72395

Impact melt Breccia

536.4 grams

Figure 1: Photo of boulder "2" on the landslide from the South Massiff, Apollo 17, showing location of 72395. AS17-137-20912.

Figure 2: Photo of exterior surface of 72395 showing numerous zap pits. Sample is about 10 cm. S73-23979.

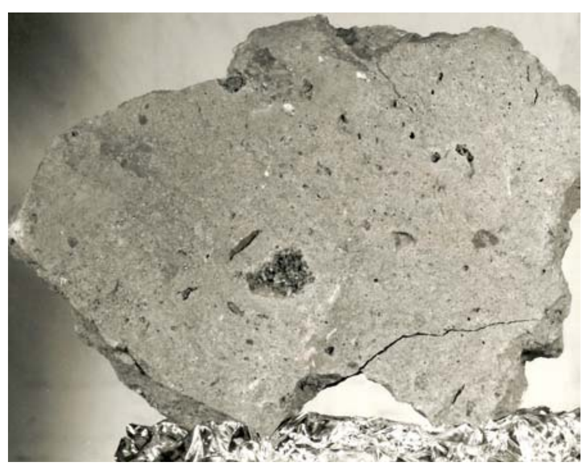


Figure 3: Photo of freshly broken surface of 72395. S73-23983.

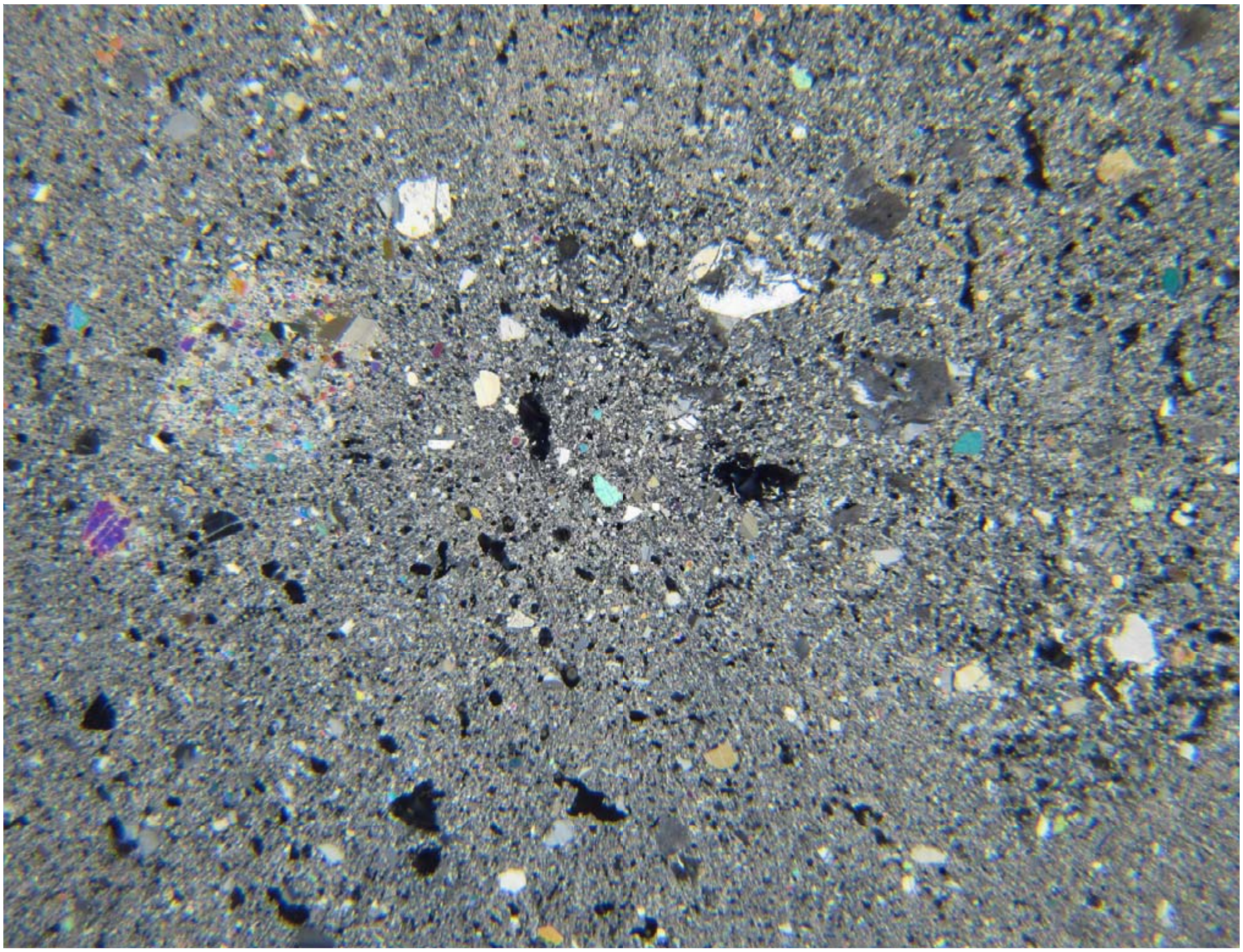


Figure 4: Photograph of thin section 72395,80 by C Meyer with partially crossed polarisers. Field of view is 2.5 cm.

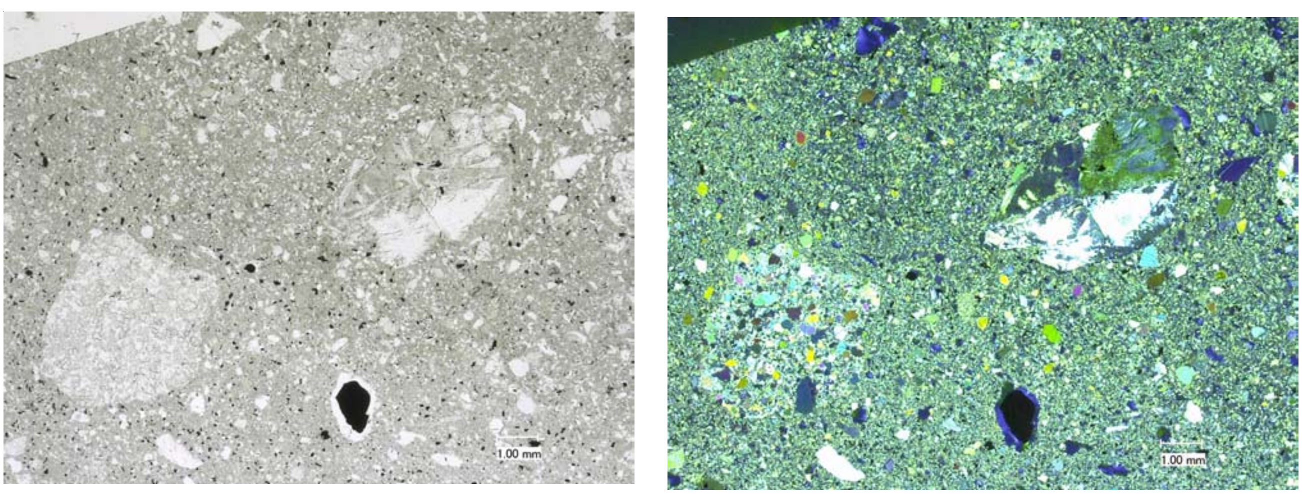


Figure 5: Photomicrographs of thin section 72395,77 by C Meyer @20x. Note reation rim around opaque.

