

**61156**  
Impact melt Breccia  
58.46 grams

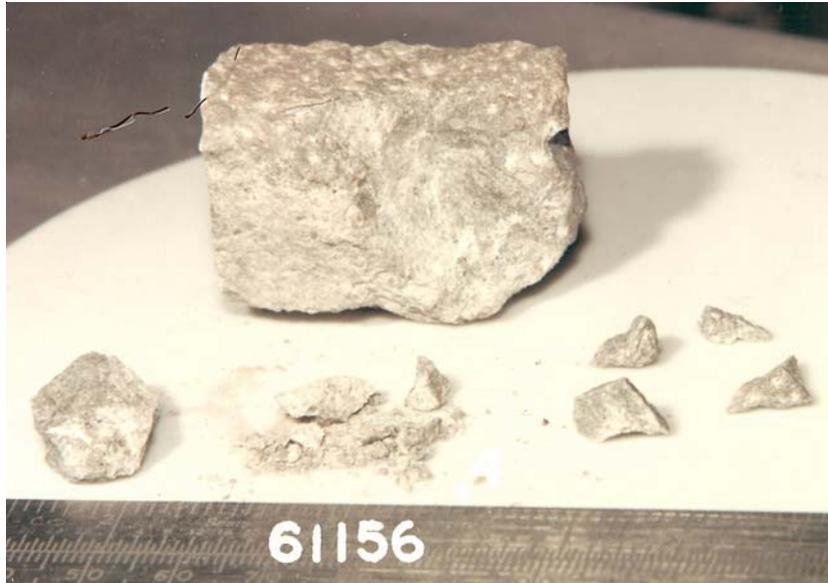


Figure 1: Photo of 61156. Ruler marked in cm. S72-41835

**Introduction**

61156 is a sample of the mysterious VHA basalt as defined by Hubbard et al. (1973) and refuted by Dowty et al. (1973). It is an impact melt rock with a high percentage of KREEP and has also been called “metagneous”. It has been dated at 3.75 b.y.

61156 was collected near Plum Crater (figure 2) – see section on 61500. Several sides of 61156 are covered with zap pits.

**Petrography**

61156 was first discussed by LSPET16 and was best characterized by Albee et al. (1973). The matrix of 61156 has a well-developed poikilitic texture (figure 5), but the sample has a significant number of xenocrystic clasts of plagioclase-rich highland material.

61156 is a dense, fine-grained poikilitic rock with relatively large (1 mm) pyroxene grains that enclose small euhedral plagioclase crystals. The matrix includes areas of interlocking plagioclase, olivine, high-Ca pyroxene and K-rich patches (Albee et al. 1973). Other minerals found in the matrix include ilmenite,

**Mineralogical Mode**

	Albee et al. 1973	Neukum et al. 1973
Olivine	10.2	12
Pyroxene	25.7	18
Plagioclase	62.1	65
Opaque	0.9	

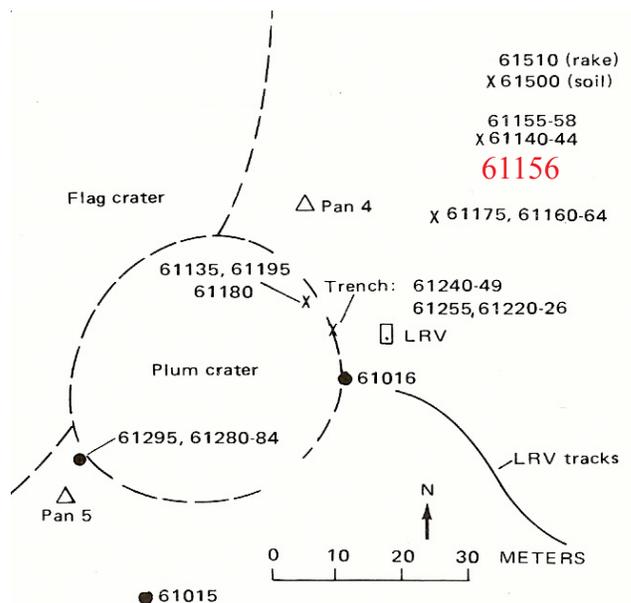


Figure 2: Map of region around Plum Crater, Apollo 16.

