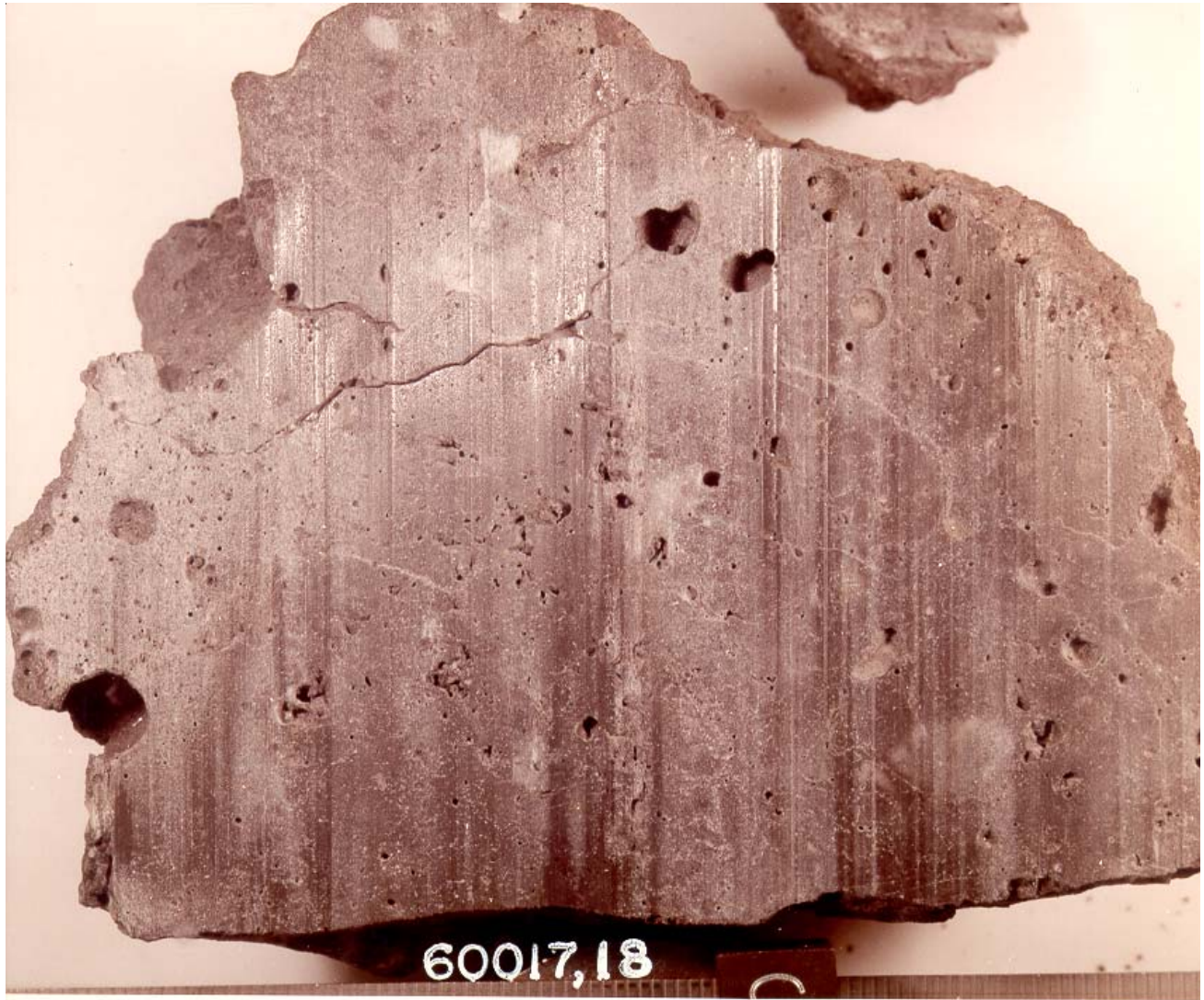


**60017**  
Impact Melt Breccia  
2102 grams



*Figure 1: Photo of sawn surface of 60017,18. NASA S75-33756. Sample is 9 cm across. Note the vesicles and saw marks.*

