10061

Regolith Breccia

346 grams

Figure 1: Photo of 10061,18. Sample 6 cm long. NASA S93-042751.

Introduction

10061 was one of the first lunar breccias samples studied and it is as if no one knew what to make of it! It was also an early display sample. This sample needs to be restudied and compared with the suite of Apollo 11 breccias.

Petrography

10061 is a friable regolith breccia with components similar to the soil at the Apollo 11 site (Keil et al. 1970). It has abundant basalt fragments, glass spheres and a lot of fine material (figures 2, 3 and 4). Quaide and

Figure 2: Photomicrograph of thin section of 10061. Field of view is 1 inch. S69-54070.

Bunch (1970) determined the size distribution of grains in 10061 (figure 7) and Cloud et al. (1970) determined the size distribution of glass beads (figure 8).

McKay and Morrison (1971) show a picture of an "accretionary structure" in 10061. Due to lack of extensive shock features, they concluded that lunar breccias are the product of impact debris flows.

Keil et al. (1970) analyzed mineral phases and reported maskelynite. Apollo 11 regolith breccias were the subject of LAPST initiative (Fruland 1983; Simon et al. 1984)

Chemistry

The major elements in 10061 were determined by Compston et al. (1970) and trace elements were reported by Goles et al. (1970) and Ganapathy et al. (1970). Schonfeld and Meyer (1972) calculated that 10061 was a mix of mare basalt with ~17 % gabboic anorthosite and ~3 % KREEP, while Rhodes and Blanchard (1981) found it was a mix of soil and high-K basalt. However, Simon et al. (1984) could not identify such a high percentage of highland component.

Epstein and Taylor (1971) determined the carbon content (181 and 216 ppm).

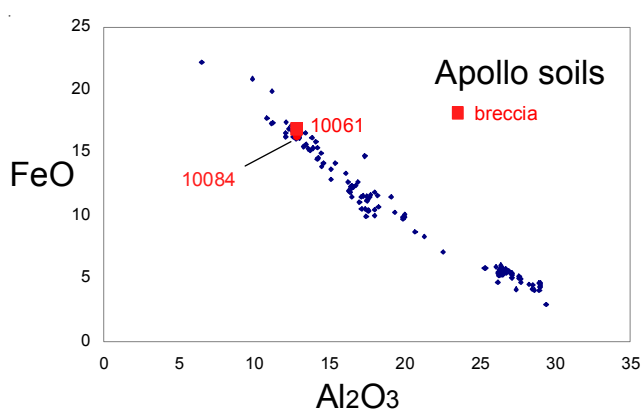

Figure 5: Composition of breccia 10061 and soil 10084 are similar.