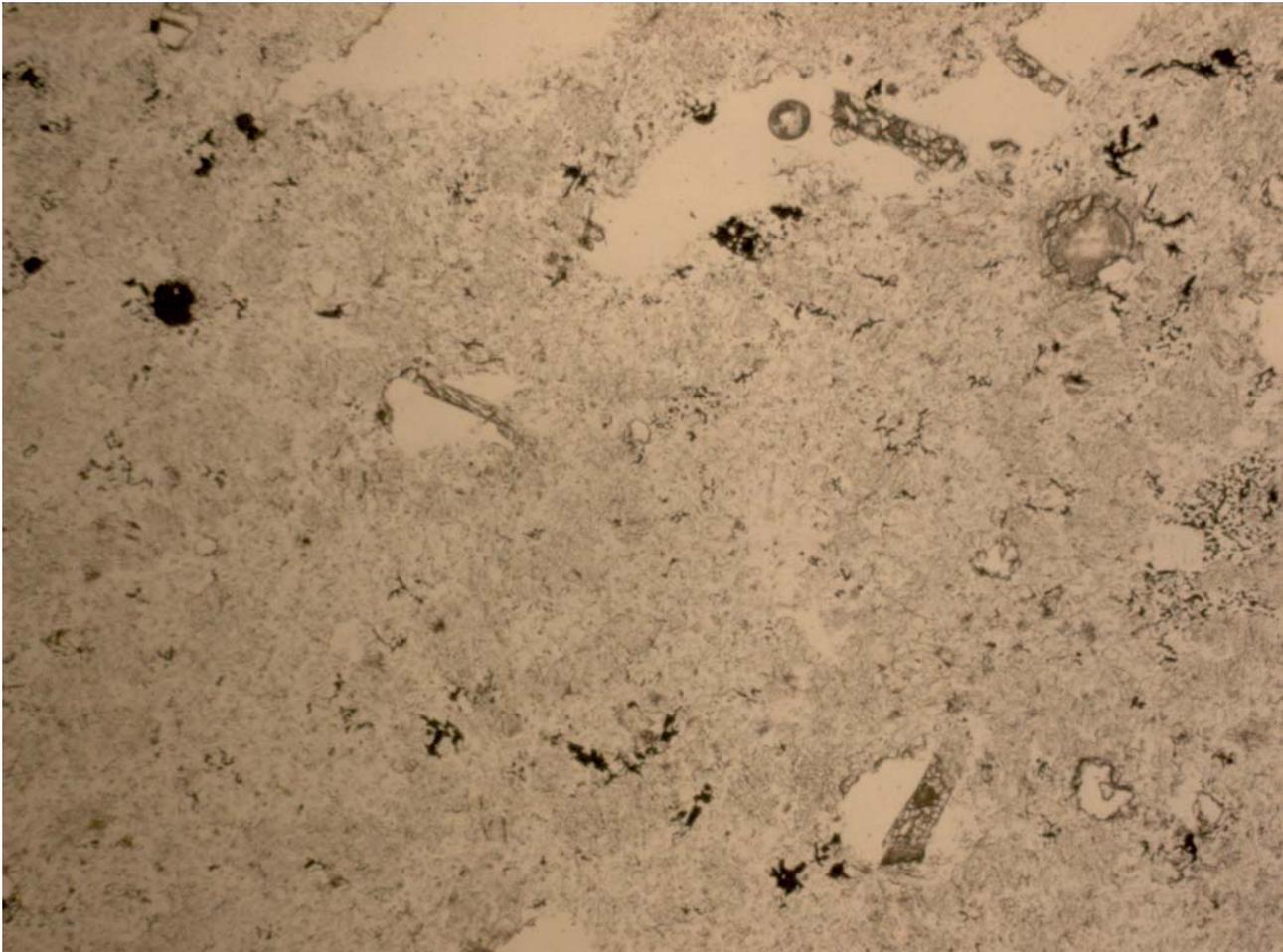


Figure 3: Photomicrograph of thin section of 61156.. Field of view is 2 mm.

