DRAFT

15030 – 303.7 g
15040 – 392.4 g
Trench Soils

"I think I've hit the bedrock"

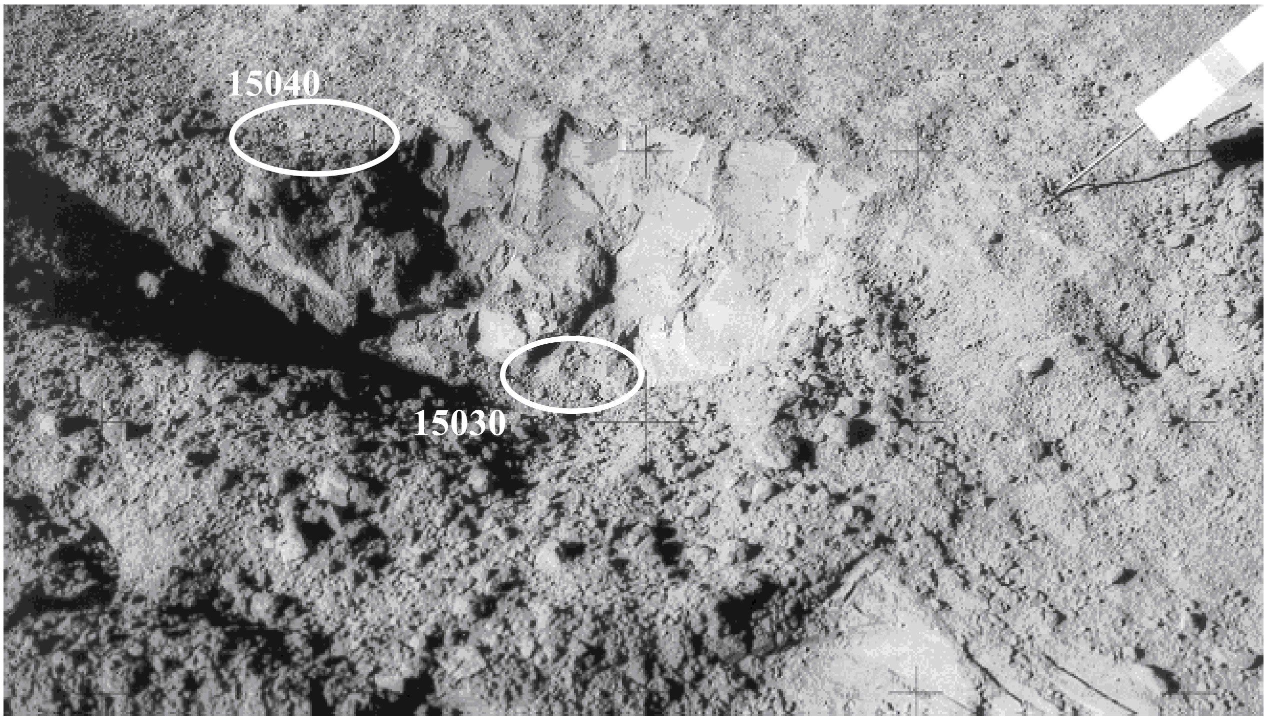


Figure 1: Trench at Apollo 15, station 8, near the ALSEP station. AS15-92-12440. Trench is about 35 cm deep and is known as the Soil Mechanics Trench. Note the apparent lighter color near the bottom of the trench.

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".

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

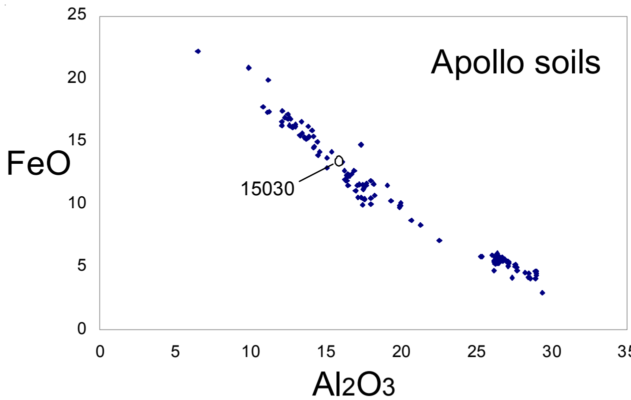


Figure 2: Chemical composition of 15030 compared with other lunar soils.

