64501 and 64530

Soil and bag residue

893 and 103 grams

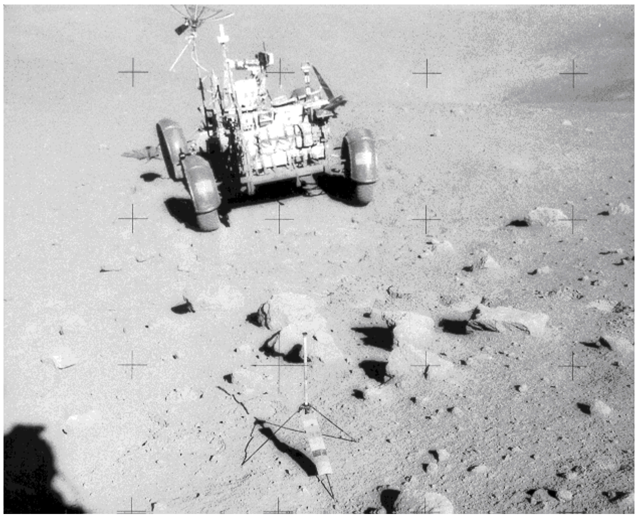


Figure 1: Blocky sample area in double crater near rim of Cinco a. Region of rake sample and soil sample 64500. AS16-110-17948.

Introduction

Sample 64500 was collected from a blocky area high up on the slope of Stone Mountain, and as such should primarily contain material from the Descartes Formation. It is a large sample from a loose regolith on the rim of a 15 meter crater. It included 11 walnut-sized samples (64505 - 64525) and an additional rake sample (64530) collected from the same location yielded 30 additional rocks (64535 - 64589). A double drive tube 64002/1 and a trench sample 64420 were collected nearby.

Note that some of the rocks from Stone Mountain were dilithologic breccias (e.g. 64535, 64475) and that 64501 has a very similar composition.

One might speculate that the 15 meter crater (Cinco a) was about 300 m.y. old, while the small double crater where the samples and the rocky area was caused by secondary material from South Ray Crater 2 m.y. ago (figure 2).

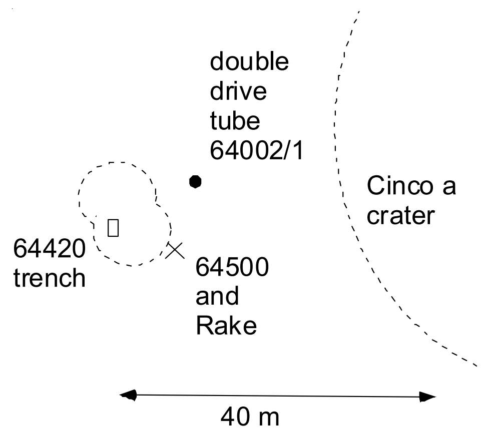


Figure 2: Location of samples at station 4, Apollo 16, on Stone Mountain, Apollo 16.

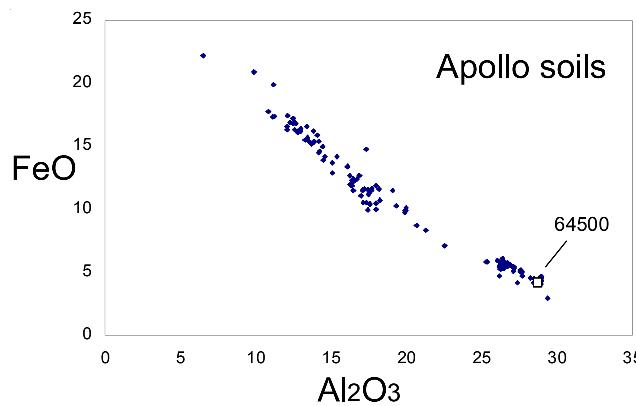


Figure 3: Composition of 64501 compared with Apollo soil samples.