armalcolite, chromite, rutile, baddelyite, metal, apatite, whitlockite and troilite.

One large (1 cm) clast of anorthositic breccia is also reported included in 61156 (Ryder and Norman 1980).

### **Mineralogy**

***Olivine:*** Olivine is Fo<sub>75</sub> as determined by Albee et al.

***Pyroxene:*** The composition of pyroxene was reported by Albee et al. (1973) (figure 6).

***Plagioclase:*** Albee et al. (1973) determined that plagioclase is An<sub>90-96</sub>. Meyer et al. (1975) showed that the trace element content of plagioclase xenocrysts in 61156 were not consistent with plagioclase crystallization from a melt with the bulk composition of the rock.

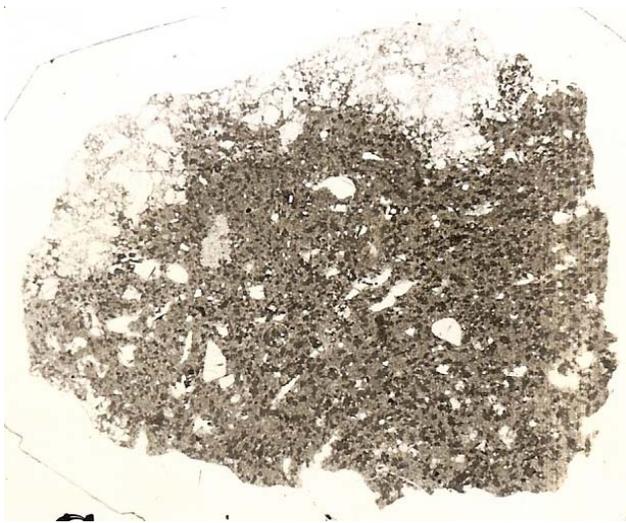
***Ilmenite:*** Albee et al. (1973) reported ilmenite in 61156.

