69920 - 60 grams
69940 - 428 grams
69960 - 508 grams
Shaded Soils

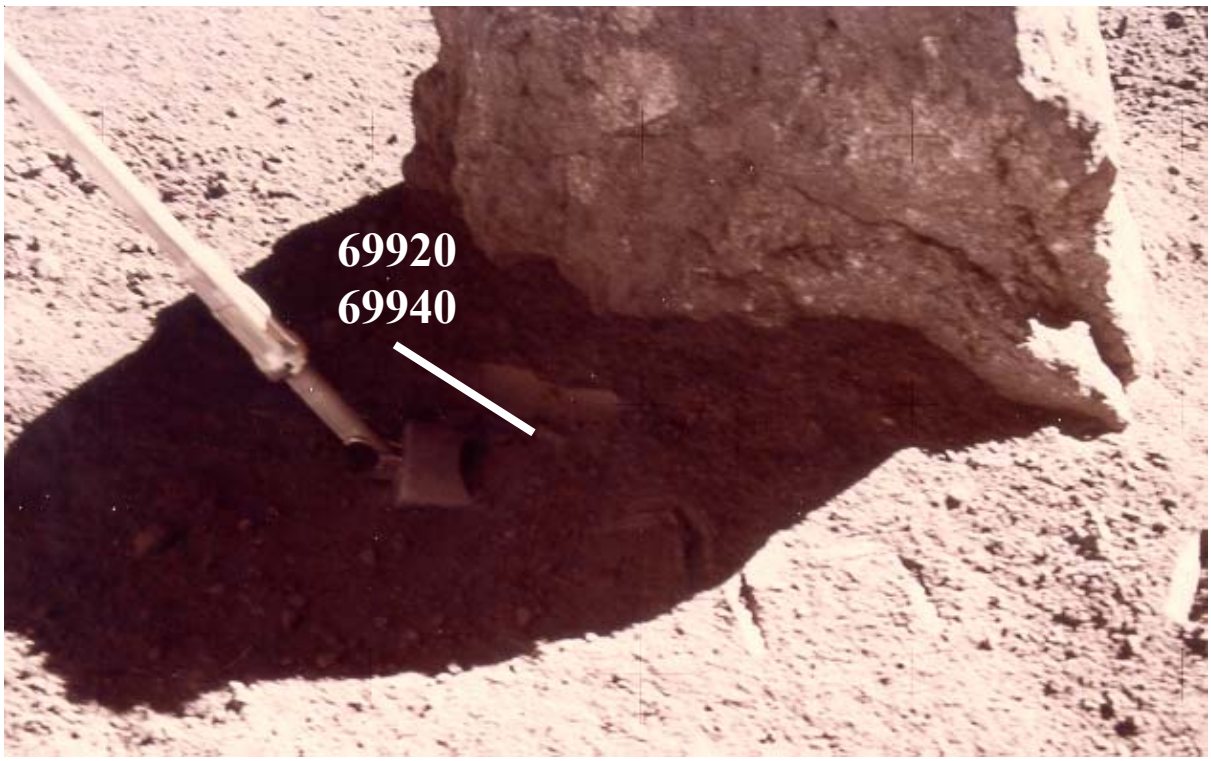


Figure 1: Soil samples collected from shaded area of small (0.5 m) boulder at station 9, Apollo 16. AS16-107-17562. Area may not be permanently shaded at all sun angles. However, 69960 was collected from under the rock, after it was rolled over, and was thus permanently shaded.

LMP We got to get a skim.
CDR Can we skim where the pristine sample was?
CC We'd like a skim next to it.
LMP No, they want it right beside it, right there
CDR You can't see any of that stuff.
LMP Yeah, I can see. Okay here we go. Get me a bag ready.
LMP Tony, I probably got 5 mm on that skim.
CDR That's going in bag 376? (69920)
CDR Okay. Charlie's scoop is being taken right under the –
LMP You got it. Okay, there you go. That's going in bag 377, Houston. (69940)
CC We'd like you to get that CSVC. (69001)
- - - - - -
CC John. Can you turn that over by yourself?
- - - - -
LMP He did it, Houston! He did it.
CC So you can not only sneak up on them, you can flip the over, huh?
CDR Yeah. That's a biggie. Man, it looks like it's been sitting there for quite a while. Look at that soil underneath. Before I stomp all over it, Charlie, sneak over here and let's get some of this soil.
LMP Yeah, okay. Look at that soil! It's all cake looking, isn't it? And it looks just like an alkali flat in the cake that under it, Tony. And that's right from the deepest part. That sample is right in the middle, which happens to be the deepest penetration that the boulder made. There's a sackful. (69960 bag 379)

