

60500 and 60510*

Soil

702 and 8 grams

*Sample Number Corrected by LPI 09/04/2015

Introduction

60500 was collected adjacent to drive tube 60010/60009, about 100 m from the LM. The rake sample, 60510, from the same area did not contain many rock fragments on the surface and came up nearly empty. The sieved portion of 60500 did not include any walnut sized rocks (> 1 cm), while 60510 included only 11 small rake samples (table 2). However, a large portion of 60500 remains unsieved.

Petrography

60500 is a mature soil with a maturity index of $Is/FeO = 80$ (Morris 1978). Graf (1993) reported the grain size distribution (figure 6). The average grain size is 79 microns.

Kempa et al. (1980) calculated that 60500 was ~ 55 % anorthosite, ~ 30 % impact melt and ~ 10 % mare component.

The Apollo Soil Survey (Ridley et al. 1973) analyzed a large number of the glass particles in 60501, grouping them by clusters in composition diagrams (figures 4 and 5). They found about ~45 % were 'highland basalt', while about ~8 % were mare basalt. Highland basalt may not be a distinct rock type, but rather a glass made from highland soil (Meyer et al. 1974).

Glass splashed on rocks is a common feature at Apollo 16 (See et al. 1986; Morris et al. 1986) and seems to derived from melted soils. Figure 2 and table 3 give the composition of a glass coat on 60527.

Rake samples

Eleven small rake samples were collected (figures 7, 8 and 9) from the same location (table 2). Both anorthosites and impact melt rocks were included (table 3).

Chemistry

Soil sample 60501 has been well analyzed by numerous investigators (table 1). The composition is similar to other lunar soils (figures 1 and 3). The soil is high in meteoritic siderophiles (Ni, Ir and Au). Kerridge et al. (1993) reported 180 ppm C (figure 10) and Cadogan et

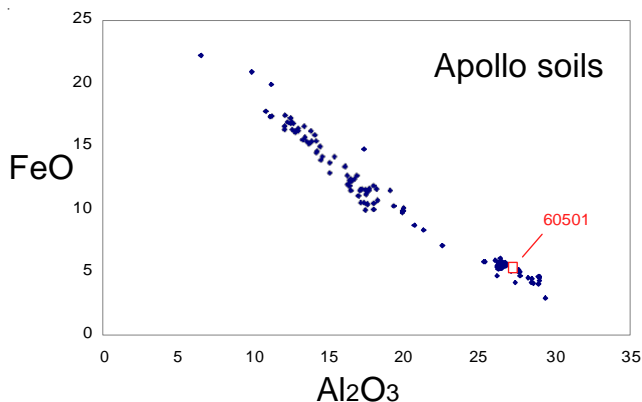


Figure 1: Chemical composition of Apollo soils including 60500.

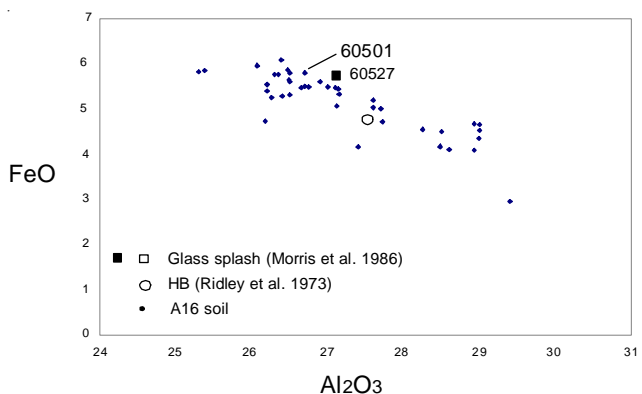


Figure 2: Composition of Apollo 16 soils with that of glass splash on 60527 and 'highland basalt' (HB).

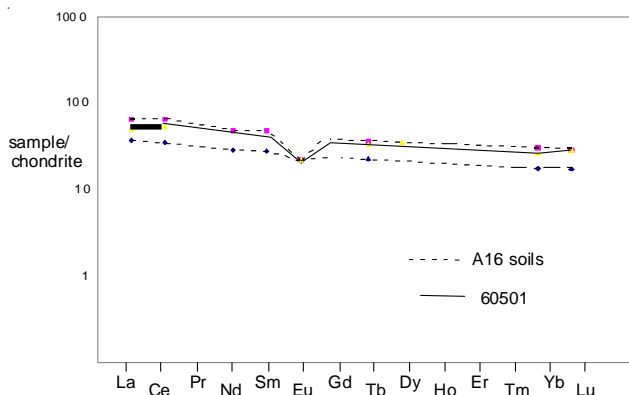


Figure 3: Normalized rare-earth-element diagram for Apollo 16 soils with 60501 shown.