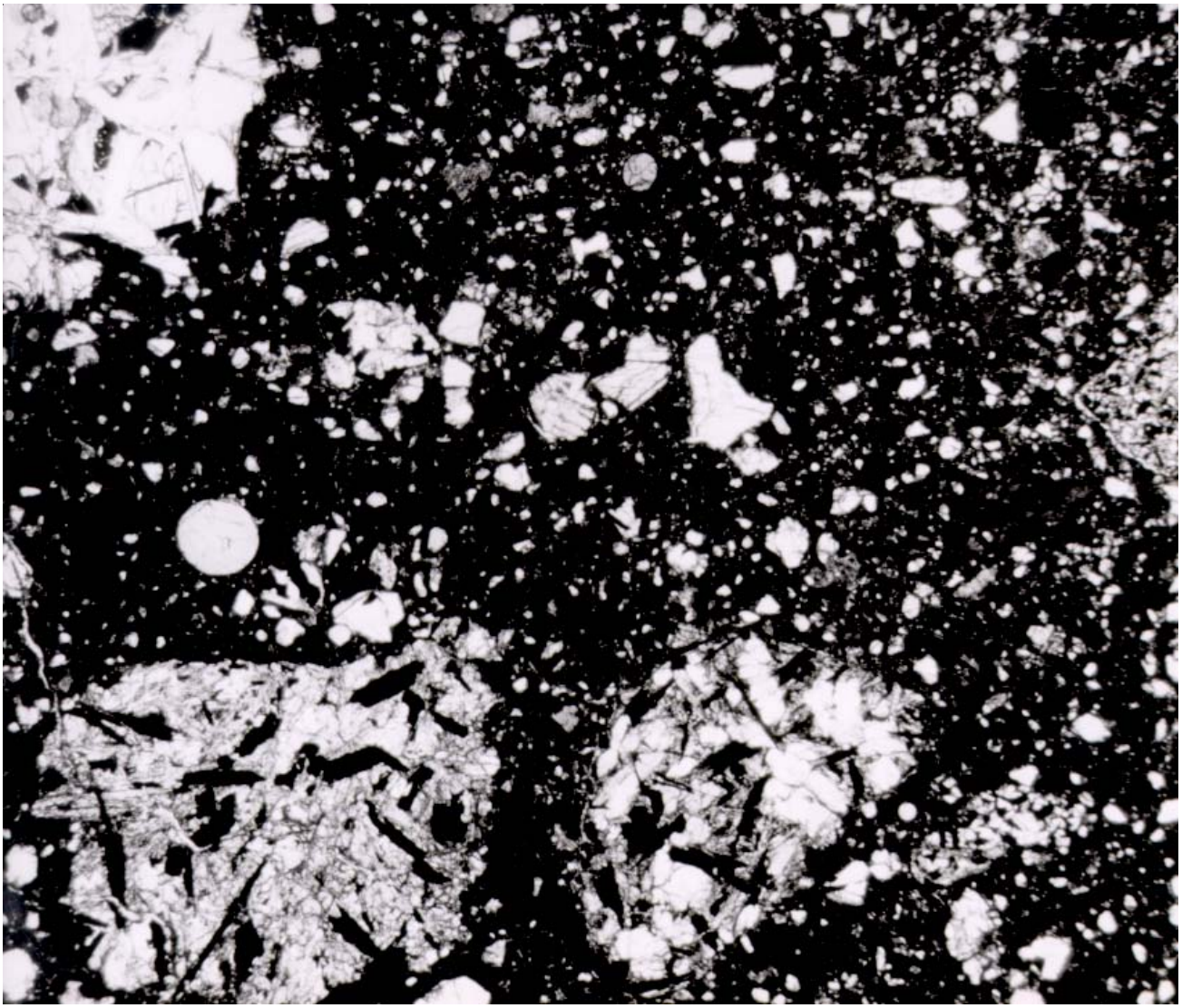

Figure 3: Photomicrograph of thin section 10061,28 showing basalt clasts, mineral fragments, glass sphere and matrix. NASA S76-26313. Scale unknown.

Other Studies

The total organic carbon content of 10061 was determined by hydrogen flame ionization pyrolysis (Ponnamperuma et al. 1970).

Funkhauser et al. (1971) studied the types of gas that were released on simple crushing of 10061 (H_2, N_2, CH_4, He and Ar) and the isotopic ratios of He and Ar. Hintenberger et al. (1971, 1975) and Pepin et al. (1970) also determined the rare gas abundance and isotopic ratios (figure 9).

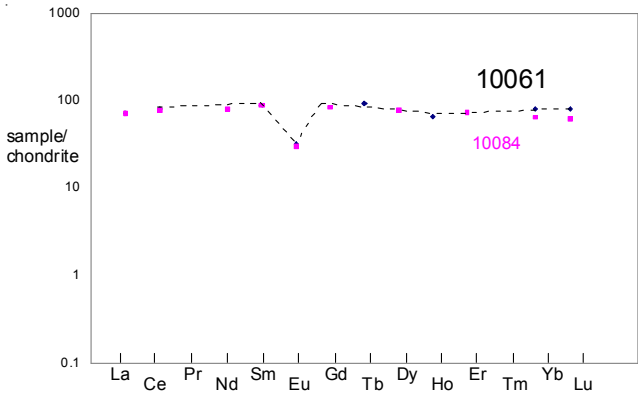

Figure 6: Normalized rare earth element diagram for breccia 10061 compared with soil 10084 (data from Goles et al. 1970).

