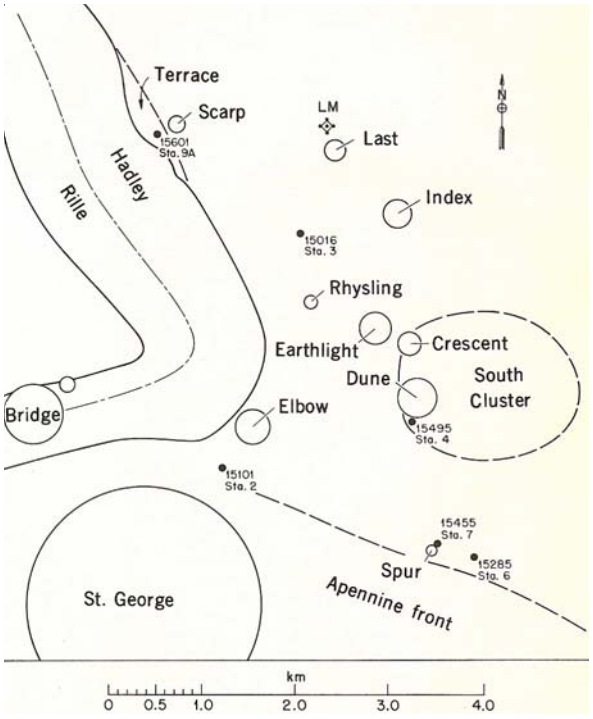
15301

Soil

1244.1 grams



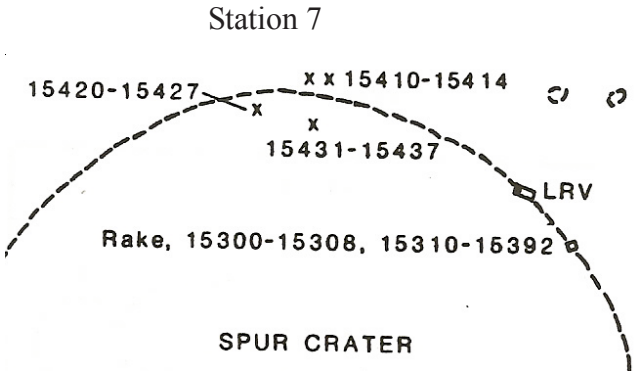


Figure 1: Soil sample 15301 was collected from the rim of Spur Crater at station 7 on the Apennine Front.

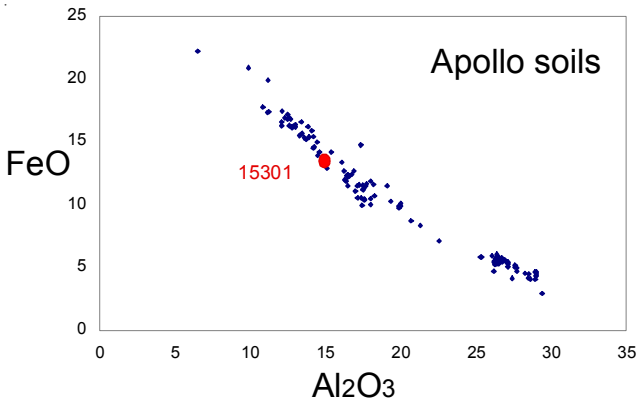


Figure 2: Composition of 15301 compared with all other Apollo soils.

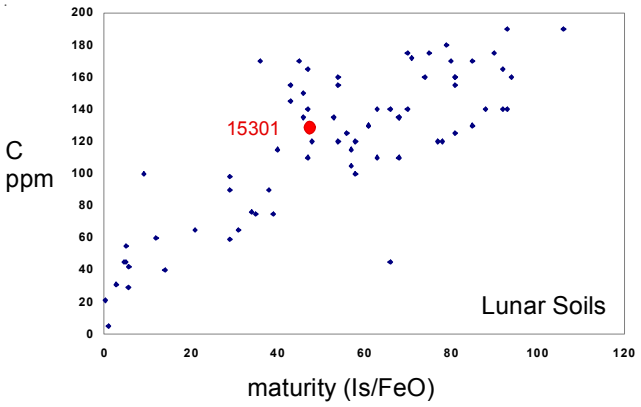


Figure 3: Carbon content and maturity index for 15301 compared with other lunar soils.

Introduction

15301 was part of a comprehensive sample collected at Spur Crater including rake sample 15310 and soils 15410, 15420 and pedestal 15431 (figure 1). The rim of Spur Crater had a significant number of small rock on the surface. This is the location of the Apollo 15 "green glass" and 15301 contained many beads of this interesting lunar material.

