14163

Bulk Soil Sample

7,776 grams

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 documetted 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 toll.

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 ltttle cratrer about this size out here that I'd swear had glass in the bottom of it, but I was to busy thumping to stop and make any comment on it.

\- - -

CDR There's a little differrnt 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.

Introduction

At the end of the first EVA on Apollo 14, a large soil sample was collected from the area near the LM. It was placed in weight bag #2 (number 1028), which was returned in D-ALSRC#1007 (it was processed in N_2 atmosphere). The area, about 15 meters from the LM, was apparently free of rock fragments (see Graf 1993), and not many were seived from the large soil collected. The transcript indicates that the bulk soil sample was scooped from a small (2 foot) crater, 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 (Is/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

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

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

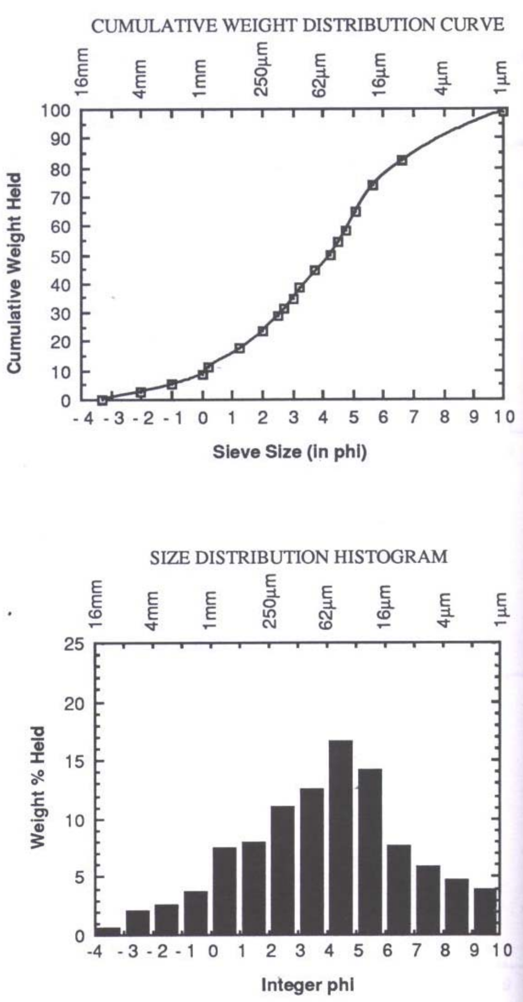

Figure 1: Grain size distribution for soil 14163 (from Graf 1993, data from King).

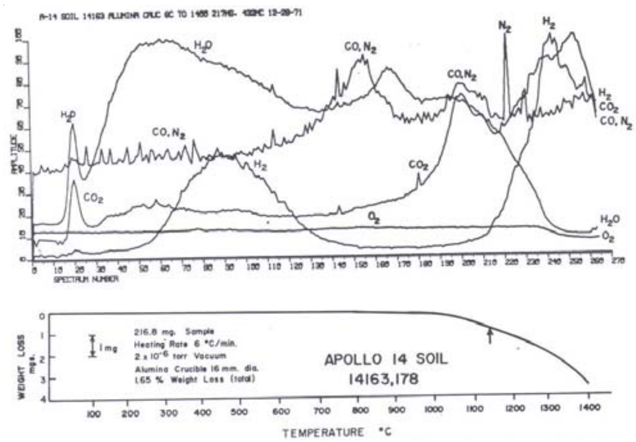

Figure 2: Evolution of gasses from 14163 as function of temperature (from Gibson and Moore 1972).

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.

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 form 16161 (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 some of the finest fraction.

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 porportion 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).