Introduction

69920 and 69940 were collected from the shade cast by a small boulder (figure 1). 69960 was soil collected from under the boulder after is was rolled over. 69920 was called a "skim soil", because it was collected from the top 1 cm. 69940 was collected beneath 69920. Rock samples 69935 and 69955 are from the top and bottom of the boulder. 69001 is a special core (CSVC) taken nearby (Sutton 1981).

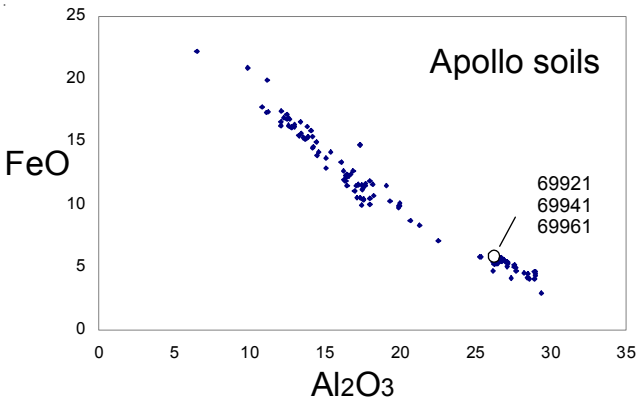


Figure 2: Composition of samples.

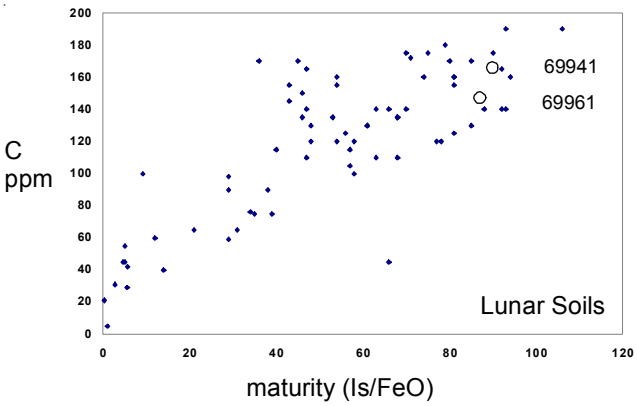


Figure 4: Carbon content and maturity of lunar soils showing Apollo 16 station 9 soils.

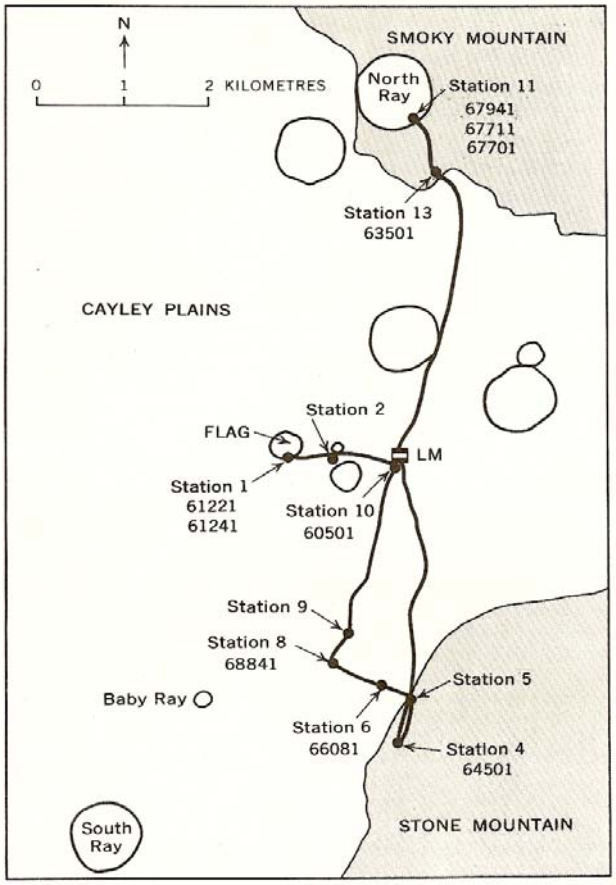
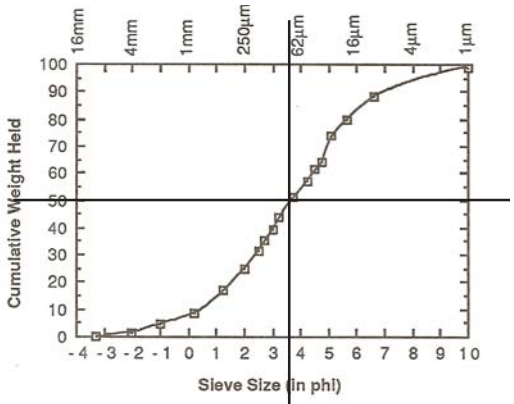