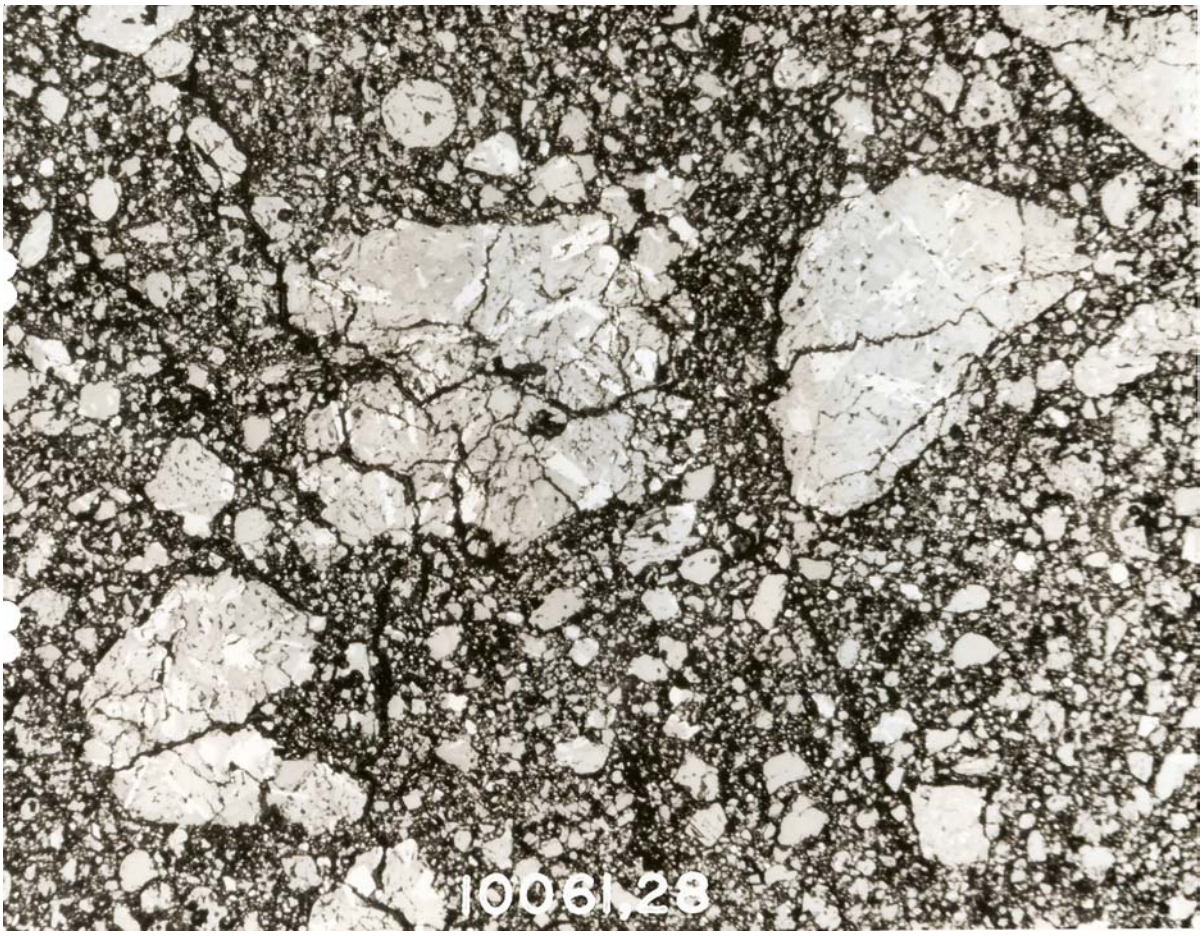

Figure 4: Reflected light view of thin section 10061,28 showing basalt clasts, glass bead and mineral frgment in fine matrix. S76-25836

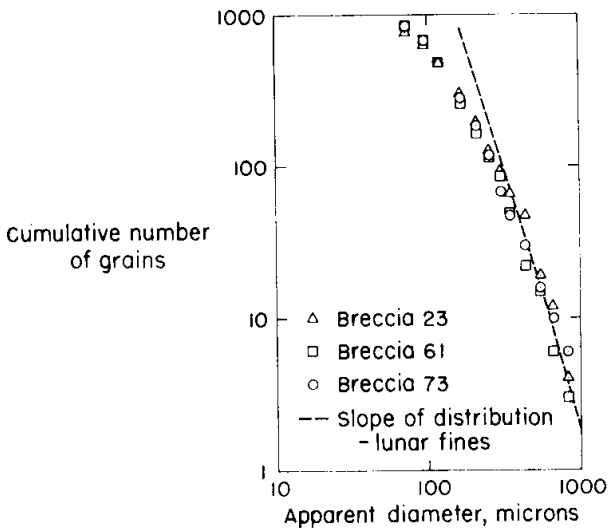

Figure 7: Size distribution for 10061 (Quaide and Bunch 1970).