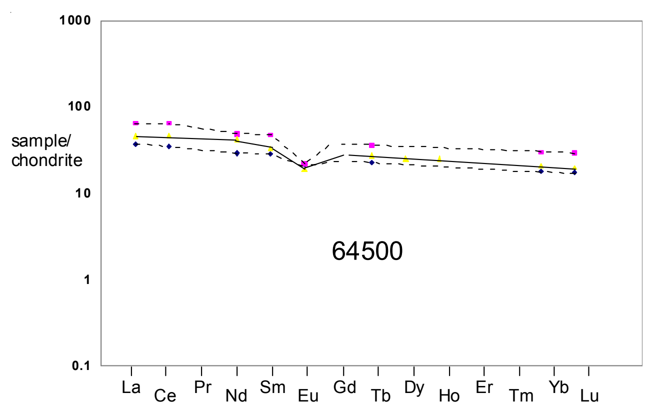


Figure 4: Normalized rare-earth-element diagram comparing composition of 64501 with other Apollo 16 soils.

Modal content of soil 64501.
From Papike et al. 1982

	1000-90 microns
Agglutinates	29.1
Dark matrix breccias	13.9
Mare basalt	0.3
Feldspathic basalt	1.6
Breccia	2.1
Anorthosite	5
Poikilitic	8.3
Plagioclase	32.1
Pyroxene	1
Glass other	6.7

Modal content 64501 (90-150 micron).

	Heiken73	Houck82
Agglutinates	51.6	29.2
Basalt	-	-
Breccia	21	26.1
Anorthosite	3	1
Norite	0.3	
Plagioclase	20	33
Pyroxene	0.6	2.5
Olivine		0.3
Ilmenite		0.4
Glass other	3	6.8

Petrography

64500 was considered one of the reference soils by the Highland Initiative (Lobatka et al. 1980, Simon et al. 1981, Papike et al. 1982). Morris (1978) reported that 64500 was a mature soil with index I_s/FeO = 61. Heiken et al. (1973) found 51% agglutinates in the 90-150 micron size range, while Houck (1982) determined an average of ~ 29 % agglutinate overall. Butler et al. (1973), Heiken et al. (1973) and Graf (1993) reported the grain size analysis (figure 5). The average grain size is about 110 microns.

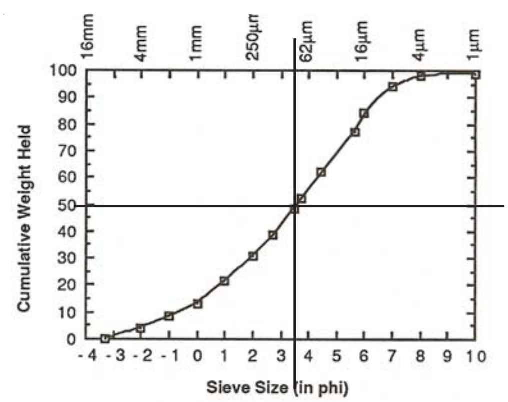
Glass (1976) studied the glass particles in 64501 and found 5% were mare component, and a few were granitic in composition. However, he did not report a group called ‘highland basalt’, as did Ridley et al. (1973) for 60501. Delano (1975), Delano et al. (1981, 2007) and Kempa and Papike (1980) analyzed a large number of glass particles from 64501. Walker and Papike (1981) and Basu and McKay (1985) studied the formation of agglutinates, while See et al. (1986) studied the glass splashes on rocks (and presumably soil fragments).

Phinney and Lofgren (1973) described rake samples, while Marvin (1972) described the 4 - 10 mm coarse fine particles.

Devine et al. (1982) and Korotev (1981) discuss two different models for the derivation of the fine fraction (differential fracturing and mixing, respectively).

Mineralogy

Mineral compositions were determined by Kempa and Papike (1980) and Labotka et al. (1980) with about half the pyroxene showing mare composition (figure 6). Bell and Mao (1973) studied the iron in plagioclase.



average grain size = 101 microns

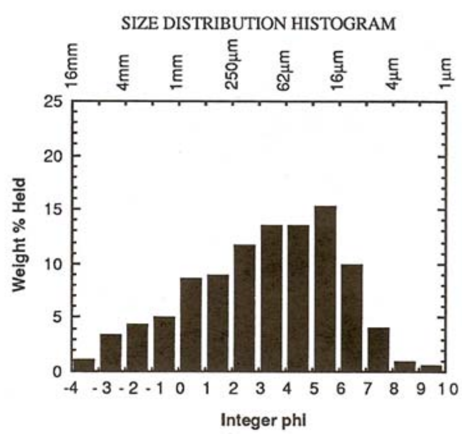


Figure 5a: Grain size distribution for 64500 (Graf 1991, data by Heiken et al.)

