

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 prominent patina.

Introduction

Sample 72315 was chipped off of boulder #2 on the landslide off of the South Massif (figure 1), because it was thought to be an anorthositic 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 granulitic 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 noticeable white halos (figure 3). 72315 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.

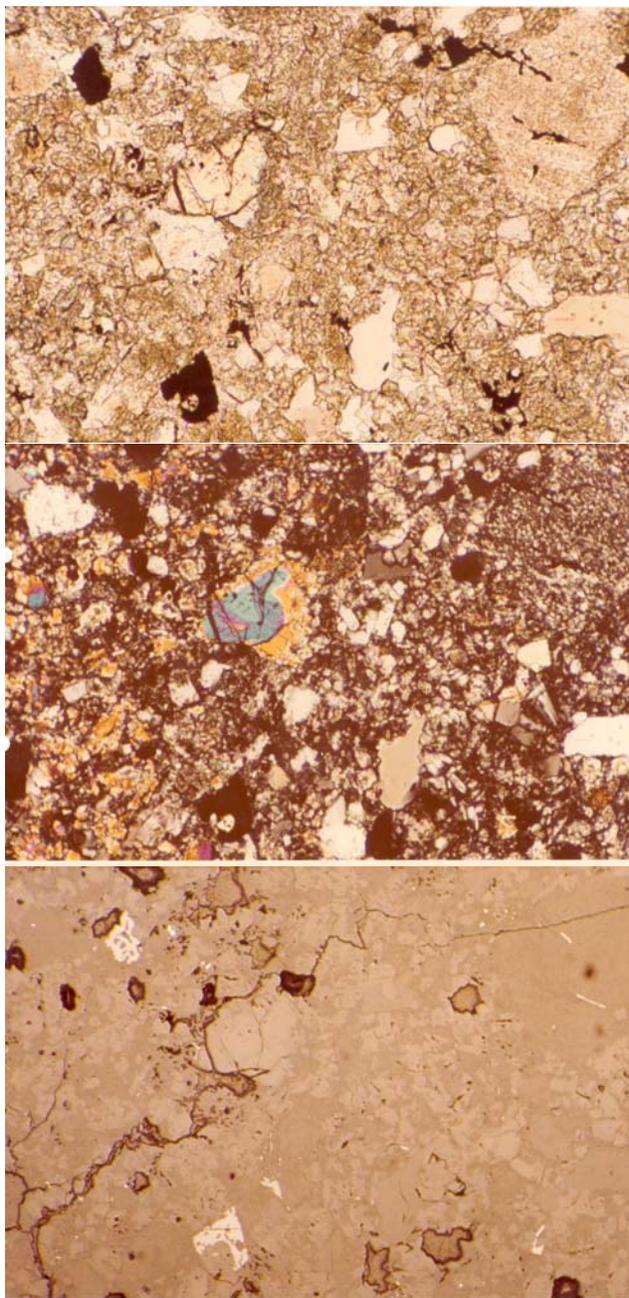


Figure 5: Thin section photomicrographs of 72315,7 showing granoblastic texture of initial clast (caution: this is not representative of whole sample). Top is plane polarized, middle is crossed polarized, and bottom is reflected light of same area. Field of view is 1.3 mm. S79-27403, 404 and 402 top-to-bottom.

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

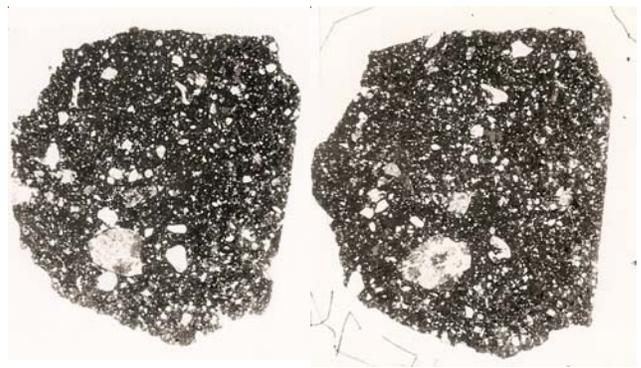


Figure 6: Thin section photos of 72315,25 and ,26 (sic). Each about 2 cm across. (from data pack)

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 recrystallized 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 lithic 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).