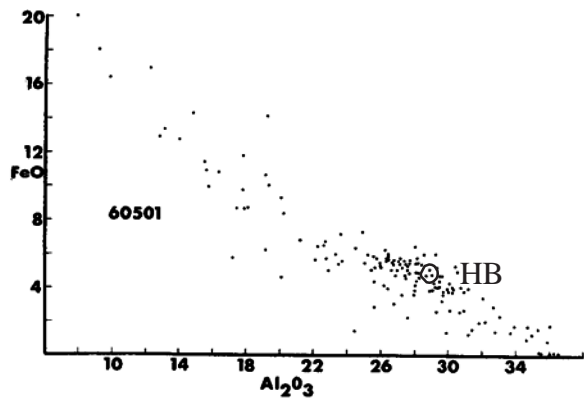


Fig. 4. FeO-Al₂O₃ wt.% plot for glasses in soil 60501.
Ridley et al. 1973

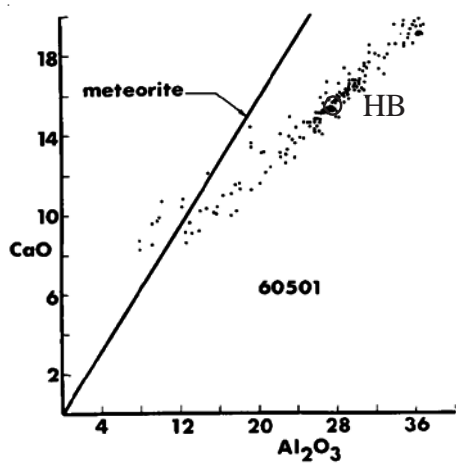
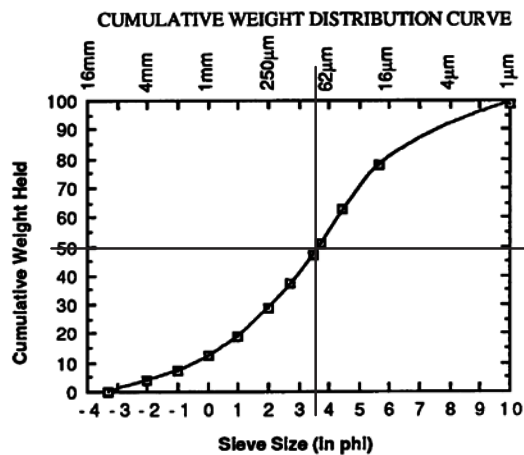


Figure 5: Composition of glass particles found in 60501 by Ridley et al. 1973. The symbol HB is the average of a cluster of glass compositions termed 'highland basalt' by Ridley et al.



average grain size = 79 microns

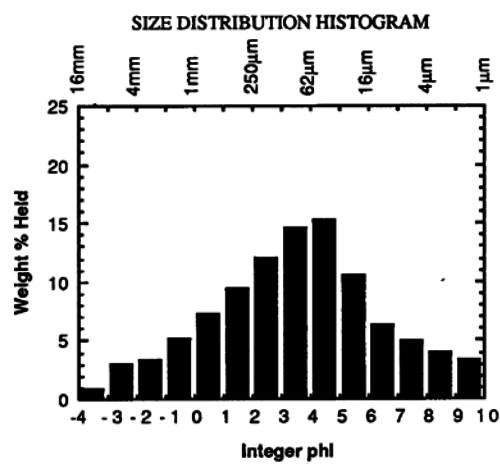


Figure 6: Grain size distribution for particles in 60501 reported by Graf 1993.

