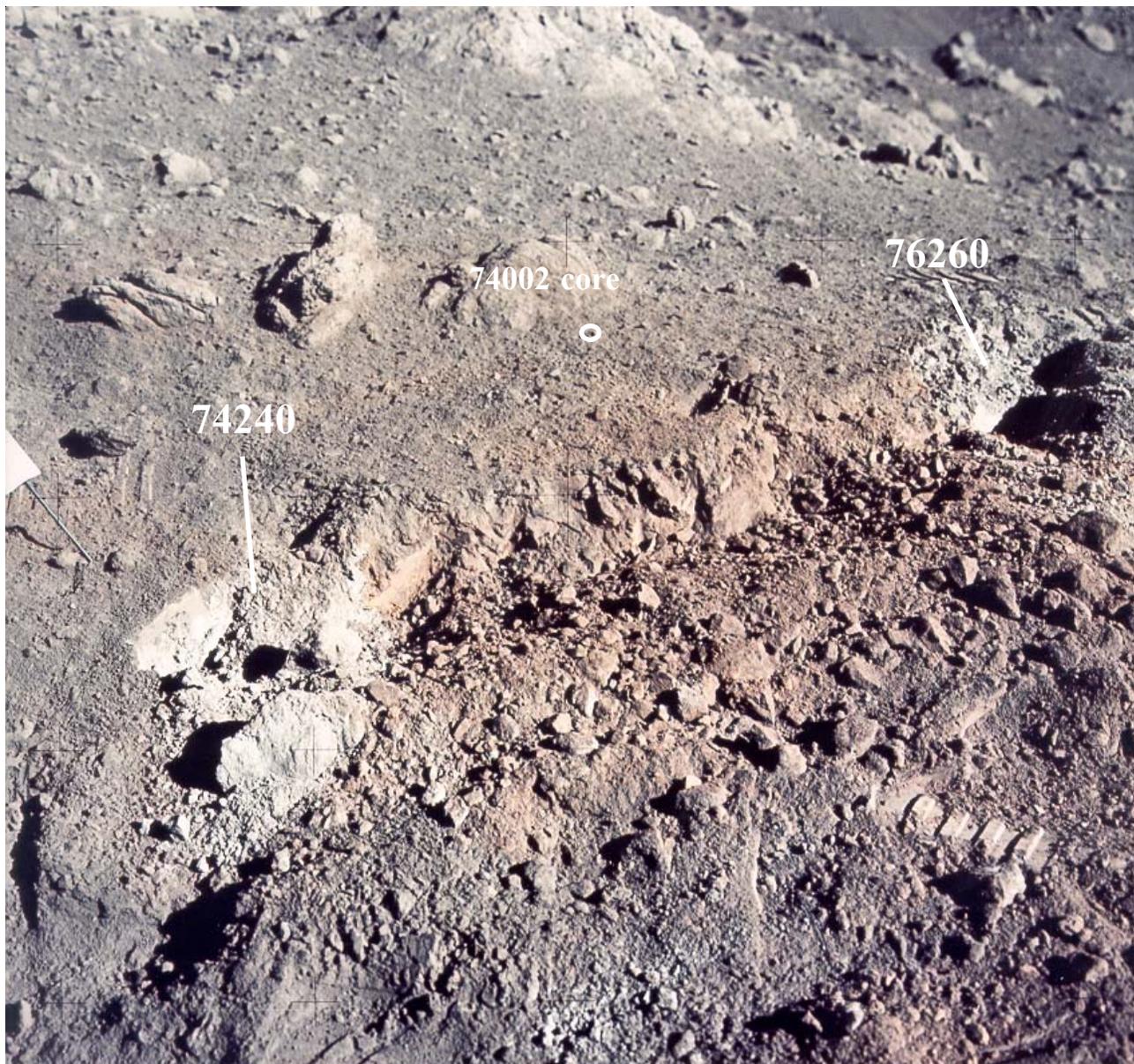


**74241** – 1040 grams

**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.

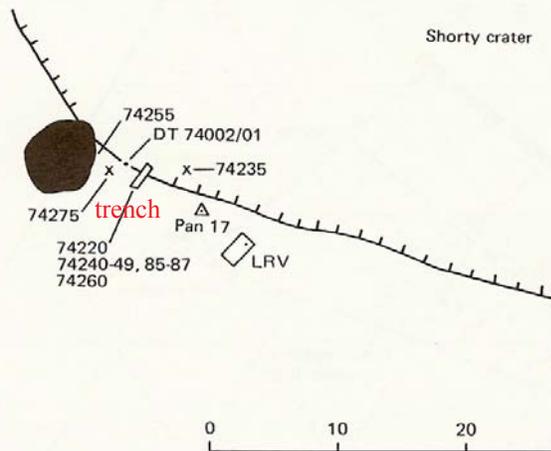


Figure 2: Map of Shorty Crater showing relative position of trench and core.