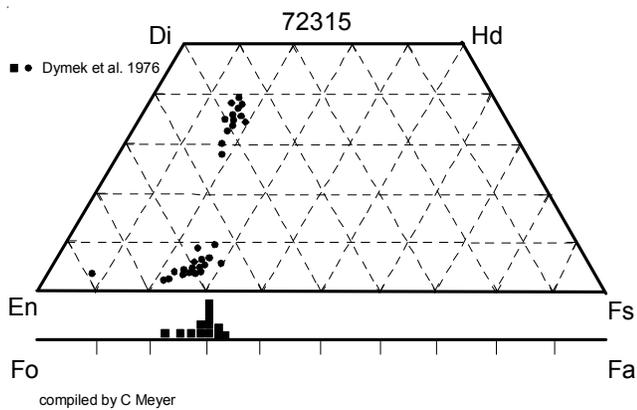


Figure 7: Pyroxene and olivine composition for 72315 (from Dymek et al. 1976, with apologies).

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

Mineralogy

Olivine: The composition of olivine grains is tightly grouped at $Fo_{70\pm 2}$.

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 fission tracks in apatite in 72315.

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

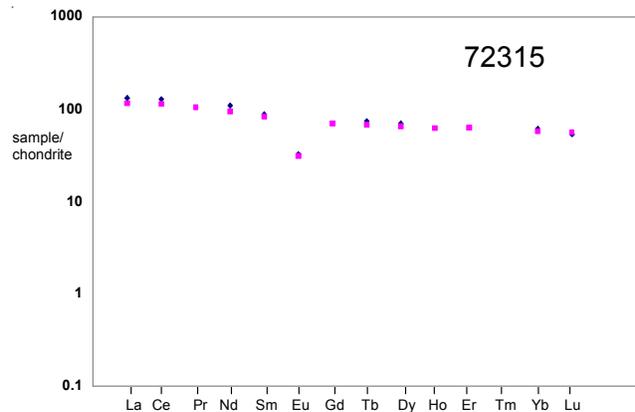


Figure 8: Normalized rare-earth-element diagram for 72315 (data by ICP-MS in 2002 is in substantial agreement with data by INAA in 1974!).

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 weight	Keith 74	Laul et al. 1974	Tera 74	Ebihara92	Norman2002	Norman2008
SiO ₂ %						46.9 (e)
TiO ₂		1.4	1.4 (b)		1.4 (d)	1.45 (e)
Al ₂ O ₃		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)
Na ₂ O		0.61	0.7 (b)			0.59 (e)
K ₂ O	0.34	(a) 0.32	0.35 (b)	0.317 (c)		0.31 (e)
P ₂ O ₅						
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

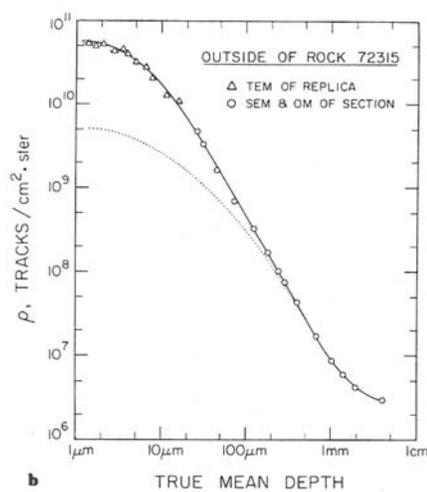
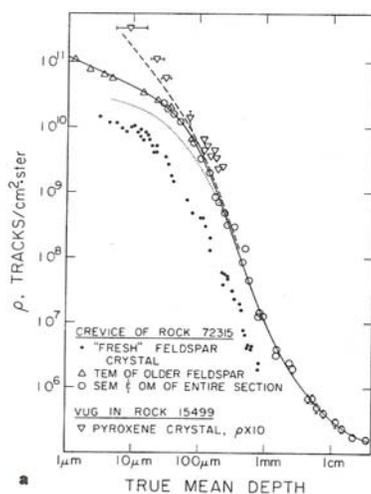
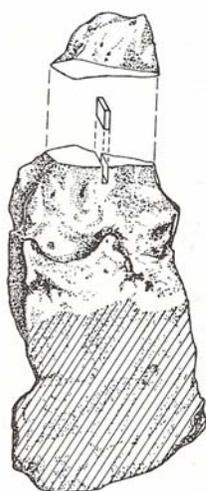


Figure 9: Sketch of 72315 showing sample studied for tracks and results for exposed surface (b) and shielded surface (a) (from Hutcheon et al. 1974).