**Introduction**

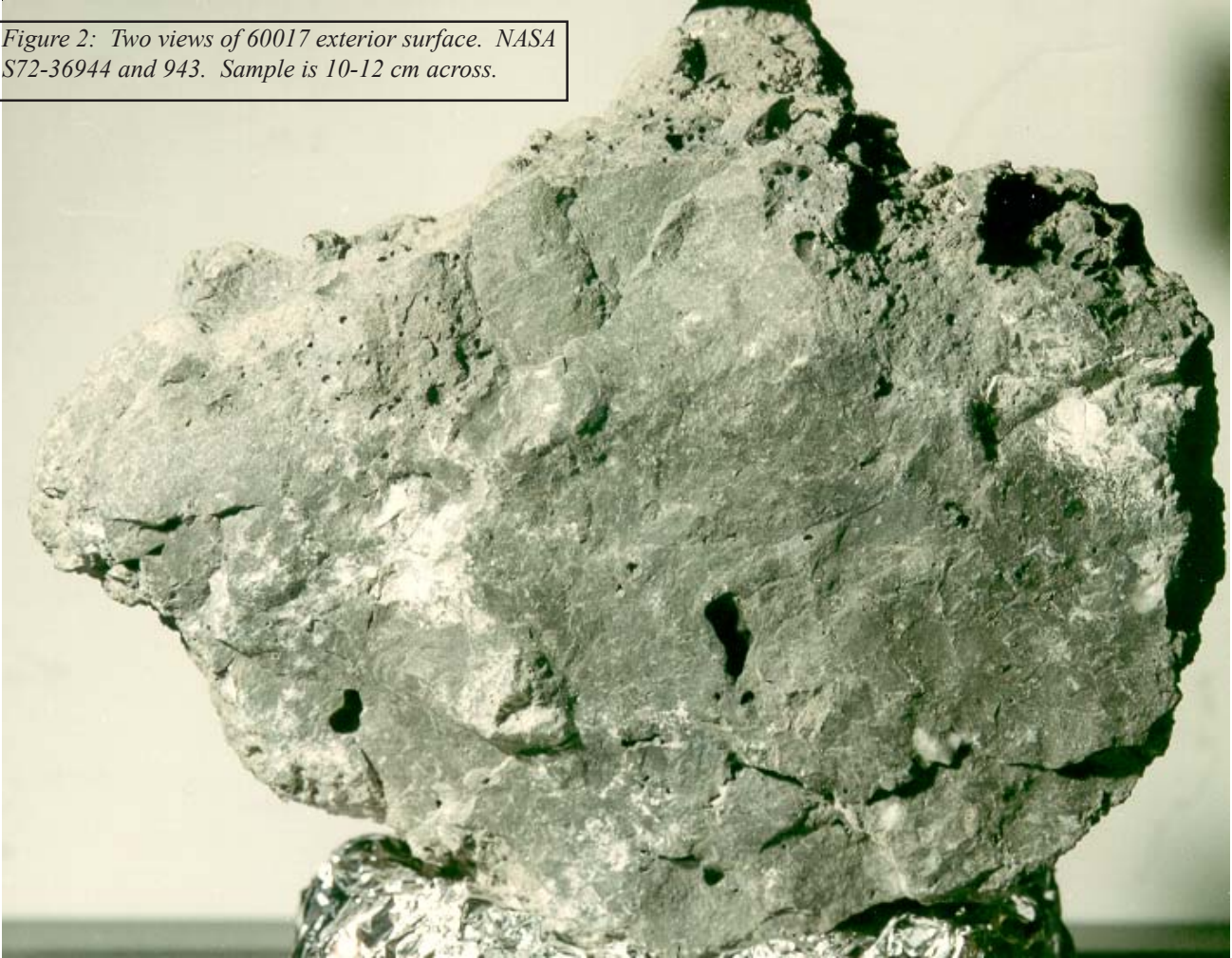
60017 is a piece of Shadow Rock from station 13, near North Ray Crater (Sutton 1981). It was too large to fit in the Teflon sample bag, and was returned in sample bag SCB7, with other large samples (Butler 1972). The outer surface has a thick patina, while the freshly broken surface is hackly (figure 2). Sample 63335 and 63355 were chipped from the same location on the boulder (and returned in documented sample bags). The astronauts remarked on the large round vesicles in the sample.