Figure 3: Map of Apollo 16 site with location of 69920 etc.

Petrography

These are very mature soils with about 65 % agglutinates, and high carbon and nitrogen contents (figure 4). The maturity index (Is/FeO) determined for 69921, 69941 and 69961 is 90, 85 and 92, respectively (Morris 1988). The grain size distribution was determined by Butler et al. (1973)(figure 5).

The mineralogy of 69941 is interesting in that several grains of pyroxene and olivine are very Mg-rich (figure



Average grain size = 100 microns

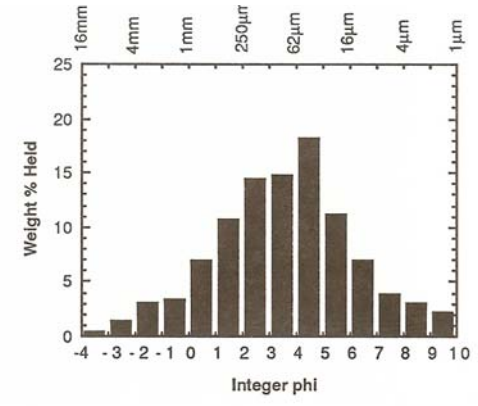


Figure 5a: Grain size distribution for 69941 (Butler et al. 1973).

Mineral Mode 69940 (63-125 microns)

	LSPET 1972
Agglutinates	64%
Basalt	1
Anorthosite	1
Breccias	14
Plagioclase	7
Pyroxene 2	
Glass	10

6). Some plagioclase grains are also very Ca-rich (Taylor and Carter 1973).

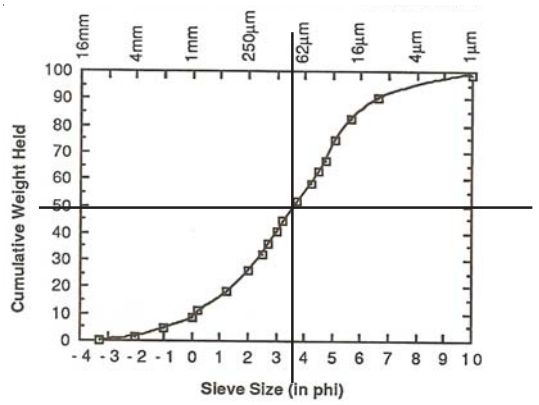
Chemistry

The chemical composition of these three soils is given in the tables herein (figures 2 and 6).

Kothari and Goel (1973) determined 140 ppm nitrogen in both 69941 and 69961. Moore et al. (1973) reported 170 ppm carbon in 69941 and 140 ppm in 69961 (figure 2). Gibson and Moore (1973) reported 765 ppm sulfur in 69941 and 794 ppm sulfur in 69961.

Cosmogenic isotopes and exposure ages

The cosmic-ray-induced activity ^{26}Al = 305 dpm/kg., ^{22}Na = 86 dpm/kg and ^{53}Mn = 630 dpm/kg for skim soil 69921 is quite high (Fructher et al. 1981) – apparently due to erosion off the top of the adjacent boulder (figure 8). The cosmic-ray-induced activity beneath the boulder (66961) is also quite high considering the shielding (Wrigley 1973, Fruchter et al. 1981).



