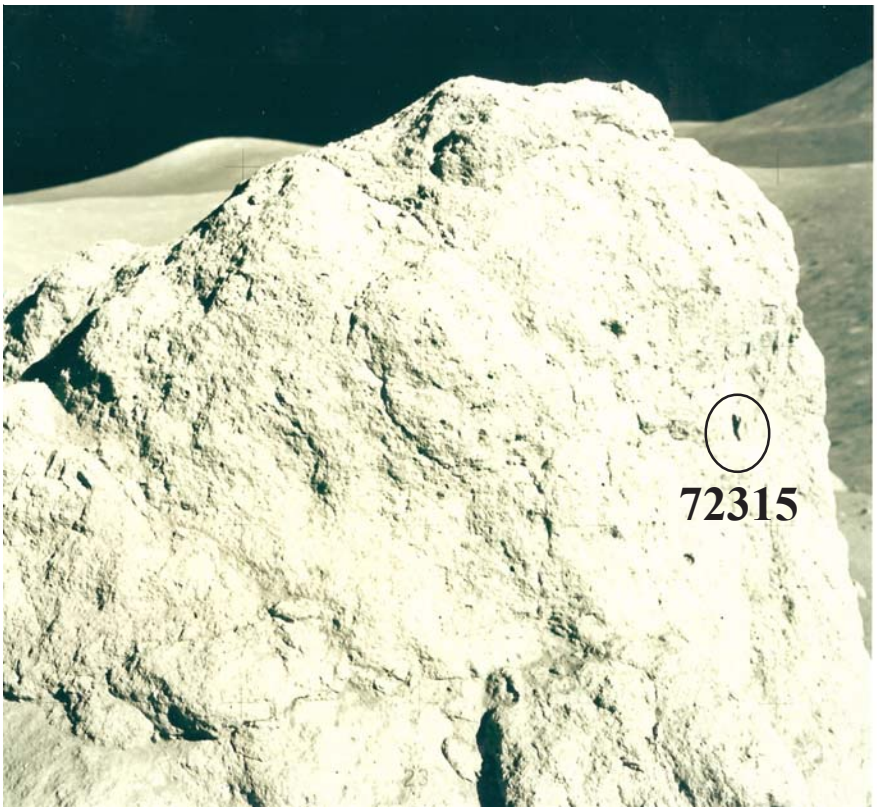


Figure 1: Location of 72315 on boulder # 2 on landslide off of South Massif.

Figure 2: Fresh-broken side of 72315. Scale in cm. S73-16657. Note dark clasts.

Figure 3: Outer surface and edge view of 72315. Scale is in cm. S73-16656 and 660. Note the micrometeorite craters, with halos, in the prominant patina.

Introduction

Samples 72315 was chipped off of boulder #2 on the landslide off of the South Massif (figure 1), because it was thought to be an anorthositc clast (light-colored patch) in the host rock (see transcript for this boulder under 72335). However, the sample turned out to be mostly an impact melt breccia – same as the other samples collected from this boulder (see 72395). It contains abundant mineral clasts, but only minor recognizable clasts of granultic anorthosite or norite.

The exterior surface of the samples of boulder #2 had a patina that masked the interior, but which recorded numerous micrometeorite pits – with noticable white halos (figure 3). 73215 stuck out like an exposed thumb, providing opportunity for cosmic ray track studies.

Figure 4: Photograph of thin section 72315,78. Section about 2 cm long.

