74241 – 1040 grams
74261 – 527 grams
Trench Soils

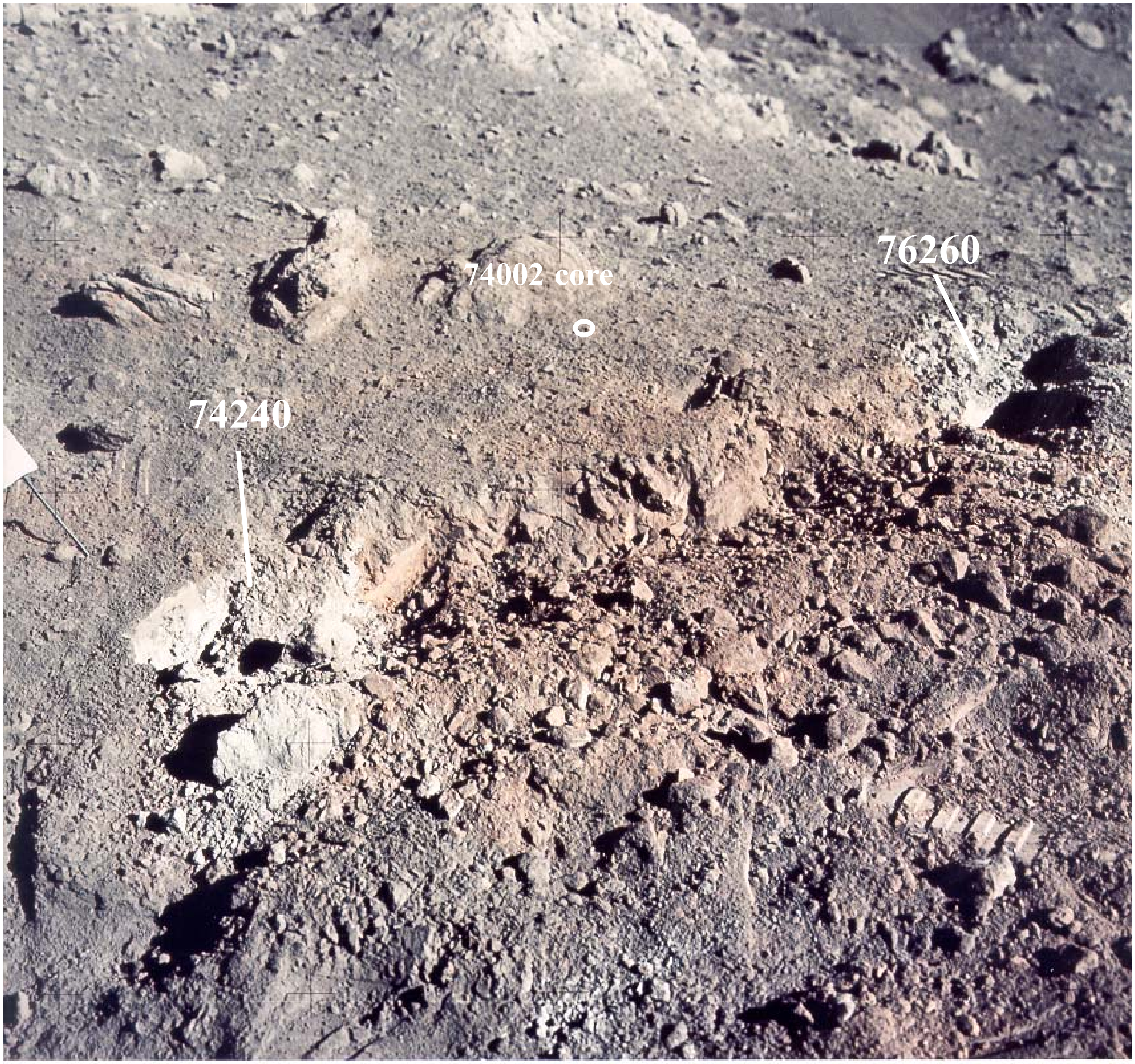


Figure 1: Trench at Shorty Crater, Apollo 17, showing orange soil (74220) surrounded by gray soils (74240 and 74260). Also location of double core (74002/1). See transcript. AS17-137-28986.

Introduction

The area on the rim of Shorty Crater where the Orange Soil was discovered was about 1 meter in size and "ellipsoidal" in dimension. The astronauts noted that it was covered with a light gray mantle (about 1 cm, *see transcript for the excitement of this discovery*). The astronauts dug a trench across the "ellipsoidal" area and tried to determine the depth of the deposit with a double core. The gray soils from either end of the trench were 74240 and 74260 (figure 1). The Orange Soil (74220) was from the middle of this trench, and the core was immediately adjacent.

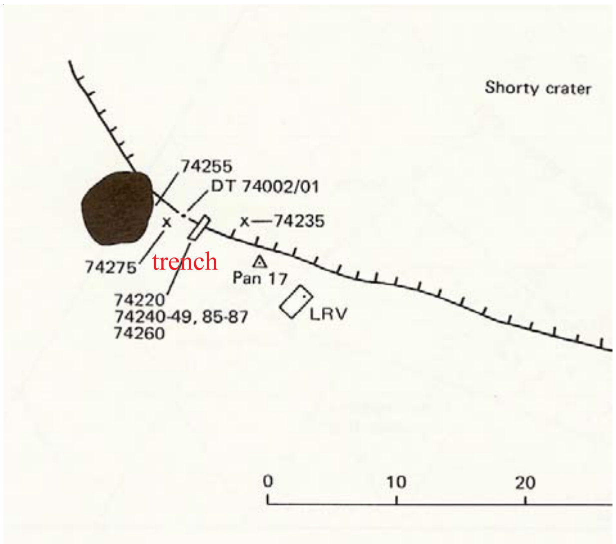


Figure 2: Map of Shorty Crater showing relative position of trench and core.