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

Introduction

Lunar breccia sample 72395 was chipped from the #2 boulder at station 2 on the landslide off of the South Massif (figure 1). It was sampled as being from the matrix (see transcript in section on 72335). On the surface, the astronauts could see the prominent halos around micrometeorite craters (figure 2).

The age of 72395 is 3.9 b.y., which is thought to be the age of Serenitatis impact.

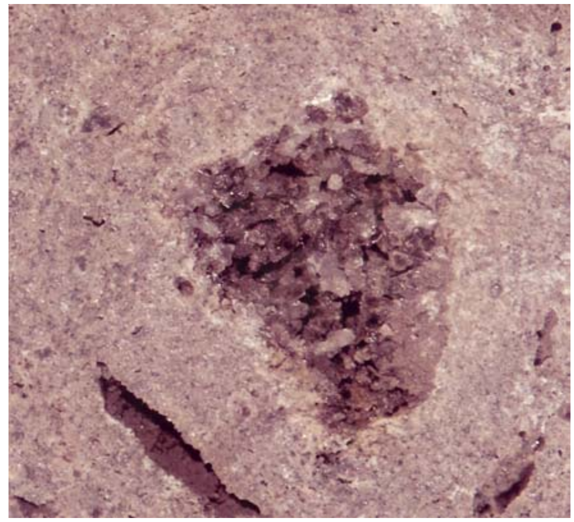


Figure 6: Close-up of crystal-filled vug on fresh surface of 72395 (see figure 3). S73-27575. Vug is 1 cm across.