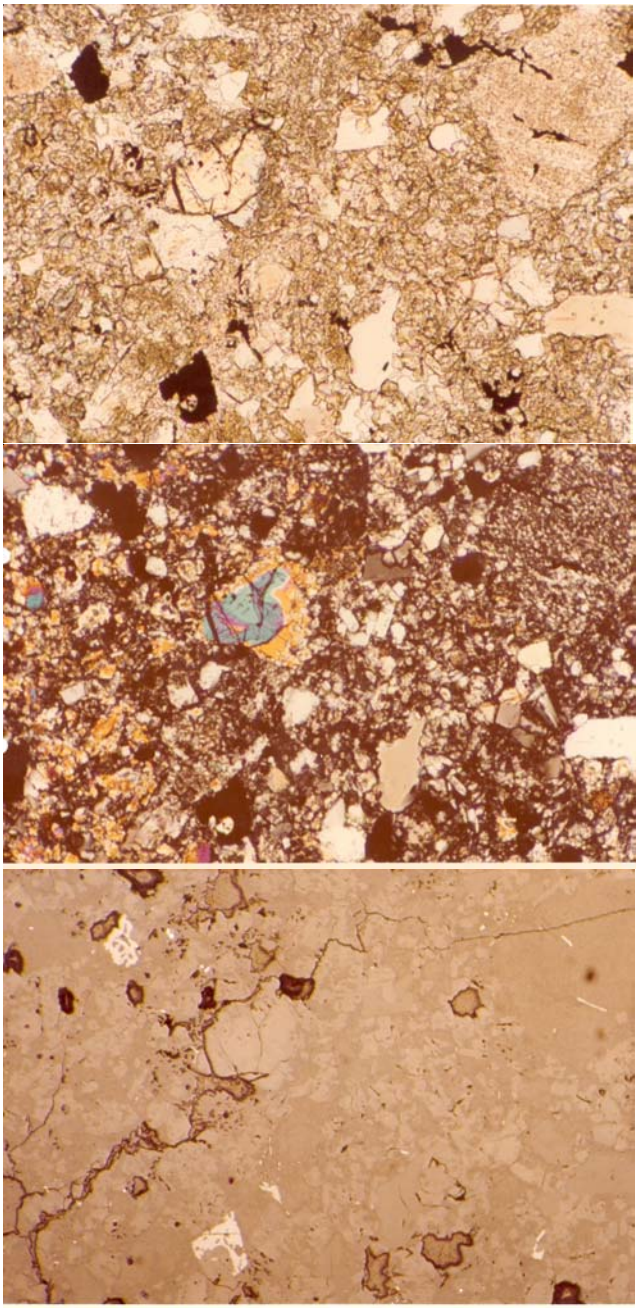


Figure 5: Thin section photomicrographs of 72315,7 showing granoblastic texture of initial clast (caution: this is not representative of whole sample). Top is plane polarized, middle is crossed polarized, and bottom is reflected light of same area. Field of view is 1.3 mm. S79-27403, 404 and 402 top-to-bottom.

Mineralogical Mode for 72395

	Dymek et al. 1976
Olivine	8.8 vol. %
Low-Ca Pyx.	25.4
High-Ca Pyx.	5.9
Plagioclase	56.2
Ilmenite	1.3
Phosphate	0.9

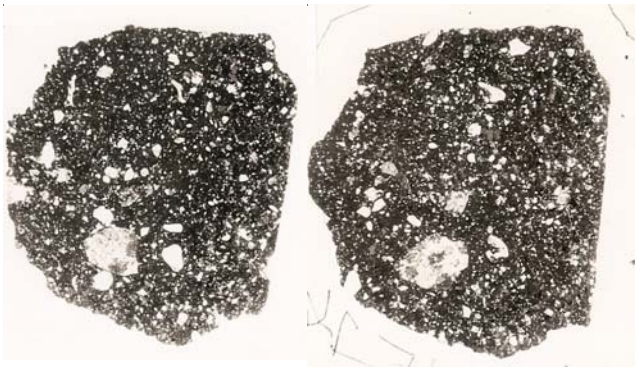


Figure 6: Thin section photos of 72315,25 and ,26 (sic). Each about 2 cm across.(from data pack)

Another piece of this boulder (72395) has been dated at 3.9 b.y., and this is the presumed age of the Serenitatis impact event.

Petrography

Dymek et al. (1976) and McGee et al. (1979) provided petrographic descriptions of 72315. There is some confusion as to what type of rock it is, because the astronauts were trying to sample a white "clast" on the boulder (probably a spall), and the first thin sections studied were apparently of a granulite clast (figure 5). However, sawn surfaces and other thin sections show that 72315 is instead a vesicular impact melt with a characteristic micropoikilitic texture. In fact, all 5 samples of this boulder have similar texture, mineralogy and chemical composition. Sample 72395, is perhaps the best described.