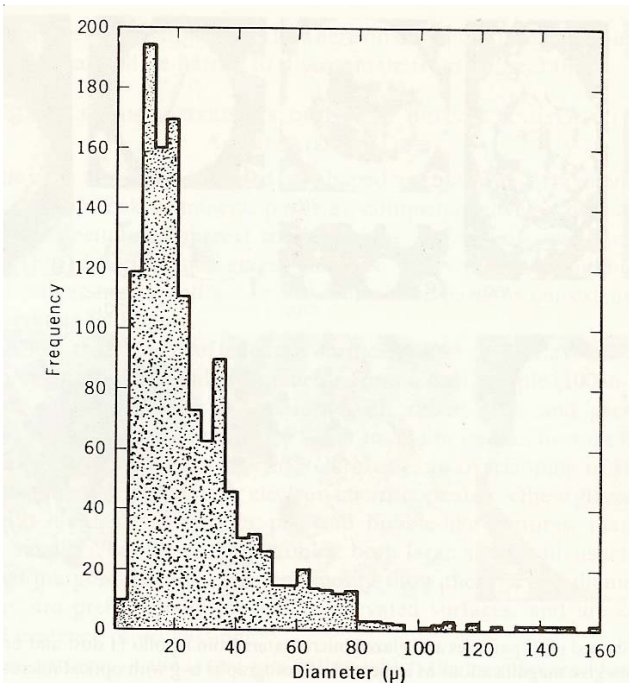

Figure 8: Size distribution of glass beads in 10061 and other regolith breccias (Cloud et al. 1970).

Table 1. Chemical composition of 10061.

reference	*LSPET69*		Compston70		Goles70		Ganapathy70		Annell70	
weight										
SiO2 %	40	(d)	41.87	(a)	40.4					
TiO2	10	(d)	7.84	(a)	7.3					
Al2O3	12	(d)	12.62	(a)	13					
FeO	16	(d)	16.45	(a)	16.2					
MnO	0.41	(d)	0.22	(a)	0.19	(b)			0.23	(d)
MgO	9	(d)	7.83	(a)	9.8					
CaO	11	(d)	11.96	(a)						
Na2O	0.48	(d)	0.47	(a)	0.48	(b)				
K2O	0.17	(d)	0.18	(a)						
P2O5			0.14	(a)						
S %			0.15	(a)						
sum										
Sc ppm	55	(d)			59.6	(b)			67	(d)
V	32	(d)	34	(a)	80	(b)			60	(d)
Cr	3000	(d)	1940	(a)	1930	(b)			2730	(d)
Co	12	(d)	23	(a)	33.7	(b)	34.2	(c)	35	(d)
Ni	235	(d)	170	(a)					241	(d)
Cu	8	(d)	25	(a)			22	(c)	16	(d)
Zn			37	(a)			29.2	(c)	27	(d)
Ga			5	(a)			5.79	(c)	5.2	(d)
Ge ppb										
As										
Se										
Rb			3.68	(a)			3.99	(c)	3.4	(d)
Sr	60	(d)	161.6	(a)					130	(d)
Y	115	(d)	108	(a)					103	(d)
Zr	400	(d)	342	(a)	240	(b)			393	(d)
Nb			19	(a)					21	(d)
Mo										
Ru										
Rh										
Pd ppb							7	(c)		
Ag ppb							163	(c)		
Cd ppb							106	(c)		
In ppb							1430	(c)		
Sn ppb										
Sb ppb										
Te ppb							73	(c)		
Cs ppm							0.146	(c)		
Ba	90	(d)	128	(a)	260	(b)			270	(d)
La			23	(a)	16.8	(b)			18	(d)
Ce			37	(a)	48.6	(b)				
Pr			15	(a)						
Nd			20	(a)						
Sm					13.2	(b)				
Eu					1.78	(b)				
Gd										
Tb					3.4	(b)				
Dy										
Ho					3.7	(b)				
Er										
Tm										
Yb	*1.8*	(d)			13.1	(b)				
Lu					1.94	(b)				
Hf					13.1	(b)				
Ta										
W ppb										
Re ppb										
Os ppb										
Ir ppb							9.18	(c)		
Pt ppb										
Au ppb							3.42	(c)		
Th ppm			2.7	(a)						
U ppm					0.59	(b)				

technique: (a) XRF, (b) INAA, (c) RNAA, (d) emission spec.