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)

### **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

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 74241 with 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.

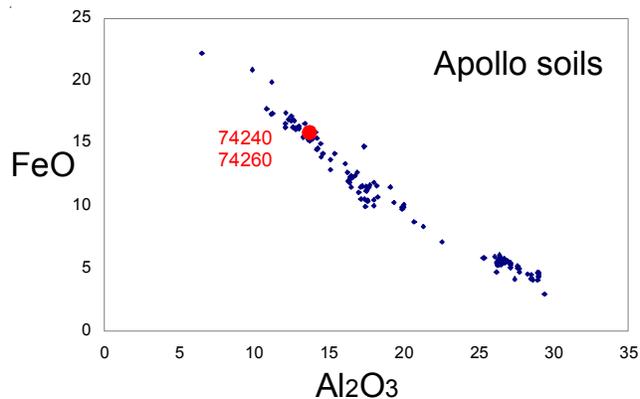


Figure 3: Composition of 74240 and 74260 compared with other Apollo soil samples.

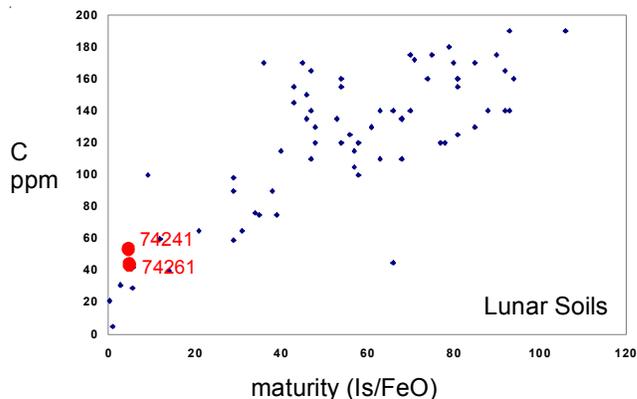
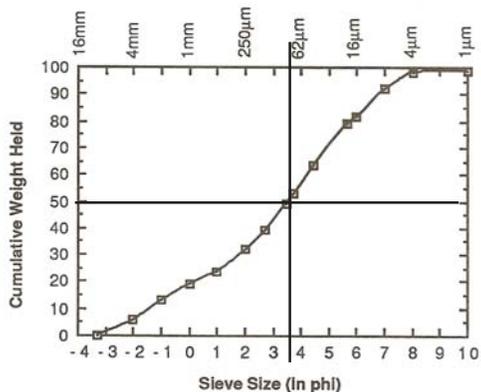
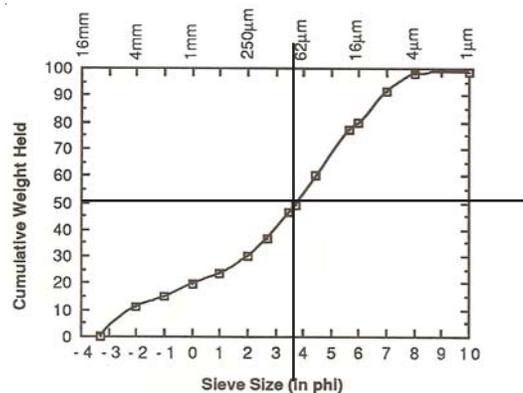


Figure 4: Carbon content of 74240 and 74260 along with maturity index. The other dots are other Apollo 17 soils.



average grain size = 87 microns



average grain size = 72 microns

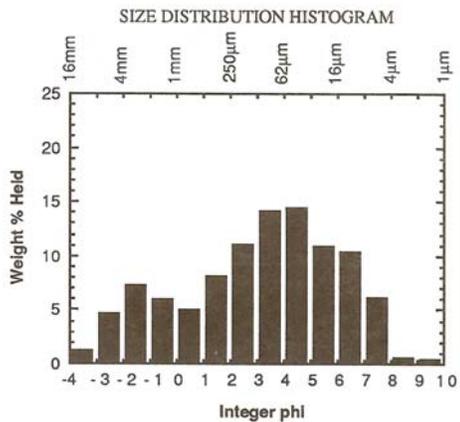


Figure 5a: Grain size distribution for 74240 (Graf 1993, data from McKay).