***Armalcolite:*** Albee et al. (1973) and Haggerty (1973) reported analyses of armalcolite (table 2).

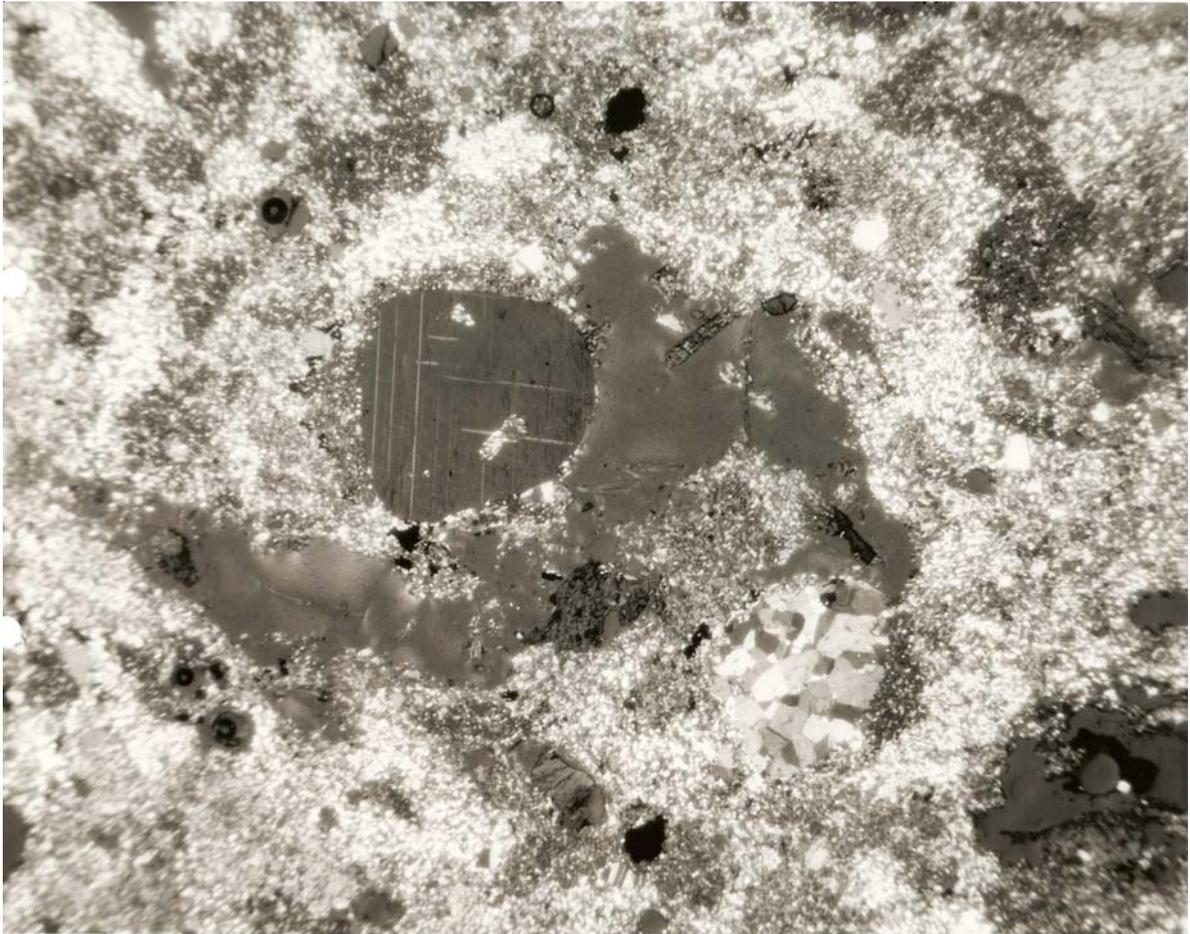
***Metallic iron:*** Hewins and Goldstein (1975) reported the Ni and Co content of metallic iron grains in the matrix and within a clast (figure 7). Hunter and Taylor (1981) reported only minor rust.

### **Chemistry**

LSPET (1972), Hubbard et al. (1973), Albee et al. (1973), Wanke et al. (1974) and Eldridge et al. (1973) determined the chemical composition of 61156 – see table and figure 7. 61156 has the trace element signature of KREEP, but at a lower absolute value. Warren (1988) has elegantly discussed mixing, while Korotev (1987, 1990) remarked on the high Ni, Co content. The sample also has very high Ir and Au, so



*Figure 4a,b: Photos of thin sections of 61156, from data pack. Scale is about 1 cm.*



*Figure 5: Thin section photomicrograph of 61156,5 (crossed nicols). Field of view is about 2.6 mm. S72-43968*

there is no doubt that it is an impact melt, and not an indigenous basalt.

### Radiogenic age dating

Nyquist et al. (1973) and Reimold et al. (1985) give Rb/Sr data, while Tera et al. (1974) give a model age of 4.2 b.y. by Pb/Pb and U/Pb. A crystallization age of  $3.749 \pm 0.036$  b.y. has recently been determined by the Ar/Ar plateau technique (Norman et al. 2006)(figure 9). Note that this is based on a 1.22 mg sample !