Average grain size = 90 microns

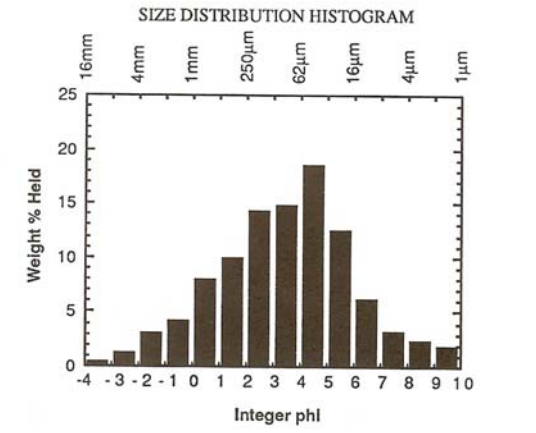


Figure 5b: Grain size distribution for 69961 (Butler et al. 1973).

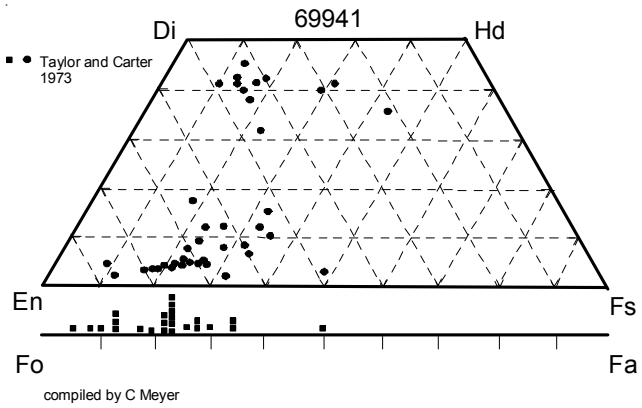


Figure 6: Composition of pyroxene and olivine in 69941 (Taylor and Carter 1973).

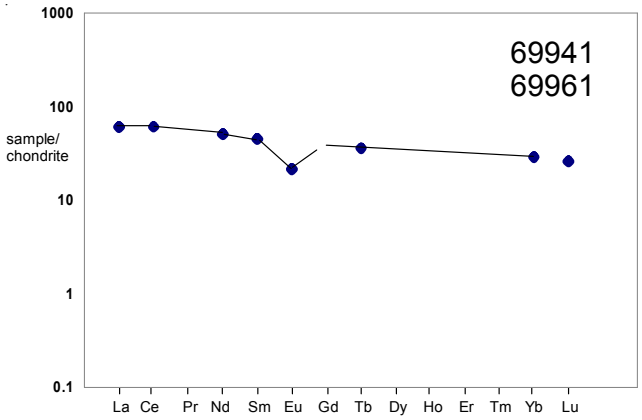


Figure 7: Normalized rare earth element diagram for 699xx soils (Haskin et al.).

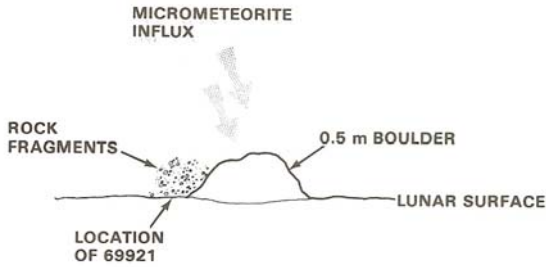


Figure 8: Fruchter's explanation for high 26Al in 69941.

