

14149 - 232 grams - bottom
14148 - 85 grams - top
14156 - 162 grams - middle
Trench Soils

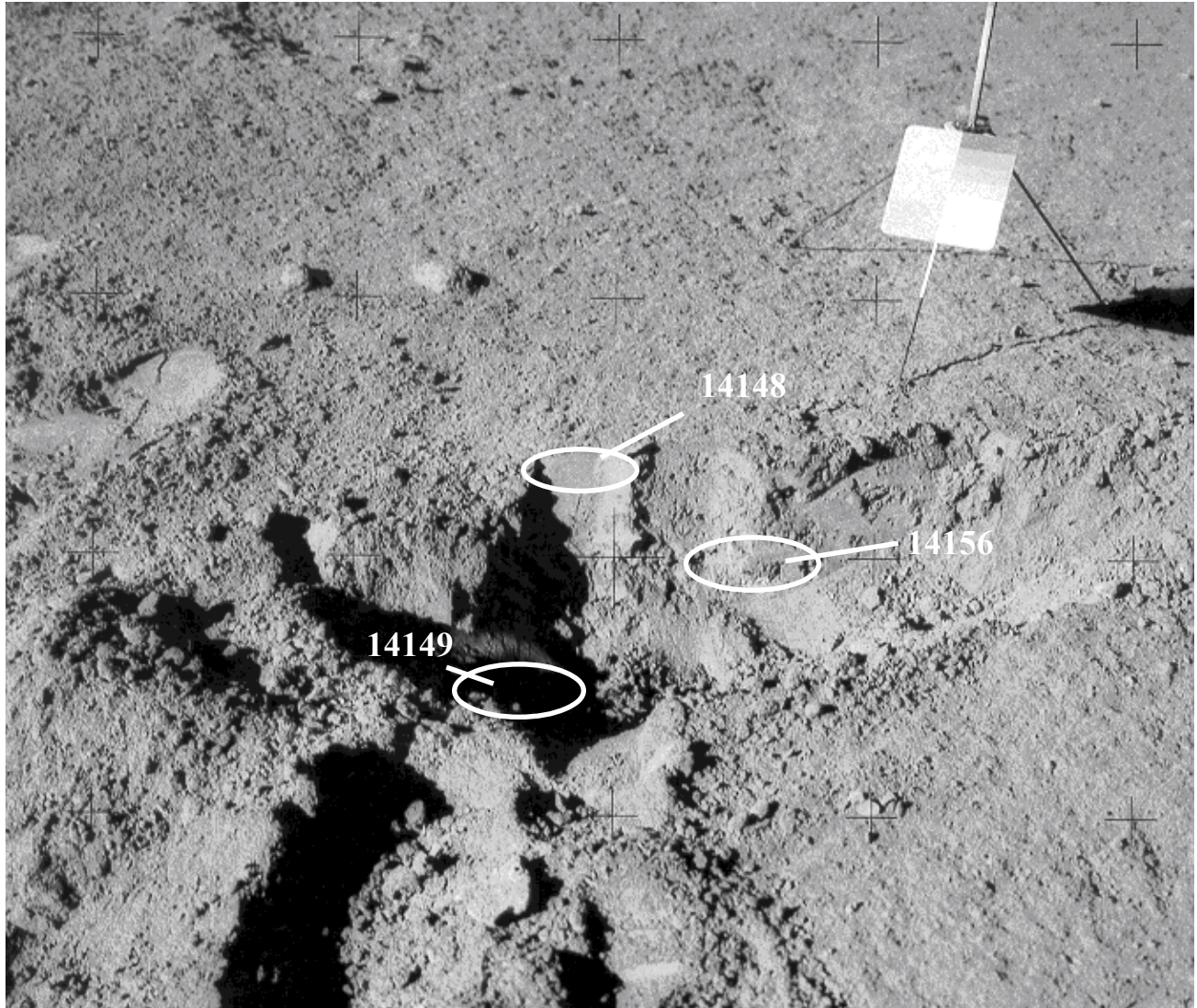


Figure 1: Soil Mechanics Trench at Apollo 14, Triplet Crater. Note walls are not stable. AS14-64-9161. Gnomon legs are 50 cm apart. Trench is about 30 cm deep. SESC sample 14240 also collected from this trench.

