14163
Bulk Soil Sample
7,776 grams

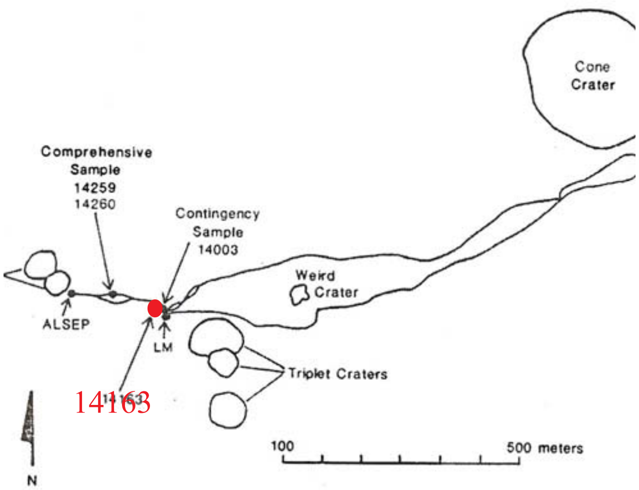


Figure 1a: Map of Apollo 14

Figure 1b: Sieving soil sample in SNAP.

Modal content of soils 14163.
From Simon et al. 1981

Agglutinates	45.7 %
Basalt	2.8
Breccia	31
Anorthosite	2.9
Norite	
Gabbro	
Plagioclase	5.1
Pyroxene	2.6
Olivine	
Ilmenite	
Glass other	10

Introduction
At the end of the first EVA on Apollo 14, a large soil sample was collected from the area near the LM. The area, about 15 meters from the LM, was apparently free of rock fragments (see Graf 1993), and not many were sieved from the large soil collected. The transcript indicates that the bulk soil sample was scooped from a small (2 foot) crater with glass in the bottom, possibly secondary in origin. 14163 should be compared with 14259, which is more of a surface sample.

Twenty nine small rock samples from this soil were numbered 14425 to 14453. Reserve soil 14421 (<1 cm) and 14422 and 14423 were also from this bag. *Note: It seems odd, that out of all this soil, only a few rock chips were collected.*

Petrography
14163 was chosen as one of the reference soils for the lunar highlands suite (Labotka et al. 1980). The maturity index for 14163 (I_s/FeO = 57, submature) was reported by Morris (1978) and the soil contained about 46 % agglutinates. King et al. (1972), McKay et al. (1972) and others determined the grain size distribution (figure 1).

Carr and Meyer (1972) and Simon et al. (1981) determined the petrographic mode, finding a very high percentage of glass (figure 4). Much of this is agglutinate glass but Papike et al. (1982) note that some of the glass has the composition of mare basalt (an exotic component at the A14 site). There is also a small percentage of "granitic" glass.

Modal content of soils 14163.
From Carr and Meyer (1972)

Glass		61.1 %
	Dark cloudy	41
	Homogeneous	20.1
Breccia		27.9
	Light matrix	17.9
	Dark matrix	10
Minerals		9.6
	Plagioclase	5.1
	Pyroxene	4.1
	Olivine	0.4

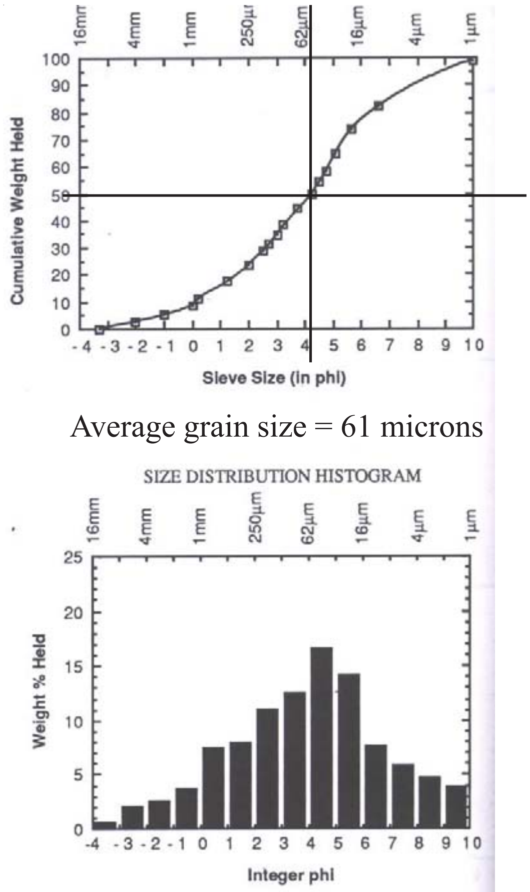


Figure 2a: Grain size distribution for soil 14163 (from Graf 1993, data from King).