**Petrography**

Kridelbaugh et al. (1973) found that 60017 was a microbreccia composed primarily of well-rounded clasts of anorthositic gabbro, mosaically recrystallized anorthosite and large crystals of olivine set in a cryptocrystalline matrix (figure 2). The clasts frequently have a fine-grained rim due to reaction of the clast with the matrix.



*Figure 2: Two views of 60017 exterior surface. NASA S72-36944 and 943. Sample is 10-12 cm across.*



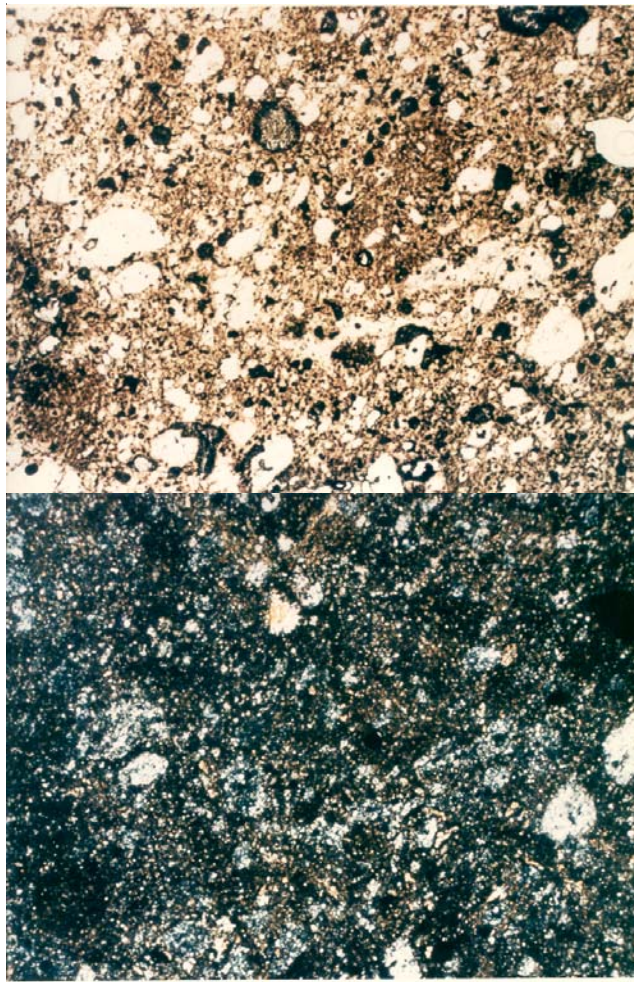


Figure 3: Thin section photomicrograph of 60017. Top is plane polarized light and bottom is cross polarized. NASA S72-42268-269. About 3 mm across.

Nord et al. (1975) found that the matrix of 60017 had a fine-grained igneous texture and that the plagioclase laths in the matrix were aligned in such a way as to indicate flow around the clasts. They conclude the occurrence of dark matrix clasts and deformation in the clasts and crystal fragments “suggest that this rock was formed by partial melting of regolith or breccia material”.

Ryder and Norman (1981) review the petrography of 60017 and made new observations. The rock contains two dominant lithologies ~70% variolitic melt and ~30% dark aphanitic clasts. The variolitic melt consists of plagioclase clasts with interstitial mafic minerals, minor ilmenite, Fe-metal, rare troilite, rare spinel and cryptocrystalline material. Plagioclase is  $An_{93-95}$  and olivine is  $Fo_{68}$ . Spherulitic texture is often found. The dark matrix clasts are aphanitic and inhomogeneous.

*LMP* Okay, Tony, I got three chips off of the rock scattered over about a 2-meter area. One of them (60017) is too big to go in the bags, but the other one is going in 429 (63355). And Tony, this rock here looks like the same – it’s the same character as the one up on the rim (60017). That great, huge black one that we sampled except that we don’t – that one up there didn’t have any of these holes in it. I can’t really say what these holes are here. They just look – they’re vugs – let’s just call them vugs. What cause them I don’t know.