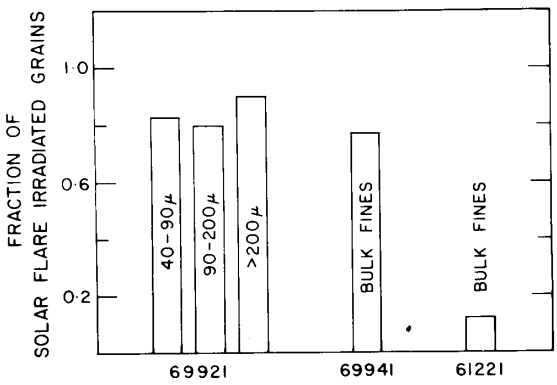
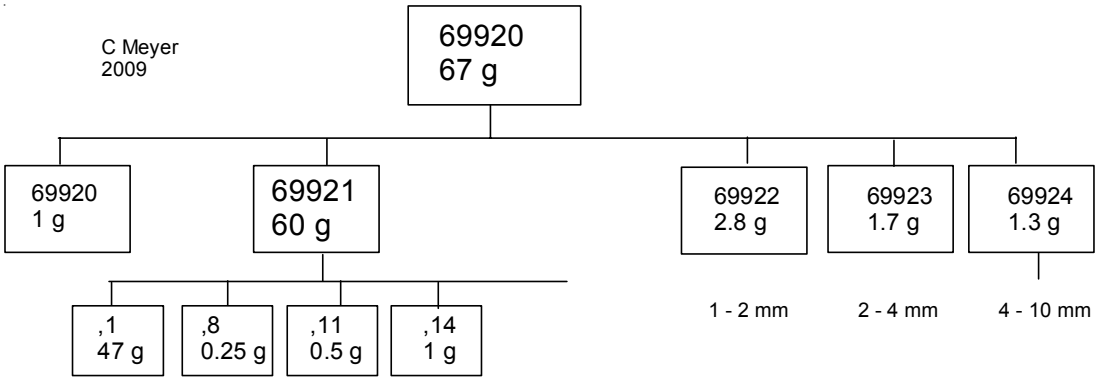
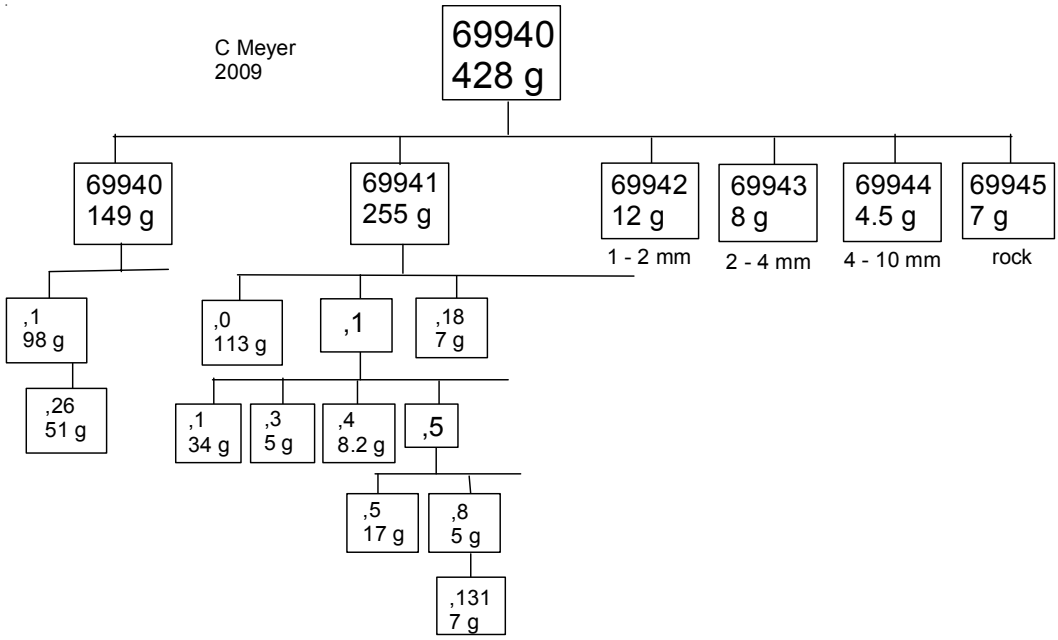


Figure 9: Cosmic ray tracks in 69921 (Rao et al. 1979).


C Meyer
2009
69920
67 g
69920
1 g
69921
60 g
69922
2.8 g
69923
1.7 g
69924
1.3 g
,1
47 g
,8
0.25 g
,11
0.5 g
,14
1 g
1 - 2 mm
2 - 4 mm
4 - 10 mm


C Meyer
2009
69940
428 g
69940
149 g
69941
255 g
69942
12 g
69943
8 g
69944
4.5 g
69945
7 g
1 - 2 mm
2 - 4 mm
4 - 10 mm
rock
,1
98 g
,26
51 g
,0
113 g
,1
,18
7 g
,1
34 g
,3
5 g
,4
8.2 g
,5
,5
17 g
,8
5 g
,131
7 g