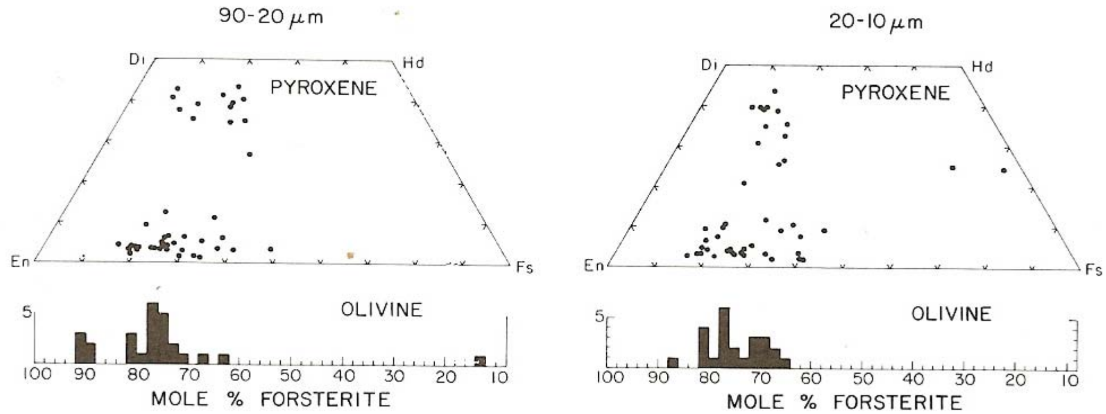


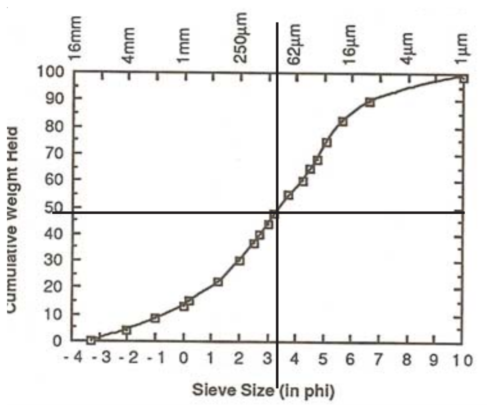
Figure 6: Composition of pyroxene and olivine grains in two different size fractions of 64501 (Labotka et al. 1980).

Chemistry

The chemical composition of 64501 (table 1) is similar to that of the nearby trench soil (64420) and the double drive tube 64002. Finkelman et al. (1975) and Laul and Papike (1980) analyzed bulk soil and several grain size separates. Cirlin and Housley (1981) determined Cd and Zn and Jovanovic and Reed (1973) reported the halogen content. Clark and Keith (1973) and Nunes et al. (1973) reported K, U and Th.

Chemical analyses for rake samples from this location are tabulated in table 4. Korotev (1981) discussed the close chemical comparison of 64501 with that of dilithologic anorthositic breccias 64474 and 64548.

Muller (1973) determined 96 ppm nitrogen, but there are no values for carbon for 64501.



Average grain size = 110 mcirons

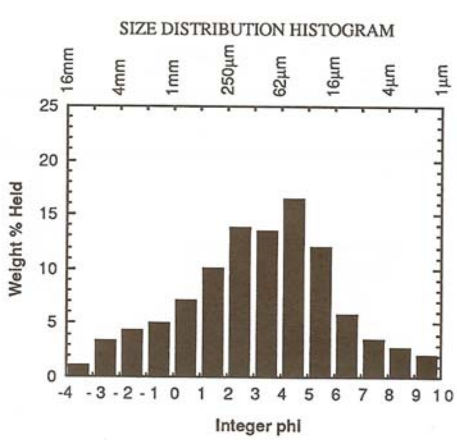


Figure 5b: Grain size distribution for 64500 (Graf 1991, data by Butler et al.)

Radiogenic age dating

Jessberger et al. (1977) have produced Ar/Ar ages for rake samples from 64535 and 64536.