Introduction

The Soil Mechanics Trench for Apollo 14 was planned for 60 cm depth, but CDR Al Shepard found that the walls were caving in (see transcript), so he discontinued digging at about 18 inches or 30 cm. Numerous samples were collected from this trench including 14149 and 14240 (SESC) which were taken from the bottom of the trench. 14148 is the soil from the surface and 14156 from about the middle of the trench wall

(figure 1). Samples 14145, 14080, 14073 to 14079 are rock samples taken from the same trench. Sample 14149, 14148 and 14156 are less than 1 mm fines. When these soil samples were sieved, additional sample numbers were assigned to the coarse-fines (see diagrams). 14220 and 14230 are drive tube samples taken nearby. 14310 (basalt) was also collected nearby.

Transcript for trench

CDR I've got a trench here. It's going easily, but I need the extension handle to get it deeper. I'm cutting into the rim of a crater which is approximately 6 meters in diameter, has a depth of about three-quarters of a meter. And we're back in about in about one diameter away from the north – Triplet. The trench is going through at least three layers that I can see. The fine-grain surface, dark brown; then, a layer of what appears to be quite a bit of black; and then, a third layer of some very light material. And, we should be able to sample all three of these.

CDR We did not mention this white layer down in this area before that was so obvious to us just below the surface up near the flank of Cone. But it appears as though it is relatively deep, as far as visual observation is concerned. And certainly not any would be picked up by footprints, or tracks or the like. But there appears to be some here in this trench.

CDR You know what's happening in this trench; surface fines are so loose that they're just falling down covering the layering that we want to get. I'll tell you we are not going to get a classical vertical wall here, Houston, on this trench.

CDR Okay, Fred. Bag 19 for the sample of the fine—that is, from the surface layer of the trench (14145-14148).

CDR I am unable to take from the wall of the trench the blocky type of material that I could see when I was digging; so, I'll just get a bag full of that, and we'll mix the surface layer with the second layer.

CC Roger, Al. How deep did you finally end up getting down?

CDR Well, the trench is about a foot and half deep. I gave up actually not because it was hard digging, but because the walls kept falling in on it; and it was covering all the evidence of stratigraphy. And bag 21(14080-81; 14153-156) is kind of a collection of the combination of the top two layers. Second layer is a thin layer of small-glassy pebbles. I was unable to separate them by the

trench method, so I gave it to you mixed up in the bag; and the last bag will be pebbles from the bottom layer.

CC Okay, Al. What is the thickness of the intermediate layer there?

CDR Well, it's really ephemeral it's very thin. I would say no more than a quarter of an inch thick, and I just noticed it because of the difference of the gain structure as I was digging the trench. And in bag 20, we'll just fill a sample of the bottom material; also, mixed up with some of the surface material that has fallen down in on top of it. And that is about 18 inches below the surface (14073-79; 14149-152).

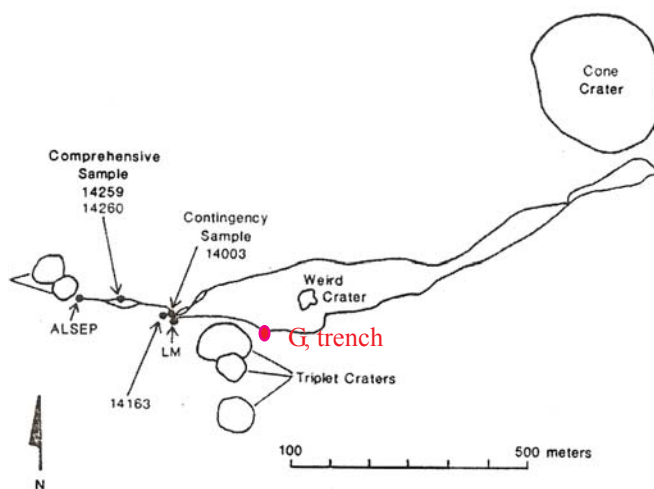
CC Okay. And, Al, one question, did you get the SESC sample (14240) out of the bottom of the trench?

CDR Well, I told you the trench was kind a miserable thing, because the walls kept falling down, but it wouldn't be the bottom, I'm afraid.

CC I guess we'd still like the SESC sample from the bottom of the trench, even though it probably isn't the bottom.

CDR Well, I'll tell you, I'll go back and whack at it a little bit. See what I can do. We're digging the bottom of the trench for you, Freddo. I'm re-digging the trench.