Modal content of soil 74241 and 74261 (90-150 micron).
From Heiken and McKay 1974.

	74241	74261
Agglutinates	8	7.7 %
Basalt	30	23.7
Breccia	16.9	16.1
Anorthosite	0.6	
Norite		
Gabbro		
Plagioclase	4.6	2.7
Pyroxene	11.3	13.7
Olivine		0.3
Ilmenite	1.3	2.3
Orange glass	4	7.7
Glass other	22.5	23.8

The astronauts also photographed the inner walls of Shorty Crater and could see vast amounts of orange material (Heiken et al. 1974, 1978). Several basalt samples were collected immediately adjacent to this trench or included in the soil bags (74235, 74255, 74275, 74245 – 74287, 74265).

Shorty Crater is ~ 17 m.y. old, but the gray soils have a much older, and complicated, exposure history (see below).

Petrography

The maturity of 74241 and 74261 is I_s/FeO = 5.1 and 5, respectively, and the average grain size is 87 and 72 microns (Morris 1978, Graf 1993). This compares with about 37- 46 microns for 74002 (top of core) and 74220 from orange soil middle of trench (see section on "orange soil"). The percentage of agglutinates is very low for a lunar soil (~8%).

Glass (1976) and Fruland et al. (1977) studied the glass particles in these gray soils. They found that there was abundant (10 – 20 %) ropy glass with a uniform highly aluminous composition (~ 23% Al_2O_3). Fruland et al. also found that the ropy glass particles were consistently covered with a diagnostic sorted and welded fine-grained debris coating.

Chemistry

The chemical composition was determined by Wanke et al. (1973), Nava (1974), Rhodes et al. (1974), Philpotts et al. (1974), Korotev and Kremser (1992) and others (see tables and see section on 74220). There is much less Cr in these gray soils, compared with the orange soil.

LSPET (1973) and Moore et al. (1974) reported 55 and 45ppm carbon for 74240 and 74260 respectively, yet 100 ppm carbon for 74220 (figure). Muller (1974) determined 23 ppm nitrogen in 74241with considerably higher amounts in the finest grain size (surface correlated). Chang et al. (1974) reported 50 and 42 ppm carbon and 18 and 18 ppm nitrogen for 74240 and 74260, respectively. Gibson and Moore (1974) reported 1080 ppm sulfur in 74260.

Radiogenic age dating

Silver (1974) and Nunes et al. (1974) reported the U, Th and Pb isotopic composition.

Lee et al. (1997) determined the Hf and W content and isotopic composition of tungsten.

Cosmogenic isotopes and exposure ages

The orange and gray soils at Shorty Crater have had a complicated exposure history (see Eugster 1985)

Other Studies

Eugster et al. (1977), Hubner et al. (1975) and Hintenberger et al. (1974) all determined rare gas content and isotopic composition.

Butler and Meyer (1976) studied the sulfur coatings on glass beads.

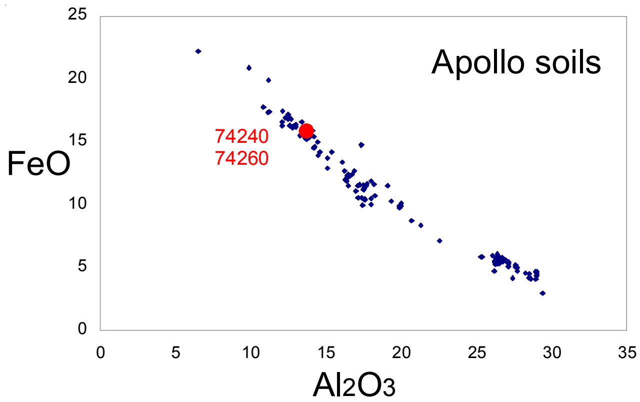


Figure 3: Composition of 74240 and 74260 compared with other Apollo soil samples.

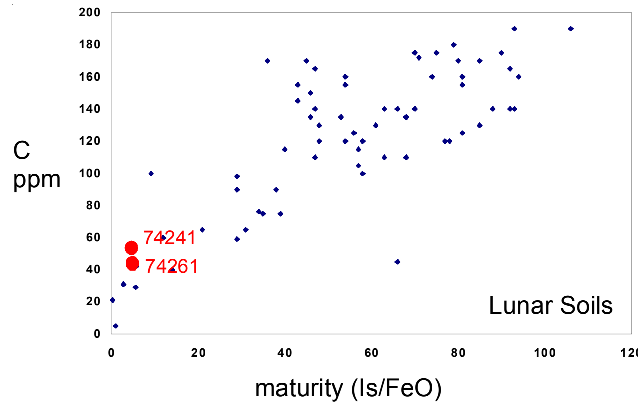
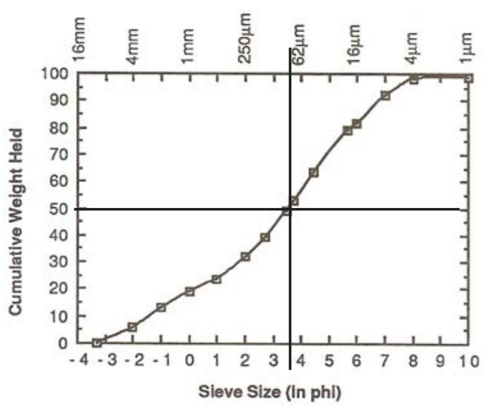