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.

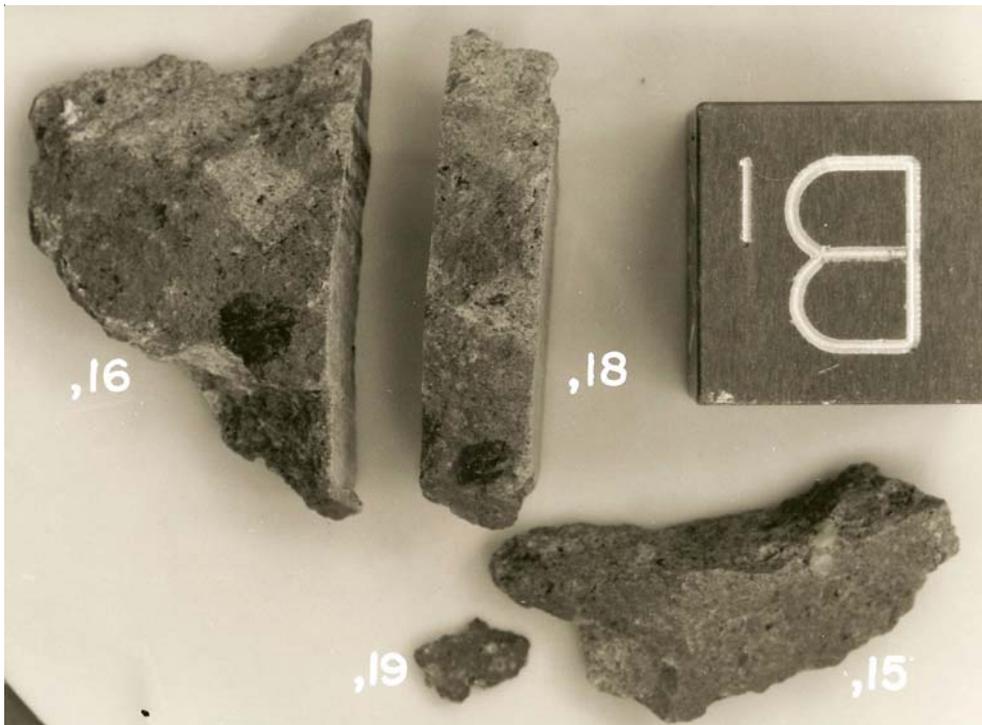


Figure 10: Thick slab (,18) cut from 72315. Cube is 1 inch. S74-15095.

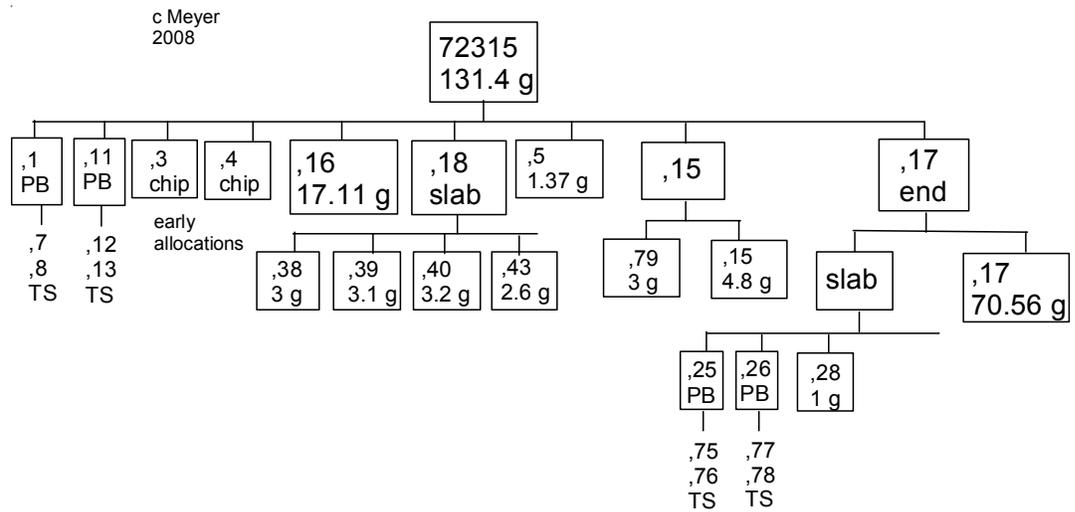




Figure 11: Front and back of thick slab (,18) of 72315. About 4 cm across. S73-37862 and 860. Note small vugs, vesicles and dark clasts.