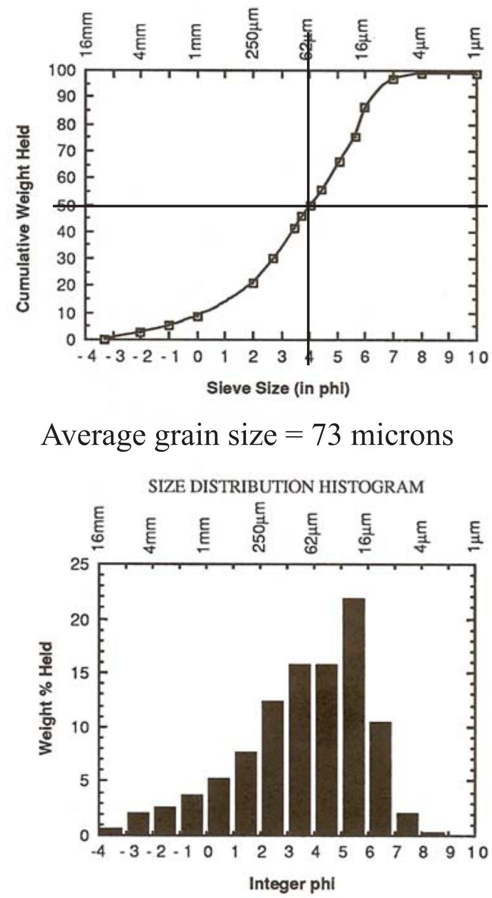


Figure 2b: Grain size distribution for soil 14163 (from Graf 1993, data from McKay).

A glass sphere (14425) was found in the particles from 14163 and was allocated to John O'Keefe. Kramer and Twedell (1977) sorted and described a portion of the coarse fine particles (14160) and also found a high percentage of agglutinates (Table 3). McKay et al. (1979) studied three breccias from 14160, while Hubbard et al. (1972), Taylor et al. (1972) and Powell and Weiblen (1972) reported on other fragments from this large soil sample. Brad Jolliff (1991) studied three crystalline coarse-fines of granitic composition from 14161 (Table 4).

Finkelman (1973) and Devine et al. (1982) studied the finest fraction, concluding that compositional differences are related to comminution of local components. Walker and Papike (1981) determined the composition and considered the origin of agglutinates in 14163, which fuse

Papike et al. (1982) summarized the mineral compositions in 14163 (figure 3). They found that the minerals in the soil were mostly derived from the Fra Mauro breccias and/or KREEP basalt.

Chemistry

Taylor et al. (1972), Laul et al. (1972), Lindstrom et al. (1972), Rose et al. (1972), Hubbard (1972), Wanke et al. (1972), Masuda et al. (1972), Laul and Papike (1980), Morgan et al. (1972), Baedecker et al. (1972), Willis et al. (1972), Brunfelt et al. (1972), Helmke et al. (1972), Philpotts et al. (1972), Quaide and Wrigley (1972) and Keith et al. (1972) all analyzed 14163 (table 1, figures 5 and 6).

Laul and Papike (1980) and Papike et al. (1982) calculate the relative proportion of rock types present in 14163 using a chemical mixing model (55-67% high-K KREEP, 6-15% exotic mare basalt and the rest low-K Fra Mauro basalt).

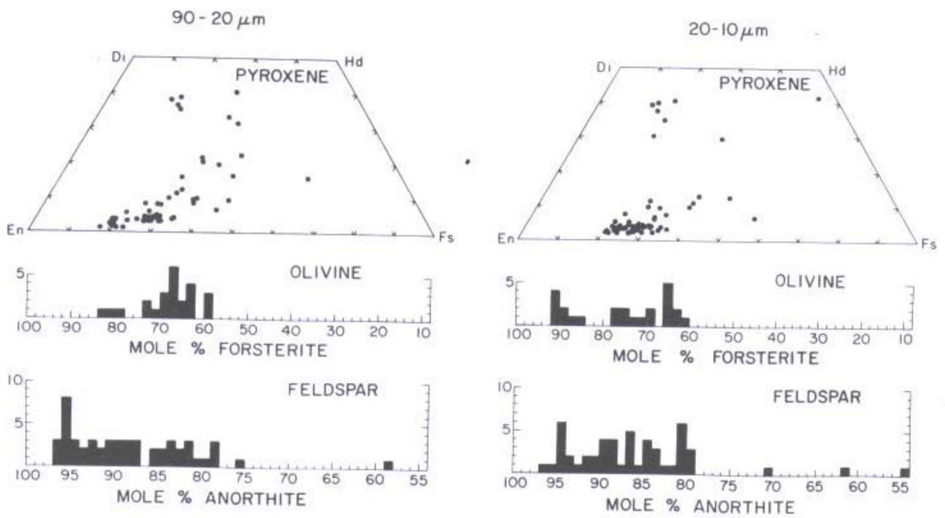


Figure 3: Labotka et al. (1980) and Papike et al. (1982) summarized the mineral compositions in 14163.

Moore et al. (1972) and Cadogen et al. (1972) reported 120 ppm carbon (figure 7). Goel and Kothari (1972) determined nitrogen = 80 ppm.