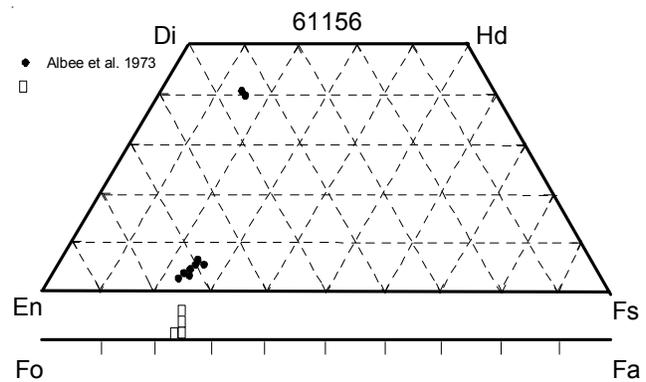
### Cosmogenic isotopes and exposure ages

Eldridge et al. (1973) determined the cosmic-ray-induced activity of  $^{22}\text{Na} = 56$  dpm/kg and  $^{26}\text{Al} = 156$  dpm/kg.

### Other Studies

Neukum et al. (1973) determined the micrometeorite density distribution on all sides of 61156 (figure 10). This does not indicated the direction of micrometeorites, but rather indicates how much rocks tumble on the regolith due to micrometeorite hits.

Studies of the magnetic properties of 61156 have been reported by Schwerer and Nagata (1976), Huffman et al. (1974) and Nagata et al. (1975).



compiled by C Meyer

Figure 6: Composition of olivine and pyroxene in poikilitic rock 61156 (Albee et al. 1973).

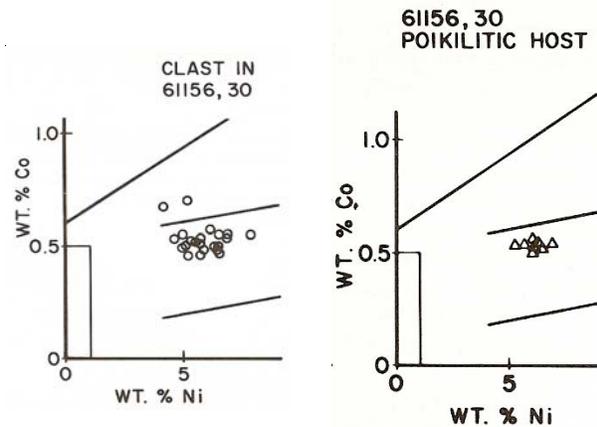


Figure 7: Co and Ni content of metal particles in matrix and clast of 61156 (Hewins and Goldstein 1974).

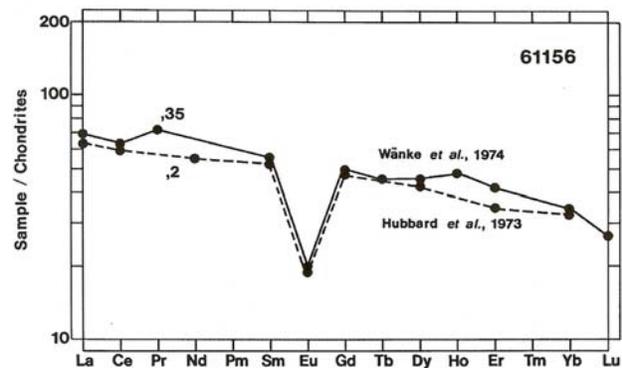


Figure 8: Normalized rare-earth-element diagram for 61156 (from Ryder and Norman 1980).