Cosmogenic isotopes and exposure ages

Clark and Keith (1973) determined the cosmic-ray-induced activity of ^{26}Al = 160 dpm/kg., ^{22}Na = 44 dpm/kg., ^{54}Mn = 6 dpm/kg. and ^{46}Sc = 2.2 dpm/kg. Kirsten et al. (1973) reported a Ne exposure age of 210 m.y.

Jessberger et al. (1977) determined the exposure age of some of the rake samples from this soil. In particular, 64535 was found to be 1.9 m.y. old, consistent with excavation by South Ray Crater (see section on 64535).

Other Studies

Kirsten et al. (1973) reported the rare gas content and isotopic ratios.

Rees and Thode (1975) determined the concentration and isotopic ratio of sulfur.

Table 1. Chemical composition of 64501.

reference	Korotev81			Finkelman75				Laul80		Krahenbuhl73		Haskin73		Morrison73		Muller75	Korotev91	
weight	C	F		90-1000	30-90	<30um												
SiO2 %								45.3	(a)			45.2						
TiO2								0.37	(a)			0.53		0.57	(b)			
Al2O3								27.7	(a)			27.4		26.8	(b)	28.1		
FeO	3.75	4.54	(a)	3.8	4.7	4.4	(a)	4.2	(a)			4.16		4.25	(b)	4.36	4.14	(a)
MnO								0.056	(a)			0.057		0.057	(b)			
MgO								4.9	(a)			4.27		6.35	(b)	5.64		
CaO								17.2	(a)			16.6		19.17	(b)	15.7	16	(a)
Na2O	0.484	0.483	(a)					0.44	(a)			0.47		0.48	(b)	0.48	0.45	(a)
K2O								0.1	(a)			0.111		0.111	(b)	0.11		
P2O5														0.14	(b)			
S %														0.045	(b)			
sum																		
Sc ppm	7	7.9	(a)	6.7	8.2	7.9	(a)	8	(a)			10.4	(a)	7.17	(b)		7.48	(a)
V								20	(a)					10	(b)			
Cr	580	775	(a)	514	613	613	(a)	616	(a)					570	(b)		581	(a)
Co	13.2	20.1	(a)	20.6	23.7	19.5	(a)	19.5	(a)			21	(a)	29	(b)		20.9	(a)
Ni	200	360	(a)					300	(a)			290	(a)	340	(b)		311	(a)
Cu														5.9	(b)			
Zn										23.4	(c)	26	(a)	20	(b)			
Ga												5.2	(a)	4.5	(b)			
Ge ppb										485	(c)							
As																		
Se																		
Rb										2	(c)	2.5	(a)	2.2	(b)	2.6		
Sr								170	(a)					158	(b)	161	167	(a)
Y														40	(b)			
Zr														218	(b)		129	(a)
Nb														11	(b)			
Mo																		
Ru																		
Rh																		
Pd ppb																		
Ag ppb																		
Cd ppb										85.5	(c)							
In ppb														330	(b)			
Sn ppb																		
Sb ppb										2.2	(c)							
Te ppb										22.8	(c)							
Cs ppm										0.085	(c)	0.11	(a)	0.02	(b)	0.12	0.1	(a)
Ba								130	(a)					206	(b)	114	124	(a)
La	10.2	12.9	(a)	13	9	14	(a)	10.8	(a)			11.7	(a)	10	(b)	10.3	10.8	(a)
Ce	26.5	33.5	(a)	24	27	35	(a)	28	(a)			30.3	(a)	29	(b)		28.1	(a)
Pr														4.1	(b)			
Nd								19	(a)			20.3	(a)	18	(b)		20	(a)
Sm	4.7	5.85	(a)	4.8	4.6	5	(a)	4.79	(a)			5.48	(a)	5.5	(b)		5.06	(a)
Eu	1.01	1.15	(a)	1.2	1.1	1.2	(a)	1.05	(a)			1.18	(a)	1.2	(b)		1.11	(a)
Gd												7.4	(a)	5.4	(b)			
Tb	1	1.22	(a)	1.1		1.4	(a)	1	(a)			1.18	(a)	1.1	(b)		0.98	(a)
Dy								6	(a)			7.3	(a)	6.9	(b)			
Ho								1.4	(a)			1.5	(a)	1.2	(b)			
Er												4.4	(a)	4.2	(b)			
Tm								0.55	(a)					0.5	(b)			
Yb	3.3	4	(a)	3.9	4.2	4.5	(a)	3.4	(a)			3.74	(a)	4	(b)		3.51	(a)
Lu	0.46	0.57	(a)	0.48	0.52	0.56	(a)	0.49	(a)			0.54	(a)	0.57	(b)		0.471	(a)
Hf	3.4	4.3	(a)	3.6	4	3.1	(a)	3.3	(a)			4.7	(a)	4.4	(b)		3.65	(a)
Ta	0.5	0.7	(a)	0.8			(a)	0.45	(a)								0.44	(a)
W ppb																		
Re ppb										0.996	(c)							
Os ppb																		
Ir ppb										11.8	(c)						8.8	(a)
Pt ppb																		
Au ppb										13.8	(c)						13.9	(a)
Th ppm	1.7	2.1	(a)	2	2	2	(a)	1.85	(a)					2.6			1.76	(a)
U ppm								0.4	(a)	0.58	(c)			0.54	(b)	0.43	0.54	(a)