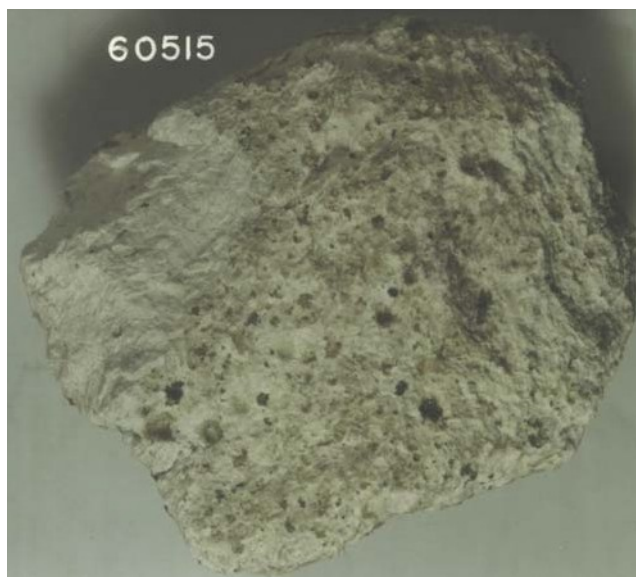


Figure 7: Photo of rake sample 60515. S72-46333

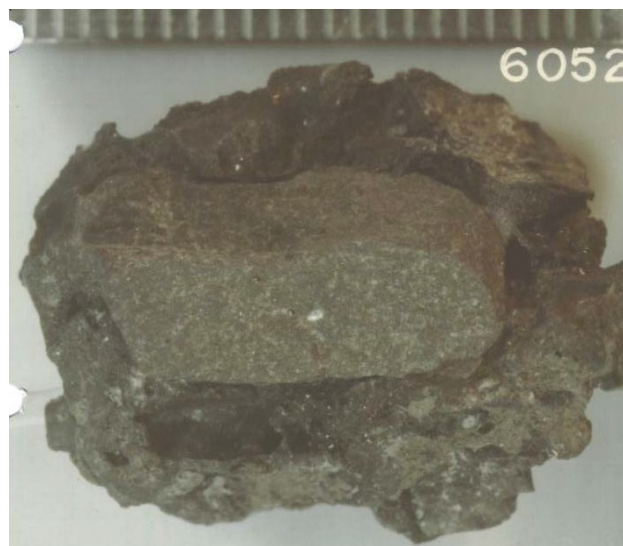


Figure 8: Photo of 60527. S-72-46328

Table 1. Chemical composition of 60500.

reference weight	Duncan73	Rose75 fines	Rose75 coarse	Morrison73	Muller75	Finkelman75 fines	Finkelman75 Clark 73	Boynton75 314 ng	Baedecker72	Compston73	Fruchter74
SiO2 %	45.22	(a) 44.95	45.44	(b)						45.17	(a)
TiO2	0.59	(a) 0.6	0.61	(b) 0.63	(c)			0.6	(d)	0.59	(a)
Al2O3	26.84	(a) 26.45	25.54	(b) 25.5	(c) 26.6			26.4	(d)	26.71	(a) 27.4 (d)
FeO	5.51	(a) 5.38	5.46	(b) 5.45	(c) 5.7			6.05	(d)	5.57	(a) 5.15 (d)
MnO	0.072	(a) 0.08	0.07	(b) 0.067	(c)			0.076	(d)	0.08	(a)
MgO	5.52	(a) 6.05	6.43	(b) 6.58	(c) 6.38			6.03	(d)	6.03	(a)
CaO	15.32	(a) 15.42	15.39	(b) 15.8	(c) 15.5			16.1	(d)	15.61	(a)
Na2O	0.4	(a) 0.44	0.45	(b) 0.44	(c) 0.53		Clark 73	0.5	(d)	0.44	(a) 0.3 (d)
K2O	0.114	(a) 0.13	0.12	(b) 0.1	(c) 0.12		0.12	(e)		0.12	(a)
P2O5	0.137	(a) 0.12	0.11	(b) 0.064	(c)					0.12	(a)
S %	0.065	(a)		0.048	(c)						
sum											
Sc ppm		11	8.8	(b) 10.1	(c)		8.8	11	(d) 9.5	(d)	10.1 (d)
V		23	14	(b) 17	(c)		14	23	(d)		
Cr		752	958	(b) 710	(c)			710	(d)		774 (d)
Co		30	37	(b) 30	(c)		37	30	(d) 59	(d)	29 (d)
Ni	321	(a) 618	720	(b) 418	(c)		700	618	(d)	495	(d)
Cu	4.8	(a) 17	15	(b) 7.7	(c)		15	17	(d)		
Zn	21.6	(a) 29	16	(b) 22	(c)		16	29	(d)	23	(d)
Ga		4.3	3.5	(b) 3.6	(c)		3.5	4.3	(d)	5.1	(d)
Ge ppb										1250	(d)
As											
Se											
Rb	2.9	(a) 3.6	2.8	(b) 2.6	(c) 3.5		2.8	3.6	(d)	2.8	
Sr	165	(a) 126	121	(b) 158	(c) 163		121	126	(d)	168	
Y	41	(a) 58	42	(b) 50	(c)		42	58	(d)		
Zr	192	(a) 196	166	(b) 210	(c)		166	196	(d)		
Nb	12.1	(a) 15	10	(b) 13	(c)		10	15	(d)		
Mo											
Ru											
Rh											
Pd ppb											
Ag ppb											
Cd ppb										102	(d)
In ppb				80	(c)					13	(d)
Sn ppb											
Sb ppb											
Te ppb											
Cs ppm				0.03	(c) 0.16						
Ba	149	(a) 161	143	(b) 210	(c) 141			130	(d)		140 (d)
La		10	10	(b) 11	(c) 12.7			11.6	(d)		12.4 (d)
Ce				27	(c)			33	(d)		31.5 (d)
Pr				4.7	(c)						
Nd				22	(c)						19 (d)
Sm				6	(c)						6.2 (d)
Eu				1.2	(c)			1.22	(d)		1.3 (d)
Gd				5.5	(c)						
Tb				1.2	(c)			1.2	(d)		1.2 (d)
Dy				7.1	(c)			8.6	(d)		
Ho				1.3	(c)						
Er				4.9	(c)						
Tm				0.52	(c)						
Yb		5.2	4.4	(b) 4.4	(c)			4.2	(d)		4.3 (d)
Lu				0.65	(c)			0.7	(d)		0.7 (d)
Hf				5.4	(c)			4.4	(d)		4.2 (d)
Ta								0.53	(d)		0.5 (d)
W ppb											
Re ppb											
Os ppb											
Ir ppb										17	(d)
Pt ppb											
Au ppb							Clark 73			8	(d)
Th ppm				2.4	(c)		2.2	(e) 2.2	(d)		2.3 (d)
U ppm				0.62	(c) 0.42		0.61	(e)			