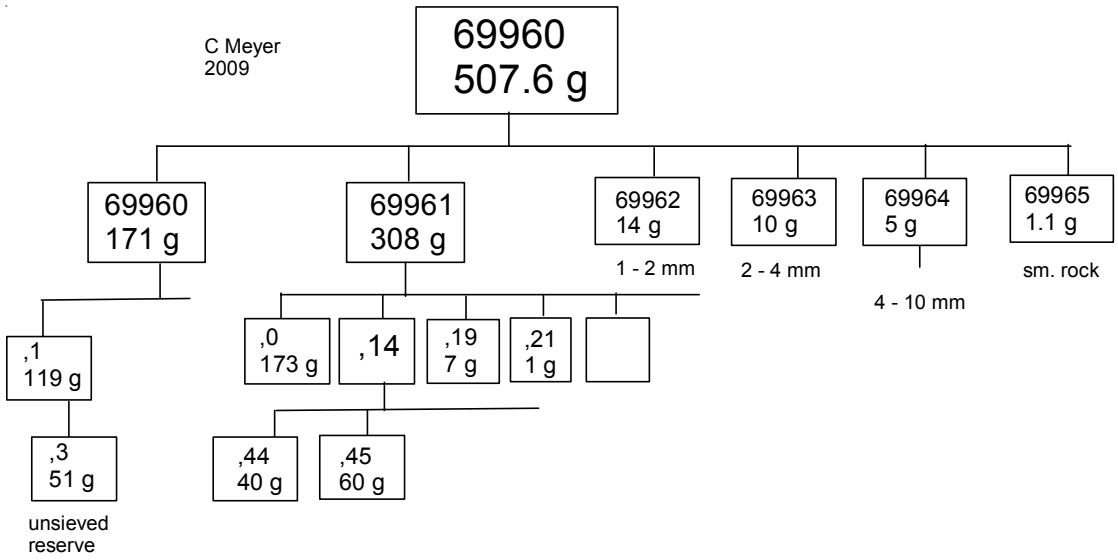

C Meyer
2009
69960
507.6 g
69960
171 g
69961
308 g
69962
14 g
69963
10 g
69964
5 g
69965
1.1 g
1 - 2 mm
2 - 4 mm
4 - 10 mm
sm. rock
,1
119 g
,3
51 g
unsieved
reserve
,0
173 g
,14
,19
7 g
,21
1 g
,44
40 g
,45
60 g

Table 1. Chemical composition of 69921.

reference	Rose73		Laul73			Rancitelli73	
weight							
SiO2 %	45.21	(a)					
TiO2	0.59	(a)	0.64	0.6	(b)		
Al2O3	26.2	(a)	26	26.3	(b)		
FeO	5.54	(a)	5.7	5.6	(b)		
MnO	0.07	(a)	0.07	0.07	(b)		
MgO	6.35	(a)	6.3	6.3	(b)		
CaO	15.35	(a)	14.7	15	(b)		
Na2O	0.53	(a)	0.47	0.46	(b)		
K2O	0.14	(a)	0.11	0.11	(b)	0.12	(c)
P2O5	0.12	(a)					
S %							
sum							
Sc ppm	10	(a)	10	10	(b)		
V	19	(a)	27	25	(b)		
Cr	958	(a)					
Co	21	(a)	30	28	(b)		
Ni	348	(a)	550		(b)		
Cu	10	(a)					
Zn	24	(a)					
Ga	4	(a)					
Ge ppb							
As							
Se							
Rb	3.2	(a)					
Sr	210	(a)					
Y	43	(a)					
Zr	144	(a)	170	170	(b)		
Nb							
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb							
Cd ppb							
In ppb							
Sn ppb							
Sb ppb							
Te ppb							
Cs ppm							
Ba	130	(a)	140	140	(b)		
La			14.2	14.2	(b)		
Ce			36	37	(b)		
Pr							
Nd			27	24	(b)		
Sm			6.6	6.6	(b)		
Eu			1.21	1.23	(b)		
Gd							
Tb			1.2	1.2	(b)		
Dy			7.8	8	(b)		
Ho							
Er							
Tm							
Yb	3.6	(a)	4.7	4.6	(b)		
Lu			0.66	0.63	(b)		
Hf			4.5	4.5	(b)		
Ta			0.56	0.6	(b)		
W ppb							
Re ppb							
Os ppb							
Ir ppb			15		(b)		
Pt ppb							
Au ppb			10		(b)		
Th ppm			2.3	2.3	(b)	2.47	(c)
U ppm			0.66	0.7	(b)	0.67	(c)