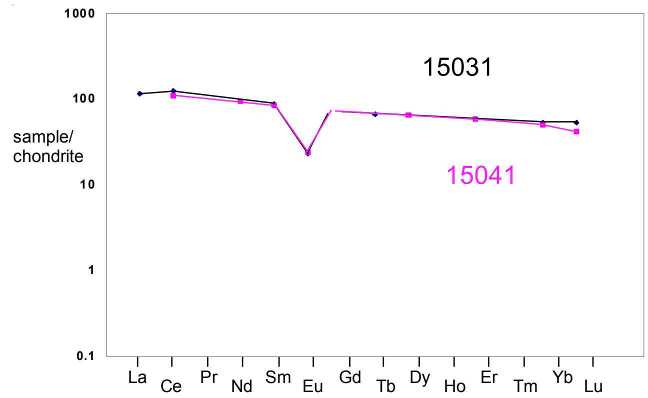


Figure 3: Noramlized rare-earth-element patterns for 15031 and 15041 (data from Laul and Schmitt 1973 and Church et al. 1973).

Petrography

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

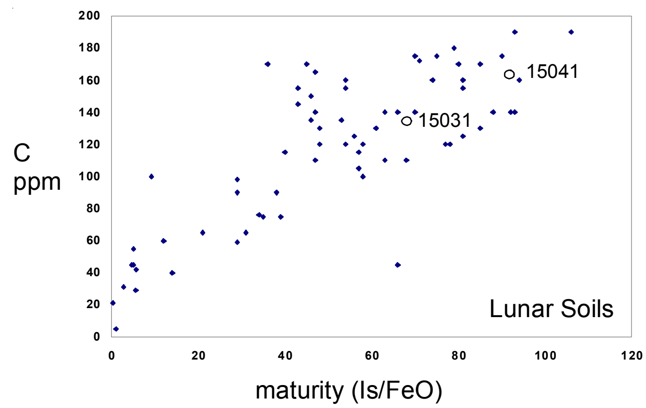


Figure 4: Carbon content and maturity index from 15031 and 15041 compared with all other lunar soils.

Cosmogenic isotopes and exposure ages

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

Wahlen et al. (1973) reported ^{60}Co for 15030, 15005 and 15001 (figure 8).

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).