Figure 4: Carbon content of 74240 and 74260 along with maturity index. The other dotes are other Apollo 17 soils.



average grain size = 87 microns

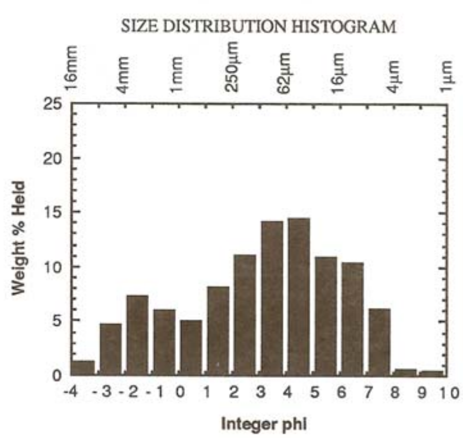
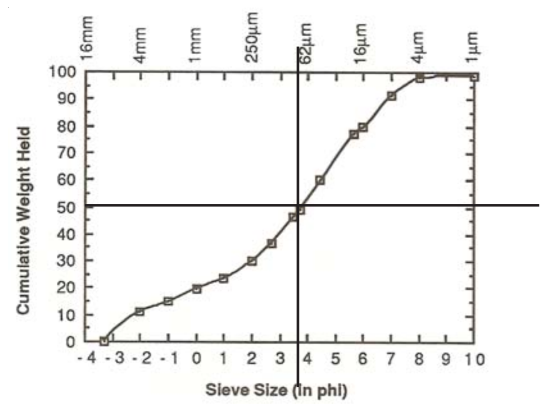


Figure 5a: Grain size distribution for 74240 (Graf 1993, data from McKay).



average grain size = 72 microns

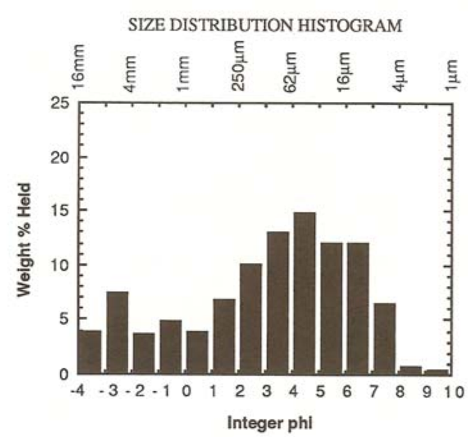
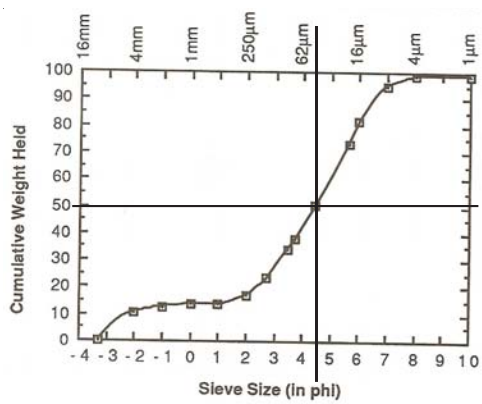


Figure 5b: Grain size distribution for 74260 (Graf 1993, data from McKay).



average grain size = 46 microns

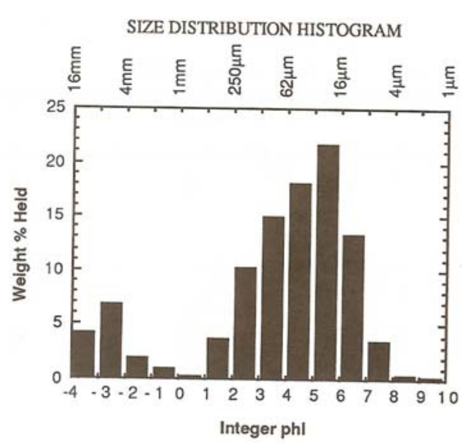
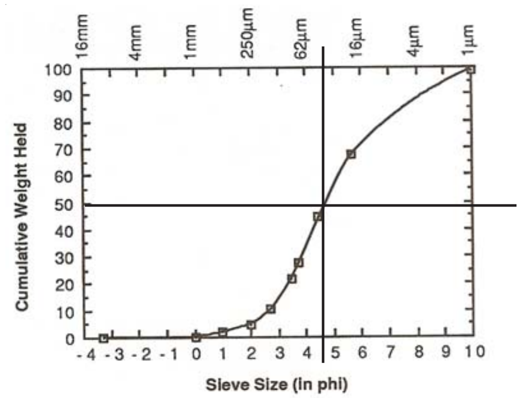


Figure 7: Grain size distribution for 74220 (Graf 1993, data from McKay).



average grain size = 37 microns

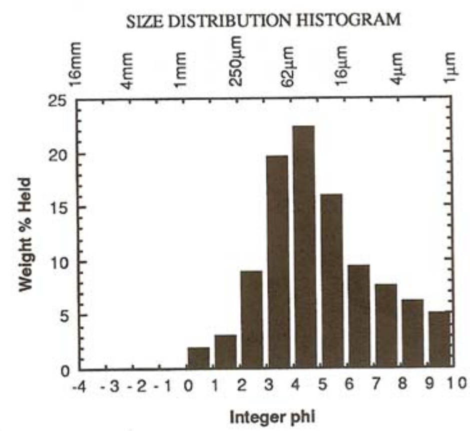


Figure 6: Grain size distribution for 74002 top (Graf 1993, data from McKay).