technique: (a) various, (b) INAA, (c) radiation counting

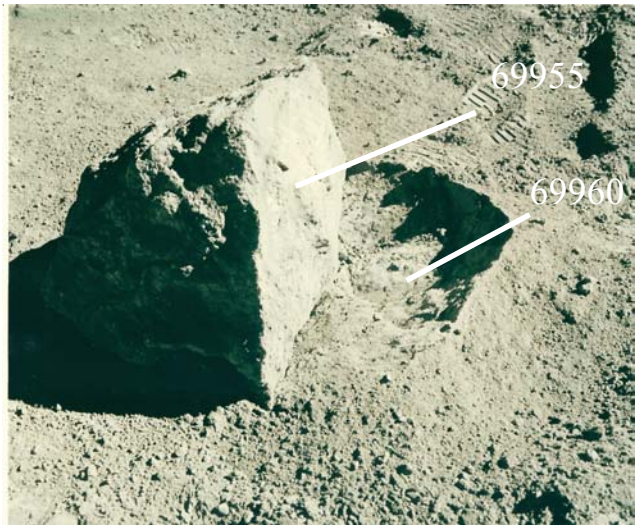


Figure 10: Bottom side of boulder after tipping over. AS16-107-17573.

Other Studies

Behrmann et al. (1973), Rao et al. (1979), Venkatesan et al. (1980) and Nautiyal et al. (1981) studied the SCR tracks and noble gases in 69921 and 69941 (figures 9 and 11).

Kirsten et al. (1973), Behrmann et al. (1973) and Walton et al. (1973) each reported rare gas contents. Becker et al. (1975, 1976, 1980) and Kerridge et al. (1975) studied the isotopic ratios of nitrogen and other elements.

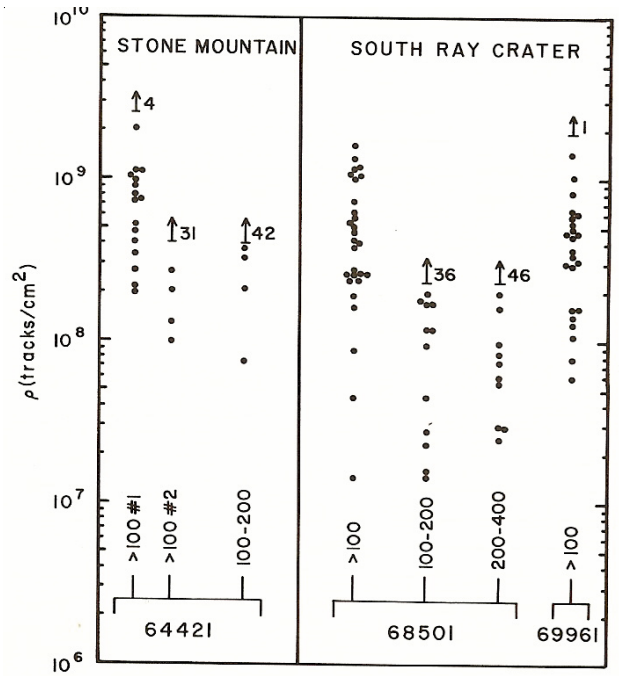


Figure 11. Density of nuclear tracks in Apollo 16 soils (Behrmann et al. 1973).