*CDR* Yeah, they look more vuggy to me although they’re round.

*LMP* They look like drill holes is what they look like.

*CDR* Okay, they look like the holes that you get in rocks where you have a venting of gas that comes up through there like along –

*LMP* Vesicle pipe.

*CDR* Yeah, vesicle pipe that’s it. Couldn’t be zap holes.

*LMP* Look at this. Tony, this is a black matrix with some excellent crystals in it and also that are milky in color. Don’t see any cleavage though, or striations – about a centimeter across, and it has a matrix that white rocks like up on the rim – not a matrix but some clasts of that.

They are plagioclase-rich and often have reaction rims with matrix.

**Metal:** Misra and Taylor (1975) found that there was a wide range in Co content in metal particles in 60017 (figure 4). Hunter and Taylor (1981) found no rust.

### **Chemistry**

Rose et al. (1973), Laul et al. (1974) and Taylor et al. (1973) obtained similar results indicating that 60017 is highly aluminous ( $Al_2O_3 = 30\%$ ) and very depleted in trace elements (table 1, figure 5). In general, the breccia samples from the rim of North Ray Crater are more aluminous than the breccia samples from the rest of the Apollo 16 collection. 60017 also has high Ni, Ir and Au (although not as high as for many lunar breccias).



Figure 4: Shadow Rock near North Ray Crater; Apollo 16. S16-106-17392, 17394.

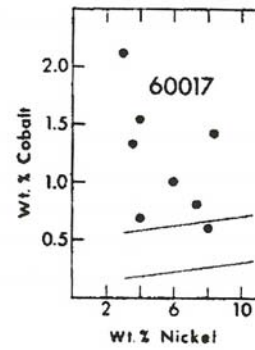


Figure 5: Ni, Co composition of iron grains in 60017 (Misra and Taylor 1975).

### **Radiogenic age dating**

Tera et al. (1974) reported U, Th and Pb isotope data for bulk sample. Murthy and Coscio (1977) and Murthy (1978) reported Sr isotopes data. No age has been given.

### **Other Studies**

Macdougall et al. (1973)	Fission track, no solar wind tracks
Housley et al. (1976)	Magnetic data
Fireman et al. (1973)	Tritium ( $^3\text{H}$ ) data
Cadenhead (1976)	Surface

### **Processing**

Ryder and Norman mistakenly give the wrong weight for 60017 (it is only 2 kg). The sample broke up during sawing, but a portion of a slab was obtained (figures 6 and 7). There are 19 thin sections.

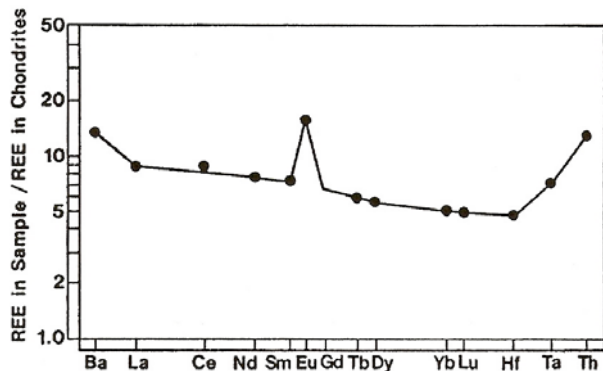


Figure 6: Normalized rare-earth-element diagram for 60017 (data from Laul et al. 1974).

