64420

Trench Soil

331.1 grams

Figure 1: Trench at station 4, Apollo 16. AS16-107-17461.

Introduction

Sample 64420 is from the bottom of a 25 cm deep trench (figure 1) at the bottom of a small double crater on the rim of a 15 meter crater (Cinco 'a') on Stone Mountain (figure 2). It included one small (14 g) fragment of 'dilithologic breccia' (64425).

Double drive tube 64002/1, a large reference soil 64500 and a rake sample (64535 - 64589) were collected nearby. Samples from station 4, high up on Stone Mountain, should primarily be materials from the Descartes Formation. However, it has not proven easy to distinguish Descartes material from that of Cayley. A complication is that this area is on a ray that extends from South Ray Crater. It has been suggested that dimict breccias (e.g. 64435, 64475, 64476 as well as 64425) may be ejecta from South Ray Crater (James and Lindstrom 1991).

It has high maturity, especially considering that it's from the bottom of a trench.

CDR: *Okay, Houston. I'm digging an exploratory trench right here to see if material is black. – the material is not white. It's just the same as it - I've gone down about shovel width, and it's all the same material, and I don't see any layering in it or anything.*
CDR: *I've got a sample out of the deepest part of this trench that I'm digging – bag 399*

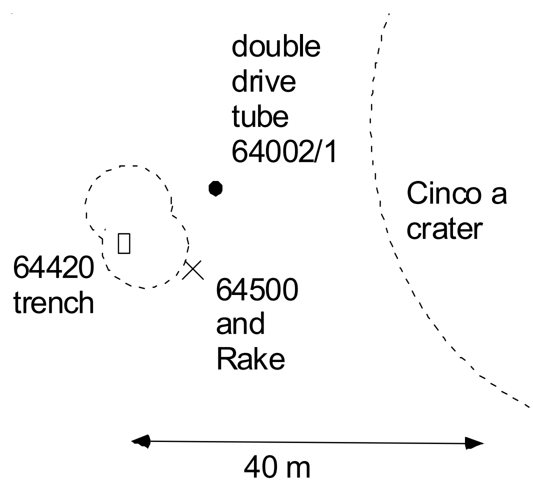


Figure 2: Plan view of samples collected at station 4 (highest point on Stone Mountain, Apollo 16).

Modal content of soil 64421.

From Butler et al. 1973.

	74 – 53 micron
Olivine	0.6
Pyroxene	1.1
Plagioclase	13.6
Glass other	10.6
Rock fragments	22.9
Welded fragments	52.6

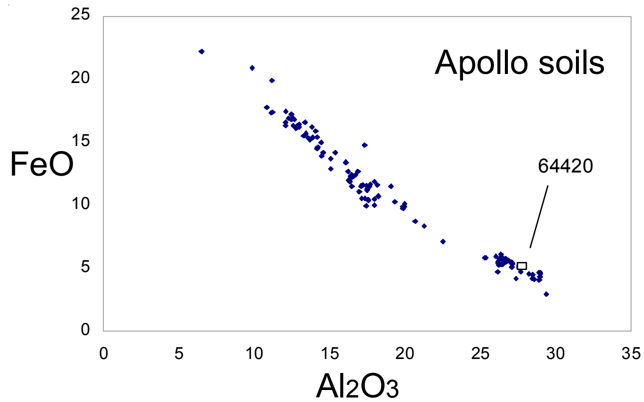


Figure 3 : Compositions of lunar soils with 64420 plotted.

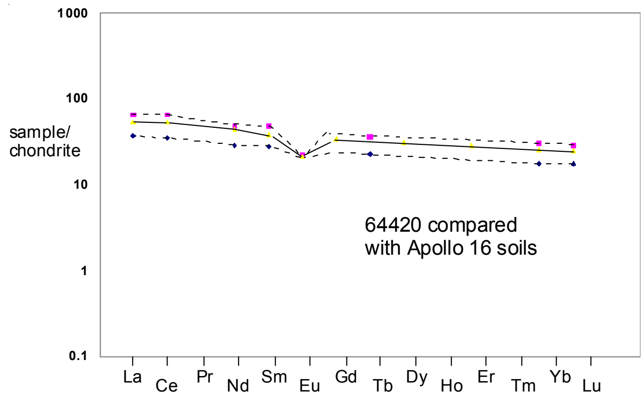


Figure 4: Normalized rare-earth-element diagram for 64421 compared with other Apollo 16 soils.