CC Rodger. If you take an additional weigh bag, and put material from the immediate vicinity of the LM into it to fill up the SRC, we request that you drop a documented sample bag in it as a tag (1 N).
CDR Okay, I guess we've got a little room to do that. I put the foot-ball-sized rocks in the STB.
- - - - -
LMP Why don't you let me help you with the – let's take the shovel, Al; it'll be faster.
CDR All right.
LMP Trenching tool.
CDR Want to hold the bag?
LPM Yes.
CDR Let's hit the little crater out there. It looks like a secondary.
LMP Let's go get it.
CDR Right out here.
LMP I saw a little crater about this size out here that I'd swear had glass in the bottom of it, but I was too busy thumping to stop and make any comment on it.
- - -
CDR There's a little different colored layer at the bottom of it there.
*LMP Yes. Scoop it out. ****
CDR See, there's a different color there, maybe. Okay how does that look to you?
LMP I can take another shovelful.
CDR Okay. Houston, that's in a small crater, looks like it might be a secondary impact, just hazarding a guess; it's about 2 feet in diameter, and it's about 130 feet from the LM.

Cosmogenic isotopes and exposure ages

Keith et al. (1972) determined the cosmic-ray-induced activity of ^{22}Na = 46 dpm/kg., ^{26}Al = 79 dpm/kg, ^{46}Sc = 0.7 dpm/kg., ^{54}Mn = 4 dpm/kg and ^{56}Co = 21 dpm/kg. for 14163. Begemann et al. (1972) obtained ^{26}Al = 86 dpm/kg. and ^{36}Cl = 25 dpm/kg. Quaide and Wrigley (1972) determined ^{22}Na = 71 dpm/kg and ^{26}Al = 88 dpm/kg.

Particles from 14161 and 14160 have long exposure ages (Kirsten et al. 1972; Lugmair and Marti 1972).

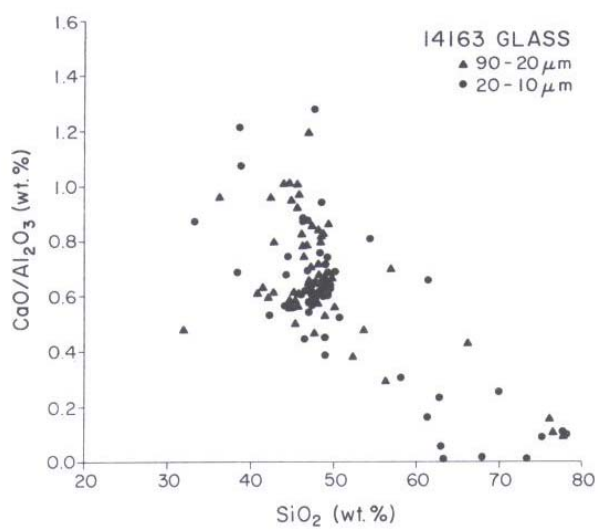


Figure 4: Labotka et al. (1980) determined glass composition in 14163.

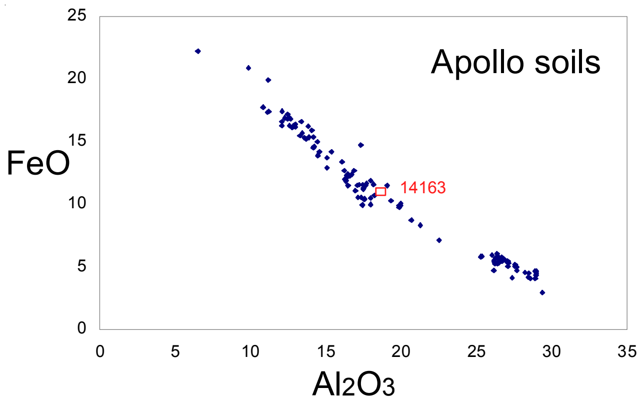


Figure 5: Composition of lunar soils with 14163.

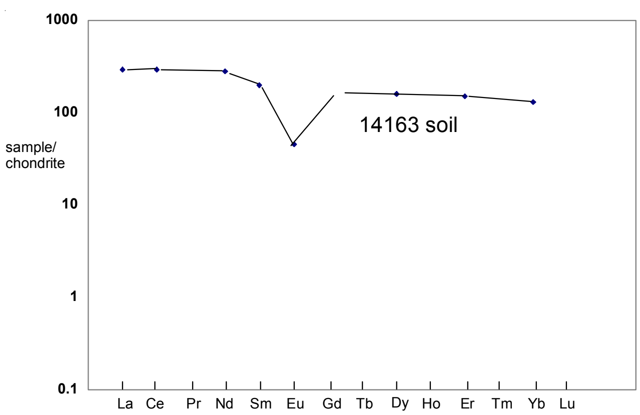


Figure 6: Normalized rare-earth-element diagram for 14163 (data by isotope dilution mass spectrometry, Hubbard et al 1972).