Transcript at Shorty Crater

LMP It's orange!

CDR Wait a minute, let me put my visor up. It's still orange!

LMP Sure it is! Crazy! ORANGE! I've got to dig a trench, Houston.

CDR It's almost the same color as the LMP decal on my camera. That is orange, Jack!

LMP It's trench time. You can see this in your color television, I'll bet you.

CDR Jack, that is really orange. It's been oxidized.

LMP It looks just like – an oxidized desert soil, that's exactly right. That orange is along the rim crest. If there ever was something that looked like a fumarole alteration, this is it. I've trenched across the trend of the yellow – or the orange. There is light gray material on either side. You need to get down-sun color - - I'll get my black and white.

CDR Let's start sampling that trench. Look at where the contact between the gray and the –

LMP Yes. Right, and it's on both sides.

CDR Before you disturb it, let me just get a couple of close-ups of that.

LMP Hey, can you get a down-sun? I think the color will be best down-sun.

CDR Okay. Let me get one more. Hey, you want any of this bagged in the can, Bob?

LMP It's quite – undurated.

CDR See if you can get a sample right across that contact too.

LMP I will. OK, bag that one.

CDR Bag 509 *(74220)* has got the orange material from, OH, about 2 to 3 inches down.

LMP OK, the light gray, which is on either side. Want me to get some more?

CDR Yes, a little more.

LMP All of this is getting a little bit *(mixed?)* with about half-centimeter thick light-gray or a medium-gray covering over the whole area.

CDR The light gray material that is adjacent to the red material is on *bag* 510 *(74240)*. And that orange band is about a meter wide, I think.

LMP About a meter.

CRD You can't get to the bottom of it though, can you?

LMP I haven't been able to yet. Just to be sure we sample this side of it, too?

CDR *Bag* 511 *(74260)* has the gray from the other side of the orange band. And the other side happens to be the crater side.

LMP That's right. North side. OK. I'm going to see if this goes on down here as a zone.

CDR It looks like it's ellipsoidal are if my footprints are any indication.

CC We'd like to get the double core here.

LMP Did you want that in the orange?

CC Rodger that. Affirm.

LMP Well, it a vertical stratigraphy. Do you want to go sideways a little with it? Or do you want to get it as deep as you can, huh?

CC Let's go as deep as we can in the orange.

CDR The bottom will be 44 (*74001*) and the top will be 35 *(74002)*.

CC And I'm not sure whether your pan will look down into the crater or not, Jack. But if it didn't, we'd like to get another one from there.

CDR It did. I'll also get you a stereo pan before we leave. Yes. I've practiced too long on taking stereo pans of craters, without getting one here. What is that right there?

LMP OH, it's a piece of glass, probably.

CDR Boy, it sure is.

LMP You know that we just about got to the upper edge of this little ellipsoid zone. I think we've messed up most of it. Let's try right over here.

CDR I've got a little piece of glass in my pocket *(74235)*.

LMP The upper portion of the core is going to be a little bit disturbed, because we've walked around the area so much.

CDR There was a little piece of black glass - - solid black glass.

LMP I'll get a shot.

CDR Take your picture. That's about as far as I can shove it.

CC Was the gray mantle over the top of this, or was this showing all the way through to the surface.

LMP No, it was over the top. It was about a half a centimeter over the top. He's getting about 3 centimeters a whack.

CC Very good.

CDR I'll tell you, it's a lot harder going in than that double core back there. It's pretty hard.

LMP It acts like it's inherently cohesive. It breaks up in angular fragments. An essential portion of the zone actually has a crimson hue, or red hue. Outside of that, it's orange. And outside of that it is gray.

CDR I'm going up to the max here for just a minute or two. OK, Let me hit it some more. Ready?

LMP Have at it. He's still getting a centimeter a whack, poor guy. I better get a locator.

CDR The only thing I question is our ability to get it out. Man, that's really hit bottom.

CDR Pull slowly. Slowly so I can cap it all right. Let me get a cap. OK, very slow. Even the core tube is red! The bottom one's black – black and orange, and the top one's gray and orange!

LMP The fact is, the bottom of the core is very black compared with anything we've seen.

CDR Hey, we must have gone through the red soil because it's filled, but it's filled with a black material. Dark stuff, almost a very fine grained - -

LMP That might be magnetite. God, it is black isn't it?

Table 1. Chemical composition of 74241.