Stoffler et al. (1979) describe 72315 as a "polymict breccia with lithic and mineral clasts in a crystalline, poikilitic matrix." Ryder (1993) refers to it as "micropoikilitic impact melt breccia". However, Simonds (1974) referred to the samples of this boulder as "clast-rich ophitic" (sic). Certainly, the sample is a recrystallixed impact melt breccia (figures 2, 4 and 6). It is about 80 % matrix (<50 microns) with about 15 % mineral clasts (<1 mm) and ~5 % annealed ltihic clasts 91 to 10 mm). It also has about 3 % pore space as small irregular vugs (figure 11).

The crystalline matrix of 72315 is composed of interlocking grains of plagioclase, pyroxene and olivine with small, poorly-developed poikilitic pyroxene and ilmenite enclosing laths of plagioclase and rounded inclusions of olivine (mode given is that of 72395).

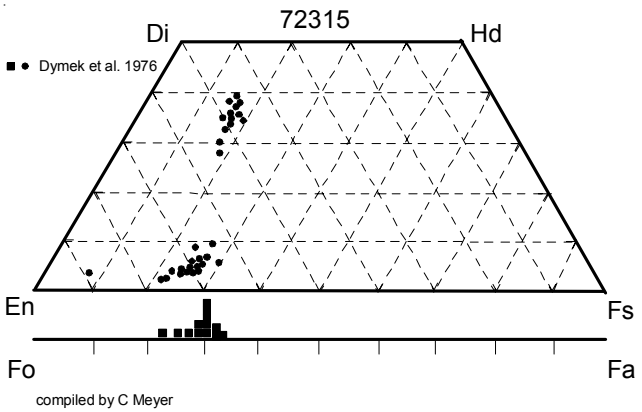


Figure 7: Pyroxene and olivine composition for 72315 (from Dymek et al. 1976, with apologies).

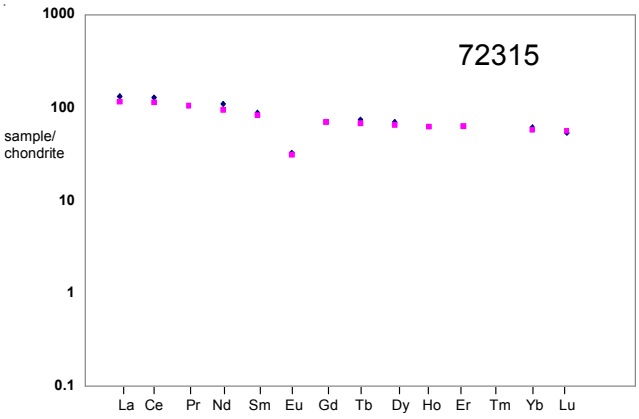


Figure 8: Normalized rare-earth-element diagram for 72315 (data by ICP-MS in 2002 is in substantial agreement with data by INAA in 1974!).

Mineral clasts include plagioclase (An_{90-97}), olivine (Fo_{68-72}), pyroxene (figure 7), opaques and rare pink spinel.

Mineralogy

Olivine: The compositon of olivine grains is tightly grouped at $Fo_{70\pm2}$.

Pink Spinel: Pink spinel grains are Mg- and Al-rich in the center and zone to more Cr-rich at the edge.

Pyroxene: The composition of pyroxene is depicted in figure 7.

Plagioclase: Plagioclase in 72315 often has undulatory extinction, and is sometimes feathery (maskelynite devitrification). Large grains have overgrowth rims with olivine "necklaces". Plagioclase ranges in composition from $Or_{0.2}Ab_2An_{98}$ to about $Or_3Ab_{22}An_{75}$ (Dymek et al. 1976).

Ilmenite: Ilmenite in 72315 is evenly dispersed in the matrix, has a seive-like texture and is Mg-rich. It has rutile and ulvospinel lamellae and rounded inclusions of armalcolite.

Metallic Iron: Metallic iron is meteoritic in origin (see figure 7 in section on 72395).