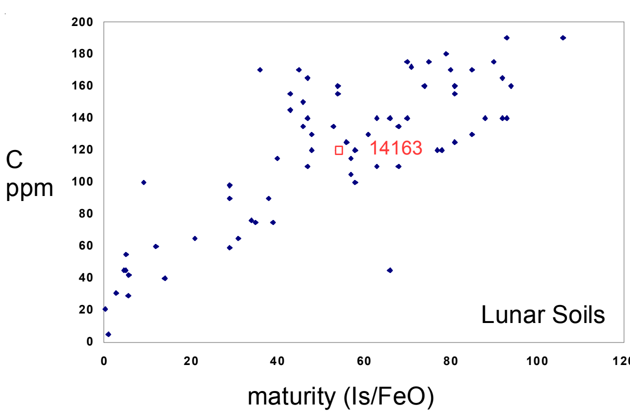


Figure 7: Maturity and carbon content of lunar soils with 14163.

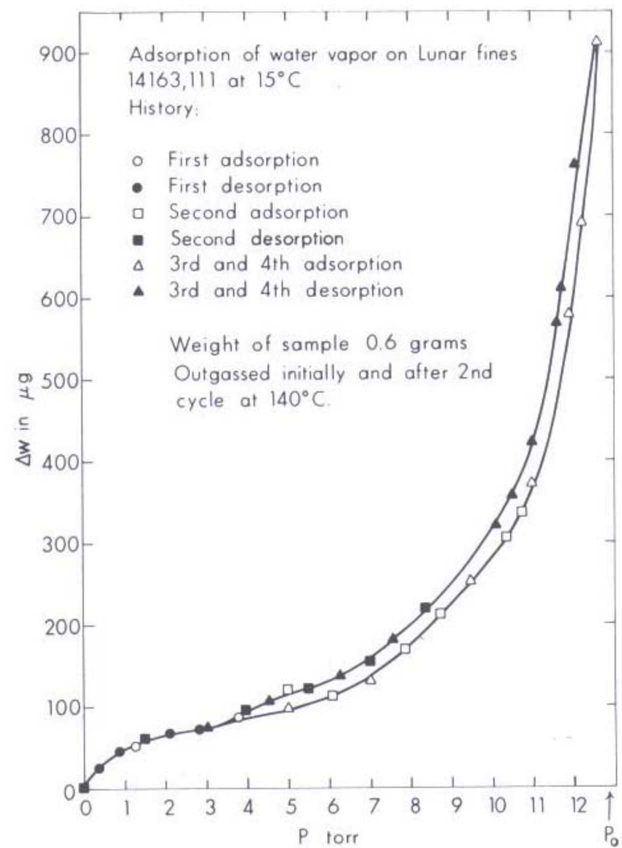


Figure 8: Adsorption isotherm for 14163 (Cadenhead et al. 1972).

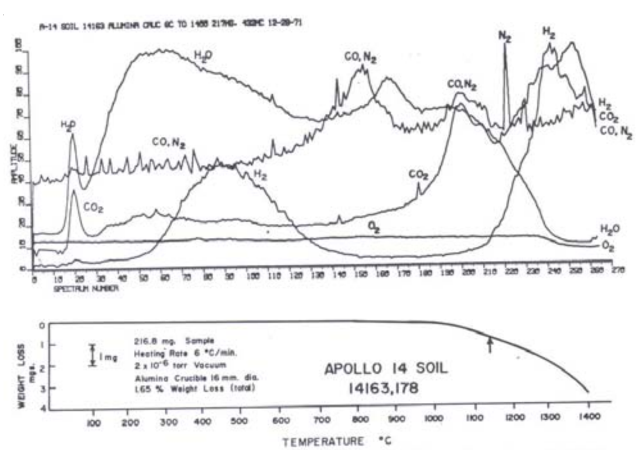


Figure 9: Evolution of gasses from 14163 as function of temperature (from Gibson and Moore 1972).

Other Studies

A very large number of highly imaginative studies have been performed on this soil; only a few are mentioned here. See also sections on 14259, 14149, 14003 etc.

Gibson and Moore (1972) determined the gas release profile (figure 9).

Cadenhead et al. (1972) studied the adsorption of water (figure 8).

Heymann et al. (1972), Bogard and Nyquist (1972) and Baur et al. (1972) reported rare gas data..

Tatsumoto et al. (1972) studied the U, Th and Pb systematics.