**Table 1. Chemical composition of 60017.**

reference weight	Rose73	Krahenbuhl73	Morrison73	Laul74	Ganapathy74	Garg76	Taylor73
SiO <sub>2</sub> %	44.43 (a)						44.5 (e)
TiO <sub>2</sub>	0.3 (a)		0.37 (c)	0.37 (d)			0.07 (e)
Al <sub>2</sub> O <sub>3</sub>	30.9 (a)		27.8 (c)	31.2 (d)			31.9 (e)
FeO	2.97 (a)		3.27 (c)	3.6 (d)			2.55 (e)
MnO	0.04 (a)		0.04 (c)	0.048 (d)			
MgO	2.77 (a)		5.27 (c)	3 (d)			2.65 (e)
CaO	17.72 (a)		15.1 (c)	17 (d)			17.5 (e)
Na <sub>2</sub> O	0.58 (a)		0.06 (c)	0.52 (d)			0.53 (e)
K <sub>2</sub> O	0.06 (a)		0.04 (c)	0.056 (d)			0.14 (e)
P <sub>2</sub> O <sub>5</sub>	0.02 (a)						
S %							
sum							
Sc ppm	7.1 (a)		6 (c)	6.7 (d)			1.7 (e)
V	17 (a)			10 (d)			10 (e)
Cr				370 (d)			390 (e)
Co	22 (a)		8 (c)	7.1 (d)			6.2 (e)
Ni	360 (a)	47 (b)	59 (c)		35 (b)		54 (e)
Cu	4 (a)		2.1 (c)				1 (e)
Zn		3.25 (b)	8.2 (c)		5.4 (b)		
Ga	2.3 (a)		3.3 (c)				
Ge ppb		9.35 (b)			20 (b)		
As							
Se		21 (b)			18 (b)		
Rb	1.2 (a)	0.7 (b)	0.8 (c)		0.78 (b)		0.67 (e)
Sr	140 (a)		250 (c)				
Y	9 (a)		6 (c)				7 (e)
Zr	26 (a)		52 (c)	30 (d)		52 (d)	37 (e)
Nb			2.1 (c)				2.82 (e)
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb		3.4 (b)			0.59 (b)		
Cd ppb		5 (b)			4.1 (b)		
In ppb							
Sn ppb							100 (e)
Sb ppb		0.347 (b)			1.01 (b)		
Te ppb		6.75 (b)			7.2 (b)		
Cs ppm	1.2 (b)	0.041 (b)	0.004 (c)		0.049 (b)		0.03 (e)
Ba	92 (d)		46 (c)	50 (d)			57 (e)
La			3 (c)	3.1 (d)			2.89 (e)
Ce			10 (c)	8 (d)			7.84 (e)
Pr							0.87 (e)
Nd			8.4 (c)	5 (d)			3.55 (e)
Sm			1.7 (c)	1.4 (d)			1 (e)
Eu			1.4 (c)	1.24 (d)			1.08 (e)
Gd			3.4 (c)	(d)			1.3 (e)
Tb			0.37 (c)	0.3 (d)			0.21 (e)
Dy			1.8 (c)	1.7 (d)			1.4 (e)
Ho			0.4 (c)				0.31 (e)
Er							0.9 (e)
Tm			0.17 (c)				0.14 (e)
Yb	0.6 (d)		1.1 (c)	1.2 (d)			0.86 (e)
Lu			0.2 (c)	0.16 (d)			0.13 (e)
Hf			0.98 (c)	1 (d)		1.17 (d)	0.58 (e)
Ta				0.14 (d)			
W ppb							
Re ppb		0.1 (b)			0.16 (b)		
Os ppb							
Ir ppb		1.24 (b)		1.5 (d)	1.75 (b)		
Pt ppb							
Au ppb		4.25 (b)		4 (d)	0.41 (b)		
Th ppm			0.6 (d)	0.5 (d)			0.36 (e)
U ppm		0.135 (b)	0.13 (c)	0.14 (d)	0.117 (b)		0.1 (e)