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

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 =

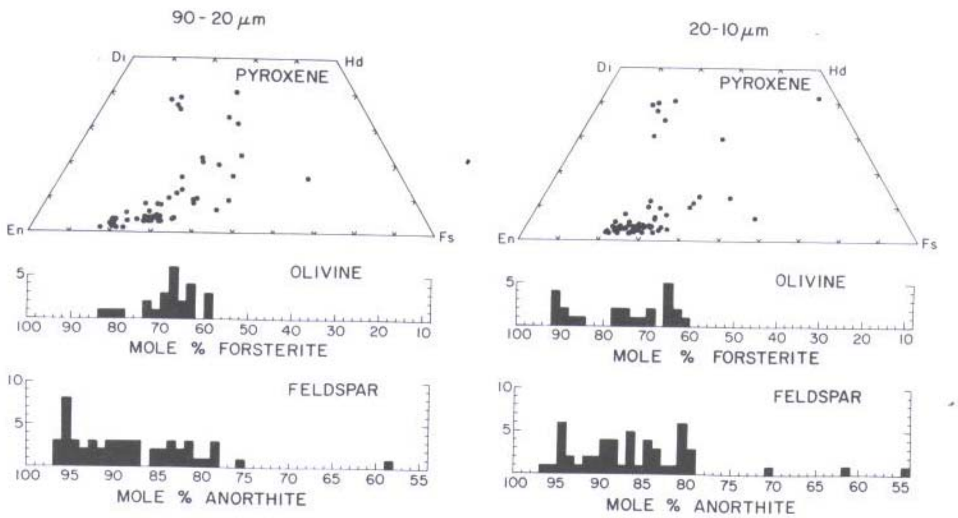

Figure 3: Labotka et al. (1980) and Papike et al. (1982) summarized the mineral compositions in 14163.

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).

Other Studies

A very large number of highly imagnative studies have been performed on this soil; only a few are mentioned here.

Gibson and Moore (1972) determined the gas release profile (figure 2).

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 sytematics.

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 processing of sample 14163 was not well documented. A portion was used as the "biopool sample" for the purpose of quarentine.

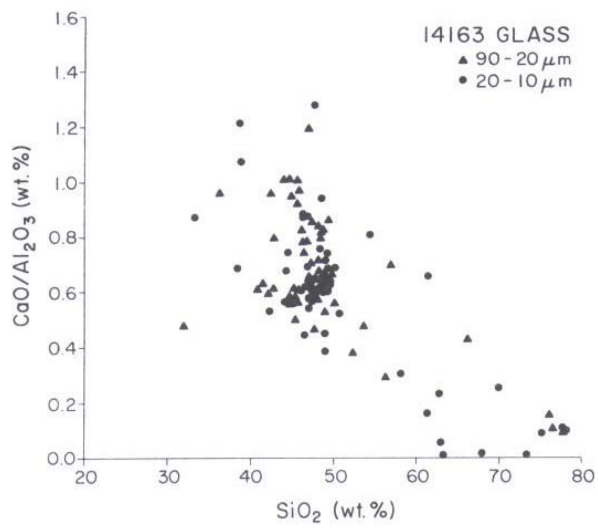

Figure 4: Labotka et al. (1980) determined glass composition in 14163.

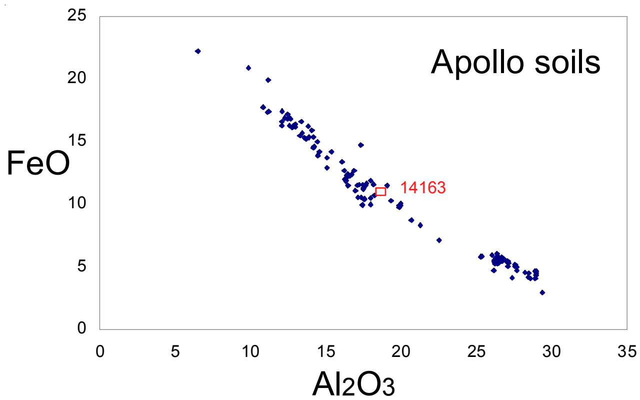

Figure 5: Composition of lunar soils with 14163.

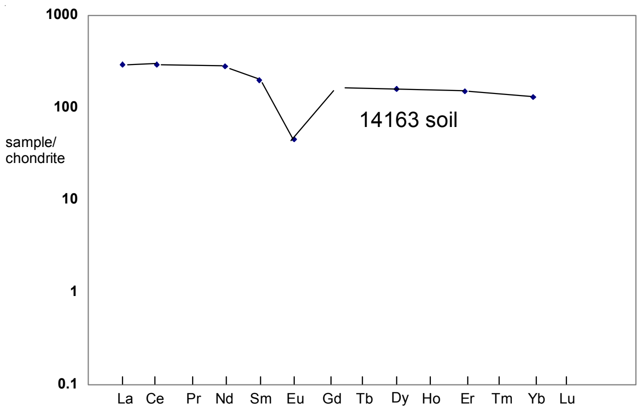

Figure 6: Normalized rare-earth-element diagram for 14163 (data by isotope dilution mass spectrometry, Hubbard et al 1972).