Petrography

Dymek et al. (1976) described the texture and analyzed the minerals of 72395 along with the adjacent samples which were found to be similar. About 80 % of 72395 is crystalline matrix (<100 microns) with 10 % mineral clasts (>100 microns) and 10 % void space. The groundmass of 72395 consists of an interlocking network of small pyroxene oikocrysts that enclose abundant chaodcrysts of plagioclase. Randomly dispersed ilmenite grains with sieve-like texture enclose both plagioclase and pyroxene (figures 4 and 5). Reaction rim around opaque phase can be seen in figure 5. A large vug filled with crystals is illustrated in figure 6.

Within the groundmass, Dymek et al. (1976) reported "areas" that consist of euhedral high- and low-Ca pyroxene crystals surround by a glass of granitic composition, which they interpret as residual from the crystallization of the matrix (?)

Mineralogy

Olivine: The compositon of olivine grains is tightly grouped at $Fo_{70\pm2}$. Olivine does not form the well-developed oikocrysts like pyroxene, but occurs as irregularly-shaped grains between pyroxene and plagioclase.

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. There is more low-Ca pyroxene than high-Ca pyroxene. Some pyroxene contains rounded grains of olivine.

Plagioclase: Plagioclase in 72395 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 72395 is evenly dispersed in the matrix, has a sieve-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 8).

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

Baddeleyite: Dymek et al. (1976) reported minor baddeleyite at the margins of some ilmenite.

Apatite: Hutcheon et al. (1974) found that fission track ages in apatite in 72395 had been lowered by "thermal annealing".

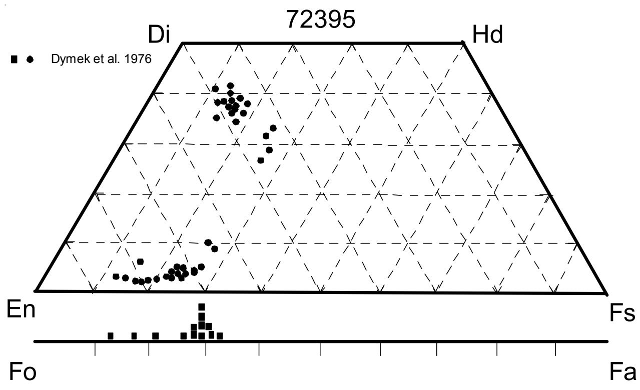


Figure 7: Composition of pyroxene and olivine in 72395 (from Dymek et al. 1976).

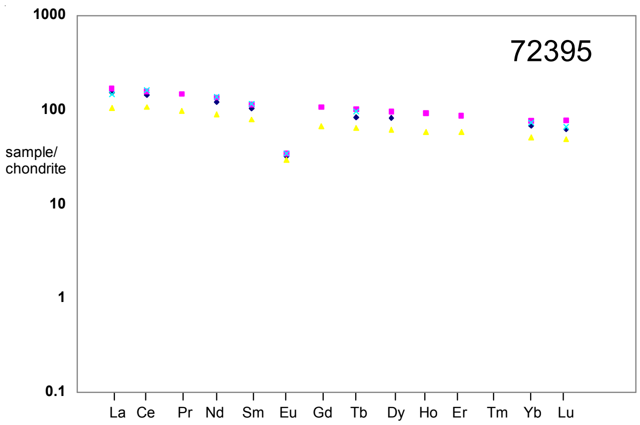


Figure 9: Normalized rare-earth-element diagram for 72395 (data from tables).

Significant Clasts

Cataclastic Troctolite:

A large (2 cm) clast in 72395 is a coarse-grained, recrystallized and cataclastic trotolite that resembles sample 76535 (Dymek et al. 1976). The original, coarse-grained, annealed, granulitic texture is locally preserved although much of the clast has undergone granulation and recrystallization resulting in a much finer grain size. This clast has symplectic intergrowths of high-Ca pyroxene, Cr-spinel and Zr-armalcolite.

Granulitic Anorthosite:

Plagioclase-rich clasts are the dominent lithic fragment in 72395. They have a range in texture, but some have a granulitic texture with 120 deg triple junctions and smooth grain boundries.