technique: (a) XRF, (b) 'microchemical', (c) INAA, RNAA, SSMS, (d) INAA, RNAA, (e) radiation count.

Table 2: Rake Samples from 60510 (DB349)

	weight	Ryder's term	ref
60515	16.74	cataclastic anorthosite	Warren et al. 1983
60516	7.91	cataclastic anorthosite	Dowty et al. 1974
60517	1.23	cataclastic anorthosite	
60518	1.12	cataclastic anorthosite	
60519	0.5	cataclastic anorthosite	
60525	12.84	poikilitic impact melt	Warner et al. 1976
60526	8.42	poikilitic impact melt	Warner et al. 1976
60527	7.36	crystalline breccia and vesicular glass	
60528	2.94	glassy impact melt	
60529	1.24	basaltic impact melt	
60535	7.23	regolith breccia	
60510	7.67	residue	

al. (1973) studied how it was distributed among various mineral separates. Muller (1973) and Kerridge et al. (1973) determined 81 ppm and 109 ppm nitrogen, respectively - standard for mature soil.

Cosmogenic isotopes and exposure ages

Clark and Keith (1973) determined the cosmic-ray-induced activity of ²⁶Al = 107 dpm/kg., ²²Na = 42 dpm/kg., ⁵⁴Mn = 8 dpm/kg. and ⁵⁶Co = 10 dpm/kg. for 60501.

Other Studies

Bogard D.D. and Nyquist L.E. (1973) determined the rare gas content of 60501.

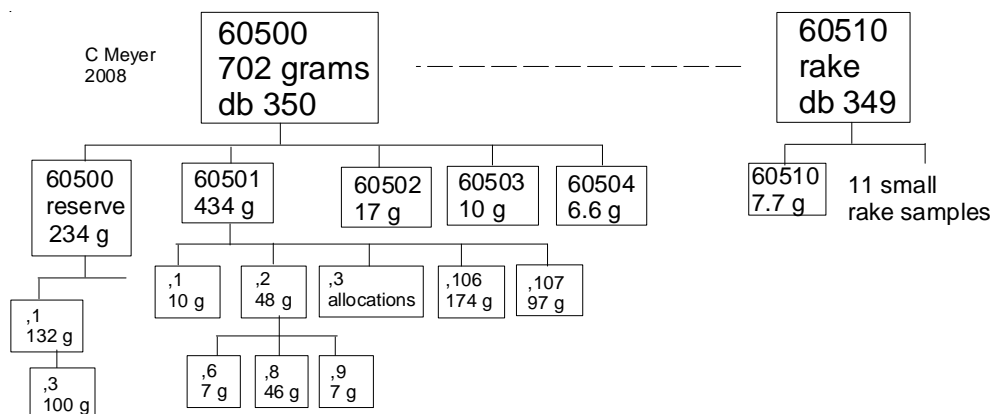


Table 3. Chemical composition of rake samples.