technique: (a) INAA, (b) multiple, (c) RNAA

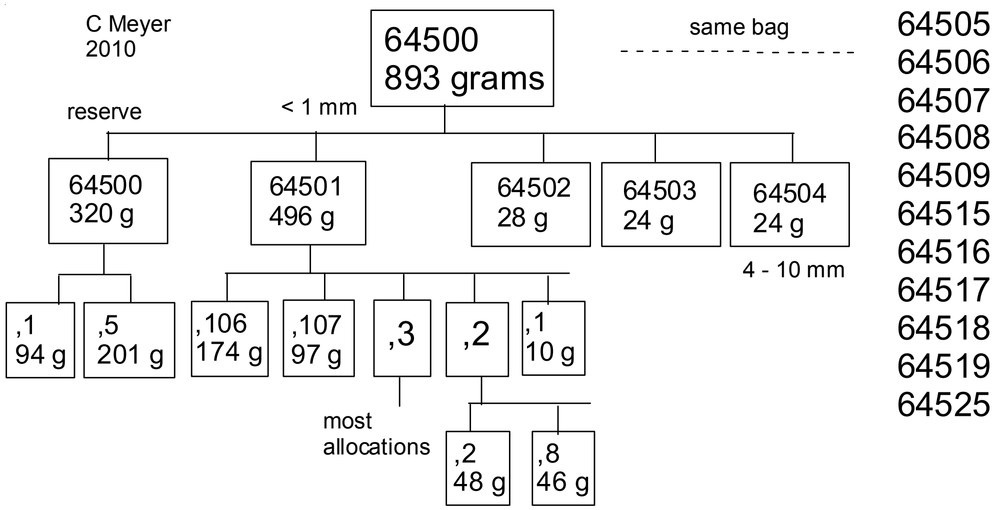


Table 2: Walnut Samples from 64500 (DB396)

	weight	Ryder's term
64505	5.392	breccia
64506	5.079	impact melt
64507	4.474	breccia
64508	4.168	breccia
64509	3.15	breccia
64515	3.761	impact melt
64516	2.929	cataclastic anorthosite
64517	1.546	breccia
64518	1.49	impact melt
64519	1.124	cataclastic anorthosite
64525	1.1	cataclastic anorthosite
	these are > 10 mm	
64504	24 g	4 to 10 mm peanuts
	see also table 3 for rake samples, same location	

Table 3: Rake Samples from 64530 (DB395)

	weight	Ryder's term	ref
64535	256.6	anorthosite and glass	Jessberger, Morris, See
64536	177.5	anorthosite and breccia	
64537	124.3	cataclastic anorthosite and impact melt	McKinley 1984
64538	30.03	breccia	
64539	17.76	breccia	
64545	14.09	breccia	
64546	12.8	cataclastic anorthosite and impact melt	McKinley 1984
64547	10.9	breccia	
64548	8.49	breccia	
64549	6.47	breccia	
64555	5.29	breccia	
64556	5.15	breccia	
64557	4.79	breccia	
64558	3.13	breccia	
64559	21.8	impact melt	McKinley 1984
64565	14.73	impact melt	McKinley 1984
64566	14.13	impact melt	
64567	13.86	impact melt	
64568	9.78	poikilitic impact melt	
64569	14.32	poikilitic impact melt	
64575	6.84	poikilitic impact melt	
64576	6.92	basaltic impact melt	
64577	5.69	breccia	
64578	6	impact melt	
64579	4.8	impact melt	
64585	4.7	impact melt	
64586	3.3	impact melt	
64587	7.2	breccia	
64588	2.55	breccia	
64589	4.04	cataclastic anorthosite	
64530	102.8	residue	
	see also table 2 for walnuts, peanuts		

Table 4. Chemical composition of rake samples.