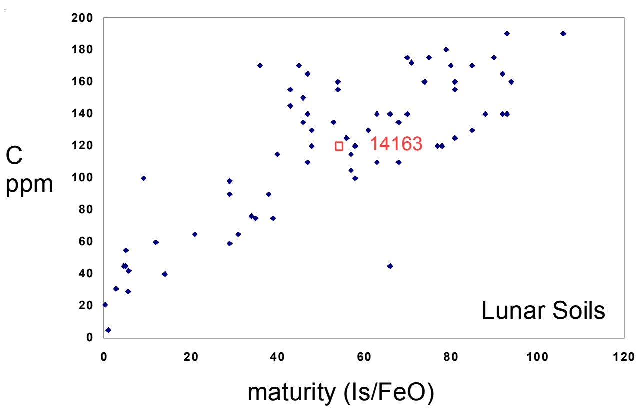

Figure 7: Maturity and carbon content of lunar soils with 14163.

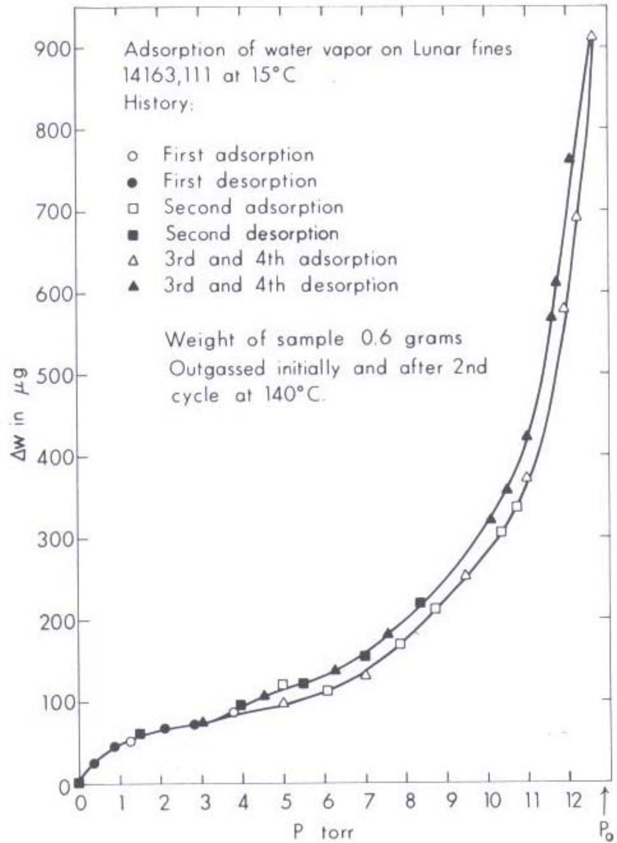

Figure 8: Adsorption isotherm for 14163 (Cadenhead et al. 1972).