technique: (a) "microchemical", (b) RNAA, (c) multi, (d) INAA, (e) SSMS

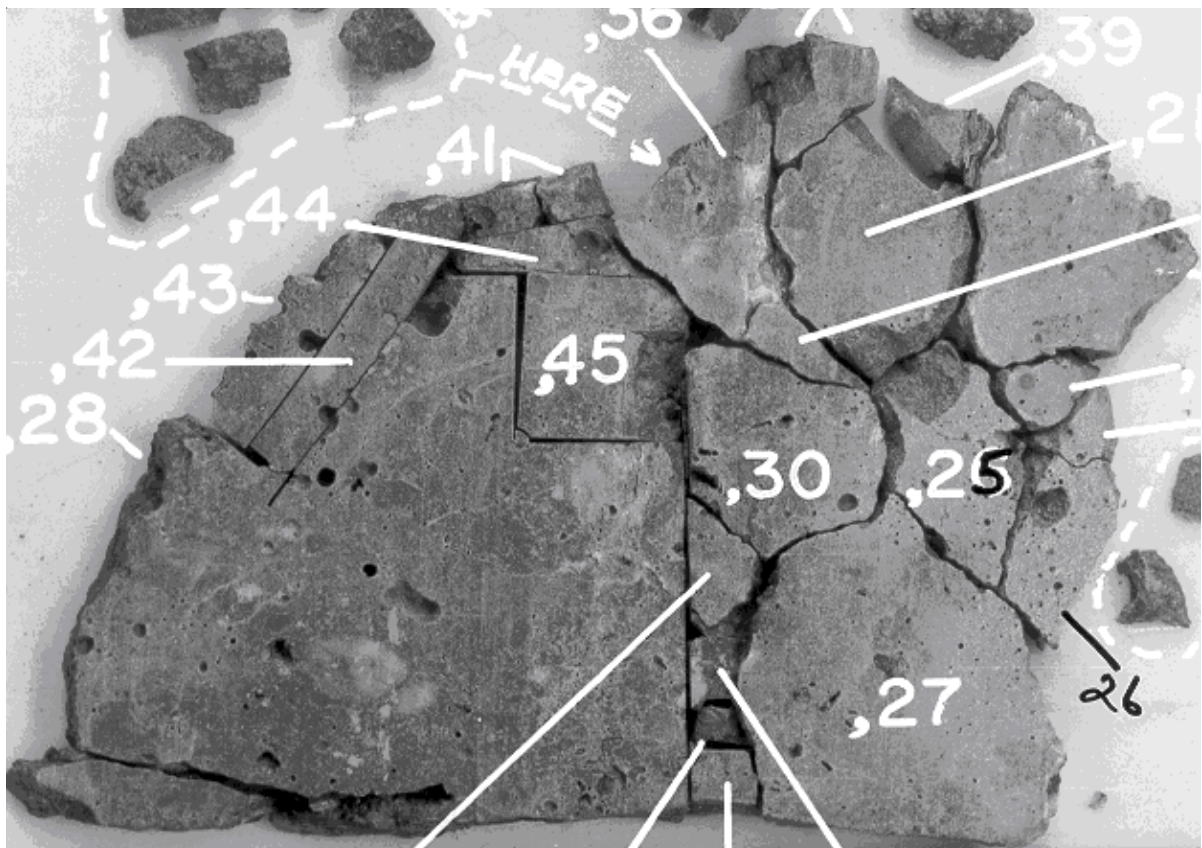
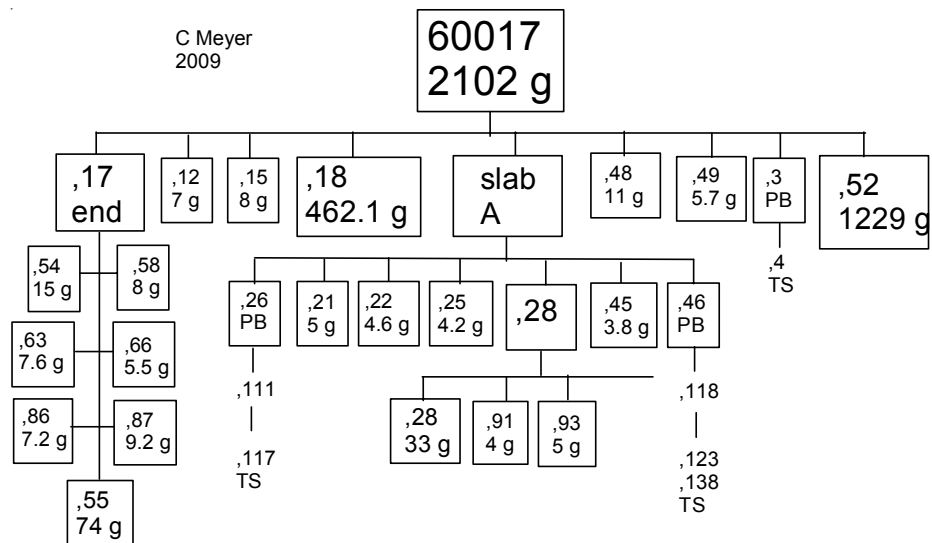


Figure 7: Photo of slab A of 60017 showing splits. NASA S73-21544. about 10 cm across.



