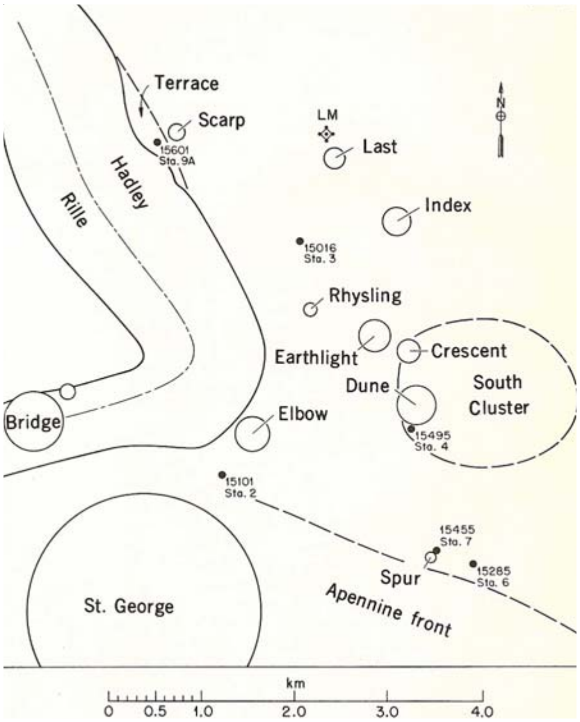
15220
Reference Soil
465.7 grams



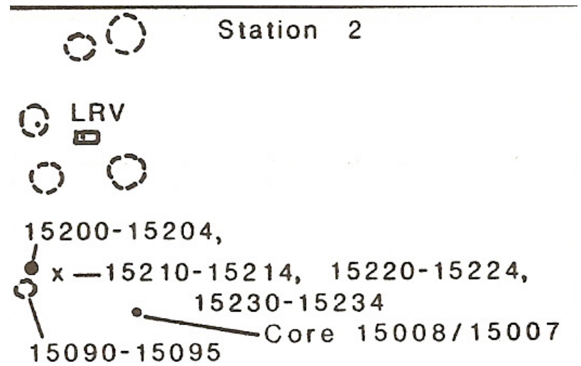


Figure 1: !5221 was collected from the flank of St. George Crater at station 2, on the Apennine Front.

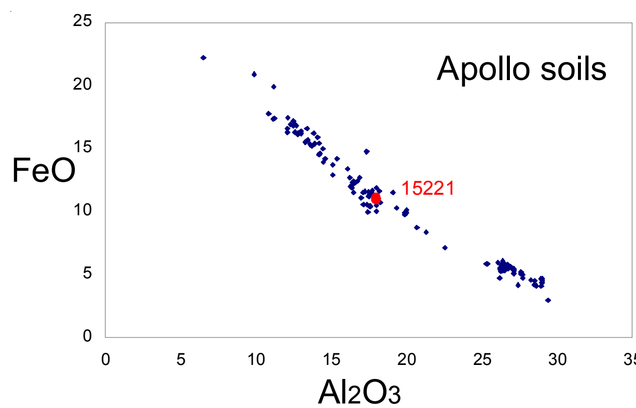


Figure 2: Chemical composition of 15221 compared with other Apollo soil samples.

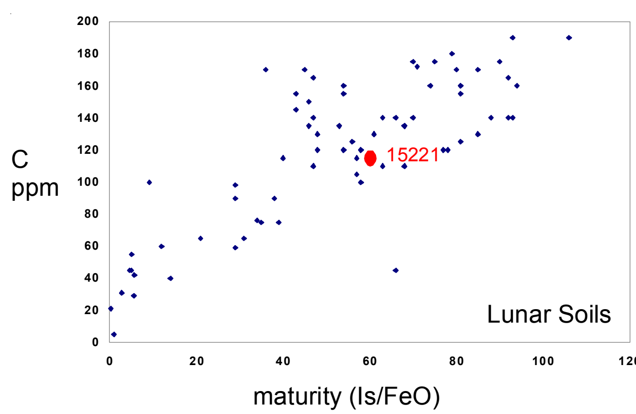


Figure 3: Carbon content and maturity index for 15221 and other Apollo soils.