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

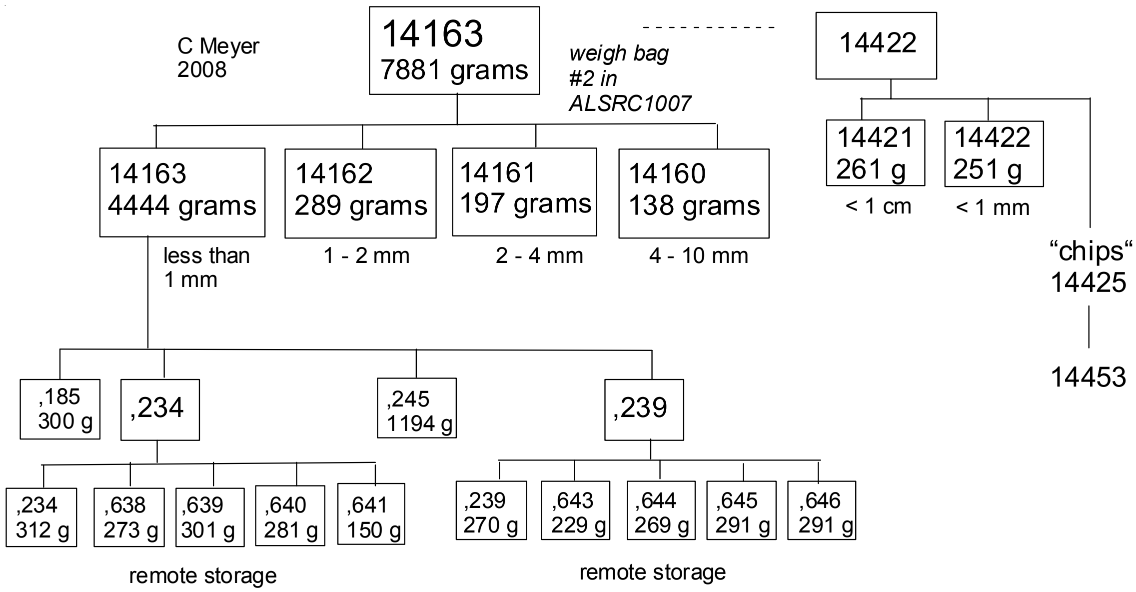

Table 2: Small rocks from 14422 - -

	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

Selected References for 14163

Baedecker P.A., Chou C-L. and Wasson J.T. (1972) The extralunar component in lunar soils and breccias. Proc. 3rd Lunar Sci. Conf. 1343-1359.

Baur H., Frick U., Funk H., Schultz L. and Signer P. (1972) Thermal release of helium, neon, and argon from lunar fines and minerals. Proc. 3rd Lunar Sci. Conf. 1947-1966.

Berdot J.L., Chetrit G.C., Lorin J.C., Pellas P. and Poupeau G. (1972) Track studies of Apollo 14 rocks and Apollo 14, Apollo 15 and Luna 16 soils. Proc. 3rd Lunar Sci. Conf. 2867-2881.

Begemann F., Born W., Palme H., Vilcsek E. and Wanke H. (1972) Cosmic-ray produced radionuclides in Apollo 12 and Apollo 14 samples. Proc. 3rd Lunar Sci. Conf. 1693-1702.

Bhandari N., Goswami J.N., Gupta S.K., Lal D., Tamhane A.S. and Venkatavaradan V.S. (1972) Collision controlled radiation history of the lunar regolith. Proc. 3rd Lunar Sci. Conf. 2811-2829.

Bogard D.D. and Nyquist L.A. (1972) Noble gas studies on regolith materials from Apollo 14 and 15. Proc. 3rd Lunar Sci. Conf. 1797-1819.

Brunfeldt A.O., Heier K.S., Nilssen B., Sundvoll B. and Steinnes E. (1972) Distribution of elements between different phases of Apollo 14 rocks and soils. Proc. 3rd Lunar Sci. Conf. 1133-1147.

Cadenhead D.A., Wagner N.J., Jones B.R. and Stetter J.R. (1972) Some surface characteristics and gas interactions of Apollo 14 fines and rock fragments. Proc. 3rd Lunar Sci. Conf. 2243-2257.

Cadogen P.H., Eglington G., Firth J.N.M., Maxwell J.R., May B.J. and Pillinger C.T. (1972) Survey of lunar carbon compounds: II. The carbon chemistry of Apollo 11, 12, 14 and 15 samples. Proc. 3rd Lunar Sci. Conf. 2069-2091.

Carr M.H. and Meyer C.E. (1972) Chemical and petrographic characterization of Fra Mauro soils. Proc. 3rd Lunar Sci. Conf. 1015-1027.

Crozaz G., Drozd R., Hohenberg C.M., Hoyt H.P., Rajan D., Walker R.M. and Yuhas D. (1972b) Solar flare and galactic cosmic ray studies of Apollo,14 and 15 samples. Proc. 3rd Lunar Sci. Conf. 2917-2931.

Devine J.M., McKay D.S. and Papike J.J. (1982) Lunar regloith: Petrology of the <10 micron fraction. Proc. 13th Lunar Planet. Sci. Conf. in J. Geophys. Res. 87, A260-A268.

Finkelman R.B. (1973) Analysis of the ultrafine fraction of the Apollo 14 regolith. Proc. 4th Lunar Sci. Conf. 179-189.

Gibson E.K. and Moore G.W. (1972) Inorganic gas release and thermal analysis study of Apollo 14 and 15 soils. Proc. 3rd Lunar Sci. Conf. 2029-2040.

Goel P.S. and Kothari B.K. (1972) Total nitrogen contents of some Apollo 14 lunar samples by neutron activation analysis. Proc. 3rd Lunar Sci. Conf. 2041-2050.

Graf J.C. (1993) Lunar Soils Grain Size Catalog. NASA Pub. 1265

Helmke P.A., Haskin L.A., Korotev R.L. and Ziege K.E. (1972) Rare earths and other trace elements in Apollo 14 samples. Proc. 3rd Lunar Sci. Conf. 1275-1292.