Station G was on the flank of North Triplet Crater (see map). The best description of the digging of the trench at station G is given in Mitchell et al. (1971). *"The site chosen for trenching was the western rim of a small crater approximately 6 m in diameter and 0.75 m deep."* *"The CDR reported digging was easy and estimated his first cut to be a depth of approximately 15 cm with sidewalls at an angle of 70 to 80 degrees, but at that point they started caving in"*. *"The excavation passed through three distinct layers. The upper 3 to 5 cm were dark brown and fine grained. Next a very thin layer (0.5 cm thick or less) of black, glassy particles was encountered. Beneath this layer was a much lighter colored and coarser grained material."*



Petrography

McKay et al. (1972) and Simon et al. (1982) showed that there was not much difference in the samples taken between the bottom and top of the trench (*however, LSPET 1971 and Mitchell et al. 1971 discuss a difference in grain size top to bottom, apparently based on data collected in PET, figure 2*). 14149 from the bottom had less agglutinates and was slightly less mature (maturity index $I_s/FeO = 53$) compared with 14148 from the top ($I_s/FeO = 70$) or 14156 from the middle ($I_s/FeO = 68$, Morris 1978). King et al. (1972)

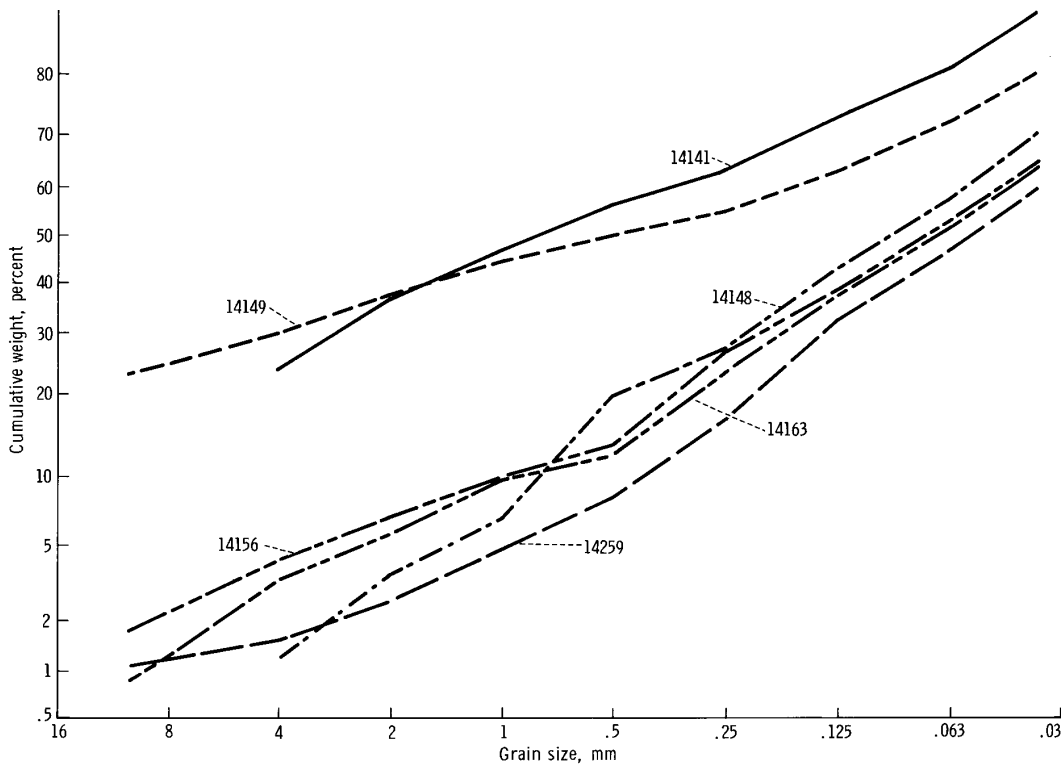


Figure 2: Grain size distribution for Apollo 14 soils showing the coarse grain size of the soil from the bottom of the trench (14149) and the rim of cone crater (14141) (from LSPET 1971).

and Graf (1993) reported the size distribution of the three soils (figures 3 a,b,c).

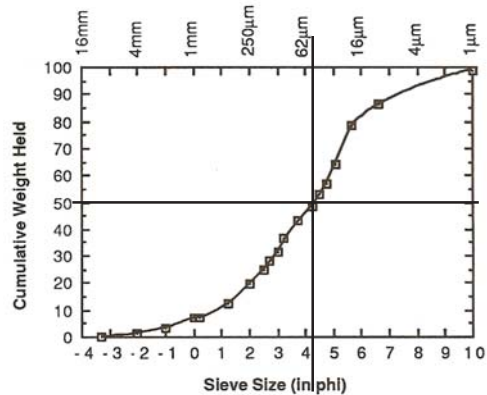
Chao et al. (1972), Nelen et al. (1972) and Glass et al. (1972) studied the glass beads in the three trench soils. 14156 was also one of the soils studied by the Apollo Soil Survey (see Reid et al. 1972a and b).