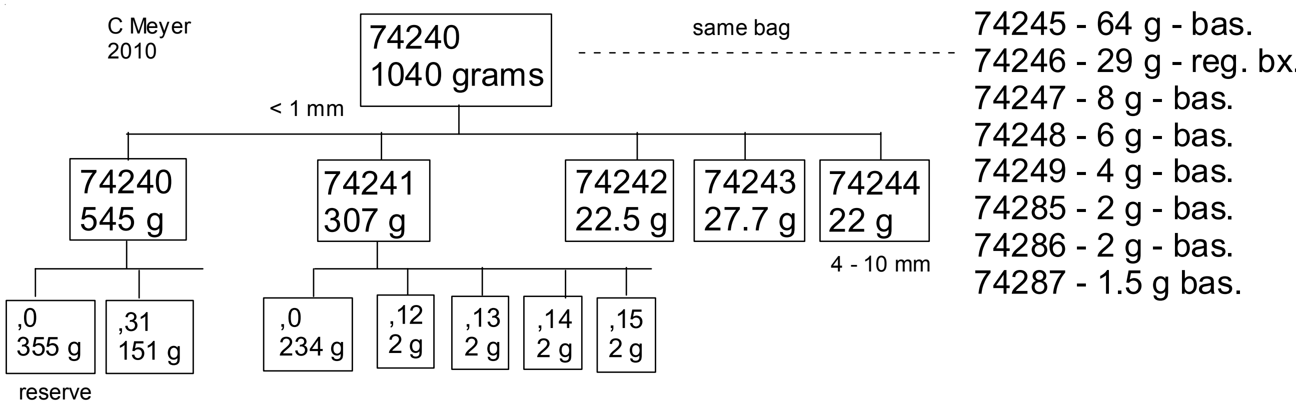
reference	Rhodes74			Rhodes74		Korotev92			Philpotts74		Keith74		Nava74		Morgan74		Wanke73	
weight		74240		Wiesmann76									Masuda74					
SiO2 %	41.55	40.78	(a)										42.3	(e)			42.4	(c)
TiO2	7.45	8.61	(a)										7.33	(e)			6.49	(c)
Al2O3	13.35	12.54	(a)										13.69	(e)			13.9	(c)
FeO	14.89	15.84	(a)			16.2	15.3	(c)					14.66	(e)			15.2	(c)
MnO	0.22	0.24	(a)										0.202	(e)			0.192	(c)
MgO	9.19	9.15	(a)										9.88	(e)			9.27	(c)
CaO	11.54	11.36	(a)										10.89	(e)			11.4	(c)
Na2O	0.48	0.38	(a)			0.46	0.47	(c)					0.48	(e)			0.45	(c)
K2O	0.12	0.12	(a)	0.12	(b)				0.124	(b)	0.17	(d)	0.123	(e)			0.1	(c)
P2O5	0.1	0.09	(a)										0.124	(e)				
S %	0.12	0.14	(a)															
sum																		
Sc ppm						61	57	(c)									50.2	(c)
V																		(c)
Cr	2805	2805	(a)	2676	(b)	2780	2800	(c)									2320	(c)
Co						26	26	(c)									24.5	(c)
Ni	101	80	(a)			90	140	(c)							64	(f)	82	(c)
Cu																	21	(c)
Zn	96	83	(a)												86	(f)	88	(c)
Ga																	13.4	
Ge ppb																	0.21	
As															155	(f)	0.22	
Se															360	(f)		
Rb	2.5	2.3	(a)	2.423	(b)				2.55	(b)					2.3	(f)		
Sr	154	163	(a)	159	(b)	170	210	(c)	155	(b)							140	(c)
Y	74	80	(a)														61	(c)
Zr	232	235	(a)	218	(b)	270	200	(c)	565	(b)							204	(c)
Nb	19	19	(a)														15.1	(c)
Mo																		
Ru																		
Rh																		
Pd ppb																		
Ag ppb															25	(f)		
Cd ppb															210	(f)		
In ppb																		
Sn ppb																		
Sb ppb															0.55	(f)		
Te ppb															24	(f)		
Cs ppm															0.107	(f)		
Ba				112	(b)	120		(c)	116	(b)							120	(c)
La				9.95	(b)	9.72	9.93	(c)									10.9	(c)
Ce				28.8	(b)	29	29.5	(c)	29.6	(b)							34	(c)
Pr																	4.4	(c)
Nd				24	(b)	22	24	(c)	24.8	(b)							31	(c)
Sm				8.55	(b)	9.05	8.72	(c)	8.8	(b)							8.7	(c)
Eu				1.6	(b)	1.68	1.55	(c)	1.64	(b)							1.65	(c)
Gd				12.6	(b)				12.2	(b)							11.1	(c)
Tb						2.19	2.1	(c)									1.9	(c)
Dy				13.7	(b)				14	(b)							14	(c)
Ho																	2.8	(c)
Er				8.07	(b)				7.85	(b)							7.7	(c)
Tm																		(c)
Yb				7.45	(b)	7.78	7.52	(c)	7.6	(b)							7.3	(c)
Lu						1.12	1.09	(c)	1.4	(b)							1	(c)
Hf						7.59	7.21	(c)									6.4	(c)
Ta						1.26	1.19	(c)									1.3	(c)
W ppb																	200	
Re ppb															0.296	(f)	0.2	
Os ppb																		
Ir ppb						3.5	4	(c)							2.78	(f)	7.9	
Pt ppb																		
Au ppb						3.5	4	(c)							1.01	(f)	2.6	
Th ppm				1.32	(b)	0.99	1.24	(c)			3.5	(d)						
U ppm				0.37	(b)	0.4	0.26	(c)			0.83	(d)			0.33	(f)	0.37	

