

15030 and 15040
Trench Soils
303.7 g and 392.4 g
"I think I've hit the bedrock"

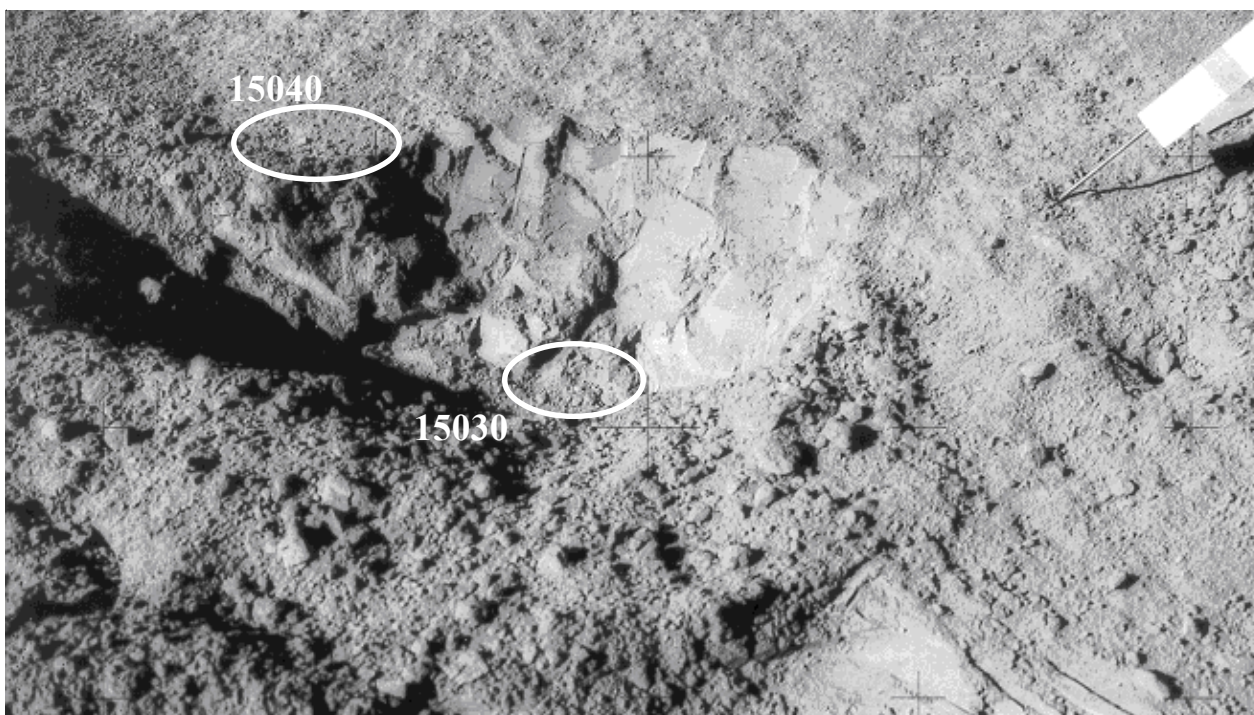
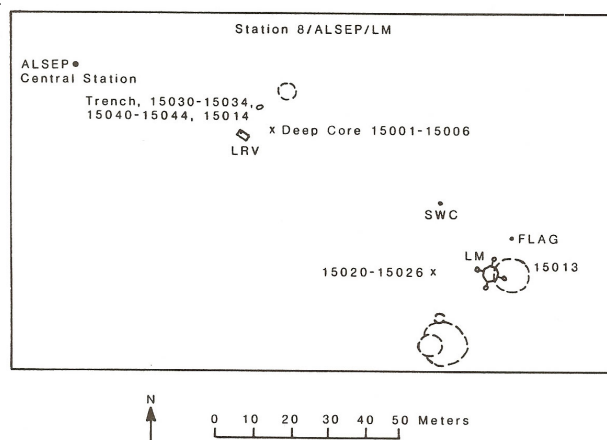


Figure 1: Trench at Apollo 15, station 8, near the ALSEP station. AS15-92-12440. Trench is about 35 cm deep and is known as the Soil Mechanics Trench. Note the apparent lighter color near the bottom of the trench.

Introduction

"Bedrock?" Well it can't be "bedrock", but apparently they ran into something more coherent at the bottom of the trench (see voice transcript).

Lunar soil sample 15030 was collected from the bottom of the Soil Mechanics Trench (Mitchell et al. 1972) at station 8, near the ALSEP site. The trench was dug about 12 - 14 inches deep (figure 1). First, several scoops were made for 15014 which was also collected from the bottom of this trench and placed in a special environment sample container (SESC). Then, 15030 was dug from the bottom of the trench (it may have included material that fell in from the sides). 15040 is a soil sample from the top of the trench. The Apollo 15 deep drill core (15001 - 15006) was also taken nearby (~10 m) and these soils provide a reference for it. The drill went in 2.4 meters and there was no indication that they reached "bedrock" with it! In any case, the high percentage of agglutinates in the subsurface soil proves that it isn't "bedrock".



Petrography

Morris (1978) found that both 15041 (surface) and 15031 (subsurface) were mature soils with $Is/FeO = 94$ and 68 respectively. Von Engelhardt et al. (1973) first reported the mode of the trench soils and found that both the surface soil and the subsurface soil were

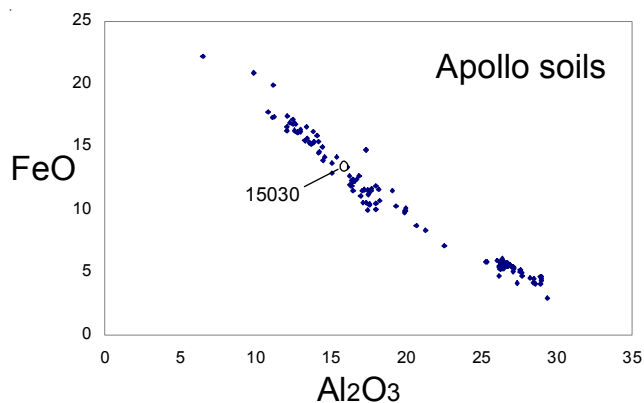


Figure 2: Chemical composition of 15030 compared with other lunar soils.

full of agglutinates. Basu et al. (1981) determined that 15041 had 47.9 % agglutinates and 15031 had 38.6 % agglutinates. Basu et al. (1981) give a full breakdown of the modal mineralogy of 15031 and 15041, including for multiple size ranges (table).