Introduction

15220 is similar to the other soils collected at station 2 (15091, 15101, 15200 etc.). It was collected from the rim of a small crater (thought to be the secondary crater produced by the nearby boulder). The station was selected to sample Apennine Front material exposed by St. George Crater. In this area, the lunar surface was free of small rocks, except for the boulder.

Modal content of soil 15221.
From Basu et al. 1981.

Agglutinates	37.6%
Mare basalt	2.8
KREEP basalt	1.8
Breccia	15
Anorthosite	1.3
Norite	
Gabbro	0.4
Plagioclase	12.2
Pyroxene	14.2
Olivine	2.8
Ilmenite	0.4
Glass other	10.1

15221 was selected as a reference soil for the Lunar Highland Initiative (Labotka et al. 1981).

Petrography

15221 is a mature lunar soil with maturity index (I_s/FeO = 63) (Morris 1978) and agglutinate count 37 % (Basu et al. 1981; Simon et al. 1981). King et al. (1972), Engelhardt et al. (1972) and McKay et al. (unpublished) determined the grain size distribution (figure 4). The average grain size is very fine (54 microns).

Labotka et al. (1981) and Basu et al. (1980) presented the modal mineralogy and as a function of grain size. Labotka et al. (1981) also determined the composition of mineral grains (olivine, pyroxene and plagioclase) and compared results for different grain sizes. They found numerous orthopyroxene grains with high Mg/Fe ratios (figure 5). These are similar in composition to the orthopyroxene found in KREEP basalt (Meyer 1977).

Powell et al. (1973), Helmke et al. (1973), Ryder and Sherman (1989) reported on coarse-fine particles. Simon et al. (1987) studied two ferroan anorthosite particles and Laul et al. (1987) analyzed one fragments of impact melt rock (table 2).

Modal Mineralogy of 15221

Simon et al. 1981

LITHIC FRAGMENTS	
Mare basalt	3.1
Highland Component	
ANT	2.6
LMB	0.6
Feld. basalt	0.4
RNB/POIK	2.7
FUSED SOIL COMPONENT	
DMB	13.3
Agglutinate	36.9
MINERAL FRAG	
Mafic	16.1
Plag	13.1
Opaque	0.1
GLASS FRAG	
Orange/black	0.4
Yellow/Green	4.5
Brown	0.3
Clear	1.5
MISC	
Devitrified glass	4.1
Others	0.3

Chemistry

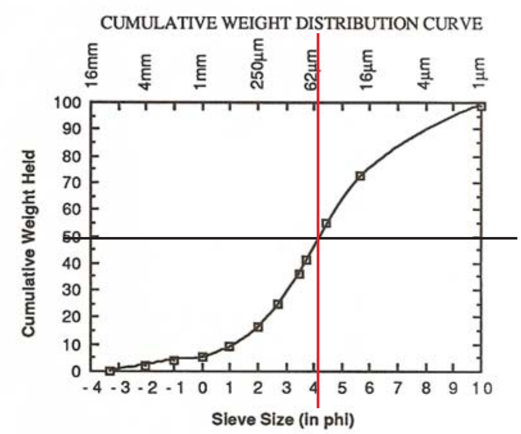
The chemical composition of all of the soils collected at station 2, Apollo 15 are all very similar, probably because they were collected close to one another. Laul and Papike (1980) determined the chemical composition of grain size fractions finding little variation with the possible exception that there may be enhanced REE in the finest fraction (figure 6).

Moore et al. (1973) reported 115 ppm C, consistent with high maturity (figure 3).

Walker and Papike (1981) used chemical mixing model techniques to calculate that 15221 is 19 – 29 % mare basalt, 16 – 23 % KREEP, and 7.6 – 14.8 % green glass.

Cosmogenic isotopes and exposure ages

Rancitelli et al. (1972) reported the cosmic-ray-induced activity of ^{22}Na = 72 dpm/kg., ^{26}Al = 169 dpm/kg., ^{46}Sc = 1.9 dpm/kg., ^{48}V = 6 dpm/kg., ^{56}Co = 5 dpm/kg etc. Stoenner et al. (1972) determined ^{37}Ar, ^{39}Ar and ^{3}H.