Petrography

15301 is a submature soil with I_s/FeO = 48 (Morris 1978) and with agglutinate content ~ 41 % (Basu et al. 1981). The average grain size is 65 microns and the grain size distribution is normal for a soil (figure 5).

The coarse fines (4-10 mm) were cataloged by Powell (1972) and partially studied by Ryder and Sherman (1989), Laul et al. (1987) and Simon et al. (1981).

Schonfeld and Meyer (1972), Wanke et al. (1973) and Walker and Papike (1981) calculated mixing models

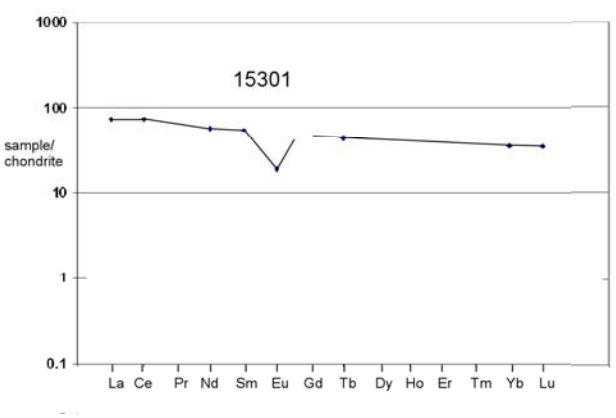


Figure 4a: Normalized rare-earth-element diagram for 15301 (Korotev 1987).

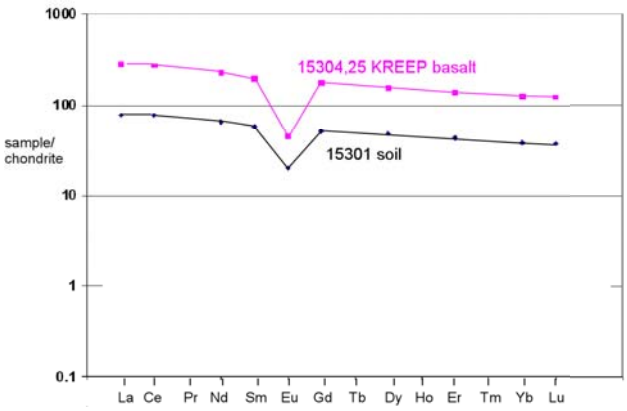


Figure 4b: Normalized rare-earth-element diagram for 15301 and 15304,25 (Wiesmann and Hubbard 1976).

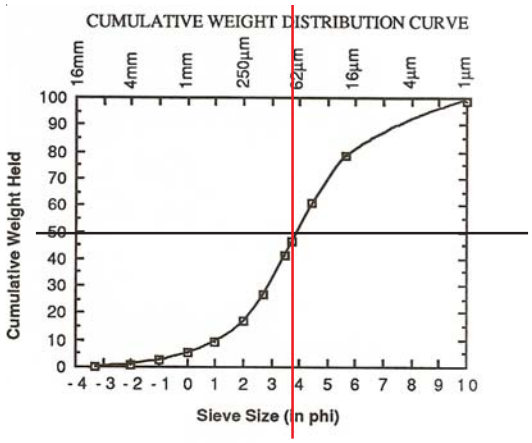
based on chemical composition of supposed components.

KREEP basalt

Simon et al. (1987) and Hubbard et al. (1972) determined the chemical composition of KREEP basalt particles found in the coarse fines (table 2).

Modal content of soils 15301.
From Basu et al. 1981

Agglutinates	25.9 %
Mare Basalt	2.2
KREEP basalt	2
Breccia	9.1
Anorthosite	0.5
Norite	
Gabbro	0.2
Plagioclase	7
Pyroxene	7.9
Olivine	1.8
Ilmenite	0.1
Glass other	25.9



Average grain size = ~65 microns

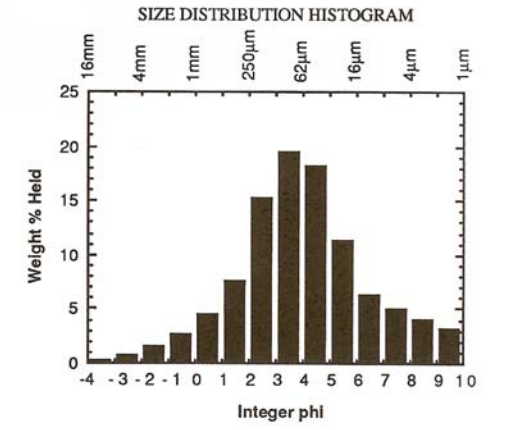


Figure 5: Grain size analysis of 15300 (Graf 1993).