Korotev (1987) and Walker and Papike (1981) and others used chemical mixing models to calculate the percentages of rock components in trench soils (about 30-40% mare basalt; 20-30% KREEP). Carr and Meyer (1974) studied the glass compositions in 15030 and other Apollo 15 soils, finding about 14% green glass (less than others).

Chemistry

Laul and Schmitt (1973), Chou et al. (1975) and Korotev (1987) obtained rather complete chemical analysis of the trench soils (table 1 and 2; figures 2 and 3). In addition, Jovanovic and Reed (1972) reported the concentration of Hg, Os, Ru and U in 15031 along with data for the deep drill core.

Modal content of soils 15030 and 15040.

From Basu et al. 1981.

	15030	15040
Agglutinates	38.6	47.9
Basalt	7.5	5.1
Breccia	12.9	8.5
Anorthosite	0.5	0.2
Norite		
Gabbro		
Plagioclase	4.8	4.8
Pyroxene	17.8	20.8
Olivine	2.2	1.2
Ilmenite	0.8	0.1
Glass other	9.1	6.7

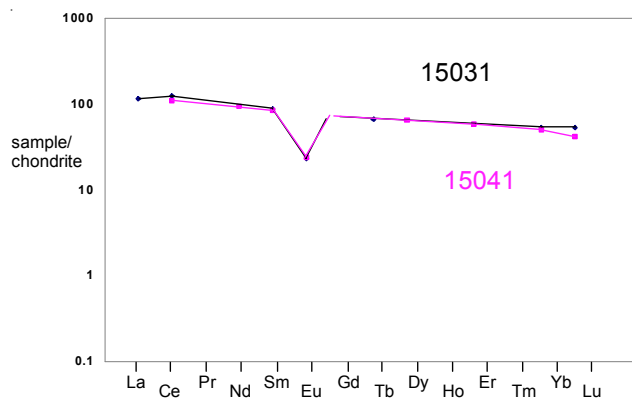


Figure 3: Normalized rare-earth-element patterns for 15031 and 15041 (data from Laul and Schmitt 1973 and Church et al. 1973).

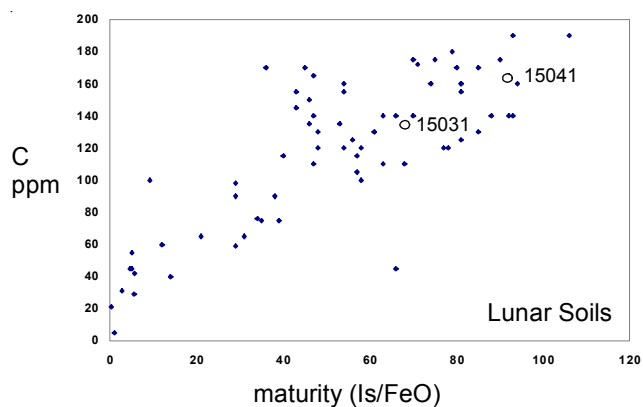


Figure 4: Carbon content and maturity index from 15031 and 15041 compared with all other lunar soils.

Papanastassiou and Wasserburg (1972) reported K, Rb, Sr and Ba for 15041 as well for samples along the deep drill.

The carbon content of a lunar soil is a kind of measure of maturity because C is implanted by solar wind. The trench soils were found to have rather high C contents (Moore et al. 1972, 1973), especially when compared with the deep drill core (figure 4).

Cosmogenic isotopes and exposure ages

For 15031, Rancitelli et al. (1972) reported the cosmic-ray-induced activity of $^{22}\text{Na} = 33$ dpm/kg., $^{26}\text{Al} = 60$ dpm/kg., $^{46}\text{Sc} = 6.3$ dpm/kg., $^{54}\text{Mn} = 24$ dpm/kg., $^{56}\text{Co} = 6$ dpm/kg. and $^{60}\text{Co} = 4.3$ dpm/kg. while the surface sample, 15041, had $^{22}\text{Na} = 65$ dpm/kg., $^{26}\text{Al} = 123$ dpm/kg., $^{46}\text{Sc} = 2.9$ dpm/kg., $^{54}\text{Mn} = 14$ dpm/kg., $^{56}\text{Co} = 27$ dpm/kg. and $^{60}\text{Co} < 1.5$ dpm/kg.