Spinel Troctolite:

Small clast of "pink spinel troctolite" with a variety of textures (intergranular, recrystallized) are found in thin sections of 72395 (Dymek et al. 1976). The pink spinel

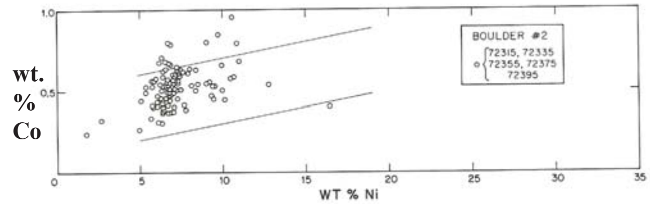


Figure 8: Composition of metal grains in samples from boulder #2, Station 2, Apollo 17 (from Dymek et al. 1976).

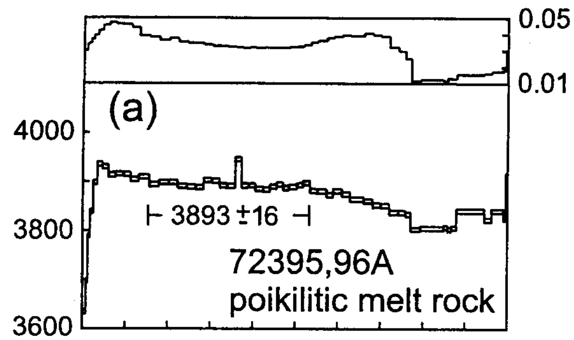


Figure 10: Ar/Ar plateau diagram for 72395 (from Dalrymple and Ryder 1996).

Summary of Age Data for 72395

	Ar/Ar	U/Pb
Dalrymple and Ryder 1996	3.893 ± 0.016 b.y	
Tera et al. 1974		?

occurs as small rounded grains in plagioclase, or sometimes as angular grains between plagioclase laths.

Crystal-filled vug: Figure 6 is an enlargement of the large (~1 cm) vug on the broken surface of 72395 (figure 3). It has apparently not been studied.

Chemistry

Laul and Schmitt (1974), Wanke et al. (1975), Ebihara et al. (1992), Norman et al. (1996) and Putchel et al. (2008) all found that 72395 had high meteoritic siderophiles (table 1). Moore et al. (1974), Moore and Lewis (1976) and Cripe and Moore (1975) have reported C, N and S. Jovanovic and Reed (1974) determined volatile elements. The trace element content is high (figure 9).

Radiogenic age dating

Dalrymple and Ryder (1996) dated 72395 by the Ar/Ar plateau technique to be 3.893 ± 0.016 b.y. (figure 10). They use this value to conclude the age of Serenitatis! Tera et al. (1974) found the U/Pb data for 72395 fit (within error bars) on the "cataclysm" chord (see figure 3 in their paper).

Table 1. Chemical composition of 72395.