Some of the best KREEP basalts were found in this trench (14073 – 14079, 14080 – 14081). Kramer and Twedell (1977) also described some of the coarse-fines, finding numerous basalt fragments. *Note: 14310 was collected nearby.*

Chemistry

Lindstrom et al. (1972), Laul et al. (1982) and others determined the chemical composition of the soils from this trench (tables, figures 4 and 5).

Cadogen et al. (1972) give a nice discussion of carbon found in samples from this trench (and correlation with track density). Consider also the results of the study of 14240.



Average grain size = 73 microns

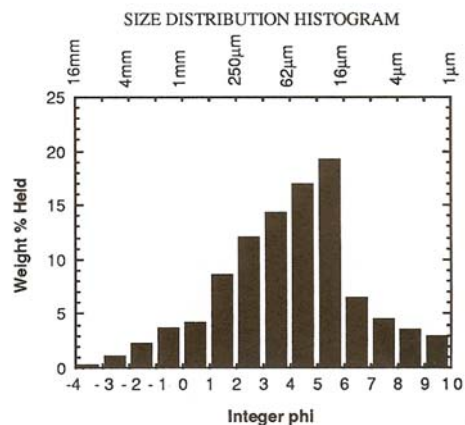
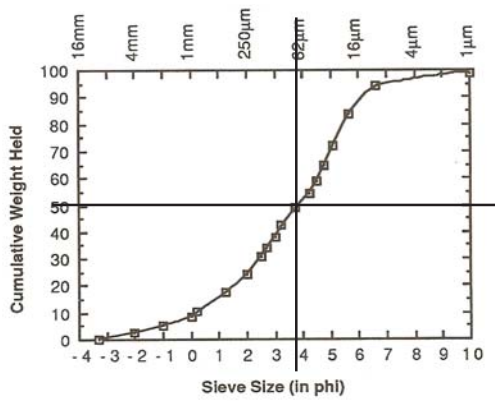
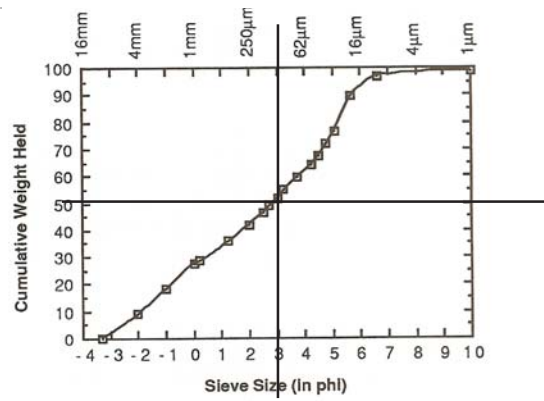


Figure 3a: Grain size distribution for 14148 (Graf 1993, from data by Butler). Top of trench.



Average grain size = 83 microns



Average grain size = 200 microns

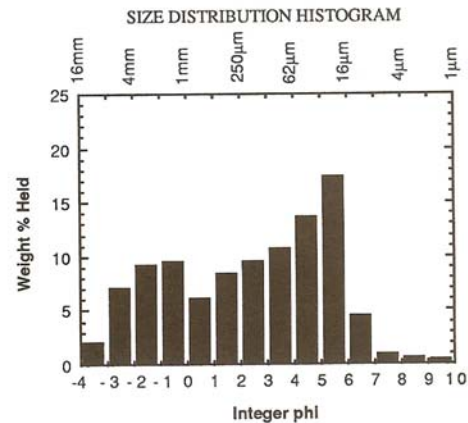
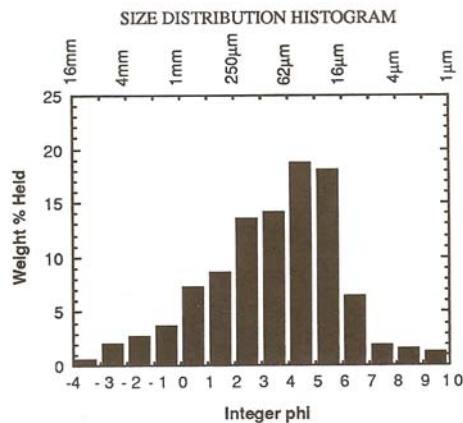


Figure 3b: Grain size distribution for 14156 (Graf 1993, from data by Butler). Middle of trench.

Figure 3c: Grain size distribution for 14149 (Graf 1993, from data by Butler). Bottom of trench.

Modal content of soils 14148, 14156 and 14149.