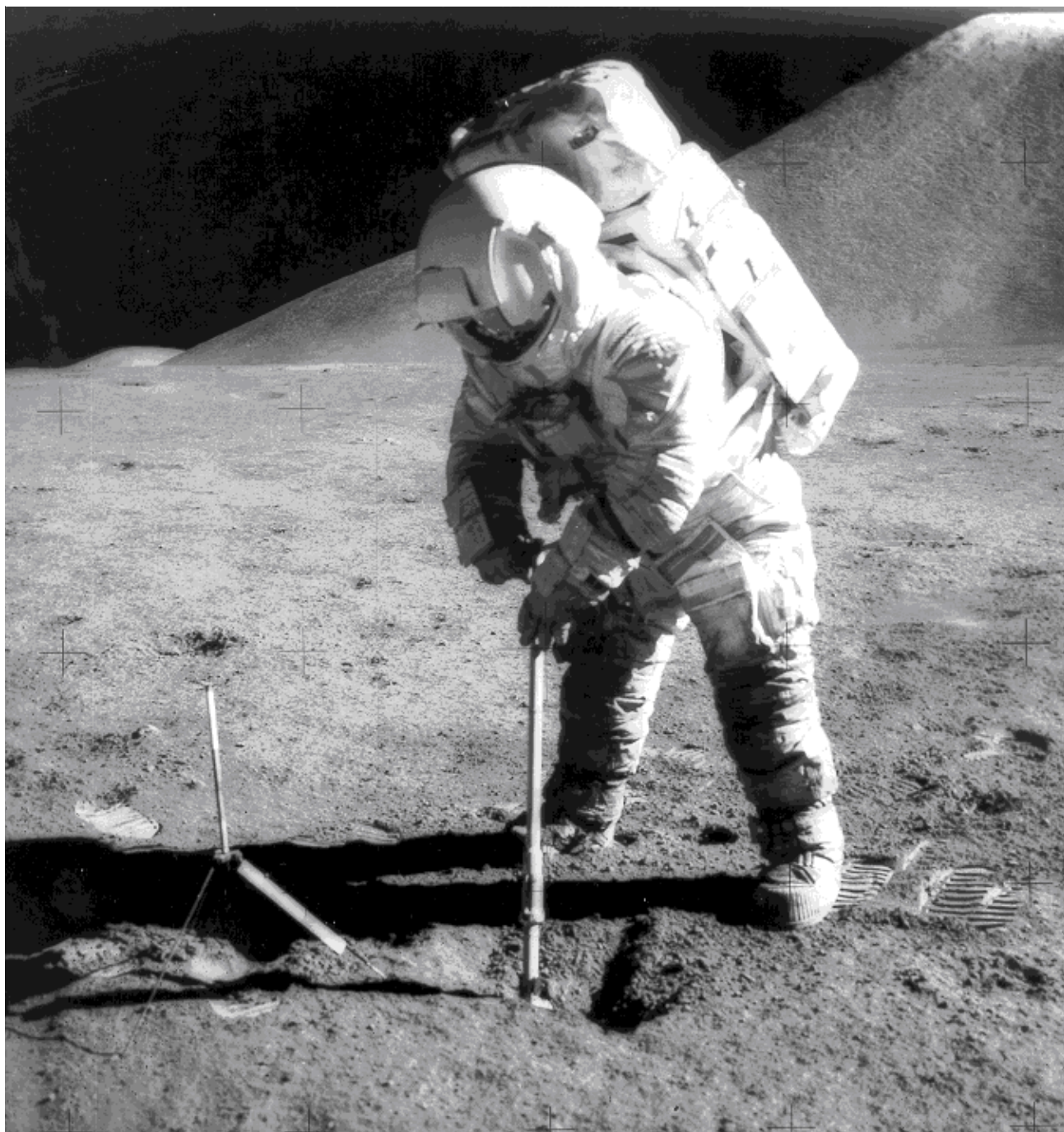


Figure 5: Photograph of Jim Irwin digging special trench at station 8, ALSEP site. Samples 15030, 15040 and 15014 (SESC) were from this trench. NASA photo AS15-92-12424.

Wahlen et al. (1973) reported ^{60}Co for 15030, 15005 and 15001 (figure 10).

Other Studies

The wall of this trench was used for soil mechanics tests (Mitchell et al. 1972) by driving the LRV near the wall to make it collapse (figure 6).

Church et al. (1976) studied the U-Th-Pb systematics (figure 7).

Bogard et al. (1974) report the isotopic composition of Xe for 15030, 15040 and the deep drill. Bogard and Hirsch (1975) report the He, Ne, Ar isotopes for 15030 and compare Xe and Kr with the core (figure 9).

Housley et al. (1974) reported Mossbauer and magnetic data for the trench soils.

Processing

The soil catalog (Morris et al. 1983), states that 15030 was brought back in an ALSRC (it did not seal properly), while 15040 was returned in a beta-cloth bag. However, Butler (1972) states that both soils were returned in beta-cloth bag #6, where they would have been exposed to cabin atmospheres and Pacific Ocean.

Splits of each are called reserve samples and have been kept in seal containers since the LRL.

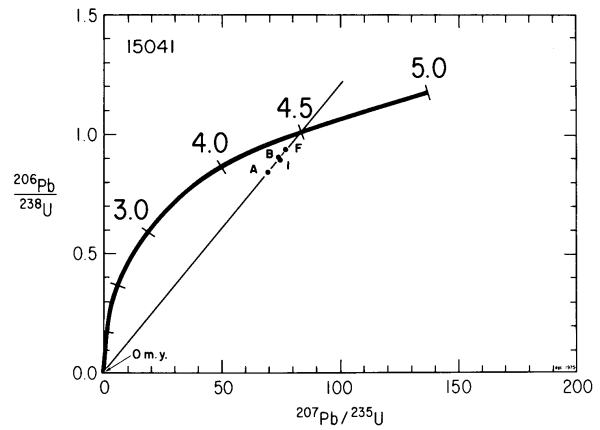
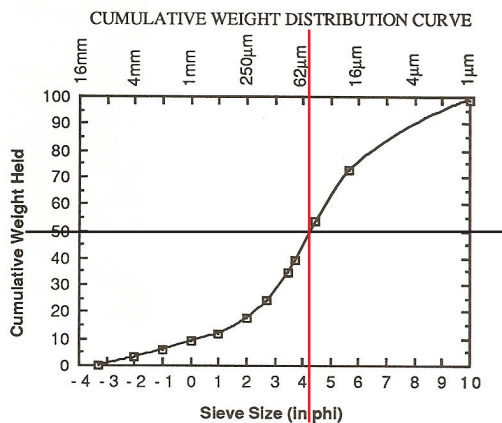


Figure 7: U-Pb isotopes for 15041 (from Church et al. 1976).



Average grain size = 52 microns

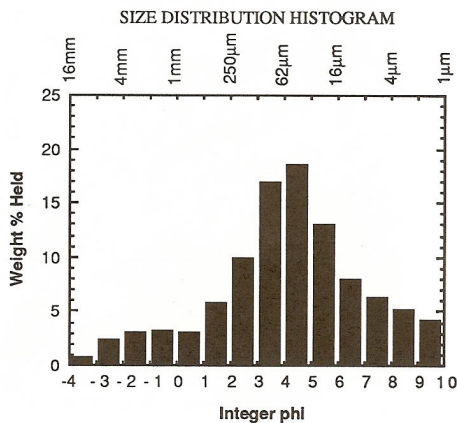
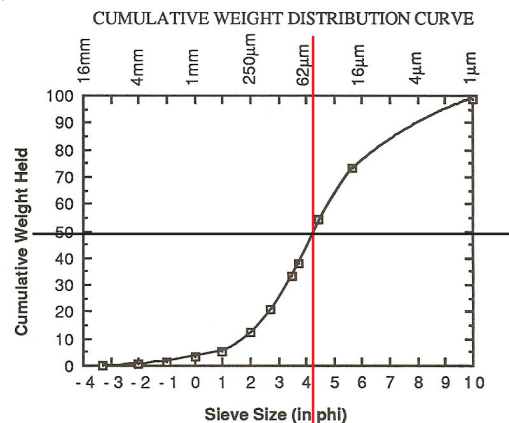


Figure 6a: Grain size distribution for 15030 (Graf 1993).