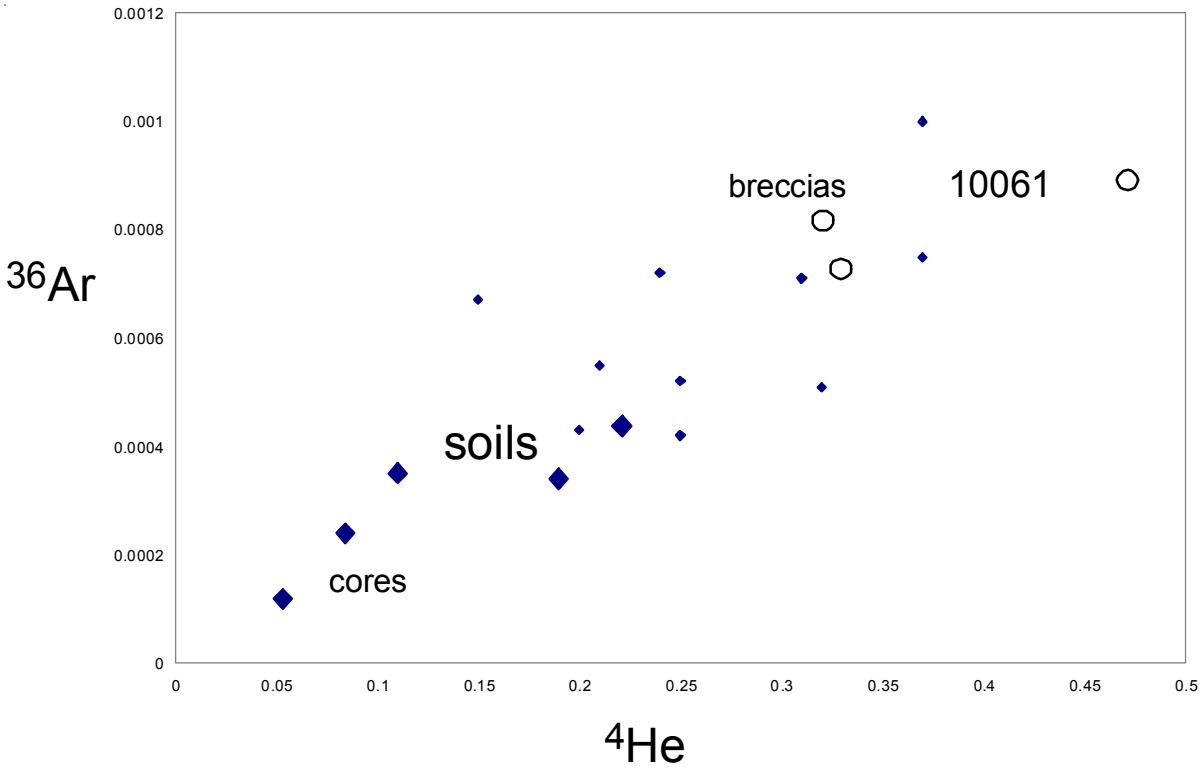

Figure 9: Implanted solar wind in 10061 compared with Apollo 11 soils and breccias (Funkhouser et al. 1070 and Hintenberger et al. 1976). Units STP cc/g.

Processing

Apollo 11 samples were originally described and cataloged in 1969 and "re-cataloged" by Kramer et al. (1977). There are 15 thin section of 10061. A subsample of 10061 (,42) was apparently used as a display sample (figure 12) and was extensively allocated for reserach, yet no petrograph descriptin resulted. Why is it in so many round ed pieces?