Average grain size = 54 microns

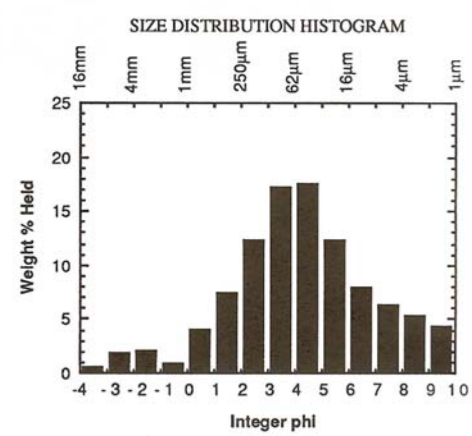


Figure 4: Grain size distribution of 15220 (Graf 1993).

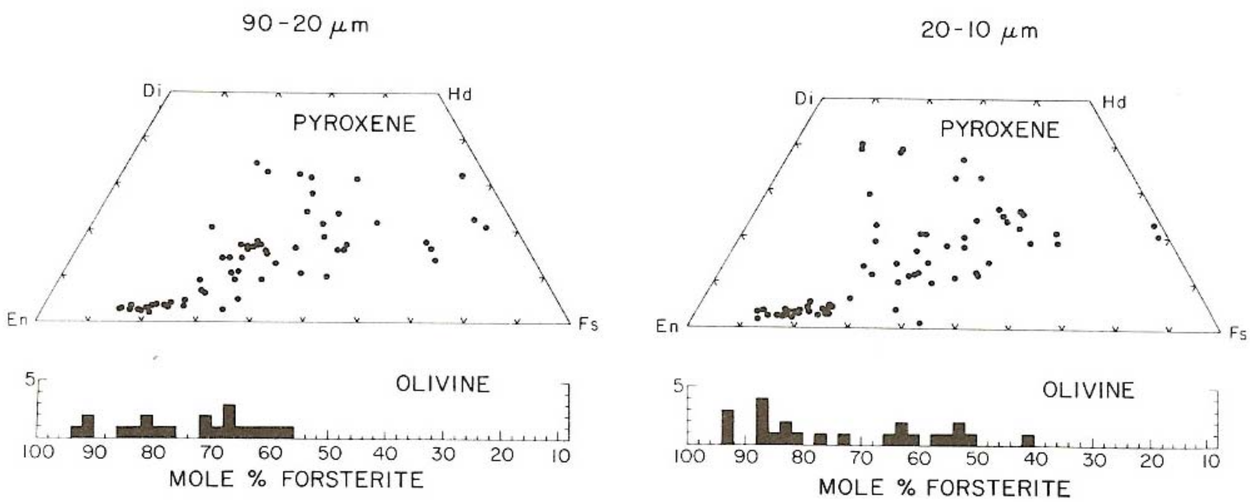


Figure 5: Composition of olivine and pyroxene in 15221 (Labotka et al. 1980).

Russ et al. (1972) determined the exposure to neutrons (produced by cosmic ray interaction with lunar material) by measuring the isotopic ratio of gadolinium in 15221 and as a function of depth in the drill core.

Bhandari et al. (1973) determined the density of solar-flare cosmic-ray tracks and give a surface irradiation age of 23 m.y.

Processing

15220 was returned in a sealed ALSRC (#1). It is a "reference soil".