Average grain size = 52 microns

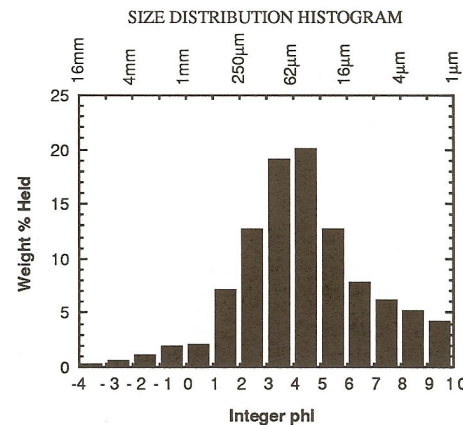


Figure 6b: Grain size distribution for 15040 (Graf 1993).

excerpts from the voice transcript

LMP = Jim Irwin; CDR = Dave Scott; CC = Joe Allen

CC Rodger, get Jim started on the ditching experiment, if you please, and then I've got another good one to lay on you here. Don't know how to explain it. We'd like for you to get the deep core for us with the drill.

LPM Well, the thing is, do you want to do the whole Station 8 activity – the comprehensive sample?

CDR Sure. I guess if they want to do Station 8, they want to do Station 8.

Decision made to use TV coverage – not 16-mm movies.

LMP You want me to dig down to bedrock (?)

CDR Yes, bedrock.

LMP Joe, do you want it 12 inches deep?

CC Whatever you think is reasonable.

LMP I'm down that far already. The wall is very smooth. The wall is fine, yet very cohesive.

CC Any sign of layering?

LMP No signs of layering. I do find some small fragments – white fragments, black fragments. I just exposed a very small fragment with about 3 millimeters of a black clast. But the wall that I've got here is only – no signs of layering at all.

LMP When I get down under 12-inch layer, the surface is much harder to dig through. Looks like more cohesive down about - Well, we ought to get a good sample at the bottom of this. Boy, its easy to make a flat bottom because its's so hard. I can see why Dave had a hard time digging through it – going through it now.

CC Jim, that's a beautiful trench. Let's stop with that one and document it. We'll want some samples from the bottom please.

LMP Say, I think I've hit bedrock. ***I think I've hit the bedrock!*** Okay, Dave, here you are.

LMP I really do think I'm almost down to bedrock. It really is hard.

CDR It looks like it has a little color change down there, too.

LMP Yea, maybe a slight. Seems to get a little darker, a lighter and a little darker.

LMP Walls are just about vertical on the trench, Joe.

CDR Okay, we need an SESC. Three quarters full.

CC Okay, Dave and Jim. Jim, we think you can collect the samples here pretty well. And Dave, in order to get that drill task accomplished, we're going to have to get you started on that shortly.

CDR Okay, I – he can't get the SESC very well by himself, I don't think, Joe. It's tough for two of us to get it.

CC Okay, when you finish that, press on with the drill. And while you're looking down in there, how deep do you think it is now?

CDR Oh, I'd say it's 14-16 inches deep, Joe. White clasts in there. A little bit more; keep coming. Good job. Yes, sir. We got 75 percent full.

LMP Okay, you're going to leave me, and I'll sample it myself. I guess I'll fill the bags myself. Okay, Joe. The soils sample from the bottom of the trench (15030) is in 252. Joe, I'm going to skip sampling the – side, I'm just going to sample the top over here. Okay, Joe; on the top of the trench, 253 (sample 15040).



Figure 8: Another view of Soil Mechanics Trench - after the dirty deeds were done! NASA AS15-88-11874. Note the Teflon protective rings from the seals on the SESC (sample 15014).

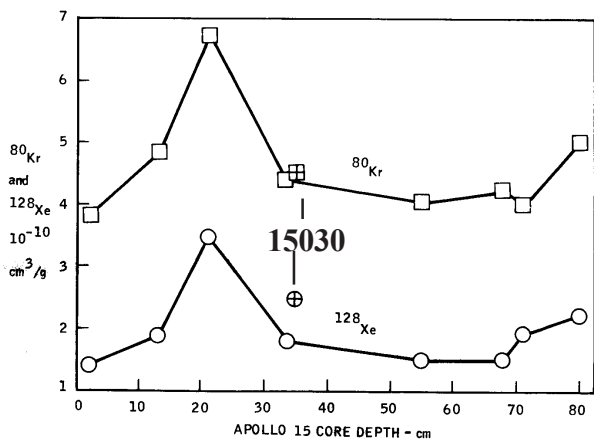


Figure 9: ⁸⁰Kr and ¹²⁸Xe for 15030 compared with data from deep drill (Bogard and Hirsch 1975).

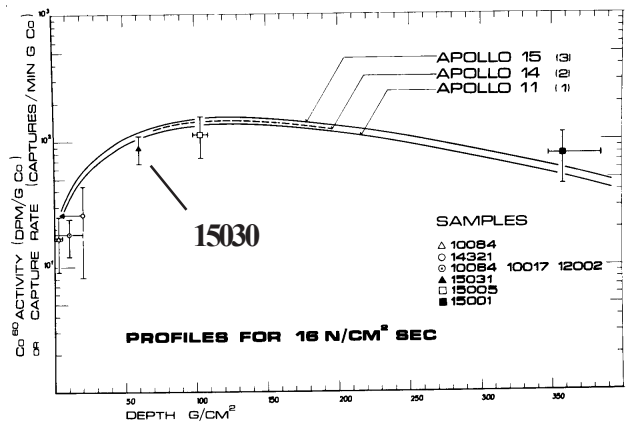


Figure 10: Activity of ⁶⁰Co as function of depth in lunar surface compared with theoretical production due to thermal neutrons (Wahlen et al. 1973).

Table 1. Chemical composition of 15030.