Green Glass

Best and Minkin (1972), Ridley (1973), Meyer et al. (1975), Hughes et al. (1990), Steele and Steele et al. (1992) and numerous others have studied the beautiful green glass beads found in 15301 and adjacent samples.

Chemistry

There are many analyses of the chemical composition of 15301 (some are repeated here in table 1). This highland soil has a relatively high Mg and Fe content because of the added green glass component (table 3, figure 1). The REE pattern is explained by the added KREEP basalt component (figure 4 a and b).

Moore et al. (1973) reported 155 and 110 ppm C in two splits of 15301. Holland et al. (1972) reported 160 ppm carbon (figure 3). However, DesMarais et al. (1973) reported only 69 ppm.

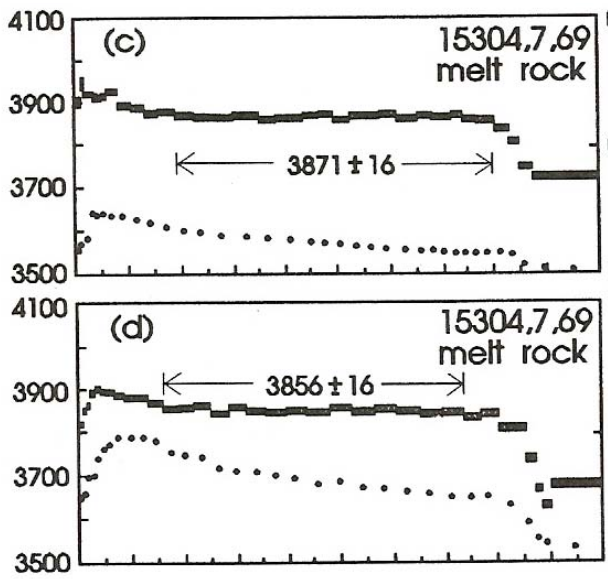


Figure 6: Ar/Ar plateau diagrams for impact melt rock from 15304,7 (Dalrymple and Ryder 1993).

Summary of Age Data for 15304

	Ar/Ar
Dalrymple and Ryder 1991	3879 ± 16 m.y.
	3856 ± 16 m.y.

Walker and Papike (1981) calculated that 15301 was 29 % mare basalt, 14 – 20 % KREEP, 24 – 28 % green glass.

Radiogenic age dating

Nyquist et al. (1973), Tatsumoto et al. (1972) and Barnes et al. (1973) reported isotopic ratios for Sr, Pb, etc.

Dalrymple and Ryder (1991, 1993) determined the age of an impact melt rock found in the coarse-fines using the Ar/Ar dating technique (figure 6), concluding that this was the age of Imbrium!

Other Studies

Phakey et al. (1972) and Bhandari et al. (1973) studied solar flare and cosmic ray tracks.

Jordan et al. (1974), Frick et al. (1973), Kirsten et al. (1972) and Bogard and Nyquist (1973) determined the concentration and isotopic ratio of the rare gasses in 15301.

Cadenhead and others (1977) reported measurements of surface area and porosity of 15301. Housley and Grant (1976 and 1977) studied the surfaces by ESCA.

Processing

15300 was returned in sample collection bag 3 placed in ALSRC#2 (which did not seal).

Table 1. Chemical composition of 15301.