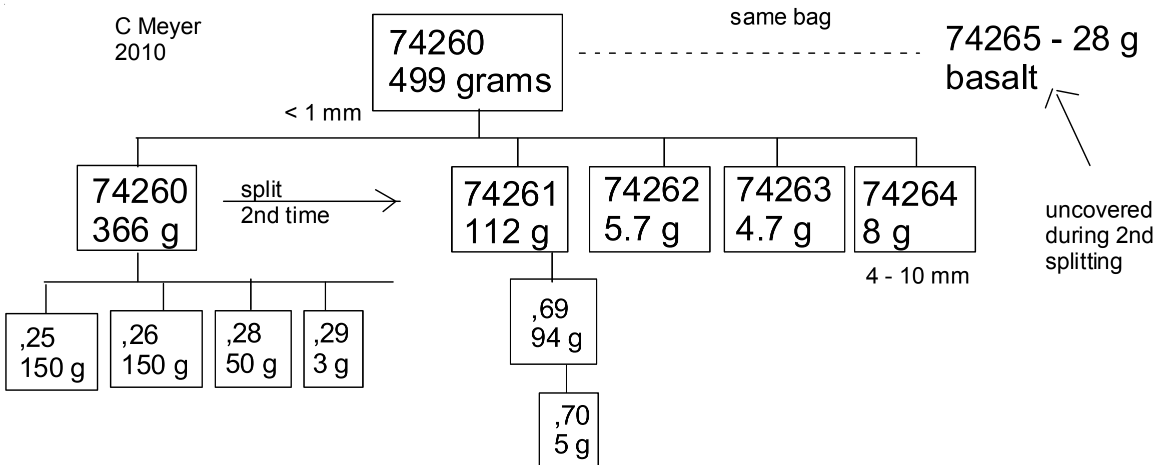
technique: (a) XRF, (b) IDMS, (c) INAA, (d) radiation count., (e) AA, color., (f) RNAA

Table 2. Chemical composition of 74261.

reference	Rhodes74		Korotev92		Masuda74		Brunfelt74		Korotev76			Karhenbuhl77		
weight					74260				90-150	<20 micron				
SiO2 %	41.22	(a)												
TiO2	7.68	(a)					6.27	(b)						
Al2O3	13.25	(a)					13	(b)						
FeO	15.31	(a)	15.6	(b)			14.3	(b)	15.5	14.7	(b)			
MnO	0.23	(a)					0.2	(b)						
MgO	9.47	(a)					9.28	(b)						
CaO	11.37	(a)					12.2	(b)						
Na2O	0.38	(a)	0.476	(b)			0.47	(b)	0.422	0.646	(b)			
K2O	0.12	(a)					0.133	(b)						
P2O5	0.09	(a)												
S %	0.12	(a)												
sum														
Sc ppm			53.9	(b)			49.1	(b)	56.3	43.8	(b)			
V							81	(b)						
Cr	2805	(a)	2950	(b)			2490	(b)	3188	2983	(b)			
Co			30.2	(b)			25.2	(b)	49.2	30.5	(b)			
Ni	99	(a)	120	(b)					160	190	(b)			
Cu							21.6	(b)						
Zn	19	(a)					120	(b)				16.5	17.5	(d)
Ga							16	(b)						
Ge ppb												364	295	(d)
As														
Se														
Rb	2	(a)					2.6	(b)						
Sr	167	(a)	140	(b)			153	(b)						
Y	75	(a)												
Zr	239	(a)	250	(b)										
Nb	19	(a)												
Mo														
Ru														
Rh														
Pd ppb														
Ag ppb														
Cd ppb												43	44	(d)
In ppb												2.8	2	(d)
Sn ppb														
Sb ppb												2	4	(d)
Te ppb												24	22	(d)
Cs ppm							0.094	(b)						
Ba			166	(b)	114	(c)	83	(b)						
La			9.37	(b)	9.81	(c)	7.1	(b)	8.29	11.6	(b)			
Ce			27	(b)	28.2	(c)			28	34.4	(b)			
Pr														
Nd			17	(b)	23.2	(c)								
Sm			8.21	(b)	8.35	(c)	7.84	(b)	7.54	9.06	(b)			
Eu			1.63	(b)	1.73	(c)	1.32	(b)	1.46	1.74	(b)			
Gd					11	(c)								
Tb			1.91	(b)			2.02	(b)	2.03	2.2	(b)			
Dy					12.8	(c)	11.5	(b)						
Ho														
Er					7.71	(c)								
Tm														
Yb			6.95	(b)	6.96	(c)	7.9	(b)	7.23	7.42	(b)			
Lu			0.96	(b)	0.975	(c)	0.98	(b)	1.03	1.06	(b)			
Hf			6.98	(b)			5.2	(b)	6.7	7.7	(b)			
Ta			1.18	(b)			1.1	(b)	1.1	1.2	(b)			
W ppb							190	(b)						
Re ppb														
Os ppb														
Ir ppb			5.4	(b)										
Pt ppb														
Au ppb			< 6	(b)										
Th ppm			1.1	(b)			0.95	(b)	0.7	1.6	(b)			
U ppm			0.23	(b)			0.34	(b)						

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





References 74241 and 74261

Becker R.H. and Clayton R.N. (1977) Nitrogen isotopes in lunar soils as a measure of cosmic-ray exposure and regolith history. *Proc. 8th Lunar Sci. Conf.* 3685-3704.

Butler P. (1973) Lunar Sample Information Catalog Apollo 17. Lunar Receiving Laboratory. MSC 03211 Curator's Catalog. pp. 447.

Butler P. and Meyer C. (1976) Sulfur prevails in coatings on glass droplets: Apollo 15 green and brown glasses and Apollo 17 orange and black (devitrified) glasses. *Proc. 7th Lunar Sci. Conf.* 1561-1581.

Chang S., Lennon K. and Gibson E.K. (1974) Abundances of C, N, H, He and S in Apollo 17 soils. *Proc. 5th Lunar Sci. Conf.* 1785-1800.

Crozaz G., Drozd R., Hohenberg C.M., Morgan C., Ralston C., Walker R.M. and Yuhas D. (1974) Lunar surface dynamics: Some general conclusions and new results from Apollo 16 and 17. *Proc. 5th Lunar Sci. Conf.* 2475-2500.