Table 1a. Chemical composition of 14163.

reference	Laul72		Laul80		Lindstrom72		Rose72		Hubbard72		Wanke72		Taylor72		Masuda72		Keith72	
weight			Papike82						Weismanm75						Strasheim72			
SiO2 %			47.3				47.97	(c)			48.35	(d)	48.1	(e)	47.3	(d)		
TiO2	1.9	(a)	1.6	(a)			1.77	(c)			1.46	(d)	1.83	(e)	1.84	(d)		
Al2O3	18.4	(a)	17.8	(a)			17.57	(c)			18.1	(d)	17.6	(e)	17.1	(d)		
FeO	10.4	(a)	10.5	(a)	10.7	(a)	10.41	(c)			10.4	(d)	10.3	(e)	10.15	(d)		
MnO	0.124	(a)	0.135	(a)			0.14	(c)			0.13	(d)	0.18	(e)	0.127	(d)		
MgO			9.6	(a)			9.18	(c)			9.28	(d)	9.78	(e)	9	(d)		
CaO	11	(a)	11.4	(a)			11.15	(c)			10.2	(d)	10.4	(e)	10.65	(d)		
Na2O	0.711	(a)	0.7	(a)	0.75	(a)	0.7	(c)	0.77	(b)	0.67	(d)	0.62	(e)	0.65	(d)		
K2O	0.52	(a)	0.55	(a)	0.52	(a)	0.58	(c)	0.58	(b)	0.53	(d)	0.52	(e)	0.53	(d)	0.57	(g)
P2O5							0.52	(c)							0.5	(d)		
S %																		
sum																		
Sc ppm	21	(a)	21.7	(a)	21.4	(a)	25	(c)			22.8	(a, h)	21	(f)				
V	57	(a)	45	(a)			57	(c)					49	(f)	42	(d)		
Cr			1368	(a)	1280	(a)	1780	(c)			1290	(a, h)	1400	(f)				
Co	38	(a)	33	(a)	36	(a)	36	(c)			43	(a, h)	34	(f)	33	(d)		
Ni			350	(a)			400	(c)			400	(a, h)	340	(f)	279	(d)		
Cu							17	(c)			15.6	(a, h)	8	(f)	14	(d)		
Zn							28	(c)							43	(d)		
Ga							5.5	(c)			8.3	(a, h)	4.5	(f)				
Ge ppb																		
As											0.087	(a, h)						
Se																		
Rb							13	(c)	15.3	(b)	23	(a, h)	13	(f)	12	(d)		
Sr			170	(a)			140	(c)	186	(b)	180	(a, h)	180	(f)	235	(d)		
Y	204	(a)					290	(c)					190	(f)	235	(d)		
Zr	900	(a)			720	(a)	820	(c)					850	(f)	766	(d)		
Nb							70	(c)					46	(f)	62	(d)		
Mo																		
Ru																		
Rh																		
Pd ppb											28	(a, h)						
Ag ppb																		
Cd ppb																		
In ppb											1010	(a, h)						
Sn ppb																		
Sb ppb																		
Te ppb																		
Cs ppm					0.78	(a)					0.74	(a, h)	0.7	(f)				
Ba	730	(a)	800	(a)	950	(a)	1100		926	(b)	775	(a, h)	710	(f)	1065	(d)		
La	68	(a)	66.7	(a)	67.3	(a)	79		68.2	(b)	68	(a, h)	64	(f)	66.6	(b)		
Ce	200	(a)	170	(a)	194	(a)			176	(b)	180	(a, h)	200	(f)	178	(b)		
Pr	24.4	(a)									22	(a, h)	26	(f)				
Nd	103	(a)	100	(a)	100	(a)			103	(b)	130	(a, h)	102	(f)	106	(b)		
Sm	32.2	(a)	29.1	(a)	29.6	(a)			29	(b)	28	(a, h)	29	(f)	30.2	(b)		
Eu	2.78	(a)	2.45	(a)	2.75	(a)			2.54	(b)	2.45	(a, h)	2.25	(f)	2.655	(b)		
Gd	37	(a)									35	(a, h)	33	(f)	34.78	(b)		
Tb	6.4	(a)	5.9	(a)	7.1	(a)					6.6	(a, h)	5	(f)				
Dy	41	(a)	36	(a)					38.3	(b)	40	(a, h)	32	(f)	40.6	(b)		
Ho	10.2	(a)	8.6	(a)							6.6	(a, h)	8	(f)				
Er	24.5	(a)							23.8	(b)	28	(a, h)	23	(f)	24.23	(b)		
Tm	4.1	(a)	3.2	(a)									3.5	(f)				
Yb	24	(a)	21.2	(a)	22	(a)	28		20.9	(b)	23.5	(a, h)	18.5	(f)	21.93	(b)		
Lu	3.6	(a)	3	(a)	3.21	(a)					2.7	(a, h)			3.17	(b)		
Hf	20	(a)	22.5	(a)	25.3	(a)					23	(a, h)	19.5	(f)				
Ta			2.9	(a)	4.3	(a)					3.2	(a, h)						
W ppb											1950	(a, h)	700	(f)				
Re ppb																		
Os ppb																		
Ir ppb											19							
Pt ppb																		
Au ppb											6.1	(a, h)						
Th ppm	13	(a)	13.3	(a)	15.2	(a)					15.9	(a, h)	12	(f)			13.7	(g)
U ppm			3.5	(a)							4.07	(a, h)	3.2	(f)			3.9	(g)

technique: (a) INAA, (b) IDMS, (c) microchemical, (d) various, (e) XRF, (f) spark-source mass spec., (g) radiation counting

Table 1b. Chemical composition of 14163 (cont.)