90-150 micron fraction

From McKay et al. 1972.

trench	14148 top	14156 middle	14149 bottom
Agglutinates	50.2%	47.7	26.4
Basalt	2	6.4	
Breccia	28.8	23.4	35.2
Anorthosite			
Norite			
Gabbro			
Plagioclase	3	5.4	7.8
Pyroxene	3.2	5.6	11
Olivine	0.8	0.2	
Ilmenite	0.4	0.4	0.4
Glass other	11.4	17.2	12.8

Modal content of soils 14148 and 14149.

From Simon et al. 1982.

90 - 1000 micron

	14148 (top)	14149 (bottom)
Agglutinates	39.6 %	24.3
Basalt	0.6	3.1
Breccia		
Dark	10.5	18.1
Light	18.9	27.4
Anorthosite	0.9	0.4
Norite		
Gabbro		
Plagioclase	4.6	1.8
Pyroxene	6.5	6.6
Olivine		
Ilmenite	0.1	0.4
Glass other	12.7	8.4

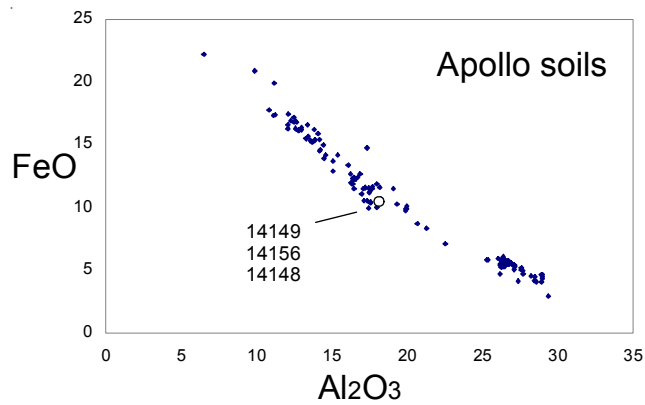


Figure 4: Chemical composition of Apollo 14 trench samples.

Cosmogenic isotopes and exposure ages

Eldridge et al. (1972) and Keith et al. (1972) found slightly less ^{26}Al and ^{22}Na in the bottom sample of the trench (14149). Keep in mind that the trench wall were constantly falling into the trench.

Other Studies

Basford et al. (1973) determined the isotopes of Xe and Kr. Nautiyal et al. (1981) and Venkatesan et al. (1980) studied the ^{22}Ne and Kr isotopes in 14148.

Bhandari et al. (1972), Hart et al. (1972), Berdot et al. (1972), Crozaz et al. (1972) and Bhai et al. (1978) studied the cosmic ray tracks in the grains of the trench, collectively finding that there was an order of magnitude less tracks in grains from the bottom of the trench (14149).

Processing

The samples from the bottom of this trench (14149 and 14240) may have been contaminated by surface material that fell into the trench during digging (see transcript).

During Apollo 14, there was a very strange numbering system (see diagrams). It appears that all of each soil was sieved, leaving no unsieved “reserve” sample, as was the case in later missions. In addition to these sample, SESC sample 14240 was also collected from the bottom of this trench (after re-digging).

About 72 grams from the bottom of this trench were apparently ground to <105 microns and sacrificed to the “biopool-quarantine” operation.

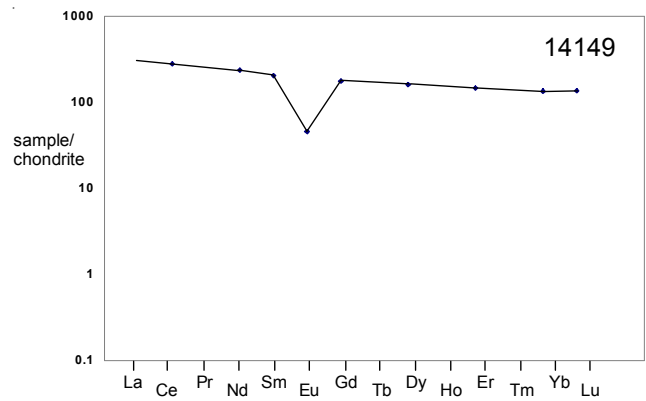


Figure 5: Normalized rare-earth-element content of trench sample 14149 (exactly the same as 14156 and 14148 same trench)(superior isotope dilution data from Philpotts et al.1972).