Curtis D.B. and Wasserburg G.J. (1977) Transport and erosional processes in the Taurus-Littrow Valley – Inferences from neutron fluences in lunar soils. *Proc. 8th Lunar Sci. Conf.* 3045-3057.

Des Marais D.J., Basu A., Hayes J.M. and Meinschein W.G. (1975) Evolution of carbon isotopes, agglutinates, and the lunar regolith. *Proc. 6th Lunar Sci. Conf.* 2353-2373.

von Engelhardt W., Hurrle H. and Luft E. (1976) Microimpact-induced changes of textural parameters and modal composition of the lunar regolith. *Proc. 7th Lunar Sci. Conf.* 373-392.

Epstein S. and Taylor H.P. (1975) Investigation of carbon, hydrogen, oxygen and silicon isotope and concentration relationships on the grain surfaces of a variety of lunar soils and in some Apollo 15 and 16 core samples. *Proc. 6th Lunar Sci. Conf.* 1771-1798.

Eugster O., Eberhardt P., Geiss J., Grögler N., Jungck M. and Mörgeli M. (1977) The cosmic-ray exposure history of Shorty Crater samples; the age of Shorty Crater. *Proc. 8th Lunar Sci. Conf.* 3059-3082.

Eugster O., Eberhardt P., Geiss J. and Grögler N. (1983) Neutron induced fission of uranium: a dating method for lunar surface material. *Science* **219**, 170-172.

Eugster O. (1985) Multistage exposure history of the 74261 soil constituents. *Proc. 16th Lunar Planet Sci. Conf.* D95-D102. J. Geophys. Res. **90** and Lunar Planet. Institute.

Eugster O., Terribilini Dario, Polnau E. and Kramers J. (2001) The antiquity indicator argon-40/argon-36 for lunar surface samples calibrated by uranium-235-xenon-136 dating. *Meteor. & Planet. Sci.* **36**, 1097-1115.

Fruland R.M., Morris R.V., McKay D.S. and Clanton U.S. (1977) Apollo 17 ropy glasses. *Proc. 8th Lunar Sci. Conf.* 3095-3111.

Gibson E.K. and Moore G.W. (1974a) Sulfur abundances and distributions in the valley of Taurus-Littrow. *Proc. 5th Lunar Sci. Conf.* 1823-1837.

Goswami J.N. and Lal D. (1974) Cosmic ray irradiation at the Apollo 17 site: Implications to Lunar regolith dynamics. *Proc. 5th Lunar Sci. Conf.* 2643-2662.

Glass B.P. (1976b) Major element compositions of glasses from Apollo 11, 16 and 17 soil samples. *Proc. 7th Lunar Sci. Conf.* 679-693.

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

Heber V.S., Baur H. and Wieler R. (2001) High resolution solar He record in lunar samples: Evidence for a temporal variation of the solar wind composition with time? (abs#1847) *Lunar Planet. Sci.* **XXXII,** Lunar Planetary Institute, Houston.

Heber V.S., Baur H. and Wieler R. (2003) Helium in lunar samples analyzed by high-resolution stepwise etching: Implications for the temporal constancy of solar wind isotopic composition. *Astophysical J.* **597**, 602-614.

Heiken G.H. (1974) A catalog of lunar soils. JSC Curator

Heiken G.H. (1975) Petrology of lunar soils. *Rev. Geophys. Space Phys.* **13**, 567-587.

Heiken G.H. and McKay D.S. (1974) Petrology of Apollo 17 soils. *Proc. 5th Lunar Sci. Conf.* 843-860.

Heiken G.H., McKay D.S. and Brown R.W. (1974) Lunar deposits of possible pyroclastic origin. *Geochim. Cosmochim. Acta* **38**, 1703-1718.

Heiken G.H. and McKay D.S. (1977) A model for the eruption behavior of a volcanic vent in eastern Mare Serenitatis. *Proc. 8th Lunar Planet. Sci. Conf.* 3243-3255.

Heiken G.H. and McKay D.S. (1978) Petrology of a sequence of pyroclastic rocks from the valley of Taurus-Littrow (Apollo 17 landing site). *Proc. 9th Lunar Planet. Sci. Conf.* 1933-1943.

Hintenberger H., Schultz L., and Weber H.W. (1975) A comparison of noble gases in lunar fines and soil breccias: Implications for the origin of soil breccias. *Proc. 6th Lunar Sci. Conf.* 2261-2270.

Hubner W., Kirsten T and Kiko J. (1975) Rare gases in Apollo 17 soils with emphasis on analysis of size and mineral fractions of soil 74241. *Proc. 6th Lunar sci. Conf.* 2009-2026.

Hughes S.S., Delano J.W., and Schmitt R.A. (1990) Chemistries of individual mare volcanic glasses: Evidence for distinct regions of hybridized mantle and a KREEP component in Apollo 14 magmatic sources. *Proc. 20th Lunar Planet. Sci. Conf.* 127-138.

Jovanovic S. and Reed G.W. (1974a) Labile and nonlabile element relationships among Apollo 17 samples. *Proc. 5th Lunar Sci. Conf.* 1685-1701.

Korotev R.L. (1976) Geochemistry of grain-size fractions of soils from the Taurus-Littrow valley floor. *Proc. Lunar Sci. Conf 7th,* 695-726.

Korotev R.L. and Kremser D. (1992) Compositional variations in Apollo 17 soils and their relationships to the geology of the Taurus-Littrow site. *Proc. 22nd Lunar Planet. Sci. Conf.* 275-301.