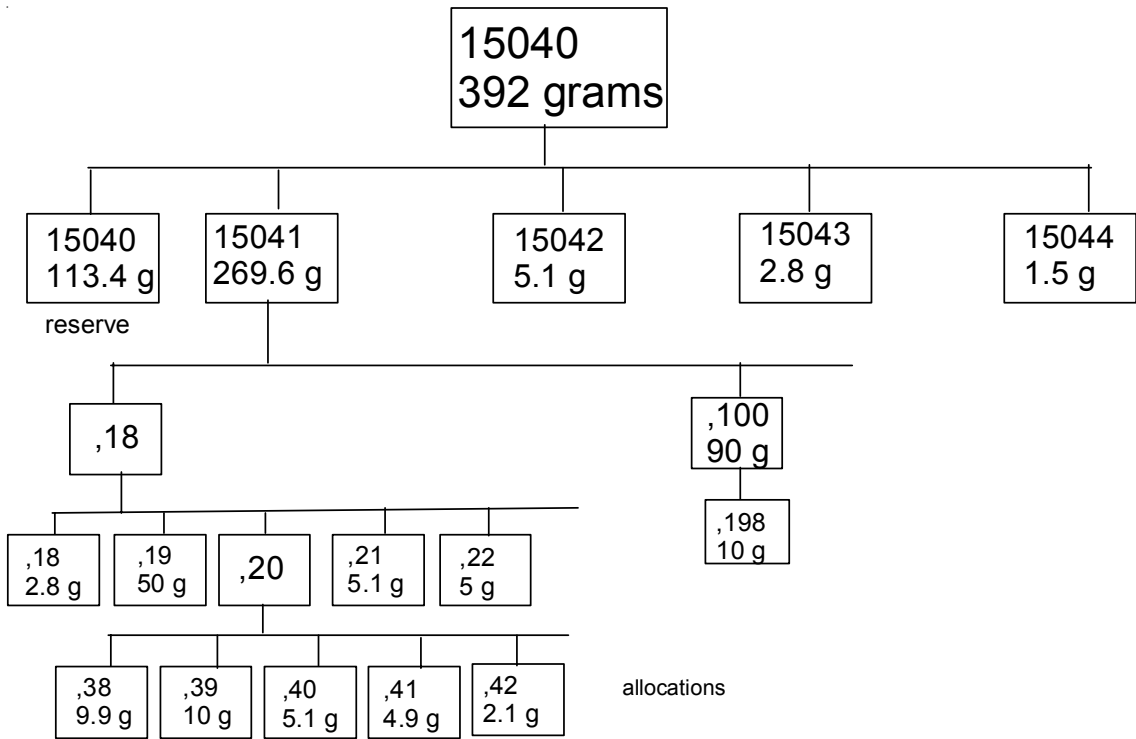
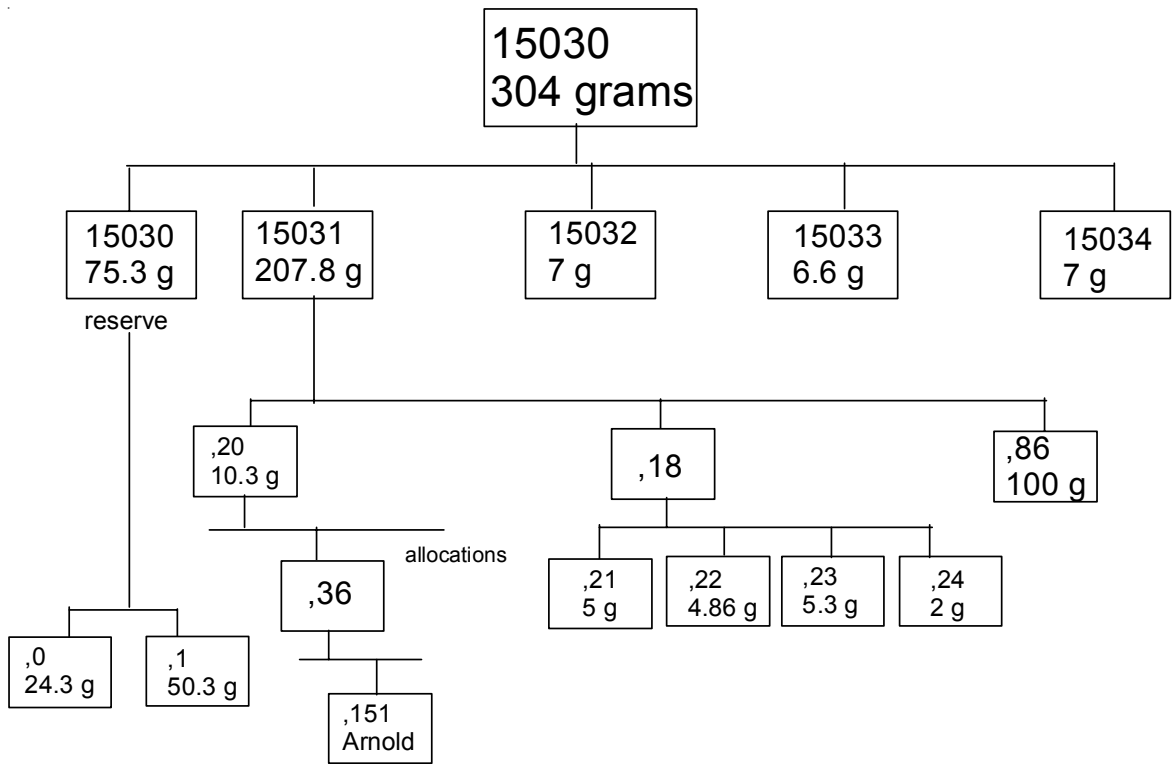
reference weight	Korotev87	Laul73	Taylor73	Keith72	Rancitelli72	Chou75	Chou75	
SiO2 %								
TiO2	1.7	(a) 1.7	(a)					
Al2O3	14.1	(a) 14.1	(a)				14.2	13.8 (a)
FeO	15.9	(a) 15	(a)				14.5	14.5 (a)
MnO	0.19	(a) 0.187	(a)					
MgO	12	(a) 12	(a)					
CaO	9.6	(a) 10.2	(a)				10.4	10.4 (a)
Na2O	0.41	(a) 0.446	(a)				0.45	0.44 (a)
K2O		0.23	(a)	0.22	0.214	(c)		0.22 (a)
P2O5								
S %								
sum								
Sc ppm	31.6	(a) 28	(a) 14	(b)			29	29 (a)
V	120	(a) 120	(a) 86	(b)			150	(a)
Cr	2840	(a) 2662	(a) 2600	(b)			2780	2840 (a)
Co	46.4	(a) 42	(a) 44	(b)			42	43 (a)
Ni	203	(a)	222	(b)		242	(d)	
Cu			8	(b)				
Zn						14.2	(d)	
Ga			4.4	(b)		4.74	(d)	
Ge ppb						369	(d)	
As								
Se								
Rb			5.9	(b)				
Sr	115	(a)						
Y			105	(b)				
Zr	430	(a) 320	(a) 540	(b)				
Nb			33	(b)				
Mo								
Ru								
Rh								
Pd ppb								
Ag ppb								
Cd ppb						44	(d)	
In ppb						18	(d)	
Sn ppb								
Sb ppb								
Te ppb								
Cs ppm	0.27	(a)	0.21	(b)				
Ba	271	(a) 270	(a) 390	(b)			290	(a)
La	26.4	(a) 27	(a) 33	(b)			29	28.6 (a)
Ce	70	(a) 75	(a) 85	(b)			77	74 (a)
Pr			12.7	(b)				
Nd	41	(a)	52	(b)				
Sm	12.6	(a) 12.9	(a) 15.1	(b)			13.4	12 (a)
Eu	1.36	(a) 1.3	(a) 1.8	(b)			1.4	1.4 (a)
Gd			17	(b)				
Tb	2.49	(a) 2.4	(a) 2.78	(b)			1.9	2.4 (a)
Dy			17.4	(b)				14 (a)
Ho			4.11	(b)				
Er			11.6	(b)				
Tm			1.8	(b)				
Yb	8.8	(a) 8.7	(a) 10.9	(b)			8.7	8.6 (a)
Lu	1.32	(a) 1.3	(a) 1.7	(b)			1.31	1.21 (a)
Hf	11.8	(a) 9.5	(a) 10.5	(b)			9.3	8.9 (a)
Ta	1.24	(a) 1.1	(a)					
W ppb								
Re ppb								
Os ppb								
Ir ppb	4.9	(a)				6.8	(d)	
Pt ppb								
Au ppb	<4	(a)				(c) 3.2	(d)	
Th ppm	4.8	(a) 4.8	(a) 4.8	(b) 4.85	4.74	(c)	4	4.6 (a)
U ppm	1.1	(a) 1.6	(a) 1.2	(b) 1.25	1.33	(c)		