reference	Korotev 87			Baedecker73		Taylor73		Weisman76		Duncan75		Keith72		Janghorbani73		Juan72
weight								Garg76	(a)			557 g		Barnes73	(d)	
SiO2 %										46.12	(e)			47.5	(a)	46.65
TiO2	1.17	1.18	(a)							1.18	(e)			0.87	(a)	1.37
Al2O3	14.5	14.7	(a)							14.67	(e)			15.2	(a)	14.7
FeO	13.9	13.8	(a)							13.83	(e)			14.4	(a)	14.5
MnO										0.18	(e)			0.18	(a)	0.188
MgO	12.1	12.2	(a)							12.2	(e)			11.3	(a)	11.08
CaO	9.7	9.7	(a)							10.71	(e)					10.44
Na2O	0.38	0.38	(a)							0.35	(e)			0.39	(a)	0.355
K2O								0.15	(d)	0.134	(e)	0.147	(f)			0.17
P2O5										0.158	(e)					
S %										0.07	(e)					
sum																
Sc ppm	26.4	26.1	(a)			17	(c)									
V						125	(c)			97	(e)					
Cr	2530	2560	(a)			3000	(c)			2566	(e)					
Co	54.7	49.6	(a)			56	(c)			51	(e)					64
Ni	253	236	(a)	250	(b)	197	(c)			234	(e)					236
Cu						4.7	(c)			4	(e)					3
Zn				31	(b)					29	(e)					40
Ga				4.6	(b)	4.4	(c)									
Ge ppb				370	(b)											
As																
Se																
Rb						3.2	(c)	4.03	(d)	4.2	(e)			3.843	(d)	2.4
Sr	110	110	(a)					115	(d)	110	(e)			112.9	(d)	233
Y						51	(c)			58.9	(e)					
Zr	260	260	(a)			251	(c)	230	(a)	268	(e)					
Nb						16.3	(c)			17.3	(e)					
Mo																
Ru																
Rh																
Pd ppb																
Ag ppb																
Cd ppb				59	(b)											26
In ppb				4.4	(b)											
Sn ppb																
Sb ppb																
Te ppb																
Cs ppm	0.15	0.2	(a)			0.19	(c)									
Ba	182	172	(a)			227	(c)	188	(d)	190	(e)					
La	17.3	17.6	(a)			17.9	(c)	18.3	(d)							
Ce	45	46	(a)			45	(c)	47.2	(d)							
Pr																
Nd	26	26	(a)			25.8	(c)	29.7	(d)							
Sm	8.07	8.29	(a)			8.25	(c)	8.37	(d)							
Eu	1.08	1.115	(a)			1.16	(c)	1.12	(d)							
Gd						9.4	(c)	10.1	(d)							
Tb	1.62	1.59	(a)			1.55	(c)									
Dy						10.4	(c)	11.8	(d)							
Ho						2.44	(c)									
Er						6.83	(c)	6.8	(d)							
Tm						1.1	(c)									
Yb	5.9	5.9	(a)			6.4	(c)	6.15	(d)							
Lu	0.86	0.86	(a)			1	(c)	0.908	(d)							
Hf	6.6	6.4	(a)			5.7	(c)	6	(a)							
Ta	0.81	0.81	(a)													
W ppb																
Re ppb																
Os ppb																
Ir ppb	4.6	5.6	(a)	6.6	(b)											
Pt ppb																
Au ppb	2.1	2.9	(a)	2	(b)											5
Th ppm	2.9	3.2	(a)			3.33	(c)					3.38	(f)	3.0375	(d)	
U ppm	0.82	0.6	(a)			0.93	(c)	0.88	(d)			0.8	(f)	0.8156	(d)	

technique: (a) INAA, (b) RNAA, (c) SSMS, (d) IDMS, (e) XRF, (f) radiation counting

Table 2. Composition of KREEP.