**Table 1. Chemical composition of 61156**

reference weight	Eldridge73	LSPET16	Wanke74	Hubbard73 Wiesmann76	Albee73
SiO2 %		44.56 (e)	45.37 (d)	Nyquist73	45.12 (e)
TiO2		0.64 (e)	0.62 (d)	0.65 (b)	0.82 (e)
Al2O3		22.94 (e)	23.05 (d)	22.9	20.28 (e)
FeO		7.75 (e)	7.73 (d)	8	8.68 (e)
MnO		0.12 (e)	0.085 (d)		0.09 (e)
MgO		9.6 (e)	9.85 (d)	9.3 (b)	12.15 (e)
CaO		13.34 (e)	13.6 (d)	13.3 (b)	12.47 (e)
Na2O		0.39 (e)	0.44 (d)	0.38	0.39 (e)
K2O	0.086 (a)	0.11 (e)	0.11 (d)	0.12 (b)	0.12 (e)
P2O5		0.22 (e)			0.13 (e)
S %		0.12 (e)			0.08 (e)
sum					

Sc ppm			9.36 (c)		
V					
Cr	960	(e)	940 (c)	852 (b)	
Co			59.4 (c)		
Ni	184	(e)	1190 (c)		
Cu			6.6 (c)		
Zn			5 (c)		
Ga			4.5 (c)		
Ge ppb			1750 (c)		
As			370 (c)		
Se					
Rb	2.5	(e)	2.44 (c)	2.461 (b)	
Sr	153	(e)	155 (c)	154 (b)	
Y	64	(e)	60.5 (c)		
Zr	293	(e)	304 (c)	297 (b)	
Nb	17	(e)	15.6 (c)		
Mo					
Ru					
Rh					
Pd ppb			59 (c)		
Ag ppb					
Cd ppb					
In ppb					
Sn ppb					
Sb ppb					
Te ppb					
Cs ppm			0.15 (c)		
Ba			220 (c)	193 (b)	
La			22.5 (c)	20.5 (b)	
Ce			55 (c)	51.8 (b)	
Pr			8 (c)		
Nd				33.1 (b)	
Sm			9.82 (c)	9.37 (b)	
Eu			1.34 (c)	1.31 (b)	
Gd			12.1 (c)	11.8 (b)	
Tb			2.1 (c)		
Dy			13.3 (c)	12.2 (b)	
Ho			3.3 (c)		
Er			8.3 (c)	7.09 (b)	
Tm					
Yb			6.8 (c)	6.5 (b)	
Lu			0.9 (c)		
Hf			7.25 (c)	7.4 (b)	
Ta			0.83 (c)		
W ppb			0.56 (c)		
Re ppb			2.6 (c)		
Os ppb					
Ir ppb			23 (c)		
Pt ppb			22 (c)		
Au ppb					
Th ppm	1.55 (a)		3.2 (c)	3.42 (b)	
U ppm	0.55 (a)		0.92 (c)	0.943 (b)	

technique: (a) radiation count., (b) IDMS, (c) INAA, (d) mixed, (e) XRF, (f) e. probe

**Table 2: Armalcolite in 61156**

	Albee73	Haggerty73	
TiO2	71.73	71.84	66.5
Al2O3	1.12	0.94	1.49
FeO	13.34	14.08	9.33
MgO	9.91	8.8	2.31
Cr2O3	1.2	1.49	10.31
ZrO2	2.12	2.76	6.01
CaO		0.33	3.4