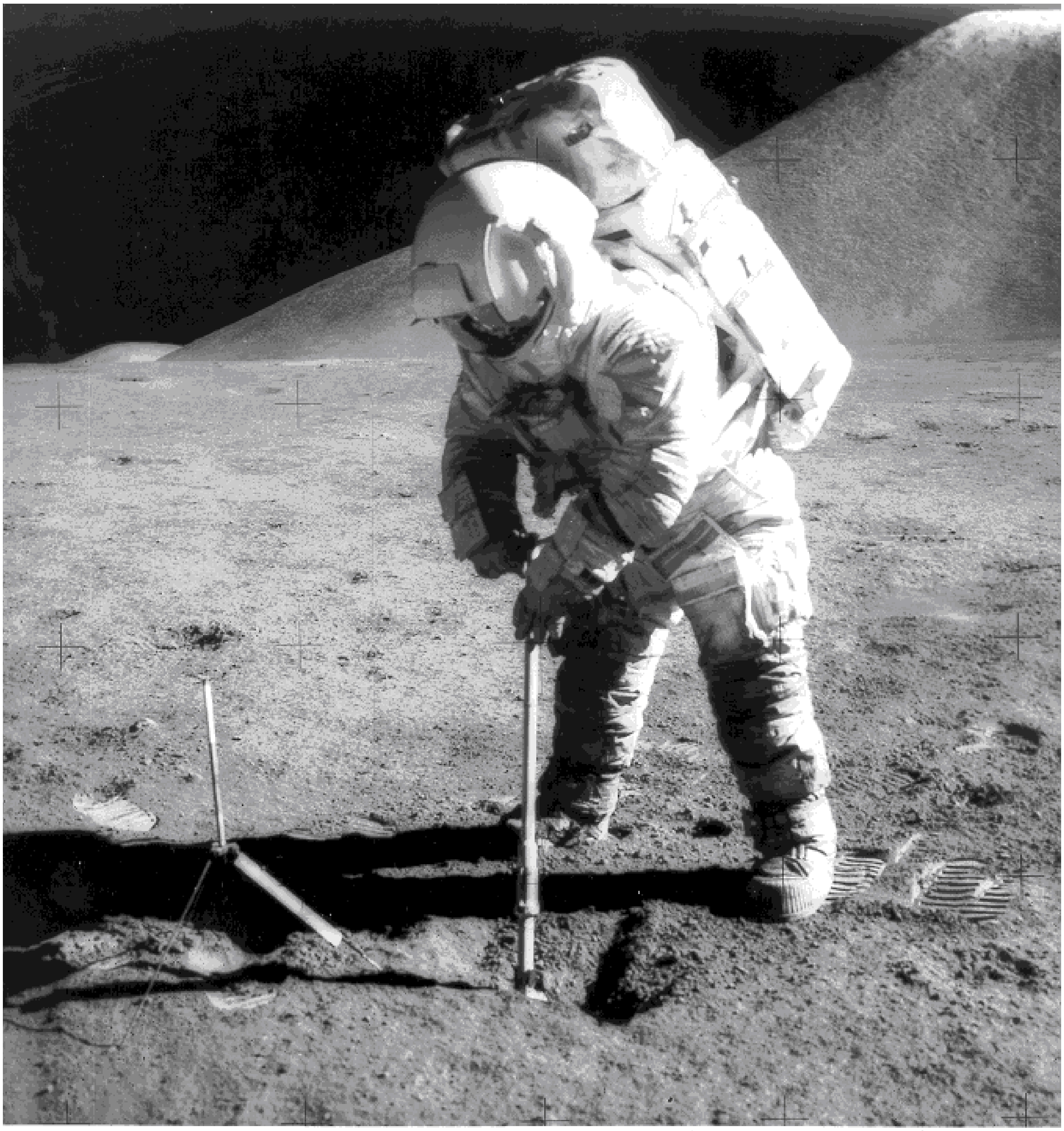


Figure 5: Photograph of Jim Irwin digging special trench at station 8, ALSEP site. Samples 15030, 15040 and 15014 (SESC) were from this trench. NASA photo AS15-92-12424.

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).

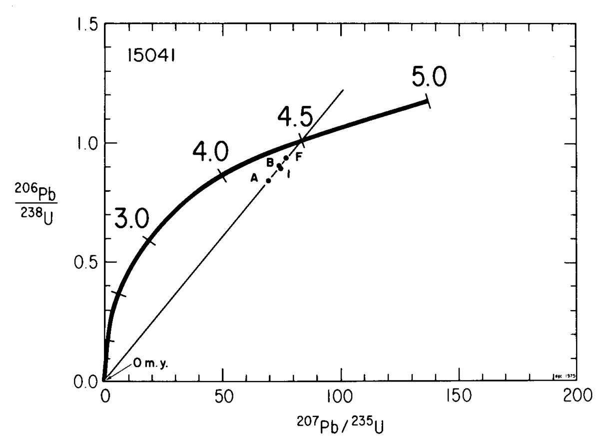


Figure 7: U-Pb isotopes for 15041 (from Church et al. 1976).

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 6: 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).