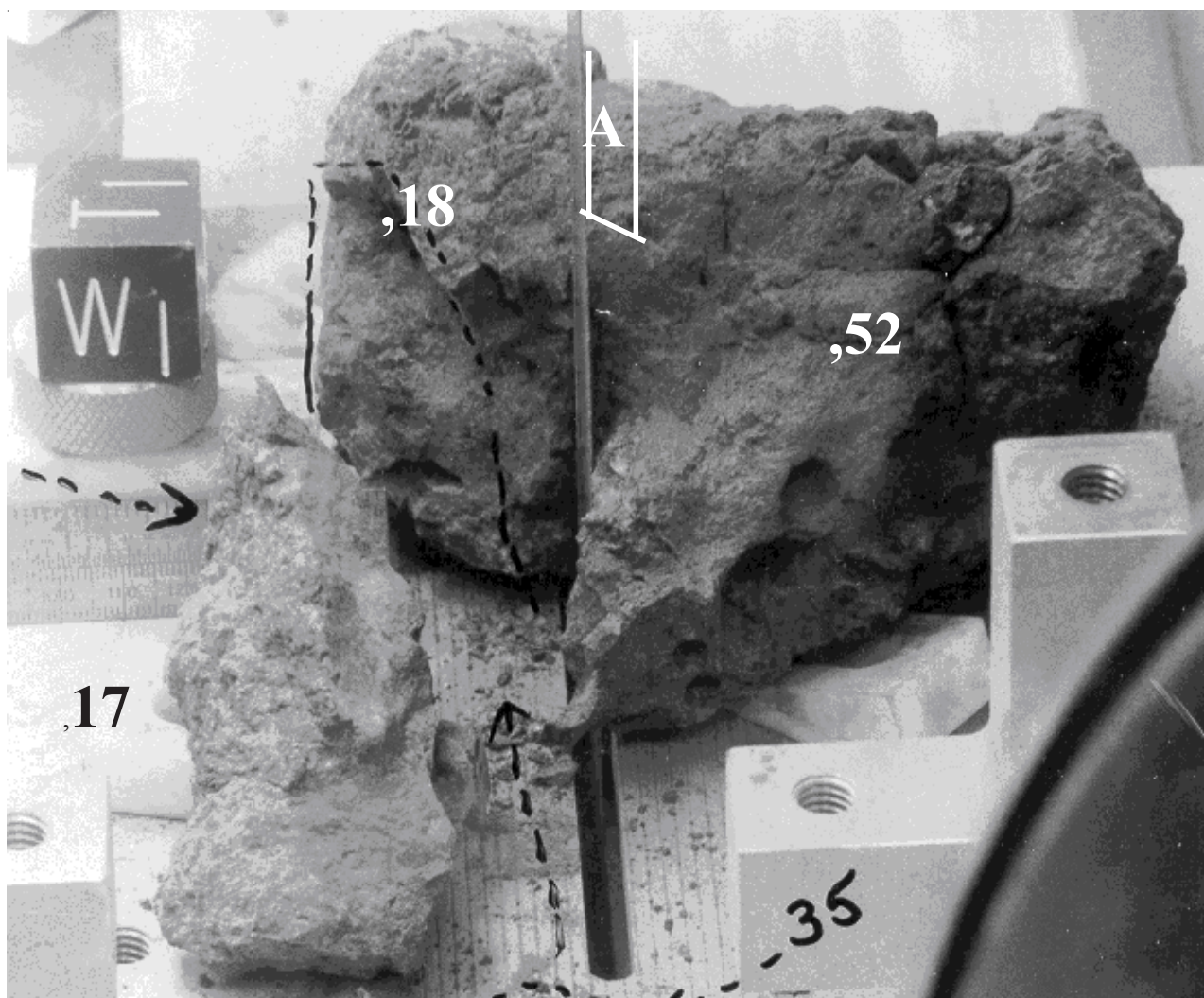


Figure 8: Processing photo of 60017. NASA 76-21703. Cube is 1 inch.

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