Heymann D., Yaniv A. and Lakatos S. (1972) Inert gases from Apollo 12, 14 and 15 fines. Proc. 3rd Lunar Sci. Conf. 1857-1863.

Hubbard N.J., Gast P.W., Meyer C., Nyquist L.E. and Shih C.-Y. (1971b) Chemical composition of lunar anorthosites and their parent liquids. Earth Planet. Sci. Lett. 13, 71-75.

Hubbard N.J., Gast P.W., Rhodes J.M., Bansal B.M., Wiesmann H. and Church S.E. (1972) Nonmare basalts: Part II. Proc. 3rd Lunar Sci. Conf. 1161-1179.

Jolliff B.L. (1991) Fragments of quartz-monzodiorite and felsite in Apollo 14 soil particles. Proc. 21st Lunar Planet. Sci. Conf. 101-118. Lunar Planetary Institute, Houston

Keith J.E., Clark R.S. and Richardson K.A. (1972) Gamma-ray measurements of Apollo 12, 14 and 15 lunar samples. Proc. 3rd Lunar Sci. Conf. 1671-1680.

King E.A., Butler J.C. and Carman M.F. (1972) Chondrules in Apollo 14 samples and size analyses of Apollo 14 and 15 fines. Proc. 3rd Lunar Sci. Conf. 673-686.

Kirsten T., Deubner J., Horn P., Kaneoka I., Kiko J., Schaeffer O.A. and Thio S.K. (1972) The rare gas record of Apollo 14 and 15 samples. Proc. 3rd Lunar Sci. Conf. 1865-1889.

Kramer F.E. and Twedell D.B. (1977) Apoloo 14 coarse fines (4-10 mm) sample location and clasification. JSC 12922

Labotka T.C., Kempa M.J., White C., Papike J.J. and Laul J.C. (1980) The lunar regolith: Comparative petrology of the Apollo sites. Proc. 11th Lunar Planet. Sci. Conf. 1285-1305.

Laul J.C., Wakita H., Showalter D.L., Boynton W.V. and Schmitt R.A (1972) Bulk, rare earth, and other trace elements in Apollo 14 and 15 and Luna 16 samples. Proc. 3rd Lunar Sci. Conf. 1181-1200.

Laul J.C. and Papike J.J. (1980) The lunar regolith: Comparative chemistry of the Apollo sites. Proc. 11th Lunar Planet. Sci. Conf. 1307-1340.

Lindstrom M.M., Duncan A.R., Fruchter J.S., McKay S.M., Stoeser J.W., Goles G.G. and Lindstrom D.J. (1972) Compositional characteristics of some Apollo 14 clastic materials. Proc. 3rd Lunar Sci. Conf. 1201-1214.

LSPET (1971) Preliminary examination of lunar samples from Apollo 14. Science 173, 681-693.

Lugmair G.W. and Marti K. (1972) Exposure ages and neutron capture record in lunar samples from Fra Mauro. Proc. 3rd Lunar Sci. Conf. 1891-1897.

Masuda A., Nakamura N., Kurasawa H. and Tanaka T. (1972) Precise determination of rare-earth elements in the Apollo 14 and 15 samples. Proc. 3rd Lunar Sci. Conf. 1307-1313.

McKay D.S., Heiken G.H., Taylor R.M., Clanton U.S., Morrison D.A. and Ladle G.H. (1972) Apollo 14 soils: Size distribution and particle types. Proc. 3rd Lunar Sci. Conf. 983-995.

McKay G.A., Wiesmann H., Bansal B.M. and Shih C.-Y. (1979a) Petrology, chemistry, and chronology of Apollo 14 KREEP basalts. Proc. 10th Lunar Planet. Sci. Conf. 181-205.

Moore C.B., Lewis C.F., Cripe J., Delles F.M., Kelly W.R. and Gibson E.K. (1972) Total carbon, nitrogen and sulfur in Apollo 14 lunar samples. Proc. 3rd Lunar Sci. Conf. 2051-2058.

Morgan J.W., Laul J.C., Krahenbuhl U., Ganapathy R. and Anders E. (1972b) Major impacts on the moon: Characterization from trace elements in Apollo 12 and 14 samples. Proc. 3rd Lunar Sci. Conf. 1377-1395.

Morris R.V. (1976) Surface exposure indicies of lunar soils: A comparative FMR study. Proc. 7th Lunar Sci. Conf. 315-335.

Morris R.V. (1978) The surface exposure (maturity) of lunar soils: Some concepts and Is/FeO compilation. Proc. 9th Lunar Sci. Conf. 2287-2297.