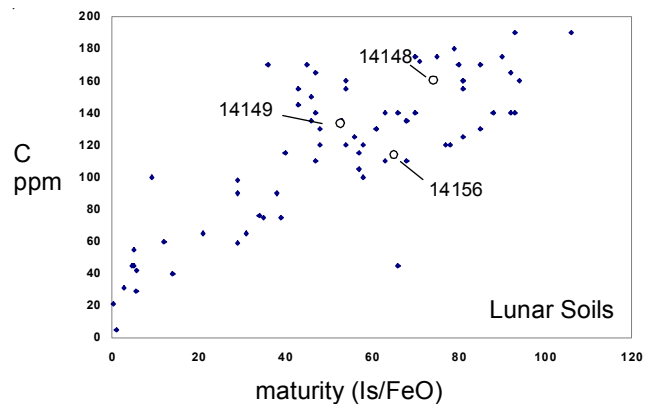


Figure 6: Carbon content and maturity from magnetic measurement

information taken
from Soil Catalog
by Morris et al. 1983

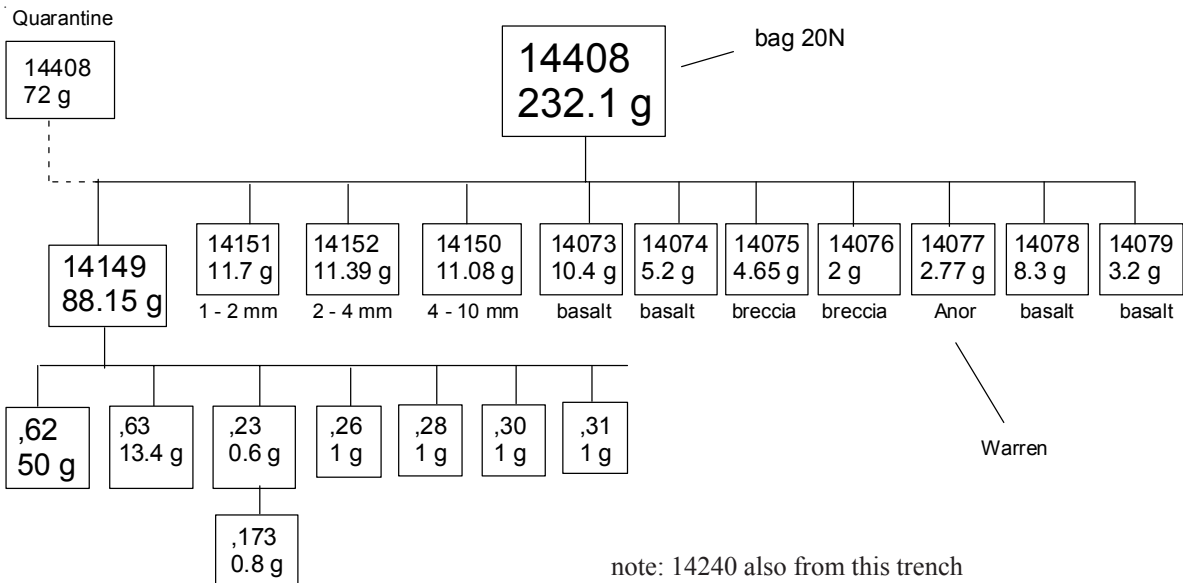
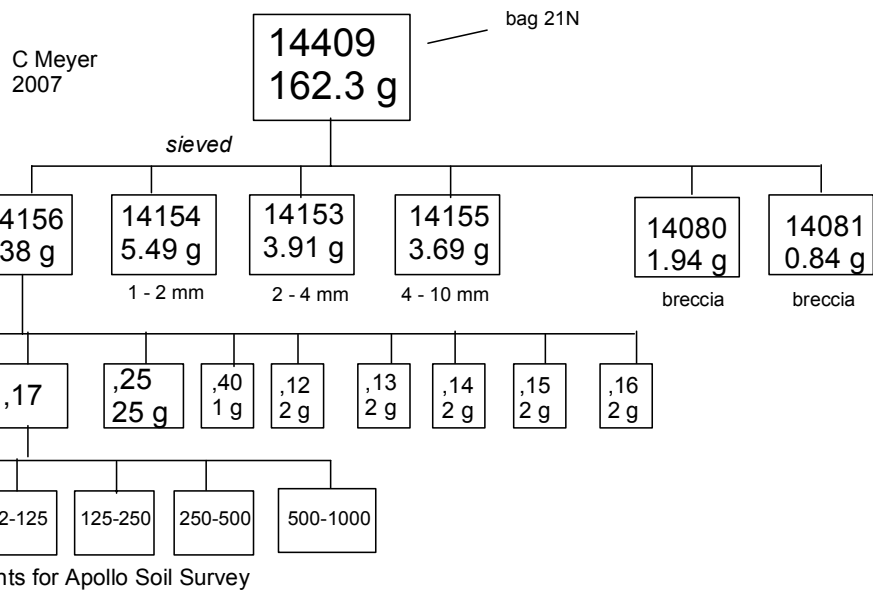
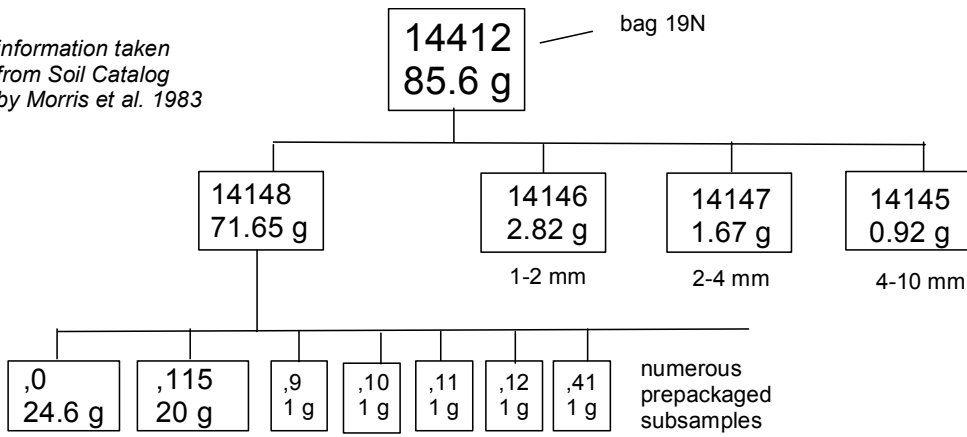