References for 10061

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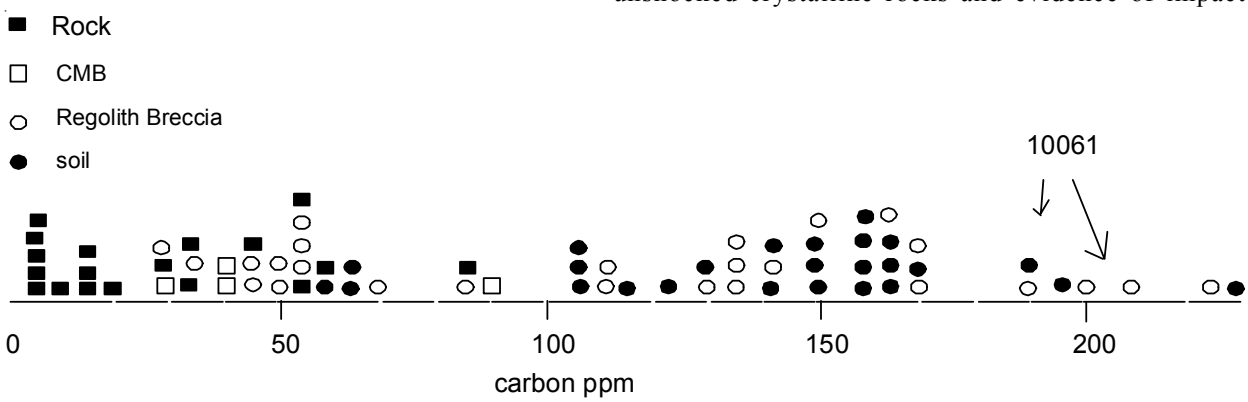