Laul J.C. and Schmitt R.A. (1974a) Chemical composition of boulder-2 rocks and soils, Apollo 17, Station 2. *Earth Planet. Sci. Lett.* **23**, 206-219.

Lee D-C., Halliday A.N., Snyder G.A. and Taylor L.A. (1997) Age and origin of the Moon. *Science* **278**, 1098-1103.

LSPET (1973a) Apollo 17 lunar samples : Chemical and petrographic description. *Science* **182**, 659-690.

LSPET (1973c) Preliminary examination of lunar samples. Apollo 17 Preliminary Science Report. NASA SP-330, 7-1—7-46.

Masuda A., Tanaka T., Nakamura N. and Kurasawa H. (1974) Possible REE anomalies of Apollo 17 REE patterns. *Proc. 5th Lunar Sci. Conf.* 1247-1253.

McKay D.S., Fruland R.M. and Heiken G.H. (1974) Grain size and the evolution of lunar soils. *Proc. 5th Lunar Sci. Conf.* 887-906.

Meyer C. (1973) Apollo 17 Coarse Fines (4-10 mm) Sample Location, Classification and Photo Index. Curator Report. pp. 182.

Mitchell J.K., Carrier W.D., Costes N.C., Houston W.N., Scott R.F. and Hovland H.J. (1973) 8. Soil-Mechanics. *In*

Apollo 17 Preliminary Science Rpt. NASA SP-330. pages 8-1-22.

Moore C.B., Lewis C.F. and Cripe J.D. (1974a) Total carbon and sulfur contents of Apollo 17 lunar samples. *Proc. 5th Lunar Sci. Conf.* 1897-1906.

Moore C.B., Lewis C.F., Cripe J.D. and Volk M. (1974b) Total carbon and sulfur contents of Apollo 17 lunar samples (abs). *Lunar Sci.* **V**, 520-522. Lunar Planetary Institute, Houston.

Morgan J.W., Ganapathy R., Higuchi H., Krahenbuhl U. and Anders E (1974a) Lunar basins: Tentative characterization of projectiles, from meteoritic dements in Apollo 17 boulders. *Proc. 5th Lunar Sci. Conf.* 1703-1736.

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

Morris R.V., Score R., Dardano C. and Heiken G. (1983) Handbook of Lunar Soils. Two Parts. JSC 19069. Curator's Office, Houston

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

Müller O. (1974a) Solar wind nitrogen and indigenous nitrogen in Apollo 17 lunar samples. *Proc. 5th Lunar Sci. Conf.* 1907-1918.

Müller O. (1974b) Solar wind and indigenous nitrogen in Apollo 17 lunar samples (abs). *Lunar Sci.* **V**, 534-536. Lunar Planetary Institute, Houston.

Müller O. (1975) Lithophile trace and major elements in Apollo 16 and 17 lunar samples. *Proc. 6th Lunar Sci. Conf. 1303*-1312.

Nunes P.D., Tatsumoto M. and Unruh D.M. (1974b) U-Th-Pb systematics of some Apollo 17 lunar samples and implications for a lunar basin excavation chronology. *Proc. 5th Lunar Sci. Conf.* 1487-1514.

Papike J.J., Simon S.B. and Laul J.C. (1982) The lunar regolith: Chemistry, Mineralogy and Petrology. *Rev. Geophys. Space Phys*. **20**, 761-826.

Philpotts J.A., Schuhmann S., Kouns C.W., Lum R.K.L. and Winzer S. (1974) Origin of Apollo 17 rocks and soils. *Proc. 5th Lunar Sci. Conf.* 1255-1267.

Rhodes J.M., Rodgers K.V., Shih C., Bansal B.M., Nyquist L.E., Wiesmann H. and Hubbard N.J. (1974) The relationships between geology and soil chemistry at the Apollo 17 landing site. *Proc. 5th Lunar Sci. Conf.* 1097-1117.

Rose H.J., Cuttitta F., Berman S., Brown F.W., Carron M.K., Christian R.P., Dwornik E.J. and Greenland L.P. (1974a) Chemical composition of rocks and soils at Taurus-Littrow. *Proc. 5th Lunar Sci. Conf.* 1119-1133.

Schonfeld E. (1974) The contamination of lunar highland rocks by KREEP: Interpretations by mixing models. *Proc. 5th Lunar Sci. Conf.* 1269-1286.

Silver L.T. (1974) Patterns for U, Th, Pb distributions and isotopic relationships in Apollo 17 soils (abs). *Lunar Sci.* **V**, 706-708.

Taylor L.A., Williams K.L. and Sardi O. (1973b) Selected Apollo 17 soils: Mineralogy and geochemistry of opaque and non-opaque phases. *Earth Planet. Sci. Lett.* **21**, 6-12.

Wänke H., Baddenhausen H., Dreibus G., Jagoutz E., Kruse H., Palme H., Spettel B. and Teschke F. (1973) Multielement analysis of Apollo 15, 16 and 17 samples and the bulk composition of the moon. *Proc. 4th Lunar Sci. Conf.* 1461-1481.

Wiesmann H. and Hubbard N.J. (1975) A compilation of the Lunar Sample Data Generated by the Gast, Nyquist and Hubbard Lunar Sample PI-Ships. Unpublished. JSC

Wolfe E.W., Bailey N.G., Lucchitta B.K., Muehlberger W.R., Scott D.H., Sutton R.L and Wilshire H.G. (1981) The geologic investigation of the Taurus-Littrow Valley: Apollo 17 Landing Site. US Geol. Survey Prof. Paper, 1080, pp. 280.