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

Table 2. Chemical composition of 15040.

reference	Korotev87	Laul73	Laul73	Church76	Keith72	Rancitelli72	Papanastassiou72
<i>weight</i>							
SiO ₂ %							
TiO ₂	1.7	(a) 1.7	(a) 1.7	1.7	(a)		
Al ₂ O ₃	14.2	(a) 14.1	(a) 14.2	14.1	(a)		
FeO	14.5	(a) 14.3	(a) 14.3	14.2	(a)		
MnO	0.19	(a) 0.187	(a) 0.187	0.187	(a)		
MgO	11.5	(a) 11	(a) 11	12	(a)		
CaO	11.6	(a) 10.4	(a) 10.6	10.3	(a)		
Na ₂ O	0.44	(a) 0.424	(a) 0.426	0.423	(a)		
K ₂ O		0.21	(a) 0.21	0.21	(a) 0.19	(d) 0.21	0.198 (c) 0.203 (d)
P ₂ O ₅							
<i>S %</i>							
<i>sum</i>							
Sc ppm	28.5	(a) 26	(a) 26	25	(a)		
V	110	(a) 110	(a) 107	114	(a)		
Cr	2710	(a) 2511	(a) 2511	2504	(a)		
Co	46.3	(a) 40	(a) 41	40	(a)		
Ni	252	(a) 240	(a)				
Cu							
Zn		14	(b)				
Ga							
<i>Ge ppb</i>							
As							
Se		275	(b)				
Rb		5.1	(b)	5.68	(d)		5.71 (d)
Sr	150	(a)					130.6 (d)
Y							
Zr	370	(a)	350				
Nb							
Mo							
Ru							
Rh							
<i>Pd ppb</i>							
Ag ppb		11	(b)				
Cd ppb		34	(b)				
In ppb		14	(b)				
Sn ppb							
Sb ppb		4.8	(b)				
Te ppb							
Cs ppm	0.27	(a) 0.22	(b)				
Ba	259	(a)	250	250	(a) 271	(d)	288 (d)
La	26.1	(a) 26	(a) 26	26	(a)		
Ce	68	(a) 68	(a) 68	68	(a) 66.4	(d)	
Pr							
Nd	36	(a)			42.4	(d)	
Sm	12.4	(a) 12.7	(a) 12.7	12.7	(a) 12.5	(d)	
Eu	1.4	(a) 1.3	(a) 1.3	1.3	(a) 1.35	(d)	
Gd							
Tb	2.5	(a) 2.2	(a) 2.2	2.2	(a)		
Dy		14	(a)	13	(a) 15.7	(d)	
Ho							
Er					9.28	(d)	
Tm							
Yb	8.3	(a) 8.1	(a) 8.1	8.8	(a) 8.2	(d)	
Lu	1.25	(a) 1.2	(a) 1.2	1.3	(a) 1.02	(d)	
Hf	9.8	(a) 9.1	(a) 9.1	9	(a)		
Ta	1.18	(a) 1.1	(a) 1.1	1.1	(a)		
<i>W ppb</i>							
<i>Re ppb</i>							
<i>Os ppb</i>							
Ir ppb	9.3	(a)					
<i>Pt ppb</i>							
Au ppb	3.9	(a) 3.6	(b)				
Th ppm	4.3	(a) 4.6	(a) 4.8	4.4	(a)	4.64	4.56 (c)
U ppm	1.18	(a) 1.6	(a) 1.6	1.5	(a)	1.2	1.28 (c)