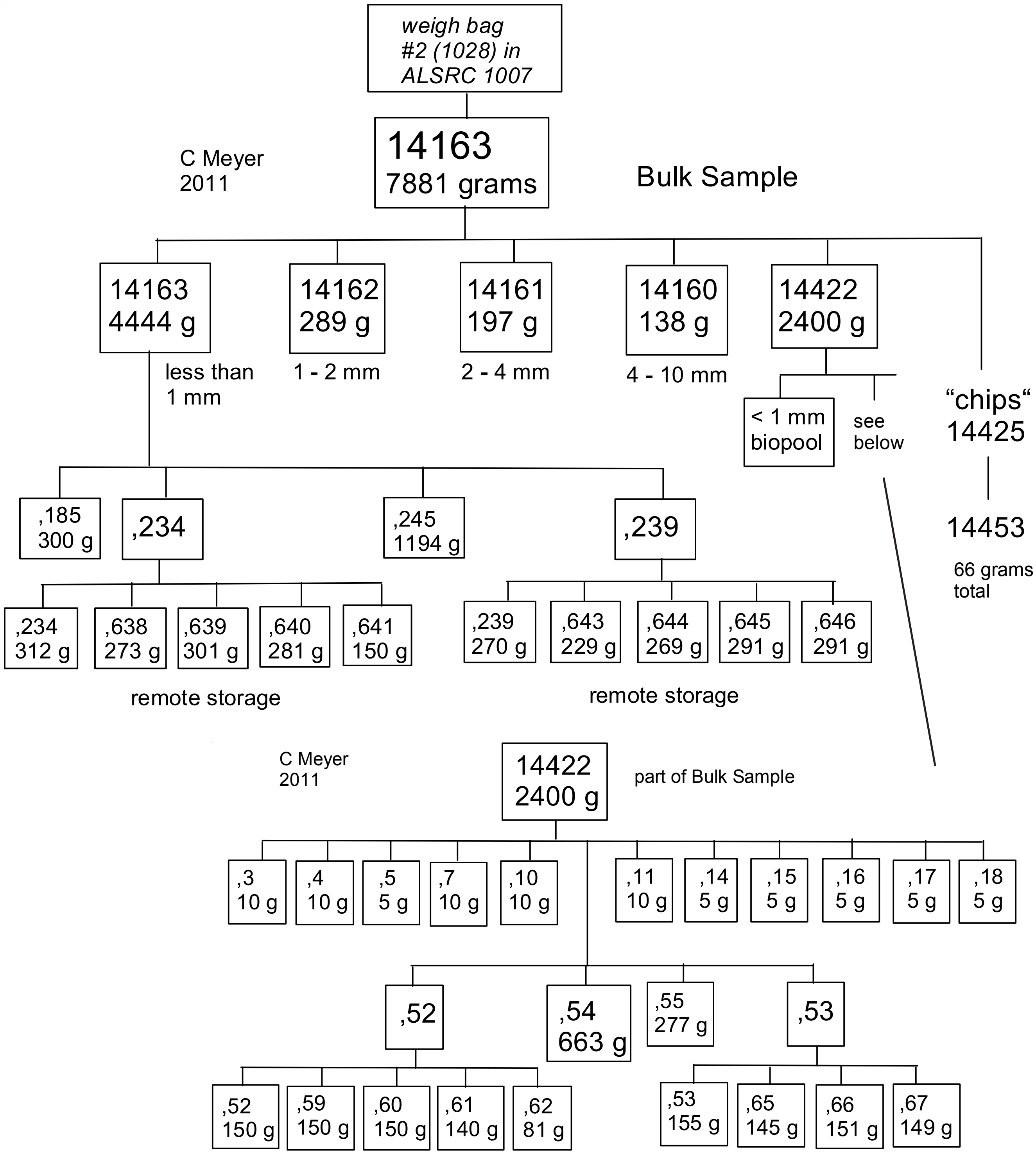
reference	Morgan72			Baedecker72		Willis72		Hubbard72		Brunfelt72			Helmke72		Philpotts72		Quaide72	
weight				Wasson73						regolith	fines				14421			
SiO2 %						47.25	(e)	47.2	(e)									
TiO2						1.79	(e)	1.79	(e)	1.5	1.85	(a)						
Al2O3						17.34	(e)	17.2	(e)	17.2	18.1	(a)						
FeO						10.32	(e)	10.4	(e)	10.4	10.5	(a)						
MnO						0.137	(e)	0.14	(e)	0.13	0.13	(a)						
MgO						9.36	(e)	9.37	(e)	9.1	11.1	(a)						
CaO						10.97	(e)	11	(e)	10	10.2	(a)						
Na2O						0.66	(e)	0.66	(e)	0.73	0.74	(a)						
K2O						0.56	(e)	0.58	(e)	0.49	0.4	(a)					0.57	(i)
P2O5						0.49	(e)	0.46	(e)									
S %						0.1	(e)	0.08	(e)									
sum																		
Sc ppm										21	20.5	(a)	20.5					
V										48	45	(a)						
Cr						1684	(e)	1505	(e)	1370	1430	(a)	1570	(a)				
Co										34	34.7	(a)	27	(a)				
Ni				359	(h)			322	(e)				331	(a)				
Cu										10.4	13.4	(a)						
Zn	31	31	(h)	37	(h)					33	40	(a)	34	(a)				
Ga				8.4	(h)					7.7	8.2	(a)	7.5	(a)				
Ge ppb				670	(h)													
As										20	100	(a)						
Se										290		(a)						
Rb	15.8	16.1	(h)			16	(e)	15	(e)	16	13	(a)			13.9	(b)		
Sr						177	(e)	186	(e)	185	170	(a)			180	(b)		
Y						209	(e)	213	(e)									
Zr						1022	(e)	978	(e)						858	(b)		