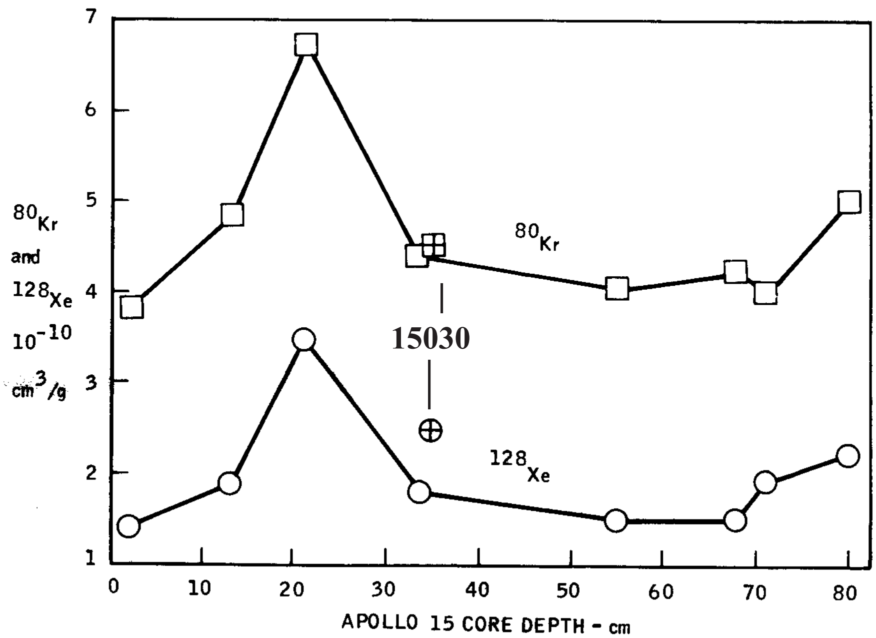


Figure 8: 80Kr and 128Xe for 15030 compared with data from deep drill (Bogard and Hirsch 1975).

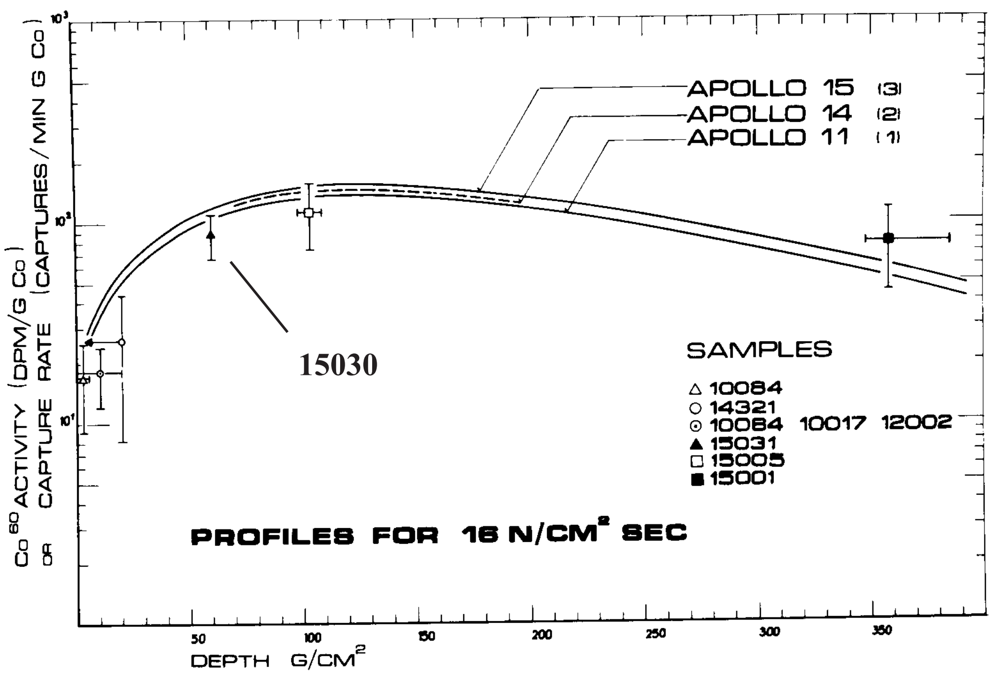


Figure 9: Activity of 60Co as function of depth in lunar surface compared with theoretical production due to thermal neutrons (Wahlen et al. 1973).