	64535	64537		64546		64548	64559	64559		64565		64567	64569	64569	64585
reference		McKinley84		McKinley84		Floran76		McKinley84		McKinley84			Wasson77		
weight						Ryder 80								Floran76	
SiO2 %	see					45.28								46.37	
TiO2	sample	0.8	(a)	0.5	(a)	0.43		0.9	(a)	0.8	(a)		1.03	0.94	
Al2O3		20.2	(a)	27.7	(a)	27.67		20.7	(a)	21.3	(a)		22.48	20.81	
FeO		9.5	(a)	4.6	(a)	4.47		9.4	(a)	8.3	(a)		8.5	7.6	
MnO		0.083	(a)	0.056	(a)			0.085	(a)	0.084	(a)		0.1		
MgO		11.1	(a)	5.1	(a)	5.67		11.6	(a)	10.8	(a)		12.4	11.25	
CaO		12	(a)	16.7	(a)	15.79		12.1	(a)	12.5	(a)		11.7	12.35	
Na2O		0.5	(a)	0.46	(a)	0.464		0.506	(a)	0.53	(a)		0.504	0.52	
K2O		0.18	(a)	0.07	(a)	0.13		0.19	(a)	0.16	(a)		0.2	0.22	
P2O5															
S %															
sum															
Sc ppm		11.3	(a)	7.2	(a)	6.78		11.3	(a)	10.7	(a)		13.3		
V		29	(a)	19	(a)			32	(a)	27	(a)		40		
Cr		1160	(a)	657	(a)	670		1184	(a)	1115	(a)		1320		
Co		97	(a)	21	(a)	24.5		94	(a)	68	(a)		59		
Ni		1725	(a)	330	(a)	380		1560	(a)	1140	(a)		930		
Cu															
Zn													3.5		
Ga													4.6		
Ge ppb													2300		
As															
Se															
Rb															
Sr															
Y															
Zr													360		
Nb															
Mo															
Ru													77		
Rh															
Pd ppb															
Ag ppb															
Cd ppb													7		
In ppb													4.5		
Sn ppb															
Sb ppb															
Te ppb															
Cs ppm															
Ba		325	(a)	95	(a)			300	(a)	300	(a)		270		
La		29	(a)	8.3	(a)	14.6		29.2	(a)	27.8	(a)		26.2		
Ce		73	(a)	23	(a)			75	(a)	70	(a)		63		
Pr															
Nd		46	(a)	15	(a)			47	(a)	42	(a)		44		
Sm		13.7	(a)	3.9	(a)			13.8	(a)	12.8	(a)		11.3		
Eu		3.78	(a)	1.26	(a)			1.67	(a)	1.57	(a)		1.5		
Gd															
Tb		2.64	(a)	0.73	(a)			2.63	(a)	2.48	(a)		2.4		
Dy		14.5	(a)	4.4	(a)			15.1	(a)	15.4	(a)		17		
Ho															
Er															
Tm															
Yb		8.87	(a)	2.7	(a)			8.96	(a)	8.4	(a)		8.7		
Lu		1.29	(a)	0.39	(a)	0.67		1.31	(a)	1.23	(a)		1.2		
Hf		9.4	(a)	2.7	(a)			9.3	(a)	8.9	(a)		8.5		
Ta		1.3	(a)	0.4	(a)			1.2	(a)	1.1	(a)		0.88		
W ppb															
Re ppb															
Os ppb															
Ir ppb		43	(a)	11	(a)			42	(a)	25	(a)		19		
Pt ppb															
Au ppb		38	(a)	9	(a)			36	(a)	25	(a)		20		
Th ppm		4.5	(a)	1.2	(a)			4.3	(a)	4.1	(a)		4		
U ppm		1.1	(a)	0.3	(a)			1.2	(a)	1.2	(a)		1.1		

technique: (a) INAA

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