reference	Ebihara92		Laul74		Dymek76		Wanke75		Norman 2002		Dalrymple96		Putchel2008		Tera74	
weight									melt		melt					
SiO2 %					46.47	(c)	46.8	(a)	46.6	(b)						
TiO2			1.7	(a)	1.5	(c)	1.75	(a)	1.36	(b)						
Al2O3			18.7	(a)	17.52	(c)	18.1	(a)	18	(b)						
FeO			9.2	(a)	8.96	(c)	9.26	(a)	8.68	(b)	8.9	(a)				
MnO			0.116	(a)	0.11	(c)	0.12	(a)	0.13	(b)						
MgO			12	(a)	12.46	(c)	11.95	(a)	12	(b)						
CaO			11	(a)	11.5	(c)	11.26	(a)	11.2	(b)						
Na2O			0.67	(a)	0.79	(c)	0.69	(a)	0.62	(c)	0.69	(a)				
K2O			0.32	(a)	0.13	(c)	0.29	(a)	0.24	(c)	0.26	(a)				
P2O5					0.44	(c)	0.32	(a)								
S %					0.09	(c)	0.056	(a)								
sum																
Sc ppm			17	(a)			18.7	(a)	20.8	(d)	18.2	(a)				
V			50	(a)					55	(d)						
Cr			1437	(a)	1684	(c)	1400	(a)	1474	(d)	1386	(a)				
Co			35	(a)			31.1	(a)	25.3	(d)	24	(a)				
Ni	357	(a)	290	(a)			260	(a)	181	(d)	215	(a)				
Cu							3.55	(a)	14.6	(d)						
Zn	1.94	(a)	2.1	(a)			2.76	(a)	13.3	(d)						
Ga							4.35	(a)	4.7	(d)						
Ge ppb	580	(a)					440	(a)								
As							78	(a)								
Se	102	(a)	190	(a)												
Rb	6.37	(a)	5.3	(a)			6.21	(a)	6.8	(d)						
Sr			152	(a)			167	(a)	172	(d)	229	(a)				
Y									102	(d)						
Zr			400	(a)			570	(a)	431	(d)	460	(a)				
Nb									30.4	(d)						
Mo																
Ru									6.97	(d)			14.3	(d)		
Rh																
Pd ppb	14.9	(a)							7.42	(d)			14.3	(d)		
Ag ppb	0.743	(a)	1.4	(a)												
Cd ppb	3.53	(a)	170	(a)												
In ppb	0.026	(a)	0.2	(a)												
Sn ppb																
Sb ppb	3.74	(a)	2.1	(a)												
Te ppb	5.55	(a)														
Cs ppm	0.2	(a)					0.19	(a)	0.22	(d)	0.18	(a)				
Ba			350	(a)			386	(a)	313	(d)	386	(a)				
La			36	(a)			39.7	(a)	24.7	(d)	37.4	(a)				
Ce			87	(a)			95	(a)	64.7	(d)	97.9	(a)				
Pr							13.1	(a)	8.7	(d)						
Nd			55	(a)			61	(a)	40.4	(d)	62	(a)				
Sm			15.2	(a)			16.8	(a)	11.6	(d)	17.1	(a)				
Eu			1.81	(a)			1.93	(a)	1.66	(d)	1.93	(a)				
Gd							21.1	(a)	13.1	(d)						
Tb			3	(a)			3.7	(a)	2.32	(d)	3.5	(a)				
Dy			20	(a)			23.2	(a)	14.8	(d)						
Ho							5.1	(a)	3.22	(d)						
Er							13.9	(a)	9.17	(d)						
Tm																
Yb			11	(a)			12.4	(a)	8.27	(d)	11.8	(a)				
Lu			1.5	(a)			1.88	(a)	1.19	(d)	1.6	(a)				
Hf			12	(a)			13.7	(a)	8.84	(d)	13.9	(a)				
Ta			1.6	(a)			1.82	(a)	1.28	(d)	1.72	(a)				
W ppb							750	(a)	0.63	(d)						
Re ppb	0.96	(a)	0.79	(a)			0.2	(a)	0.4	(d)			0.75	(d)		
Os ppb	11.7	(a)											7.613	(d)		
Ir ppb	8.9	(a)	8	(a)			11	(a)	3.6	(d)			7.27	(d)		
Pt ppb									7.38	(d)			18.3	(d)		
Au ppb	5.42	(a)	5.8	(a)			4.7	(a)								
Th ppm			5.5	(a)			6.05	(a)	4.84	(d)	6.1	(a)			5.88	(e)
U ppm	1.78	(a)	1.72	(a)			2.06	(a)	1.27	(d)	1.64	(a)			1.67	(e)

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

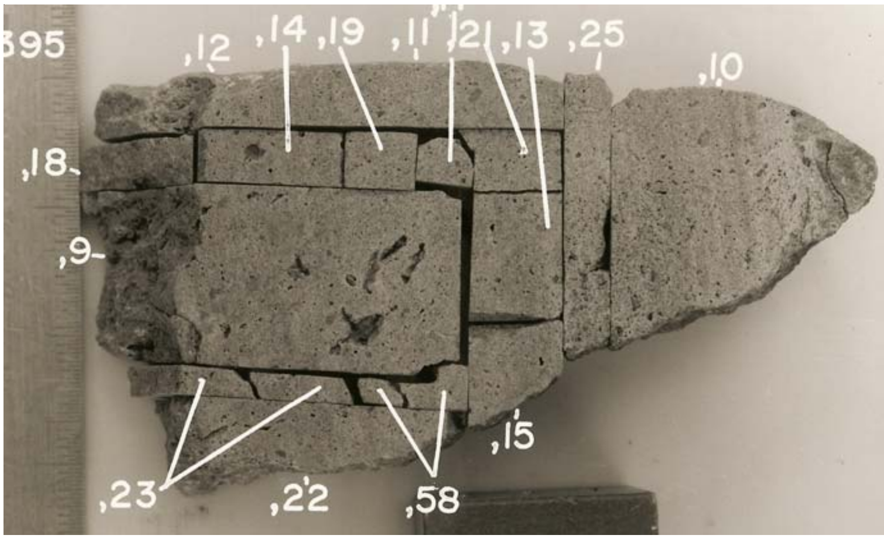


Figure 10: Photo of slab of 72395. S74-15101.