Philpotts J.A., Schnetzler C.C ., Nava D.F., Bottino M.L., Fullagar P.D., Thomas H.H., Schumann S. and Kouns C.W. (1972) Apollo 14: Some geochemical aspects. Proc. 3rd Lunar Sci. Conf. 1293-1305.

Powell B.N. and Weiblen P.W. (1972) Petrology and origin of lithic fragments in the Apollo 14 regolith. Proc. 3rd Lunar Sci. Conf. 837-852.

Quaide W. and Wrigley R. (1972) Mineralogy and origin of Fra Mauro fines and breccias. Proc. 3rd Lunar Sci. Conf. 771-784.

Rose H.J., Cuttitta F., Annell C.S., Carron M.K., Christian R.P., Dwornik E.J., Greenland L.P. and Ligon D.T. (1972) Compositional data for twenty-one Fra Mauro lunar materials. Proc. 3rd Lunar Sci. Conf. 1215-1229.

Stasheim A., Jackson P.F.S., Coetzee J.H.J., Strelow F.W.E., Wybenga F.T., Gricius A.J., Kokot M.L. and Scott R.H. (1972a) Analysis of lunar samples 14163, 14259 and 14321 with isotopic data for 7Li/6Li. Proc. 3rd Lunar Sci. Conf. 1337-1342.

Sutton R.L., Hait M.H. and Swann G.A. (1972) Geology of the Apollo 14 landing site. Proc. 3rd Lunar Sci. Conf. 27-38.

Simon S.B., Papike J.J. and Laul J.C. (1981) The lunar regolith: Comparative studies of the Apollo and Luna sites. Proc. 12th Lunar Planet. Sci. Conf. 371-388.

Swann G.A., Bailey N.G., Batson R.M., Eggleton R.E., Hait M.H., Holt H.E., Larson K.B., McEwen M.C., Mitchell E.D., Schaber G.G., Schafer J.P., Shepard A.B., Sutton R.L., Trask N.J., Ulrich G.E., Wilshire H.G. and Wolf E.W. (1971) Preliminary geologic investigations of the Apollo 14 landing site. In Apollo 14; Preliminary Science Report. NASA SP-272, 39-85.

Swann G.A., Bailey N.G., Batson R.M., Eggleton R.E., Hait M.H., Holt H.E., Larson K.B., Reed V.S., Schaber G.G., Sutton R.L., Trask N.J., Ulrich G.E. and Wilshire H.G. (1977) Geology of the Apollo 14 landing site in the Fra Mauro highlands. U.S. Geological Survey Professional Paper 880

Tatsumoto M., Hedge C.E., Doe B.R. and Unruh D.M. (1972a) U-Th-Pb and Rb-Sr measurements on some Apollo 14 lunar samples. Proc. 3rd Lunar Sci. Conf. 1531-1555.

Taylor G.J., Marvin U.B., Ried J.B. and Wood J.A. (1972) Noritic fragments in the Apollo 14 and 12 soils and the origin of Oceanus Procellarum. Proc. 3rd Lunar Sci. Conf. 995-1014.

Taylor S.R., Kaye M., Muir P., Nance W., Rudowski R. and Ware N. (1972) Composition of the lunar uplands: Chemistry of Apollo 14 samples from Fra Mauro. Proc. 3rd Lunar Sci. Conf. 1231-1249.

Walker R.J. and Papike J.J. (1981a) The relationship of the lunar regolith < 10 micron fraction and agglutinates. Part II:

Chemical composition of agglutinate glass as a test of the F3 model. Proc. 12th Lunar Planet. Sci. Conf. 421-432.

Wänke H., Baddenhausen H., Balacescu A., Teschke F., Spettel B., Dreibus G., Palme H., Quijano-Rico M., Kruse H., Wlotzka F. and Begemann F. (1972) Multielement analysis of lunar samples and some implications of the results. Proc. 3rd Lunar Sci. Conf. 1251-1268.

Wasson J.T., Chou C-L., Bild R.W. and Baedecker P.A. (1973) Extralunar materials in Cone-crater soil 14141. Geochim. Cosmochim Acta 37, 2349-2353.

Willis J.P., Erlank A.J., Gurney J.J., Theil R.H. and Ahrens L.H. (1972) Major, minor, and trace element data for some Apollo 11, 12, 14 and 15 samples. Proc. 3rd Lunar Sci. Conf. 1269-1273.