Apatite: Hutcheon et al. (1974) studied the "thermal fading" of fision tracks in apatite in 72315.

Armalcolite: Armalcolite is found included in ilmenite and is Zr-rich.

Significant Clasts

Feldspathic Granulite: Initially, the first thin sections studied were of a feldspathic granulite clast (figure 5). Presumably, that is what the dark grey clasts in figures 2 and 12 are.

Feldspathic Norite: ,73 There is a large clast of feldspathic norite with poikilitic pyroxene in thin section 72315,78 (figure 4) that remains to be studied.

Chemistry

Keith et al. (1974) determined the K, U and Th content of 84 grams of 72315 (table 1). All of the samples of boulder 2 have similar composition. The overall composition is that of a feldspathic basalt, but clearly it is a mixture of highland components. The trace element content is high (figure 8). Laul et al. (1974), Ebihara et al. (1992) and Norman et al. (2002) all found high concentrations of "meteoritic siderophiles".

Radiogenic age dating

Tera et al. (1974) determined a Rb-Sr model age of 4.54 b.y., but this has no meaning. The age of the crystalline matrix of the boulder is ~ 3.9 b.y. (as determined on 72395).

Cosmogenic isotopes and exposure ages

72315 was exposed to cosmic radiation as a prominent knob on the side of boulder #2. Keith et al. (1974) determined ^{26}Al = 62 dpm/kg., ^{22}Na = 73 dpm/kg. and ^{54}Mn = 90 dpm/kg.

Table 1. Chemical composition of 72315.

reference	Keith 74		Laul et al. 1974			Tera 74		Ebihara92		Norman2002		Norman2008	
weight													
SiO2 %												46.9	(e)
TiO2			1.4	1.4	(b)					1.4	(d)	1.45	(e)
Al2O3			19.8	19.2	(b)							18.7	(e)
FeO			8.5	8.5	(b)							8.27	(e)
MnO			0.111	0.111	(b)					0.116	(d)	0.12	(e)
MgO			11	12	(b)							11	(e)
CaO			11.6	11.3	(b)							11.1	(e)
Na2O			0.61	0.7	(b)							0.59	(e)
K2O	0.34	(a)	0.32	0.35	(b)	0.317	(c)					0.31	(e)
P2O5													
S %													
sum													
Sc ppm			16	16	(b)					17.8	(d)		
V			50	50	(b)					45	(d)		
Cr			1273							1313	(d)	1710	(e)
Co			21	32	(b)					25	(d)		
Ni			180	330	(b)			367	(b)	213	(d)		
Cu													
Zn			2.6	2.5				2.34	(b)	12.8	(d)		
Ga										5.2	(d)		
Ge ppb								538	(b)				
As													
Se			110	120				106	(b)				
Rb			8.5	9.6		8.2	(c)	10.7	(b)	11.7	(d)		
Sr			157	165		165	(c)			177	(d)		
Y										111	(d)		
Zr			400	400	(b)					473	(d)		
Nb										35.1	(d)		
Mo													
Ru										12	(d)		
Rh													
Pd ppb								15.2	(b)	11.8	(d)		
Ag ppb			1.1	0.84				0.873	(b)				
Cd ppb			300	8.1				9.7	(b)				
In ppb			0.4	0.5				0.16	(b)				
Sn ppb													
Sb ppb			1.3	2				1.93	(b)				
Te ppb								6.52	(b)				
Cs ppm			0.45	0.53				0.434	(b)	0.57	(d)		
Ba			290	280	(b)					374	(d)		
La			30	31	(b)					27.2	(d)		
Ce			76	77	(b)					68.8	(d)		
Pr										9.39	(d)		
Nd			50	50	(b)					42.8	(d)		
Sm			12.8	12.9	(b)					12.2	(d)		
Eu			1.82	1.83	(b)					1.75	(d)		
Gd										13.7	(d)		
Tb			2.6	2.7	(b)					2.46	(d)		
Dy			17	17	(b)					15.8	(d)		
Ho										3.46	(d)		
Er										9.99	(d)		
Tm													
Yb			10	10	(b)					9.33	(d)		
Lu			1.3	1.3	(b)					1.36	(d)		
Hf			10	10	(b)					9.74	(d)		
Ta			1.4	1.4	(b)					1.49	(d)		
W ppb										0.83	(d)		
Re ppb			0.43	0.98				0.933	(b)	0.64	(d)		
Os ppb								12.9	(b)				
Ir ppb			4.3	9	(b)			11.3	(b)	6.55	(d)		
Pt ppb										14.1	(d)		
Au ppb			2.8	6.1	(b)			5.81	(b)				
Th ppm	4.8	(a)	5.2	5.4	(b)					6.24	(d)		
U ppm	1.53	(a)	1.58	1.53	(b)			1.6	(b)	1.66	(d)		