	60515	60516	60525	60526	60527	60527
reference	Warren83	Dowty 74	Warner 76	Warner 76	See86	Morris86
weight		Ryder 80			glass	rock
SiO ₂ %	43.2	44.8	(a) 46.1	(a) 47.5	(a) 45.57	46.27 (a)
TiO ₂	0.07		1.05	(a) 1.4	(a) 0.88	0.39 (a)
Al ₂ O ₃	35.3	35.2	(a) 21.2	(a) 17.4	(a) 26.92	18.88 (a)
FeO	0.77	0.28	(a) 7.2	(a) 8.9	(a) 5.37	5.75 6.64 (a)
MnO	0.0015		0.08	(a) 0.09	(a) 0.06	(a)
MgO	0.33	(b) 0.05	(a) 9.3	(a) 13.5	(a) 5.43	13.95 (a)
CaO	19.2	(b) 19.2	(a) 12.9	(a) 10.8	(a) 15.21	12.93 (a)
Na ₂ O	0.42	(b) 0.44	(a) 0.64	(a) 0.71	(a) 0.57	0.63 0.31 (a)
K ₂ O	0.007	(b) 0.01	(a) 0.27	(a) 0.45	(a) 0.14	0.15 (a)
P ₂ O ₅		0.02	(a) 0.26	(a) 0.44	(a)	
S %						
sum		100	100	100		
Sc ppm	2.03	(b)				10.23 (b)
V						
Cr	121	(b)				774 (b)
Co	1.7	(b)				20 (b)
Ni	8	(b)				317 (b)
Cu						
Zn	0.44	(b)				
Ga	4.2	(b)				
Ge ppb	4.2	(b)				
As						
Se						
Rb	2.7	(b)				
Sr	209	(b)				
Y						
Zr						
Nb						
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb	29	(b)				
In ppb						
Sn ppb						
Sb ppb						
Te ppb						
Cs ppm						
Ba	13	(b)				196 (b)
La	0.28	(b)				13.85 (b)
Ce	0.74	(b)				43.8 (b)
Pr						
Nd						
Sm	0.124	(b)				6.57 (b)
Eu	0.92	(b)				0.94 (b)
Gd						
Tb	0.021	(b)				1.09 (b)
Dy						
Ho						
Er						
Tm						
Yb	0.067	(b)				4.54 (b)
Lu	0.014	(b)				0.63 (b)
Hf	0.1	(b)				4.07 (b)
Ta	0.037	(b)				0.87 (b)
W ppb						
Re ppb	0.006	(b)				
Os ppb						
Ir ppb	0.003	(b)				
Pt ppb						
Au ppb	0.0055	(b)				
Th ppm	0.023	(b)				2.08 (b)
U ppm	0.06	(b)				0.93 (b)

technique: (a) broad beam e. probe, (b) INAA



Figure 9: Getting ready to rake for sample 60510. AS16-117-18826 (from old faded photo).

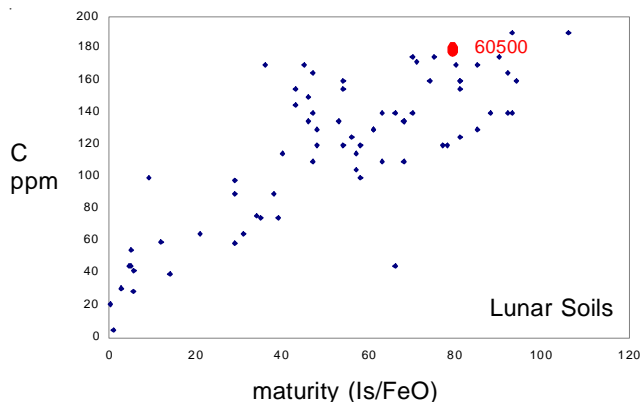


Figure 10: Carbon vrs. maturity for 60500.

References 60500

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