Nb						63.4	(e)	65	(e)									
Mo																		
Ru																		
Rh																		
Pd ppb										110	100	(a)						
Ag ppb	16.6	18.4	(h)															
Cd ppb	140	139	(h)	192	(h)													
In ppb				120	(h)													
Sn ppb																		
Sb ppb		5.7	(h)							3	10	(a)						
Te ppb	70	30	(h)															
Cs ppm	0.645	0.73	(h)							0.68	0.57	(a)						
Ba						855	(e)			748	740	(a)			806	(b)		
La										67	61	(a)	70.4	(a)				
Ce										203		(a)	157	(a)	170	(b)		
Pr											26	(a)						
Nd													101	(a)	105	(b)		
Sm										30	27.3	(a)	30.8	(a)	29.7	(b)		
Eu										2.5	2.8	(a)	2.57	(a)	2.68	(b)		
Gd													36	(a)				
Tb										6.3	5.8	(a)	6.4	(a)				
Dy											33.5	(a)	44.8	(a)	38.8	(b)		
Ho											8.2	(a)	8.6	(a)				
Er											17.3	(a)	25	(a)	23	(b)		
Tm																		
Yb										21	15	(a)	24.6	(a)	21.7	(b)		
Lu										3.1		(a)	3.16	(a)	3.27	(b)		
Hf										19	20.6	(a)	22	(a)	20.9	(b)		
Ta										2.7	2.9	(a)						
W ppb										1800	1400	(a)						
Re ppb	0.93	1.07	(h)															
Os ppb																		
Ir ppb	13.6	11.7	(h)	9.1	(h)													
Pt ppb																		
Au ppb	5.4	5.3	(h)								2.3	(a)						
Th ppm								13	(e)	11.3	10.6	(a)					13.2	(i)
U ppm										3.4	3.4	(a)					3.75	(i)