technique: (a) radiation counting, (b) INAA, RNAA, (c) IDMS, (d) ICP-MS, (e) fused bead e-probe

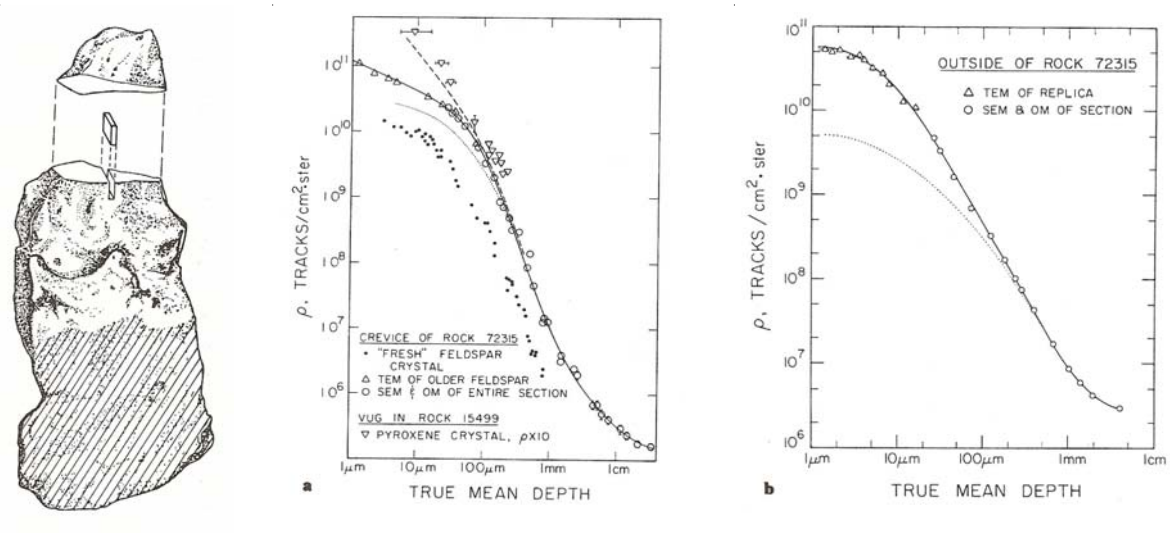


Figure 9: Sketch of 72315 showing sample studied for tracks and results for exposed surface (b) and shielded surface (a) (from Hutcheon et al. 1974).

Other Studies

Hutcheon et al. (1974) claimed that "72315 is a new lunar standard for solar flare and micrometeorite exposure". They studied the density of tracks on an outside surface and in an area that was shielded (figure 9).

Processing

Boulder 2 was a "Wasserburg consortium". Two slabs were cut from 72315. There are seven thin sections.