Petrography

Morris (1978) reported a maturity index I_s/FeO = 83 (figure 5) and the mode shows a high percentage of 'welded fragments' (agglutinates). Butler et al. (1973) and Graf (1993) report the grain size analysis based on sieving (figure 7).

Note that sample 64425 is a dimict breccia from this soil (James and Lindstrom 1991). Breccias 64535 and 64475 are large pieces of 'dilithologic breccia' from the same location.

Chemistry

The chemical composition of 64421 (table 1) is similar to that of soil sample 64501 and the drive tube 64002 – 1 (figures 3 and 4). Duncan et al. (1973) calculate that this soil is ~ 76 % anorthosite, 11 % KREEP, 9 % mare basalt and 3 % meteorite, while Kempa et al. (1980) calculate ~ 60 % anorthosite, 30 % low-K Fra Mauro (impact melt) and 10 % mare basalt (using components found in the sample itself).

Moore et al. (1973) reported very high total carbon for this sample (280 ppm), while Epstein and Taylor (1975) found more normal amounts (figure 6). Muller (1973) determined 124 ppm nitrogen, consistent with the Epstein and Taylor results.

Rhodes et al. (1975) found a systematic change in composition of agglutinates; apparently refuted by Hu and Taylor (1977).

Cirlin and Housley (1981) reported on Cd and Zn.

Cosmogenic isotopes and exposure ages

Clark and Keith (1973) determined the cosmic-ray-induced activity for ^{26}Al = 111 dpm/kg., ^{22}Na = 39 dpm/kg. and ^{56}Co = 19 dpm/kg. Nishiizumi et al. (1983) determined ^{53}Mn along the length of the core 64002. They seem to have found that the top of the core had been recently "disturbed", which would also apply to the trench soil (which seem to be unusually mature at depth).

Kirsten et al. (1973) reported a Ne exposure age of 210 m.y.

Other Studies

Behrmann et al. (1973) and Poupeau et al. (1975) found an abundance of cosmic ray tracks in this mature soil from the bottom of the trench (figure 8)! Bogard and Nyquist (1973), Kirsten et al. (1973) and Wieler et al. (1980) reported rare gases and their isotopes. Muller (1973) discusses the positive correlation of bound N with C, He and Ne contents – all derived from solar wind implantation.

Nyquist et al. (1973) and Papanastassiou and Wasserburg (1973) reported Rb and Sr composition and Sr isotopic composition.

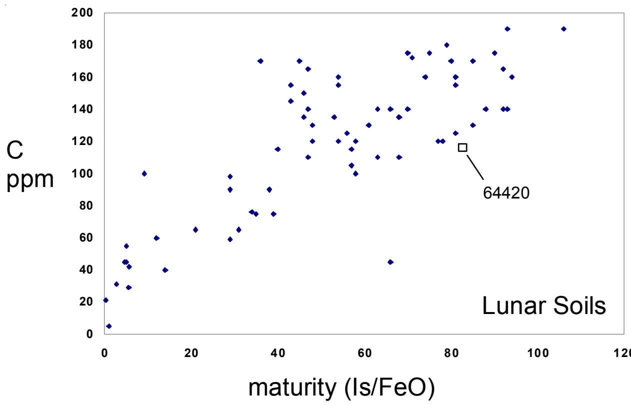
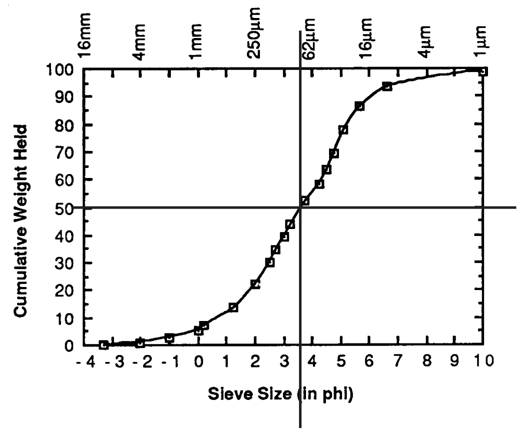


Figure 5: Carbon from Epstein and Taylor (1974); maturity index from Morris (1978).