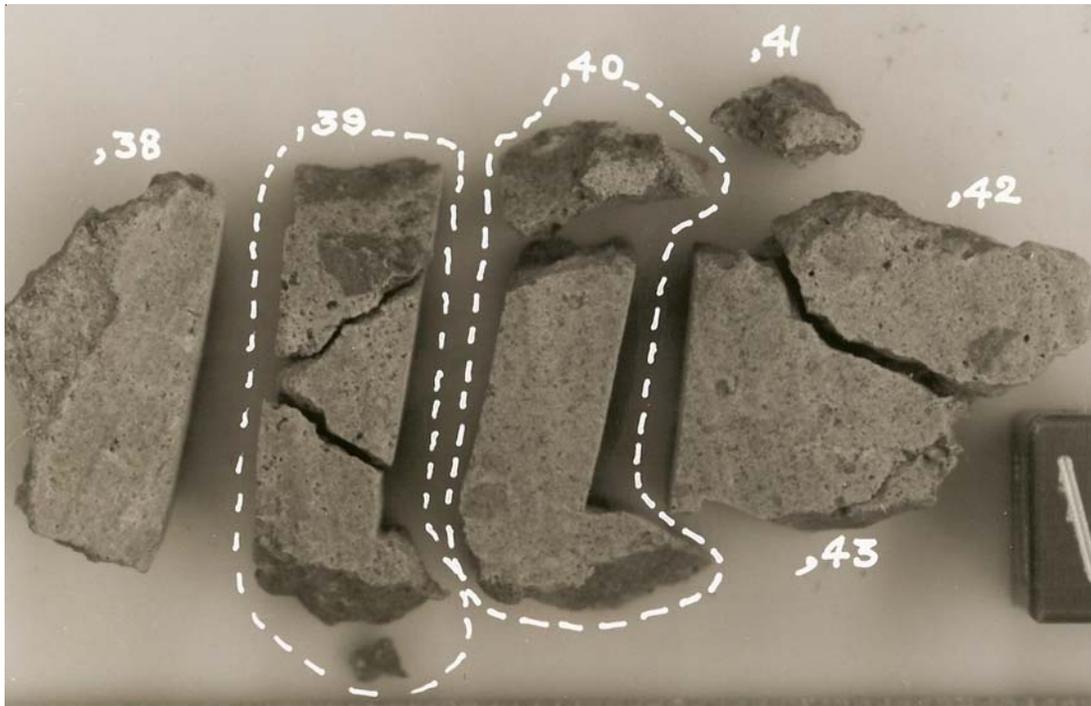


Figure 12: Subdivision of slab 72315,18 (see figure 11). Edge of cube is 1 cm. S74-17835.

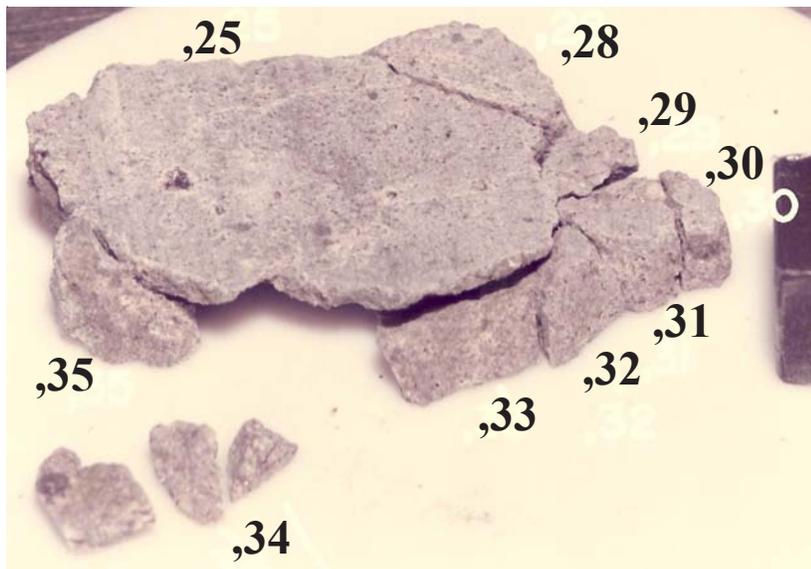


Figure 13: Subdivision of thin slab of 72315. S74-16785.

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