Table 1. Chemical composition of 14149.

reference weight	Lindstrom72	Philpotts72	Morgan72	Laul82	Murthy72	Eldridge72	Keith72
SiO2 %							
TiO2	1.55	(a)		1.6	(a)		
Al2O3	17.3	(a)		17.9	(a)		
FeO	10.16	(a)		10	(a)		
MnO	0.117	(a)		0.13	(a)		
MgO				9.9	(a)		
CaO				11	(a)		
Na2O	0.71	(a)		0.78	(a)		
K2O	0.54	(a)	0.64	(b)	0.58	(a) 0.62	(b) 0.6
P2O5						(d) 0.62	(d)
S %							
sum							
Sc ppm	20.5	(a)		21	(a)		
V				40	(a)		
Cr	1300	(a)		1232	(a)		
Co	40	(a)		27.5	(a)		
Ni				320	(a)		
Cu							
Zn			19	(c)			
Ga							
Ge ppb							
As							
Se			290	(c)			
Rb		14.5	(b) 13.9	(c)	17.9	(b)	
Sr		177.5	(b)	170	(a) 183.5	(b)	
Y							
Zr	660	(a) 907	(b)	680	(a)		
Nb							
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb			11.8	(c)			
Cd ppb			199	(c)			
In ppb							
Sn ppb							
Sb ppb			2.8	(c)			
Te ppb			15	(c)			
Cs ppm	0.66	(a)	0.6	(c)			
Ba	740	(a) 827	(b)	870	(a) 817	(b)	
La	65.1	(a)		60.5	(a)		
Ce	177	(a) 169	(b)	170	(a)		
Pr							
Nd	100	(a) 108	(b)	110	(a)		
Sm	31.6	(a) 30.1	(b)	26.5	(a)		
Eu	2.76	(a) 2.56	(b)	2.2	(a)		
Gd		34.7	(b)				
Tb	6.7	(a)		5.4	(a)		
Dy		39.3	(b)	37	(a)		
Ho				8.2	(a)		
Er		23.4	(b)				
Tm				3.3	(a)		
Yb	21.7	(a) 22	(b)	20.2	(a)		
Lu	3.08	(a) 3.34	(b)	2.8	(a)		
Hf	23	(a) 20.8	(b)	21.9	(a)		
Ta	4.8	(a)		3	(a)		
W ppb							
Re ppb			1.05	(c)			
Os ppb							
Ir ppb			11.1	(c)			
Pt ppb							
Au ppb			7.5	(c)			
Th ppm	13.6	(a)		13.3	(a)	11.4	(d) 13.3
U ppm				3.6	(a)	3.2	(d) 3.5

technique: (a) INAA, (b) IDMS, (c) RNNA, (d) radiation counting

Table 2. Chemical composition of 14148.