Table 1. Chemical composition of 15030.

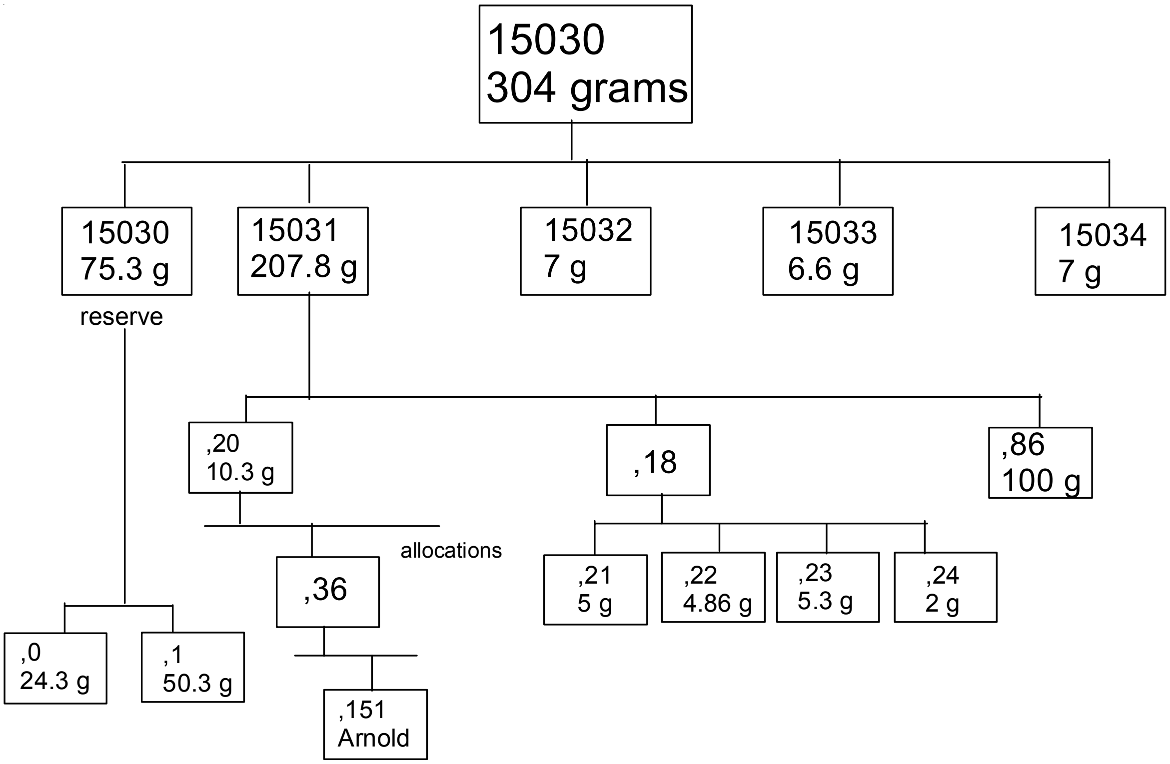
reference	Korotev87		Laul73		Taylor73		Keith72	Rancitelli72		Chou75		Chou75		
weight														
SiO2 %														
TiO2	1.7	(a)	1.7	(a)										
Al2O3	14.1	(a)	14.1	(a)								14.2	13.8	(a)
FeO	15.9	(a)	15	(a)								14.5	14.5	(a)
MnO	0.19	(a)	0.187	(a)										
MgO	12	(a)	12	(a)										
CaO	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)					