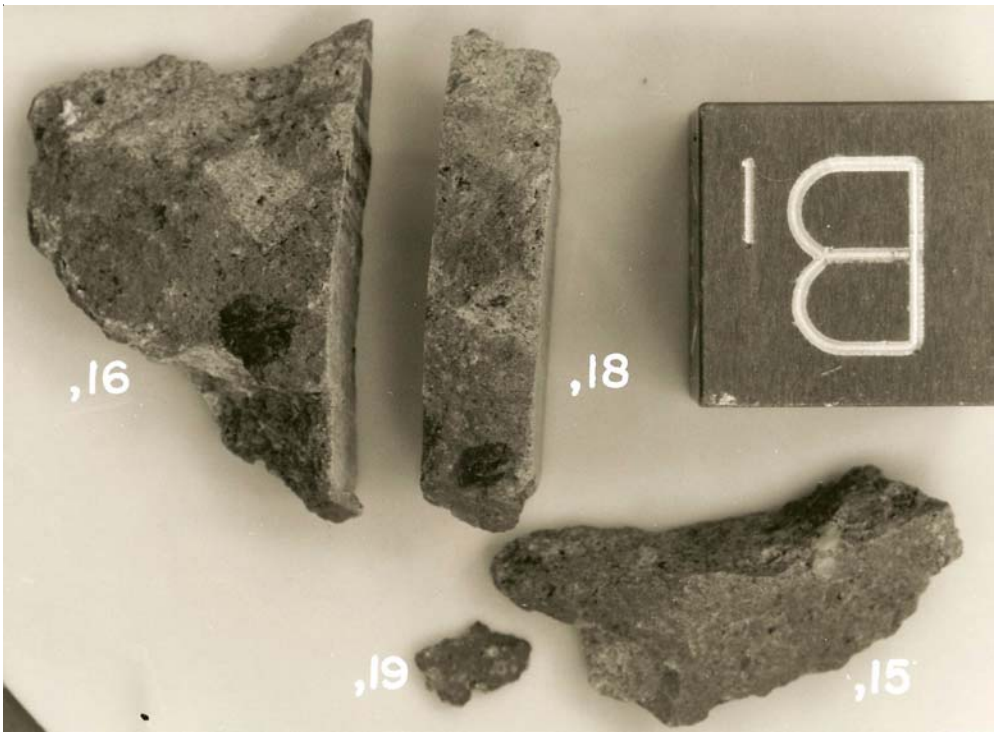
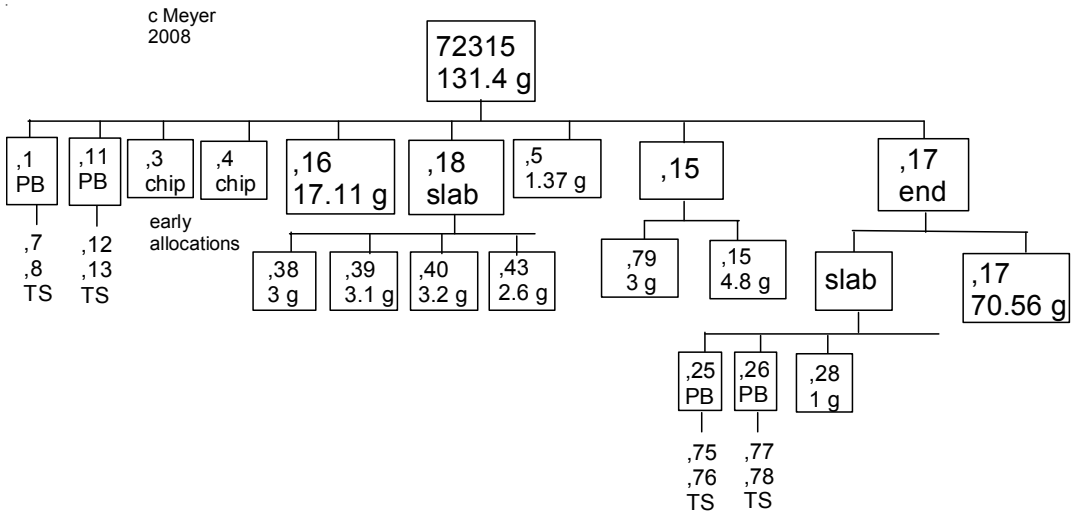


Figure 10: Thick slab (,18) cut from 72315. Cube is 1 inch. S74-15095.