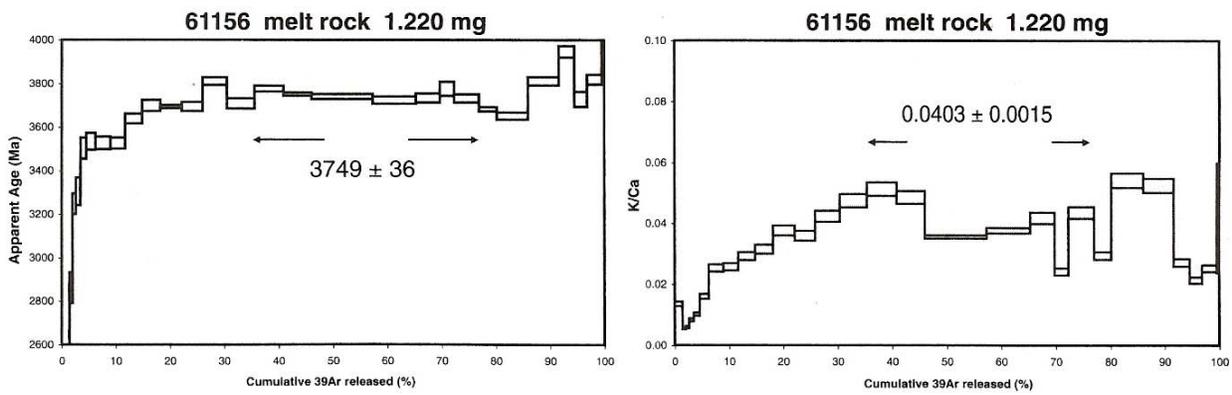


Figure 9: Ar/Ar plateau age determined by Norman et al. (2006).