technique: (h) RNAA, (e) XRF, (a) INAA, (b) IDMS, (i) radiation counting

Table 2. Chemical composition of some coarse-fines from 14163.

	14160	14160,79	14160		14161,35 breccias						14161 anor.		14163		
reference	McKay 79				Hubbard 72						Hubbard71		Brunfelt72		
weight					Weismann76						Weismann76		light rx.	dark rx.	
SiO2 %	48.3	47.8	47.6												
TiO2	2.1	1.66	1.99		1.83	1.57	1.97	1.62	1.6	(a)			1.2	1.4	(a)
Al2O3	16	16.2	15.4										19.3	16.8	(a)
FeO	10	10.2	10.5										8.5	10.2	(a)
MnO	0.12	0.14	0.12										0.11	0.13	(a)
MgO	10.1	10.7	11.6		12.4	11.3	9.8	12.2	11.4	(a)	3.6	(a)	9.7	12.2	(a)
CaO	10.1	10.3	9.67		9.1	9.8	10.1	8.7	9.4	(a)	17.8	(a)	12	10.1	(a)
Na2O					0.81	0.78		0.73	0.75	(a)	0.39	(a)	0.81	0.76	(a)
K2O	0.81	0.62	0.7		0.57	0.28	0.62	0.57	0.68	(a)	0.018	(a)			
P2O5															
S %															
sum															
Sc ppm													16.5	19.7	(a)
V													18	38	(a)
Cr	1163	1300	1300						2095	(a)			1160	1470	(a)
Co													19.8	24.6	(a)
Ni													220	230	(a)
Cu															
Zn															
Ga															
Ge ppb															
As															
Se															
Rb	(a)	16.3	18.4	(a)	12.9	3.34	15.4	14.7	16.9	(a)	0.32	(a)	18	15	(a)
Sr	187	182	178	(a)	171	180	197	170	182	(a)	163	(a)			
Y															
Zr															
Nb															
Mo															
Ru															
Rh															
Pd ppb															
Ag ppb															
Cd ppb															
In ppb															
Sn ppb															
Sb ppb															
Te ppb															
Cs ppm															
Ba	1039	850	976	(a)	1022	775	811	817	916	(a)	16	(a)	647	753	(a)
La	109	77.2	81.5	(a)	55.6								64	81	(a)
Ce	276	196	208	(a)	252	205	266	165	212	(a)	3.33	(a)	189	214	(a)
Pr															
Nd	171	119	126	(a)	149	122	158	106	132	(a)	1.87	(a)			
Sm	48	33.6	35.4	(a)	42.8	34.4	44.3	29.7	38.7	(a)	0.49	(a)	30	37.3	(a)
Eu	2.98	2.74	2.75	(a)	2.76	2.74	3.04	2.49	2.76	(a)	0.756	(a)	2.8	2.8	(a)
Gd	55	38.9	41.5	(a)	49.1	43		34.9	43.6	(a)					
Tb													5.8	7.1	(a)
Dy	60.5	44.1	46.8	(a)	55.8	45.6	56.8	40.3	49.3	(a)			33.4	41.5	(a)
Ho															
Er	35.2	26.3	28.4	(a)		31.2		24.6		(a)	0.34	(a)			
Tm											0.37	(a)			
Yb	29.6	23.2	25.1	(a)		26.1	37.6	23.4	27.4	(a)			19	25	(a)
Lu	4.12	3.35	3.58	(a)											
Hf													23.3		(a)
Ta													2.7	3.6	(a)
W ppb															
Re ppb															
Os ppb															
Ir ppb															
Pt ppb															
Au ppb															
Th ppm													10.9	13.6	(a)
U ppm					5.03	4.08	4.71	3.92	4.61	(a)	0.058	(a)	4	4.4	(a)

technique: (a) IDMS



Crozaz et al. (1972), Bhandari et al. (1972) and Berdot et al. (1972) reported the density of nuclear and cosmic-ray tracks (less than for 14259).

Processing

The bulk soil was placed in weight bag #2 (number 1028), which was returned in D-ALSRC#1007 (it was processed in N_2 atmosphere). The processing of sample 14163/14422 was not well documented (figure 1b). A portion of 14422 (285 g) was used as the “biopool sample” for the purpose of quarantine. Other portions were set aside as “organic reserves”.

Table 2: Small rocks from 14422 - -

	wt. grams	type
14425	0.79	glass sphere
14426	1.59	breccia
14427	4.47	breccia
14428	1.47	CMB
14429	3.03	CMB
14430	4.81	breccia
14431	1.7	melt rock
14432	1.81	
14433	1.23	breccia
14434	1.68	CMB
14435	0.92	CMB
14436	3.76	basalt
14437	2.65	breccia
14438	2.35	breccia
14439	1	breccia
14440	1.5	basalt
14441	1.23	breccia
14442	3.52	breccia
14443	2.54	basalt
14444	1.56	basalt
14445	9.22	breccia
14446	0.82	basalt
14447	0.91	breccia
14448	1.06	breccia
14449	1.7	breccia
14450	1.27	breccia
14451	2.1	basalt
14452	1.77	breccia
14453	6.03	breccia

Table 3: Coarse fines.

from Kramer and Twedell 1977

	number	weight	split
Soil breccia	50	18 g	,87
Anorthosite	2	0.2 g	,88
breccia, light matrix	13	2 g	,89
breccia, dark matrix	14	3.5 g	,92
fine grained basalt, light	24	6.6 g	,90
fine grained basalt, dark	37	9.7 g	,91
aphanitic basalt ?	2	1.6 g	,93
impact melt	10	2.2 g	,94
aphanite	2	1.7 g	,95
total	154	45 g	

Table 4: Composition of granitic coarse-fines, 14161.

	Jolliff 1993			
	,7069	,7373	,7269	
FeO	14	16	7.4	(a)
CaO	9	11.3	7.5	(a)
Na2O	1.41	0.75	0.71	(a)
Sc	30.2	42.2	15.6	(a)
Cr	361	982	680	(a)
Ni	110		110	(a)
Rb	52	21	107	(a)
Sr	160	207	190	(a)
Zr	4240	7150	1240	(a)
Cs	1.6	0.36	5	(a)
Ba	2050	740	2290	(a)
La	228	696	95.3	(a)
Sm	97	326	35.6	(a)
Eu	3.35	5.68	2.69	(a)
Tb	18.7	62.2	7.95	(a)
Yb	73.6	146	55.3	(a)
Lu	10.2	18.7	7.93	(a)
Hf	100	163	33	(a)
Ta	9.2	4.3	11	(a)
Ir ppb			6	(a)
Au ppb			4	(a)
Th	44	37	66	(a)
U	12	5.4	20	(a)

technique: a) INAA

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