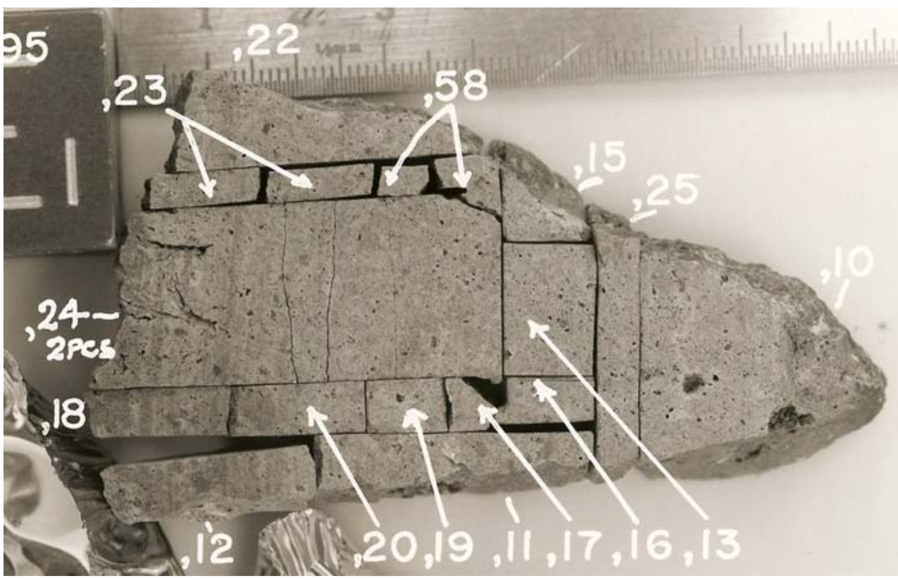
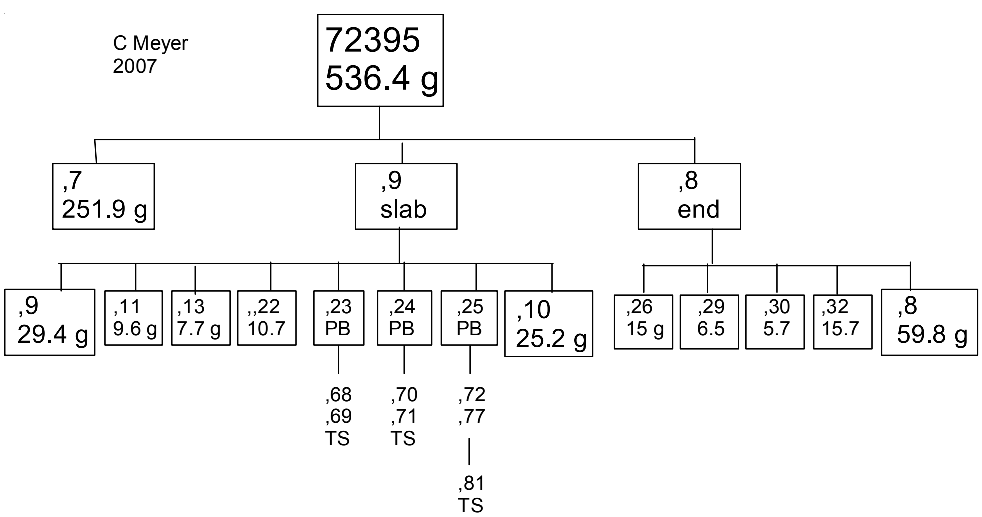


Figure 11: Photo of slab of 72395. S74-15100. Scale in cm.



Summary of Age Data for 72395

	Ar/Ar	U/Pb
Dalrymple and Ryder 1996	3.893 ± 0.016 b.y	
Tera et al. 1974		?

Other Studies

Horai and Winkler (1976) determined the thermal diffusivity and Charette and Adams (1977) determined the optical reflectance spectra of 72395.

Processing

A slab was cut through 72395 in 1974 with numerous allocations (figures 11 and 12). Boulder 2 was part of a "Wasserburg consortium". Ryder (1993) discussed what was known about it at that time.

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