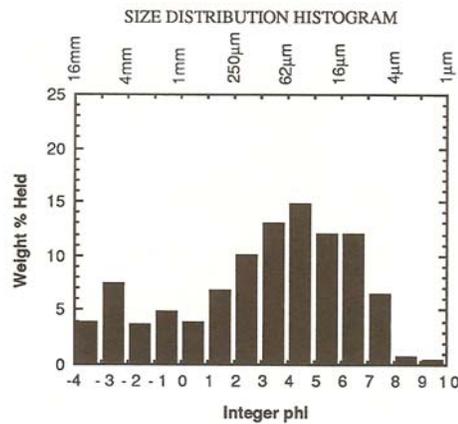
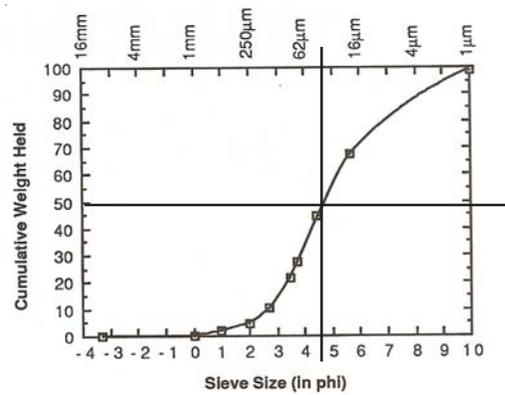


Figure 5b: Grain size distribution for 74260 (Graf 1993, data from McKay).



average grain size = 37 microns

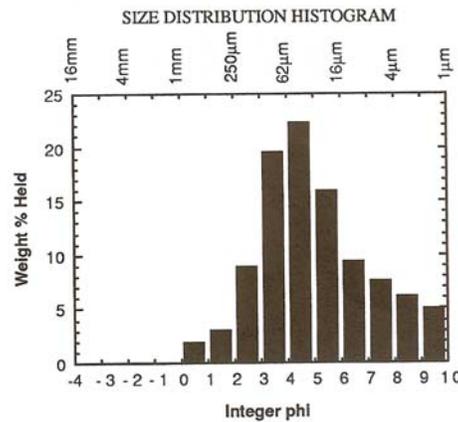
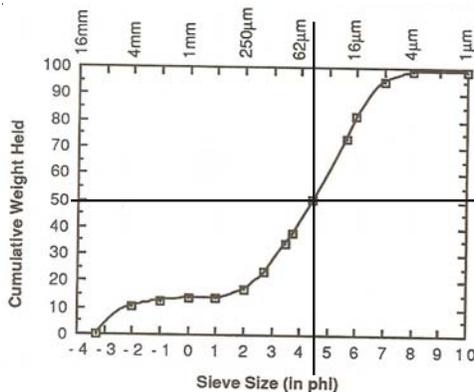


Figure 6: Grain size distribution for 74002 top (Graf 1993, data from McKay).



average grain size = 46 microns

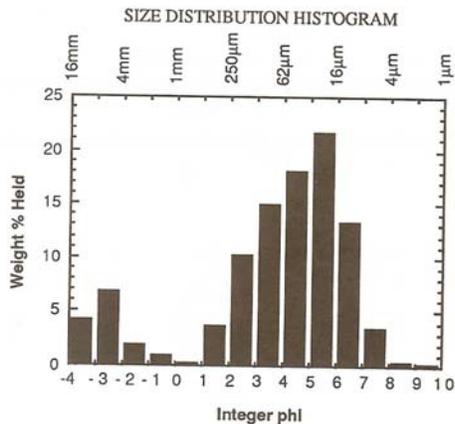


Figure 7: Grain size distribution for 74220 (Graf 1993, data from McKay).