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



References 15030, 15040

- Allen R.O., Jovanovic S. and Reed G.W. (1973) Geochemistry of primordial Pb, Li and Zn in Apollo 15 samples. Proc. 4th Lunar Sci. Conf. 1169-1176.
- Alvarez R. (1977) Photoconductive effects on lunar and terrestrial fines. Proc. 8th Lunar Sci. Conf. 1277-1290.
- Axon H.J. and Goldstein J.I. (1973) Metallic particles of high cobalt content in Apollo 15 soil samples. Earth Planet. Sci. Lett. 18, 173-180.
- Basu A. and Bower J.F. (1977) Provenance of Apollo 15 deep drill core sediments. Proc. 8th Lunar Sci. Conf. 2841-2867.
- Basu A. and McKay D.S. (1979) Petrography and provenance of Apollo 15 soils. Proc. 10th Lunar Sci. Conf. 1413-1424.
- Basu A., McKay D.S., Griffiths S.A. and Nace G. (1981) Regolith maturation on the Earth and the Moon with an example from Apollo 15. Proc. 12th Lunar Planet. Sci. Conf. 433-449.
- Birkebak R.C. and Dawson J.P. (1973) Solar albedo and spectral reflectance for Apollo 15 and 16 lunar fines. Proc. 4th Lunar Sci. Conf. 2447-2452.
- Bogard D.D. and Hirsch W.C. (1975) Noble gas studies on grain size separates of Apollo 15 and 16 deep drill cores. Proc. 6th Lunar Sci. Conf. 2057-2084.
- Bogard D.D. and Nyquist L.E. (1972) Noble gases in the Apollo 15 drill cores. *In* The Apollo 15 Lunar Samples 342-346. LPI.
- Bogard D.D. and Nyquist L.E. (1973) ⁴⁰Ar-³⁹Ar variations in Apollo 15 and 16 regolith. Proc. 4th Lunar Sci. Conf. 1975-1986.
- Bogard D.D., Nyquist L.E., Hirsch W.C. and Moore D.R. (1973) Trapped solar and cosmogenic noble-gas abundances in Apollo 15 and Apollo 16 deep drill samples. Earth Planet. Sci. Lett. 21, 52-69.
- Bogard D.D., Hirsch W.C. and Nyquist L.E. (1974) Noble gases in Apollo 17 fines: Mass fractionation effects in trapped Xe and Kr. Proc. 5th Lunar Sci. Conf. 1975-2003.
- Butler (1972) Lunar Sample Information Catalog: Apollo 15. MSC 03209
- Cadogen P.H., Eglinton G., Firth J.N.M., Maxwell J.R., Mays 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.
- Carrier W.D., Mitchell J.K. and Mahmood A. (1973) The relative density of lunar soil. Proc. 4th Lunar Sci. Conf. 2403-2412.
- Carr M.H. and Meyer C.E. (1974) The regolith at the Apollo 15 site and its stratigraphic implications. Geochim. Cosmochim. Acta 38, 1183-1197.
- Chou C.-L., Boynton W.V., Sundberg L.A. and Wasson J.T. (1975) Volatiles on the surface of Apollo 15 green glass and trace-element distributions among Apollo 15 soils. Proc. 6th Lunar Sci. Conf. 1701-1728.
- Church S.E., Tilton G.R. and Chen J.H. (1976a) Lead isotopic studies of lunar soils: Their bearing on the time scale of agglutinate formation. Proc. 7th Lunar Sci. Conf. 351-371.
- Church S.E., Tilton G.R., Wright J.E. and Lee-Hu C. (1976b) Volatile element depletion and ³⁹K/⁴¹K fractionation in lunar soils. Proc. 7th Lunar Sci. Conf. 423-439.
- Cremers C.L. and Hsia H.S. (1973) Thermal conductivity and diffusivity of Apollo 15 fines and rock samples. Proc. 4th Lunar Sci. Conf. 2459-2464.
- Cremers C.L. and Hsia H.S. (1974) Thermal conductivity of Apollo 16 lunar fines. Proc. 5th Lunar Sci. Conf. 2703-2708.
- Eldridge J.S., O'Kelley G.D. and Northcutt K.J. (1972) Concentrations of cosmogenic radionuclides in Apollo 15 rocks and soil. (abs) The Apollo 15 Lunar Samples. 357-392. LPI
- Engelhardt W.V., 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.
- Farr T.G., Bates B., Ralph R.L. and Adams J.B. (1980) Effects of overlapping optical absorption bands of pyroxene and glass on the reflectance spectra of lunar soils. (abs) LS XI, 276-278. LPI.
- Finkel R.C., Wahlen M., Arnold J.R., Kohl C.P. and Imamura M. (1973) The gradient of cosmogenic radionuclides to a depth of 400 g/cm² in the Moon. (abs) LS IV, 242-244. LPI.
- Gold T., Bilson E. and Baron R.L. (1976) Electrical properties of Apollo 17 rock and soil samples and a summary of electrical properties of lunar material at 450 MHz frequency. Proc. 7th Lunar Sci. Conf. 2593-2603.