reference weight	Lindstrom72	Philpotts72	Morgan72	Laul82	Eldridge72	Keith72
SiO ₂ %						
TiO ₂	1.68	(a)		1.6	(a)	
Al ₂ O ₃	17.25	(a)		16.6	(a)	
FeO	10.3	(a)		12.2	(a)	
MnO	0.127	(a)		0.14	(a)	
MgO				9.9	(a)	
CaO				10.3	(a)	
Na ₂ O	0.68	(a)		0.74	(a)	
K ₂ O	0.5	(a) 0.54	(b)	0.53	(a) 0.53	(d) 0.55 (d)
P ₂ O ₅						
S %						
sum						
Sc ppm	21	(a)		25.5	(a)	
V	44	(a)		45	(a)	
Cr	1310	(a)		1437	(a)	
Co	34.4	(a)		39	(a)	
Ni				700	(a)	
Cu						
Zn			22	(c)		
Ga						
Ge ppb						
As						
Se						
Rb		14.8	(b) 16.8	(c)		
Sr		177.4	(b)	170	(a)	
Y						
Zr	690	(a) 992	(b)	830	(a)	
Nb						
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb			12.6	(c)		
Cd ppb			111	(c)		
In ppb						
Sn ppb						
Sb ppb			2.8	(c)		
Te ppb			25	(c)		
Cs ppm	0.4	(a)	0.695	(c)		
Ba	750	(a) 824	(b)	850	(a)	
La	64.3	(a)		61	(a)	
Ce	176	(a) 171	(b)	170	(a)	
Pr						
Nd	98	(a) 107	(b)	100	(a)	
Sm	31.5	(a) 30.6	(b)	27	(a)	
Eu	2.68	(a) 2.55	(b)	2.5	(a)	
Gd		34.4	(b)			
Tb	6.6	(a)		6	(a)	
Dy		38.9	(b)	38	(a)	
Ho				9.2	(a)	
Er		23.2	(b)			
Tm				3.3	(a)	
Yb	21.7	(a) 21.6	(b)	20.2	(a)	
Lu	3.18	(a) 3.31	(b)	2.85	(a)	
Hf	25.7	(a) 20.6	(b)	26	(a)	
Ta	4.7	(a)		3.3	(a)	
W ppb						
Re ppb			1.34	(c)		
Os ppb						
Ir ppb			13.7	(c)		
Pt ppb						
Au ppb			6.9	(c)		
Th ppm	13.8	(a)		14	(a) 11.4	(d) 13.4 (d)
U ppm				3.5	(a) 3.3	(d) 3.7 (d)

technique: (a) INAA, (b) IDMS, (c) RNAA, (d) radiation counting

Table 3. Chemical composition of 14156.

reference weight	Lindstrom72	Philpotts72	Morgan72	Eldridge72	Keith72
SiO2 %					
TiO2	1.65	(a)			
Al2O3	16.95	(a)			
FeO	10.42	(a)			
MnO	0.125	(a)			
MgO					
CaO					
Na2O	0.68	(a)			
K2O	0.52	(a)	0.54 (b)	0.57 (d)	0.52 (d)
P2O5					
S %					
sum					
Sc ppm	20.9	(a)			
V	36	(a)			
Cr	1350	(a)			
Co	36.2	(a)			
Ni					
Cu					
Zn			20	(c)	
Ga					
Ge ppb					
As					
Se			280	(c)	
Rb		14.7	(b) 13.5	(c)	
Sr		179.2	(b)		
Y					
Zr	700	(a) 913	(b)		
Nb					
Mo					
Ru					
Rh					
Pd ppb					
Ag ppb			11.7	(c)	
Cd ppb			77	(c)	
In ppb					
Sn ppb					
Sb ppb			3.6	(c)	
Te ppb			25	(c)	
Cs ppm	0.54	(a)			
Ba	780	(a) 813	(b)		
La	65.1	(a)			
Ce	175	(a) 169	(b)		
Pr					
Nd		107	(b)		
Sm	31.4	(a) 29.9	(b)		
Eu	2.66	(a) 2.57	(b)		
Gd		34.9	(b)		
Tb	6.6	(a)			
Dy		38.9	(b)		
Ho					
Er		23.1	(b)		
Tm					
Yb	21.5	(a) 21.8	(b)		
Lu	3.05	(a) 3.27	(b)		
Hf	23.2	(a)			
Ta	4.8	(a)			
W ppb					
Re ppb			1.11	(c)	
Os ppb					
Ir ppb			12.7	(c)	
Pt ppb					
Au ppb			5.3	(c)	
Th ppm	13.8	(a)		11.9 (d)	13.9 (d)
U ppm				3.3 (d)	3.8 (d)

technique: (a) INAA, (b) IDMS, (c) RNAA, (d) radiation counting

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