### 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.**

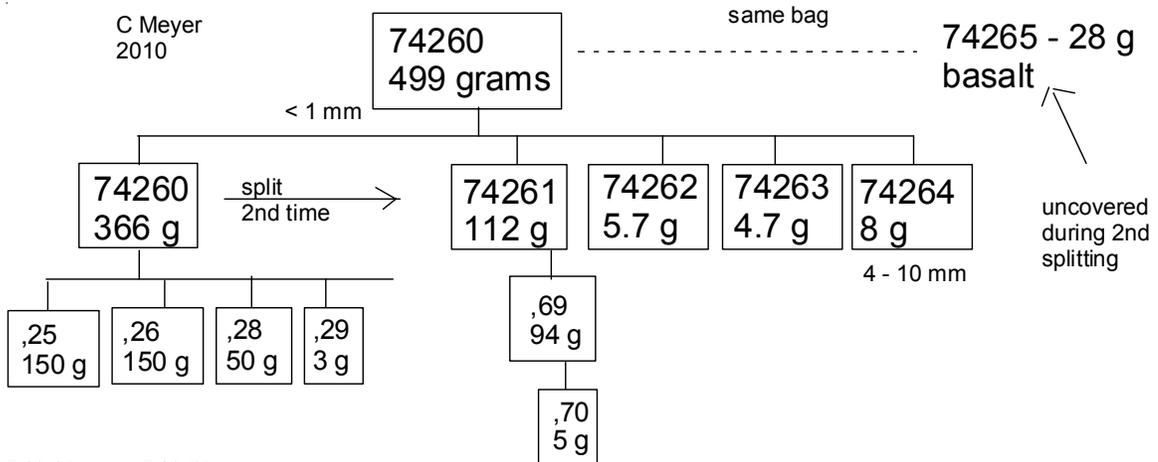
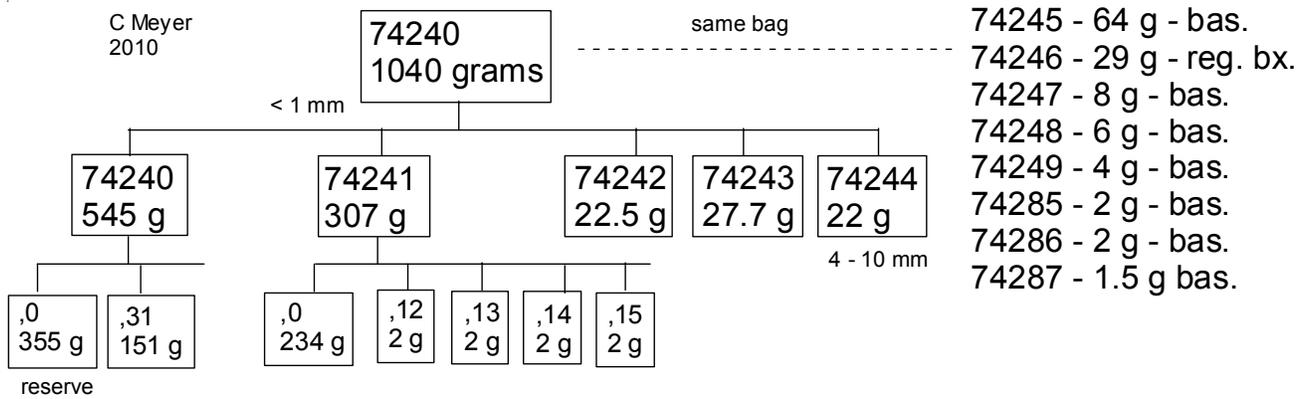
reference weight	Rhodes74 74240			Rhodes74 Wiesmann76		Korotev92		Philpotts74	Keith74	Nava74 Masuda74	Morgan74	Wanke73	
SiO2 %	41.55	40.78	(a)							42.3 (e)		42.4	(c)
TiO2	7.45	8.61	(a)							7.33 (e)		6.49	(c)
Al2O3	13.35	12.54	(a)							13.69 (e)		13.9	(c)
FeO	14.89	15.84	(a)			16.2	15.3	(c)		14.66 (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)		0.1	(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 (c)	9.93 (c)							10.9 (c)
Ce				28.8 (b)	29 (c)	29.5 (c)	29.6 (b)						34 (c)
Pr													4.4 (c)
Nd				24 (b)	22 (c)	24 (c)	24.8 (b)						31 (c)
Sm				8.55 (b)	9.05 (c)	8.72 (c)	8.8 (b)						8.7 (c)
Eu				1.6 (b)	1.68 (c)	1.55 (c)	1.64 (b)						1.65 (c)
Gd				12.6 (b)			12.2 (b)						11.1 (c)
Tb					2.19 (c)	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 (c)	7.52 (c)	7.6 (b)						7.3 (c)
Lu					1.12 (c)	1.09 (c)	1.4 (b)						1 (c)
Hf					7.59 (c)	7.21 (c)							6.4 (c)
Ta					1.26 (c)	1.19 (c)							1.3 (c)
W ppb													200
Re ppb											0.296 (f)	0.2	
Os ppb													
Ir ppb					3.5 (c)	4 (c)					2.78 (f)	7.9	
Pt ppb													
Au ppb					3.5 (c)	4 (c)					1.01 (f)	2.6	
Th ppm				1.32 (b)	0.99 (c)	1.24 (c)			3.5 (d)				
U ppm				0.37 (b)	0.4 (c)	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 weight	Rhodes74	Korotev92	Masuda74 74260	Brunfelt74	Korotev76 90-150	<20 micron	Karhenbuhl77			
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



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