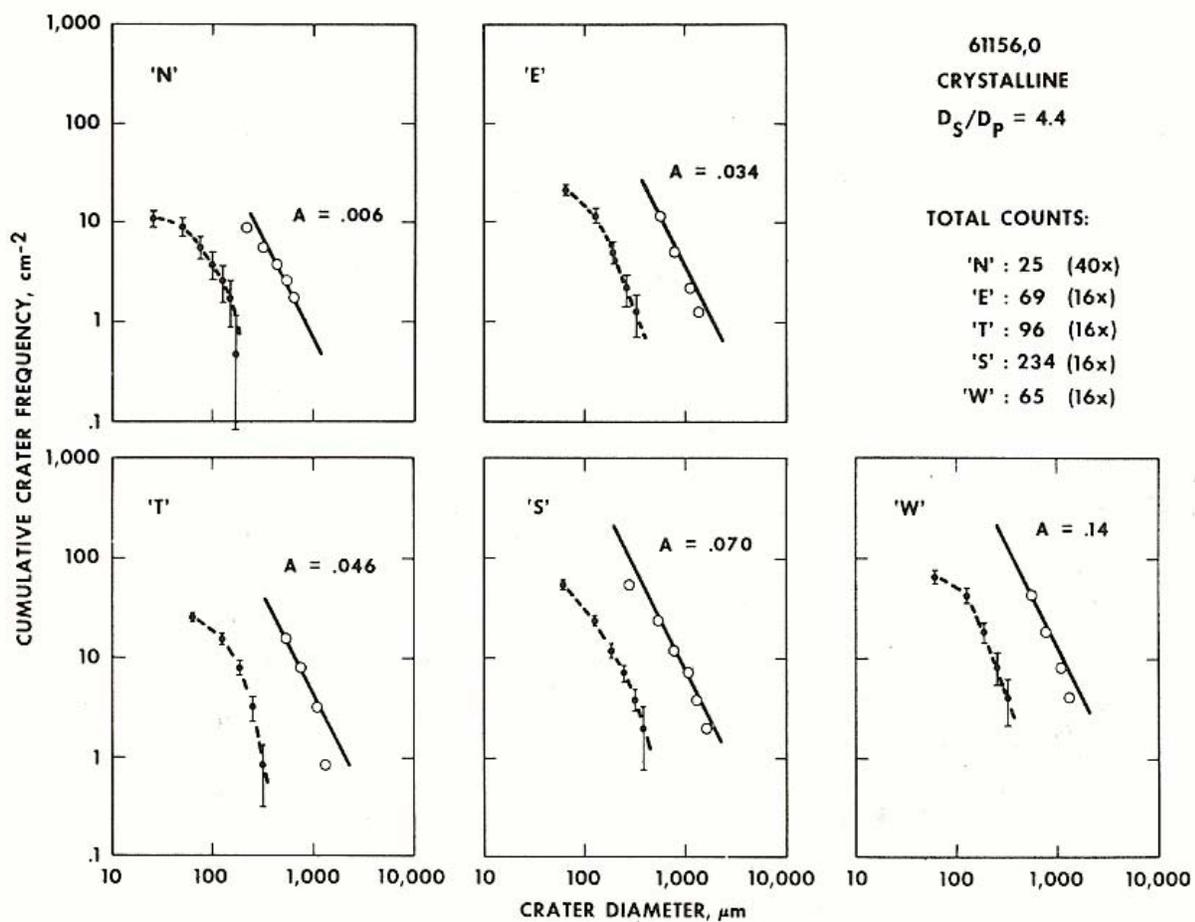


Figure 10: Density distribution of micrometeorite craters on surfaces of 61156 (Neukum et al. 1973).

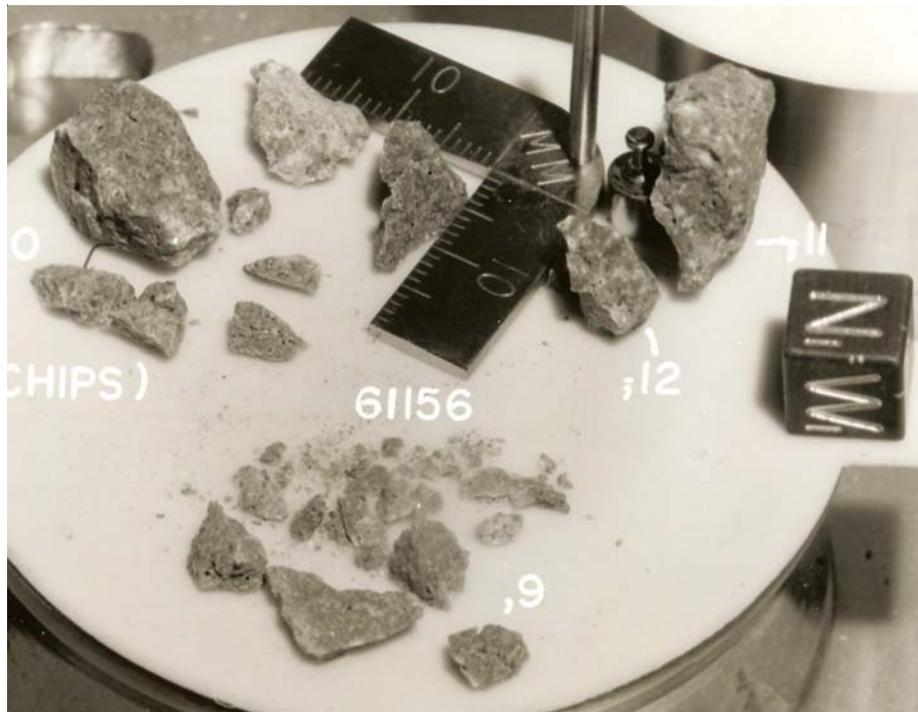
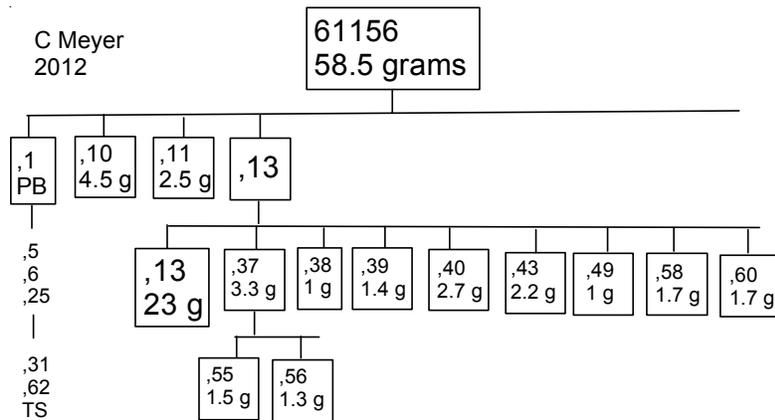


Figure 101: What have they done to this very fine sample? S72-53529



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