- Goldstein J.I. and Axon H.J. (1972) Metallic particles from 3 Apollo 15 soils. (abs) *In* The Apollo 15 Lunar Samples 78-81. LPI.
- Goetz H., White E.W., Johnson G.G. and Pearson M.W. (1972) SEM studies of Apollo 14 and 15 fines. Proc. 3rd Lunar Sci. Conf. 3194-3201.
- Housley R.M., Cirlin E.H., Paton N.E. and Goldberg I.B. (1974) Solar wind and micrometeorite alteration of the lunar regolith. Proc. 5th Lunar Sci. Conf. 2623-2642.
- Imamura M., Nishiizumi K., Honda M., Finkel R.C., Arnold J.R. and Kohl C.P. (1974) Depth profiles of ⁵³Mn in lunar rocks and soils. Proc. 5th Lunar Sci. Conf. 2093-2104.
- Jordan J.I., Heyman D. and Lakatos S. (1974) Inert-gas patterns in regolith at Apollo 15 landing site. *Geochim. Cosmochim. Acta* 38, 65-78.
- Jovanovic S. and Reed G.W. (1972) Trace-element profiles, notably Hg, from a preliminary study of Apollo 15 deep drill core. *Earth Planet. Sci. Lett.* 16, 257-262.
- Keihm S.J. and Langseth M.G. (1973) Surface brightness temperatures at the Apollo 17 heat flow site – thermal conductivity of the upper 15 cm of the regolith. Proc. 4th Lunar Sci. Conf. 2503-2514.
- Keihm S.J., Peters K., Langseth M.G. and Chute J.L. (1973) Apollo 15 measurement of lunar surface brightness temperatures: Thermal conductivity of the upper 1½ meters of regolith. *Earth Planet. Sci. Lett.* 330-336.
- Keith J.E., Clark R.S. and Richardson K.A. (1972) Gamma-ray measurements Apollo 12, 14 and 15 lunar samples. Proc. 3rd Lunar Sci. Conf. 1671-1681.
- Korotev R.L. (1987) Mixing levels, the Apennine Front soil component, and compositional trends in the Apollo 15 soils. Proc. 17th Lunar Planet. Sci. Conf. E411-431.
- Laul J.C. and Schmitt R.A. (1973a) Chemical composition of Luna 20 rocks and soil and Apollo 16 soils. *Geochim. Cosmochim. Acta* 37, 927-942.
- Laul J.C. and Schmitt R.A. (1973b) Chemical composition of Apollo 15, 16 and 17 samples. Proc. 4th Lunar Sci. Conf. 1349-1367.
- LSPET (1972a) Apollo 15 Lunar samples – preliminary description. *Science* 175, 363-375.
- LSPET (1972b) 6. Preliminary Examination of Lunar Samples. *In* Apollo 15 preliminary Science Report. NASA SP-289.
- Mitchell J.K., Bromwell L.G., Carrier W.D., Costes N.C., Houston W.N. and Scott R.F. (1972) 7. Soil Mechanics Experiment. *In* Apollo 15 Preliminary Science Report NASA SP-289.
- Moore C.B. and Cripe J.D. (1974) Total sulfur contents of Apollo 15 and Apollo 16 lunar samples. (abs) LS V, 523-525. LPI.
- Moore C.B., Lewis C.F. and Gibson E.K. (1972) Carbon and nitrogen in Apollo 15 lunar samples. (abs) *In* The Apollo 15 Lunar Samples 316-318. LPI.
- Moore C.B., Lewis C.F. and Gibson E.K. (1973) Total carbon contents of Apollo 15 and 16 lunar samples. Proc. 4th Lunar Sci. Conf. 1613-1624.
- Morris R.V. (1976) Surface exposure indices 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 Planet. Sci. Conf. 2287-2298.
- Morris R.V. (1980) Origins and size distribution of metallic iron particles in the lunar regolith. Proc. 11th Lunar Planet. Sci. Conf. 1697-1712.
- Morris R.V., Score R., Dardano C. and Heiken G. (1983) *Handbook of Lunar Soils*. JSC 19069
- O'Kelley G.D., Eldridge J.S., Northcutt K.J. and Schonfeld E. (1972) Primordial radionuclides and cosmogenic radionuclides in lunar samples from Apollo 15. Proc. 3rd Lunar Sci. Conf. 1659-1671.
- Papanastassiou D.A. and Wasserburg J.J. (1972) Rb-Sr systematics of Luna-20 and Apollo 16 samples. *Earth Planet. Sci. Lett.* 17, 52-63.
- Pillinger C.T., Davis P.R., Eglinton G., Gowar A.P., Jull A.J.T., Maxwell J.R., Housley R.M. and Cirlin E.H. (1974) The association between carbide and finely-divided metallic iron in lunar fines. Proc. 5th Lunar Sci. Conf. 1949-1962.
- Rancitelli L.A., Perkins R.W., Felix W.D. and Wogman N.A. (1972) Lunar surface processes and cosmic ray characterization from Apollo 12-15 lunar sample analyses. Proc. 3rd Lunar Sci. Conf. 1681-1693.
- Rancitelli L.A., Perkins R.W., Felix W.D. and Wogman N.A. (1974) Solar flare and lunar surface processes characterization at the Apollo 17 site. Proc. 5th Lunar Sci. Conf. 2185-2204.

Reed G.W., Jovanovic S. and Fuchs L.H. (1972) Trace element relations between Apollo 14 and 15 and other lunar samples, and the implications of a moon-wide Cl-KREEP coherence and Pt-metal noncoherence. Proc. 3rd Lunar Sci. Conf. 1989-2003.

Reed G.W. and Jovanovic S. (1973) Fluorine in lunar samples – implications concerning lunar fluoroapatite. Geochim. Cosmochim. Acta 37, 1457-

Reed G.W. and Jovanovic S. (1978) Primordial Pb, radiogenic Pb and lunar soil maturation. Proc. 9th Lunar Planet. Sci. Conf. 2215-2220.

Russ G.P., Burnett D.S. and Wasserburg G.J. (1972) Lunar neutron stratigraphy. Earth Planet. Sci. Lett. 15, 172-186.

Stoerner R.W., Lindstrom R.M., Lyman W. and Davis R. (1972) Argon, Radon and Tritium radioactivities in the sample return container and the lunar surface. Proc. 3rd Lunar Sci. Conf. 1703-1719.

Swann G.A., Hait M.H., Schaber G.G., Freeman V.L., Ulrich G.E., Wolfe E.W., Reed V.S. and Sutton R.L. (1971) Preliminary description of Apollo 15 sample environments. U.S.G.S. Interagency report : 36.

Swann G.A., Bailey N.G., Batson R.M., Freeman V.L., Hait M.H., Head J.W., Holt H.E., Howard K.A., Irwin J.B., Larson K.B., Muehlberger W.R., Reed V.S., Rennilson J.J., Schaber G.G., Scott D.R., Silver L.T., Sutton R.L., Ulrich G.E., Wilshire H.G. and Wolfe E.W. (1972) 5. Preliminary Geologic Investigation of the Apollo 15 landing site. *In* Apollo 15 Preliminary Science Rpt. NASA SP-289. pages 5-1-112.

Taylor S.R., Gorton M.P., Muir P., Nance W., Rudowski W. and Ware N.G. (1973) Lunar highlands composition – Apennine front. Proc. 4th Lunar Sci. Conf. 1445-1460.

Von Engelhardt W., Arndt J. and Schneider H. (1973) Apollo 15 – evolution of the regolith and origin of glasses. Proc. 4th Lunar Sci. Conf. 239-250.

Wahlen M., Finkel R.C., Imamura M., Kohl C.P. and Arnold J.R. (1973) ⁶⁰Co in lunar samples. Earth Planet. Sci. Lett. 19, 315-320.

Walker R.J. and Papike J.J. (1981) The Apollo 15 regolith: Chemical modeling and mare/highland mixing. Proc. 12th Lunar Planet. Sci. Conf. 509-517.

Yokoyama Y., Reys J.L. and Guichard F. (1975) ²²Na-²⁶Al studies of lunar regolith. Proc. 6th Lunar Sci. Conf. 1823-1844.