Table 2. Chemical composition of 69941.

reference	Haskin74		Rose73		Laul73		Rancitelli73		Korotev91	
weight										
SiO2 %	46.3	(a)	44.67	(c)						
TiO2	0.73	(a)	0.63	(c)	0.6	(b)				
Al2O3	24.2	(a)	26.3	(c)	26.4	(b)				
FeO	5.41	(a)	5.76	(c)	5.7	(b)			5.52	(b)
MnO	0.075	(a)	0.07	(c)	0.068	(b)				
MgO	6.11	(a)	6.35	(c)	6.4	(b)				
CaO	14.2	(a)	15.57	(c)	15.4	(b)			15.4	(b)
Na2O	0.47	(a)	0.42	(c)	0.47	(b)			0.45	(b)
K2O	0.118	(a)	0.14	(c)	0.11	(b)	0.14	(d)		
P2O5			0.12	(c)						
S %										
sum										
Sc ppm	10	(b)	12.7		10	(b)			9.94	(b)
V			31		26	(b)				
Cr			890		739	(b)			802	(b)
Co	32.1	(b)	34		29	(b)			26.3	(b)
Ni	470	(b)	545		460	(b)			382	(b)
Cu			8.3							
Zn	32	(b)	27							
Ga	4.5	(b)	3.3							
Ge ppb										
As										
Se										
Rb	2.9	(b)	3.4							
Sr			120						164	(b)
Y			58							
Zr			218		140	(b)			177	(b)
Nb			14							
Mo										
Ru										
Rh										
Pd ppb										
Ag ppb										
Cd ppb										
In ppb										
Sn ppb										
Sb ppb										
Te ppb										
Cs ppm	0.14	(b)							0.16	(b)
Ba			140		130				158	(b)
La	14.2	(b)			14				14.3	(b)
Ce	37	(b)			34				36.9	(b)
Pr										
Nd	24	(b)			25				23	(b)
Sm	6.8	(b)			6.2				6.66	(b)
Eu	1.28	(b)			1.21				1.21	(b)
Gd	8.3	(b)								
Tb	1.41	(b)			1.2				1.3	(b)
Dy	9	(b)			7.8					
Ho										
Er										
Tm										
Yb	4.81	(b)	3.9		4.7				4.68	(b)
Lu	0.68	(b)			0.66				0.633	(b)
Hf	5.3	(b)			4.5				4.87	(b)
Ta					0.59				0.574	(b)
W ppb										
Re ppb										
Os ppb										
Ir ppb					13	(b)			11.4	(b)
Pt ppb										
Au ppb					9				6.8	(b)
Th ppm					2.2		2.44	(d)	2.42	(b)
U ppm					0.67		0.6	(d)	0.65	(b)

technique: (a) AA, (b) INAA, (c) various, (d) radiation counting

Table 3. Chemical composition of 69961.

reference	Laul73		Rose73		Rancitelli73	
weight						
SiO2 %			44.76	(a)		
TiO2	0.61	(b)	0.6	(a)		
Al2O3	26.2	(b)	26.35	(a)		
FeO	5.7	(b)	5.76	(a)		
MnO	0.068	(b)	0.07	(a)		
MgO	6.4	(b)	6.33	(a)		
CaO	14.5	(b)	15.55	(a)		
Na2O	0.47	(b)	0.41	(a)		
K2O	0.11	(b)	0.14	(a)	0.14	(d)
P2O5			0.12	(a)		
S %						
sum						
Sc ppm	10	(b)	11.8	(a)		
V	22	(b)	29	(a)		
Cr	732	(b)	890	(a)		
Co	30	(b)	47	(a)		
Ni	460	(b)	600	(a)		
Cu			8.7	(a)		
Zn			31	(a)		
Ga			3.2	(a)		
Ge ppb						
As						
Se						
Rb			2.9	(a)		
Sr			135	(a)		
Y			52	(a)		
Zr	160	(b)	229	(a)		
Nb			13	(a)		
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb						
In ppb						
Sn ppb						
Sb ppb						
Te ppb						
Cs ppm						
Ba	140	(b)	140	(a)		
La	14.1	(b)				
Ce	34	(b)				
Pr						
Nd	22	(b)				
Sm	6.4	(b)				
Eu	1.22	(b)				
Gd						
Tb	1.2	(b)				
Dy	7.6	(b)				
Ho						
Er						
Tm						
Yb	4.7	(b)	3.7	(a)		
Lu	0.64	(b)				
Hf	4.5	(b)				
Ta	0.59	(b)				
W ppb						
Re ppb						
Os ppb						
Ir ppb	15	(b)				
Pt ppb						
Au ppb	9	(b)				
Th ppm	2.2	(b)			2.47	(d)
U ppm	0.64	(b)			0.61	(d)

technique: (a) AA, (b) INAA, (c) various, (d) radiation counting

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