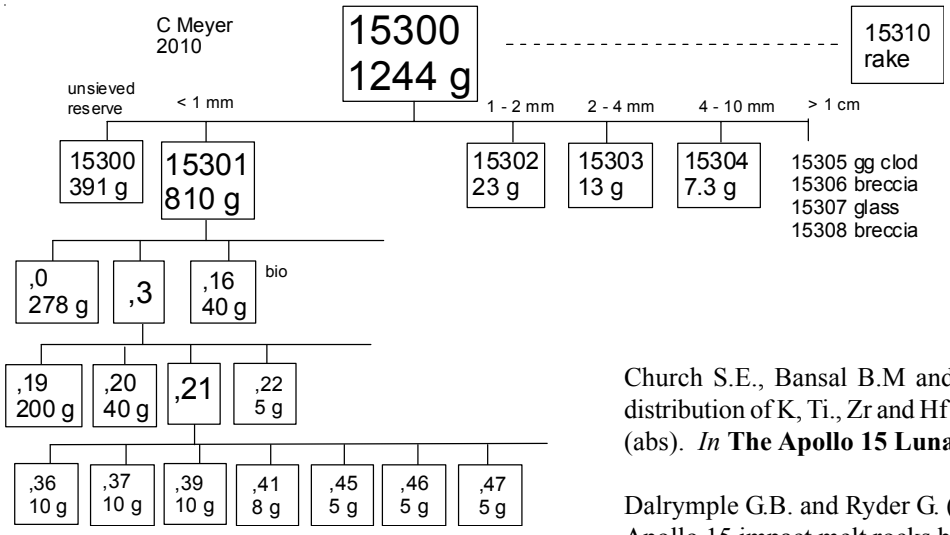
	15303,51		15304,25		15304,46	
reference	Simon87		Hubbard73		Simon87	
weight			Wiesmann76			
SiO2 %						
TiO2	1.6	(a)	1.85	(b)	1.7	(a)
Al2O3	15.7	(a)	15.6	(b)	15.1	(a)
FeO	9.2	(a)	10.3	(b)	10	(a)
MnO	0.126	(a)			0.136	(a)
MgO	10.2	(a)	8.49	(b)	9.2	(a)
CaO	9.3	(a)	9.94	(b)	9.3	(a)
Na2O	0.7	(a)	0.71	(b)	0.74	(a)
K2O	0.48	(a)	0.55	(b)	0.53	(a)
P2O5						
S %						
sum						
Sc ppm	19	(a)			20.2	(a)
V	60	(a)			63	(a)
Cr	2326	(a)	2074	(b)	2326	(a)
Co	19.4	(a)			20	(a)
Ni	20	(a)			20	(a)
Cu						
Zn						
Ga						
Ge ppb						
As						
Se						
Rb			14	(b)		
Sr	180	(a)	183	(b)	210	(a)
Y						
Zr	860	(a)	976	(b)	800	(a)
Nb						
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb						
In ppb						
Sn ppb						
Sb ppb						
Te ppb						
Cs ppm						
Ba	650	(a)	685	(b)	710	(a)
La	61	(a)	65.8	(b)	71	(a)
Ce	160	(a)	166	(b)	180	(a)
Pr						
Nd	95	(a)	103	(b)	105	(a)
Sm	26	(a)	29.1	(b)	29.5	(a)
Eu	2.5	(a)	2.53	(b)	2.75	(a)
Gd	33	(a)	34.3	(b)	39	(a)
Tb	5.5	(a)			6.27	(a)
Dy	33	(a)	37.4	(b)	37	(a)
Ho	6.9	(a)			8.5	(a)
Er			21.9	(b)		
Tm	2.7	(a)			3.1	(a)
Yb	18.5	(a)	20.2	(b)	20.5	(a)
Lu	2.65	(a)			3	(a)
Hf	20	(a)	22.9	(b)	22.4	(a)
Ta	2.4	(a)			2.8	(a)
W ppb						
Re ppb						
Os ppb						
Ir ppb						
Pt ppb						
Au ppb						
Th ppm	10.9	(a)	10.9	(b)	12.2	(a)
U ppm	2.9	(a)	3.14	(b)	3.3	(a)

technique: (a) INAA, (b) IDMS

Table 3. Composition of Green Glass.

reference	Wiesmann76			Taylor73		Reid72	
weight							
SiO2 %				45.3	(b)	45.43	(c)
TiO2	0.43	0.48	(a)	0.4	(b)	0.42	(c)
Al2O3				7.52	(b)	7.72	(c)
FeO				20	(b)	19.61	(c)
MnO				0.22	(b)		
MgO	16.9		(a)	17.1	(b)	17.49	(c)
CaO	8.4		(a)	8.43	(b)	8.34	(c)
Na2O	0.2	0.175	(a)	0.13	(b)	0.12	(c)
K2O	0.018	0.017	(a)	0.06	(b)	0.01	(c)
P2O5							
S %							
sum							
Sc ppm				30	(b)		
V				160	(b)		
Cr							
Co				72	(b)		
Ni				185	(b)		
Cu				6.8	(b)		
Zn							
Ga				4.7	(b)		
Ge ppb							
As							
Se							
Rb	0.253	0.329	(a)	0.41	(b)		
Sr	18.6	27.8	(a)				
Y				9.5	(b)		
Zr		21.5	(a)	28	(b)		
Nb				2.1	(b)		
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb							
Cd ppb							
In ppb							
Sn ppb							
Sb ppb							
Te ppb							
Cs ppm							
Ba	15.9	15.6	(a)	20	(b)		
La	0.8	1.24	(a)	1.42	(b)		
Ce		3.74	(a)	3.9	(b)		
Pr				0.51	(b)		
Nd	2.65	2.5	(a)	2.1	(b)		
Sm	0.866	0.818	(a)	0.8	(b)		
Eu	0.27	0.246	(a)	0.26	(b)		
Gd	1.44	1.2	(a)	0.99	(b)		
Tb				0.16	(b)		
Dy	1.61	1.52	(a)	1.1	(b)		
Ho				0.28	(b)		
Er	0.87	1.02	(a)	0.85	(b)		
Tm				0.14	(b)		
Yb	1.04	0.995	(a)	0.81	(b)		
Lu	0.164	0.15	(a)	0.13	(b)		
Hf		0.7	(a)				
Ta							
W ppb							
Re ppb							
Os ppb							
Ir ppb							
Pt ppb							
Au ppb							
Th ppm				0.21	(b)		
U ppm	0.063	0.088	(a)				

technique: (a) IDMS, (b) SSMS, (c) e probe



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