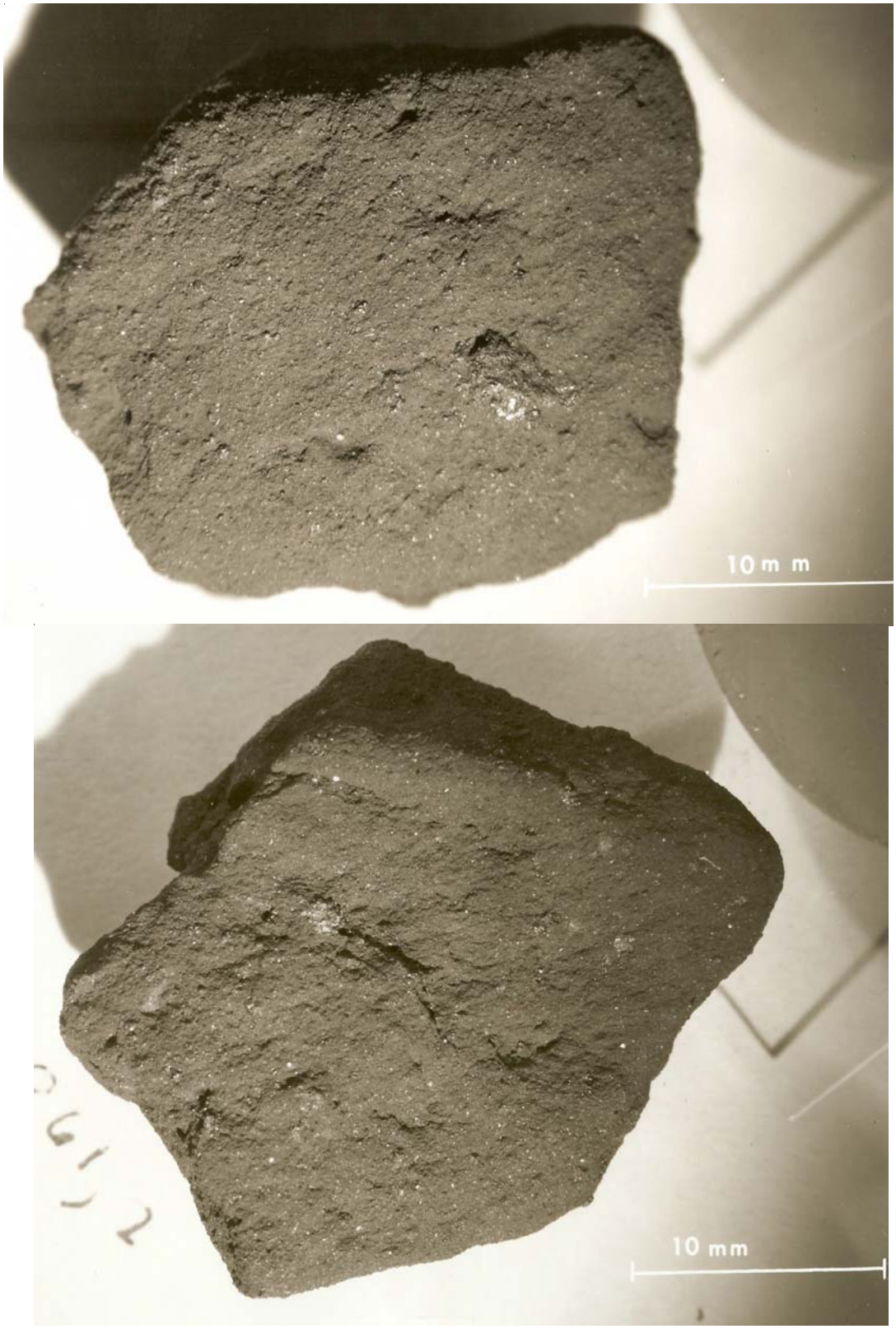


Figure 10: Two views of 10061,12. Scale is 1 cm. S69-463 and 464,

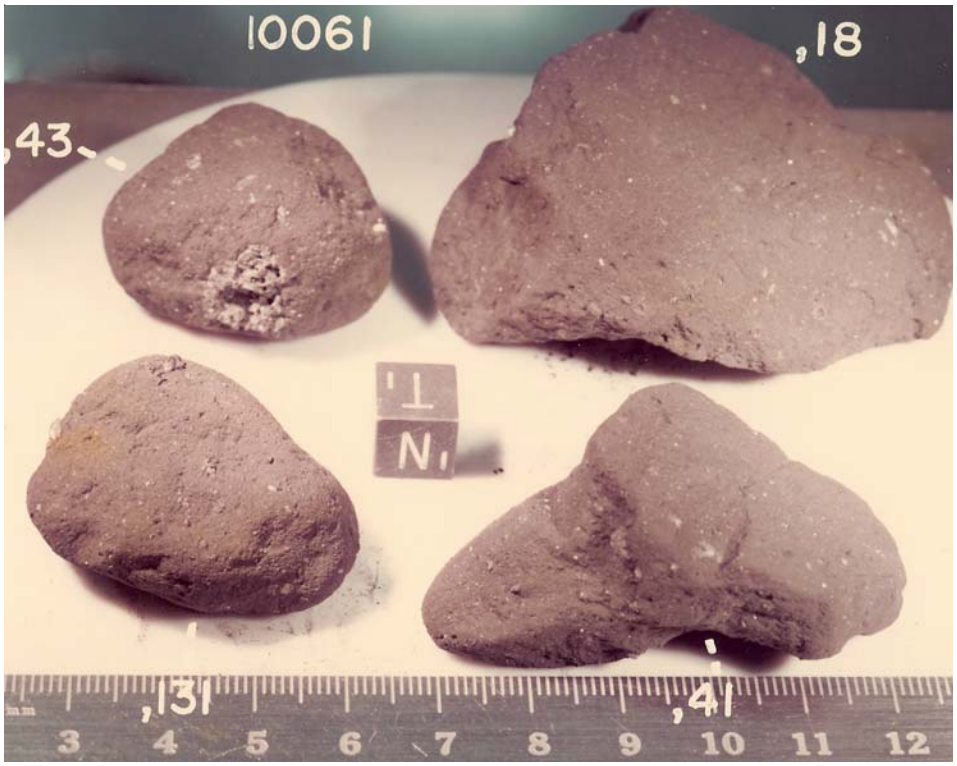


Figure 11: Photo of 10061, 18 ,41 ,43 and ,131. Scale and cube are in cm. S75-34224.

Figure 12: It took a while to learn that soil breccias do not make display samples. This is what happened to 10061,42. S72-46772.