Average grain size = 87 mcirons

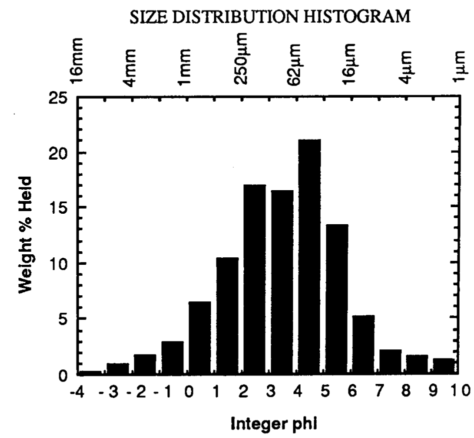


Figure 7: Grain size distribution of 64421 (from Graf 1993; from data by Butler et al. 1973).

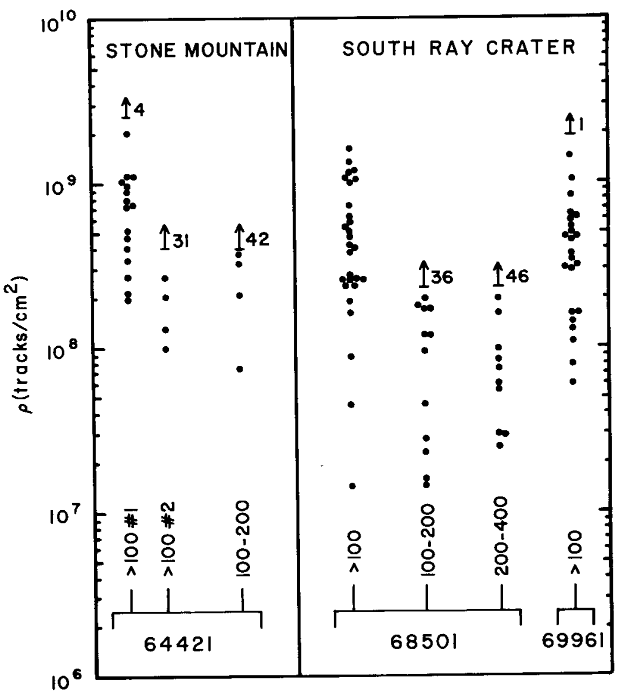


Figure 8: Track density for samples affected by South Ray Crater (Behrmann et al. 1973).

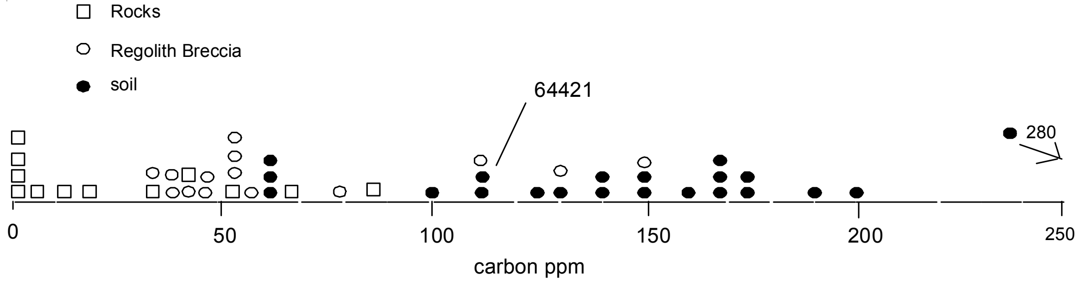
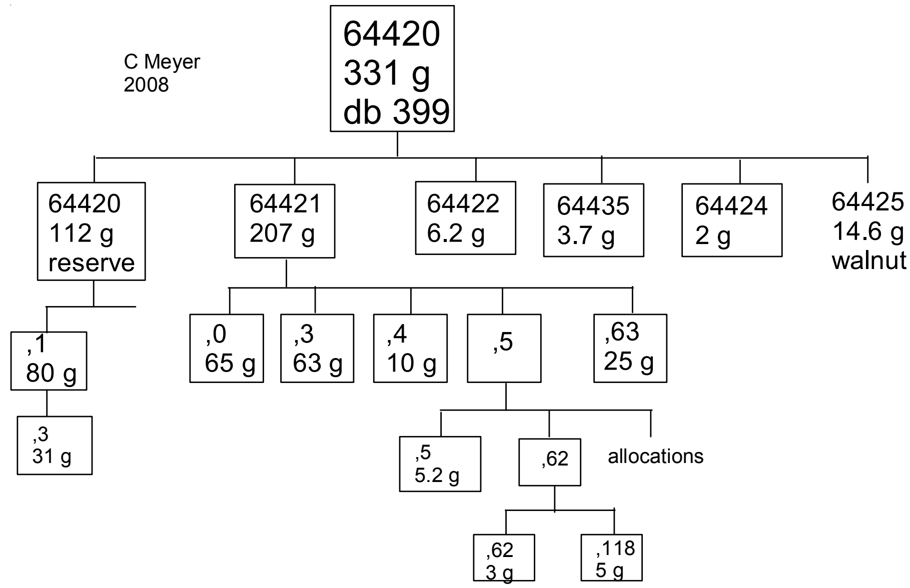