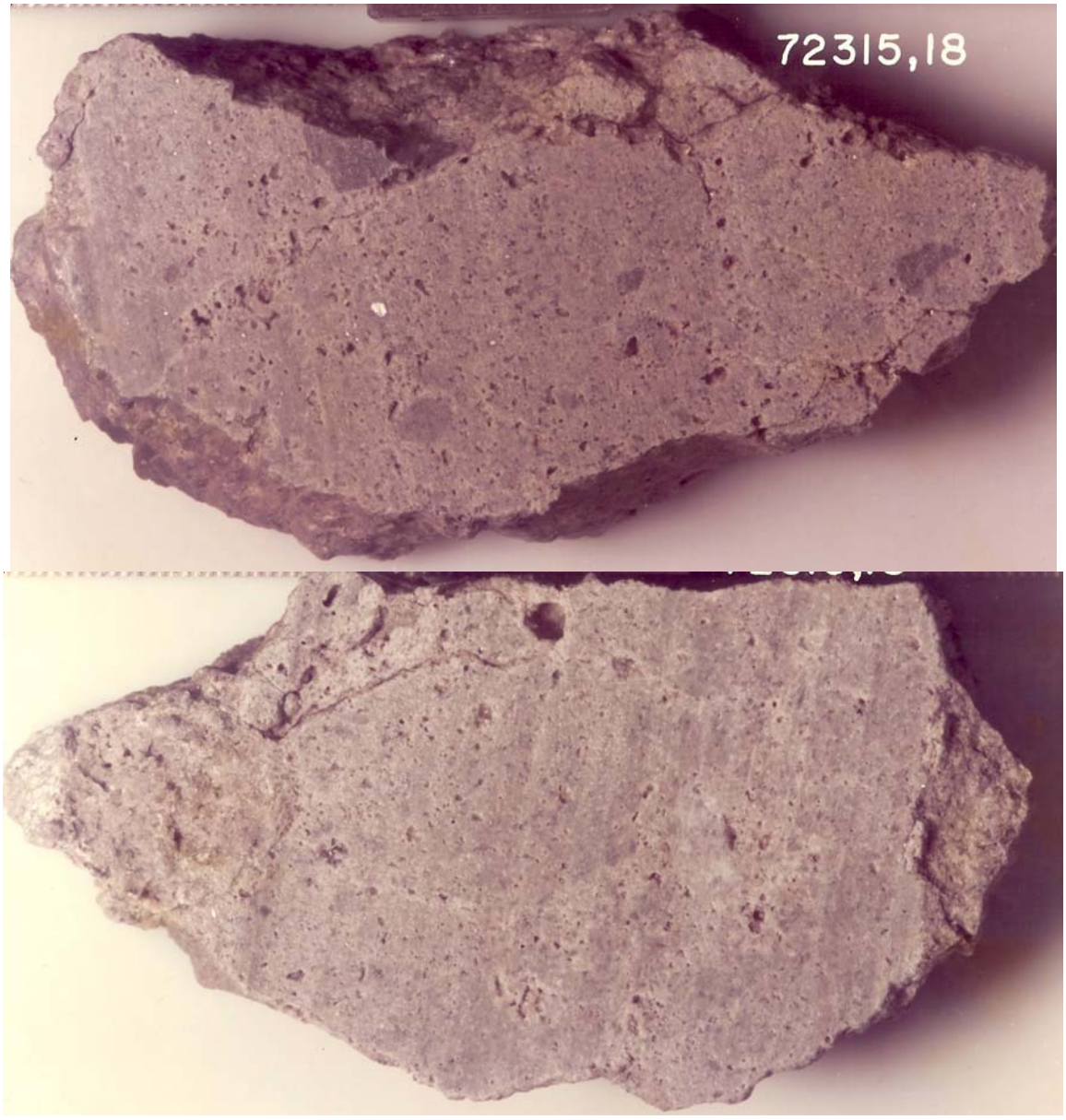


Figure 11: Front and back of thick slab (,18) of 72315. About 4 cm across. S73-37862 and 860. Note small vugs, vesicles and dark clasts.