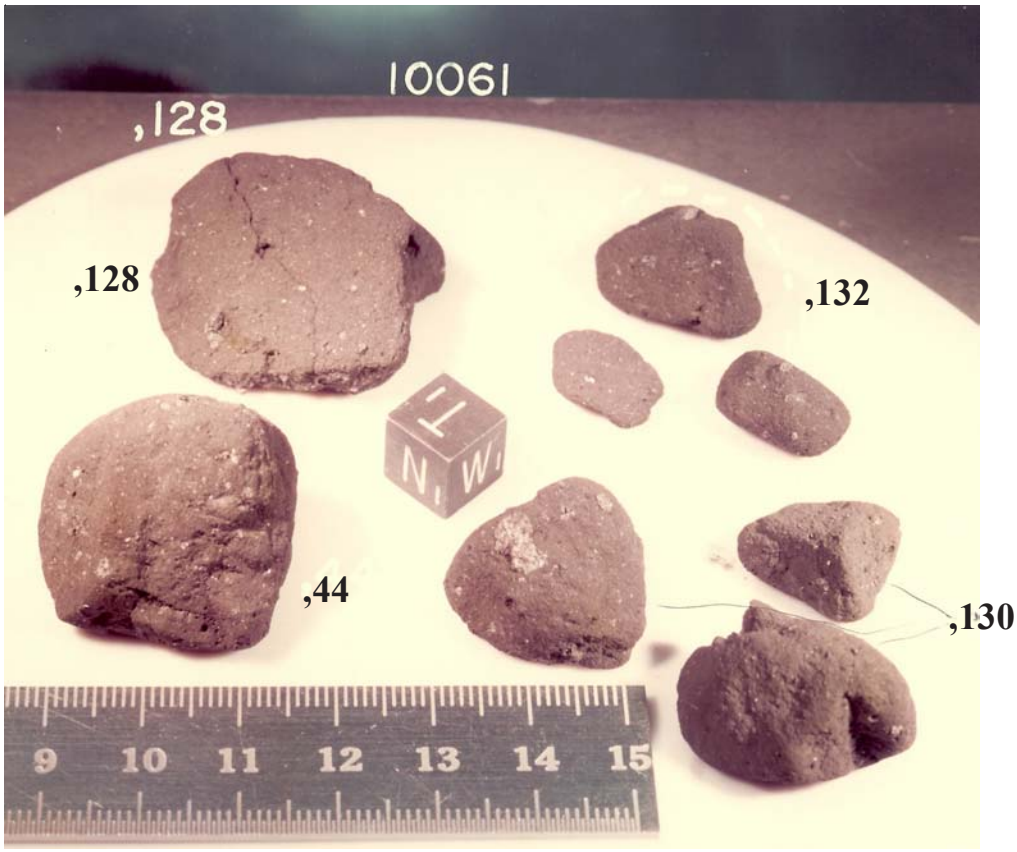
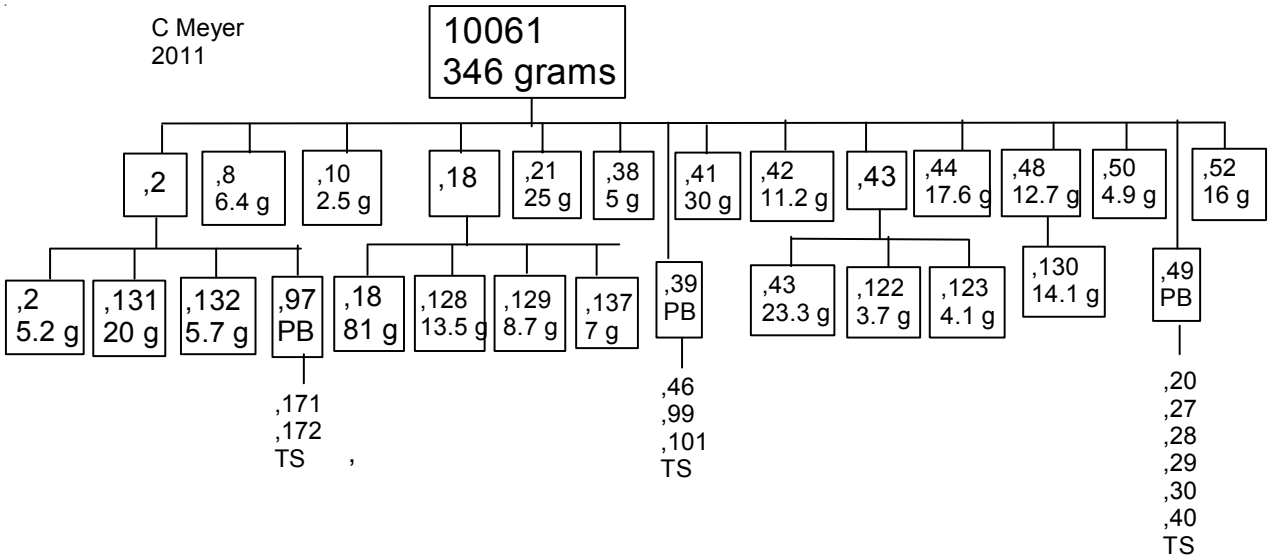


Figure 13: Photo of small pieces of 10061 including ,128,130 ,132 and ,44. Note that they are rounded because of their extreme friablitiy. Cube is 1 cm. S75-34226.



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