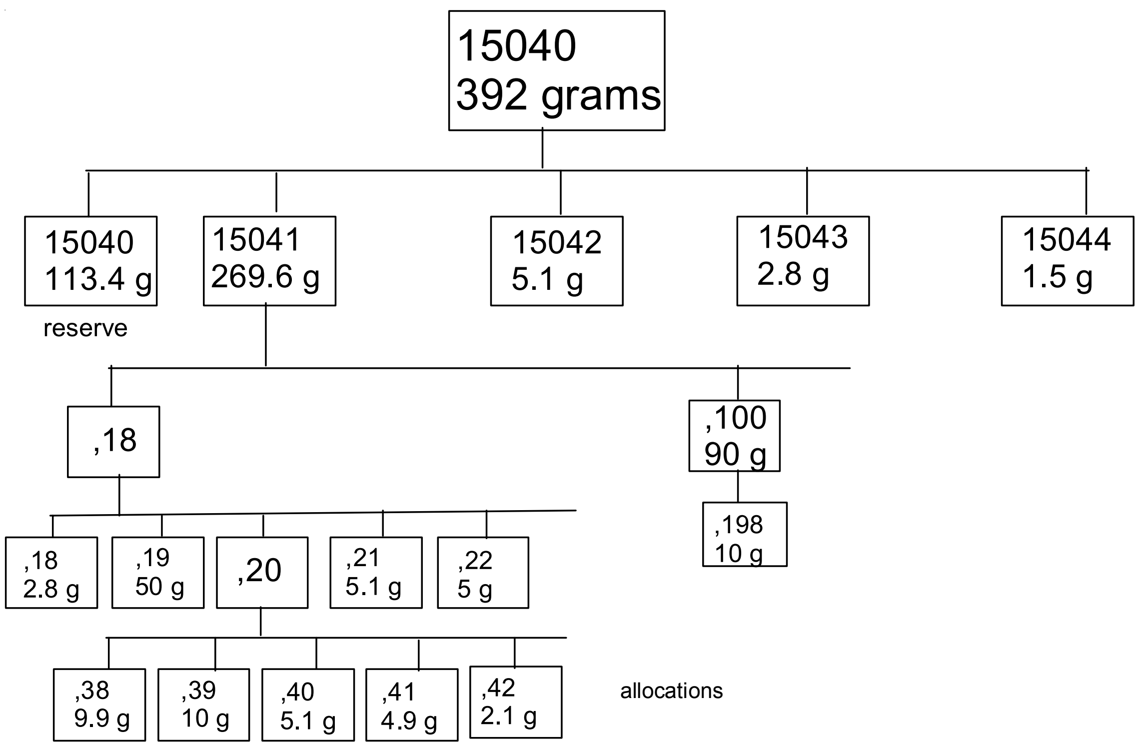
technique: (a) INAA, (b) SSMS, (c) radiation counting, (d) RNAA

Table 2. Chemical composition of 15040.

reference	Korotev87		Laul73		Laul73			Church76		Keith72	Rancitelli72		Papanastassiou72	
weight														
SiO2 %														
TiO2	1.7	(a)	1.7	(a)	1.7	1.7	(a)							
Al2O3	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)							
Na2O	0.44	(a)	0.424	(a)	0.426	0.423	(a)							
K2O			0.21	(a)	0.21	0.21	(a)	0.19	(d)	0.21	0.198	(c)	0.203	(d)
P2O5														
S %														
sum														
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														
Ge ppb														
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														
Pd ppb														
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)							
W ppb														
Re ppb														
Os ppb														
Ir ppb	9.3	(a)												
Pt ppb														
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


15030
304 grams
15030
75.3 g
reserve
15031
207.8 g
15032
7 g
15033
6.6 g
15034
7 g
,20
10.3 g
,18
,86
100 g
allocations
,36
,21
5 g
,22
4.86 g
,23
5.3 g
,24
2 g
,0
24.3 g
,1
50.3 g
,151
Arnold


15040
392 grams
15040
113.4 g
reserve
15041
269.6 g
15042
5.1 g
15043
2.8 g
15044
1.5 g
,18
,100
90 g
,198
10 g
,18
2.8 g
,19
50 g
,20
,21
5.1 g
,22
5 g
,38
9.9 g
,39
10 g
,40
5.1 g
,41
4.9 g
,42
2.1 g
allocations

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