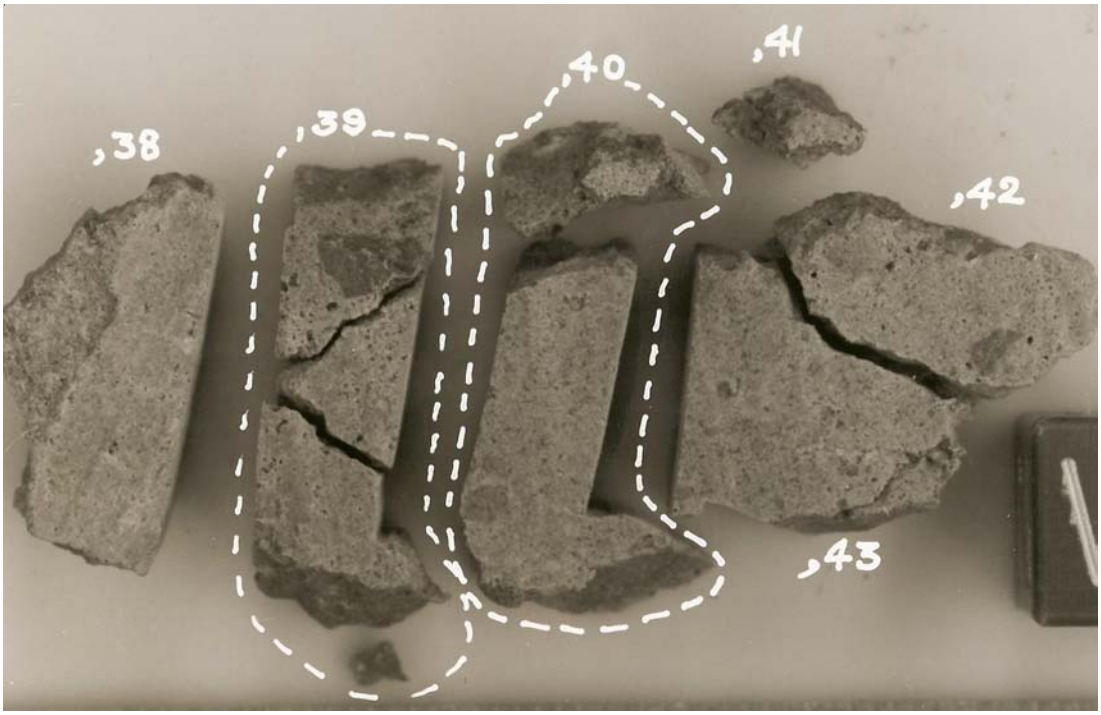


Figure 12: Subdivision of slab 72315,18 (see figure 11). Edge of cube is 1 cm. S74-17835.

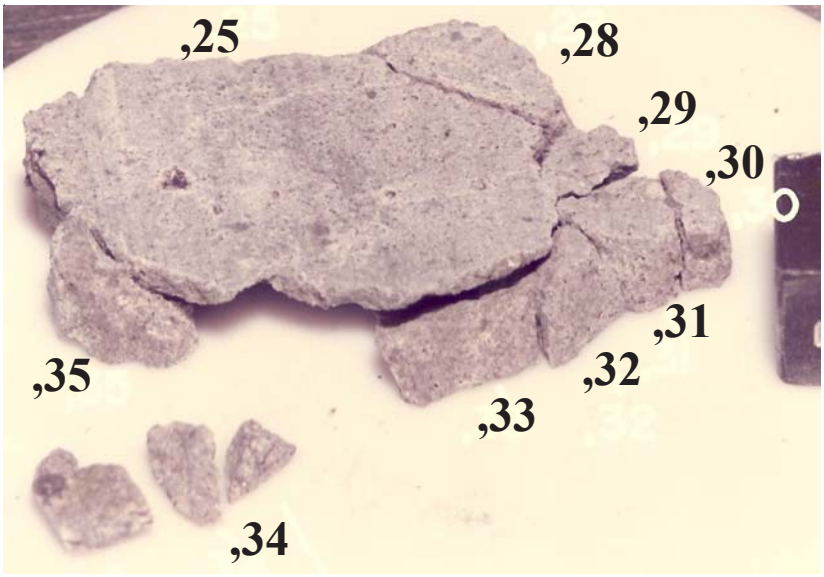


Figure 13: Subdivison of thin slab of 72315. S74-16785.

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