Figure 6: Carbon content from Epstein and Taylor (1974) and Moore et al. (1973) compared with other Apollo 16 samples.

Table 1. Chemical composition of 64421.

reference	LSPET73		Wanke73		Bansal72		Muller75		Compston73		Rhodes75		Clark 73		Hubbard73	
weight																
SiO2 %	44.88	(a)	45.14	(a)					45.01	(a)	44.97	(a)			44.68	(a)
TiO2	0.55	(a)	0.53	(a)	0.52	(d)			0.56	(a)	0.53	(a)			0.55	(a)
Al2O3	27.6	(a)	27.8	(a)			27.4	(e)	27.62	(a)	27.82	(a)			27.63	(a)
FeO	5.03	(a)	4.95	(a)			4.89	(e)	5	(a)	4.71	(a)			4.9	(a)
MnO	0.06	(a)	0.06	(a)					0.07	(a)	0.05	(a)			0.08	(a)
MgO	5.35	(a)	5.24	(a)			5.39	(e)	5.47	(a)	5.36	(a)			5.33	(a)
CaO	15.81	(a)	15.81	(a)			15.7	(e)	16.01	(a)	15.71	(a)			15.69	(a)
Na2O	0.39	(a)	0.44	(a)	0.46	(d)	0.45	(e)	0.44	(a)	0.58	(a)			0.47	(a)
K2O	0.1	(a)	0.1	(a)	0.12	(d)	0.13	(b)	0.11	(a)	0.11	(a)	0.112	(f)	0.11	(a)
P2O5	0.13	(a)							0.12	(a)	0.09	(a)			0.11	(a)
S %	0.07	(a)							0.08	(a)	0.05	(a)			0.07	(a)
sum																
Sc ppm			7.9	(b)							8.21	(b)				
V																
Cr	710	(a)	620	(b)	700	(d)					530	(b)				
Co			25	(b)							16.6	(b)				
Ni	316	(a)	330	(b)							210	(b)				
Cu																
Zn																
Ga																
Ge ppb																
As																
Se																
Rb	2.9	(a)			2.72	(d)	2.7	(b)	2.7							
Sr	172	(a)	160	(b)	173	(d)	177	(b)	165							
Y	42	(a)	40	(b)												
Zr	183	(a)	174	(b)	185	(d)										
Nb	11	(a)	9.5	(b)												
Mo																
Ru																
Rh																
Pd ppb																
Ag ppb																
Cd ppb																
In ppb																
Sn ppb																
Sb ppb																
Te ppb																
Cs ppm							0.13	(b)								
Ba			115	(b)	143	(d)	159	(b)								
La			12.3	(b)	12.5	(d)	13.4	(b)			10.1	(b)				
Ce			35	(b)	32.1	(d)					26	(b)				
Pr																
Nd					19.8	(d)										
Sm			5.7	(b)	5.61	(d)					4.7	(b)				
Eu			1.14	(b)	1.18	(d)					1.23	(b)				
Gd					6.67	(d)										
Tb			1.1	(b)							1.1	(b)				
Dy			6.8	(b)	7.5	(d)										
Ho			1.6	(b)												
Er					4.57	(d)										
Tm																
Yb			4	(b)	4.14	(d)					3.6	(b)				
Lu			0.57	(b)	0.61	(d)					0.49	(b)				
Hf			4	(b)							3.9	(b)				
Ta			0.5	(b)							0.4	(b)				
W ppb																
Re ppb																
Os ppb																
Ir ppb			9													
Pt ppb																
Au ppb			7.5													
Th ppm	2.8	(a)									1.6	(b)	2	(f)		
U ppm					0.66	(d)	0.58	(b)					0.62	(f)		

technique: (a) XRF, (b) INAA, (c) RNAA, (d) IDMS, (e) AA, (f) radiation counting



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