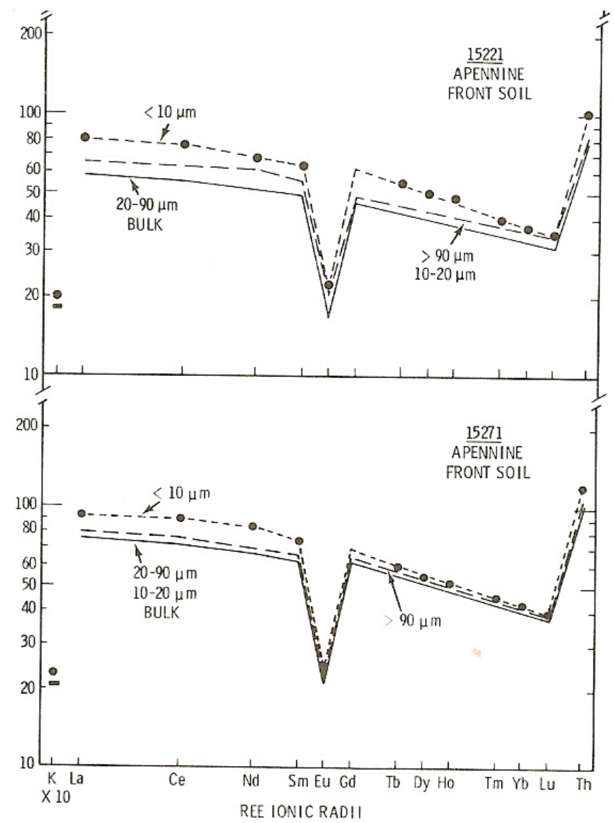


Figure 6: Normalized rare-earth-element diagram for different grain size fractions of 15220 (Laul and Papike 1980).

Table 1. Chemical composition of 15221.

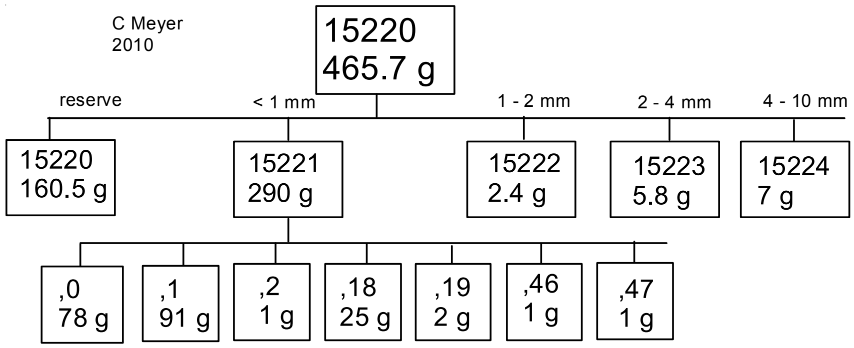
	15221		15221		15221		Rancitelli72	
reference	Laul 1980		Fruchter73		Cuttitta73			
weight	bulk						96 g	
SiO2 %	46	(a)			46.56	(b)		
TiO2	1.1	(a)	1.43	(a)	1.27	(b)		
Al2O3	18	(a)	17	(a)	17.54	(b)		
FeO	11.3	(a)	11.7	(a)	11.32	(b)		
MnO	0.15	(a)			0.15	(b)		
MgO	10.7	(a)			10.69	(b)		
CaO	12.3	(a)			11.87	(b)		
Na2O	0.43	(a)	0.41	(a)	0.45	(b)		
K2O	0.16	(a)	0.14	(a)	0.19	(b)	0.18	(c)
P2O5					0.16	(b)		
S %								
sum								
Sc ppm	21.2	(a)	23	(a)	20	(b)		
V	80	(a)			84	(b)		
Cr	2224	(a)	2130	(a)				
Co	41	(a)	38	(a)	44	(b)		
Ni	360	(a)			320	(b)		
Cu					8.5	(b)		
Zn					17	(b)		
Ga					3.4	(b)		
Ge ppb								
As								
Se								
Rb					4.9	(b)		
Sr	120	(a)			160	(b)		
Y					70	(b)		
Zr					320	(b)		
Nb					18	(b)		
Mo								
Ru								
Rh								
Pd ppb								
Ag ppb								
Cd ppb								
In ppb								
Sn ppb								
Sb ppb								
Te ppb								
Cs ppm								
Ba	240	(a)	240	(a)	300	(b)		
La	20.5	(a)	23.5	(a)	24	(b)		
Ce	54	(a)	56	(a)				
Pr								
Nd	36	(a)	37	(a)				
Sm	9.7	(a)	8.8	(a)				
Eu	1.3	(a)	1.36	(a)				
Gd								
Tb	2	(a)	1.8	(a)				
Dy	12	(a)						
Ho	2.9	(a)						
Er								
Tm	1.1	(a)						
Yb	6.9	(a)	6.6	(a)	7.2	(b)		
Lu	0.97	(a)	0.98	(a)				
Hf	6.7	(a)	6.9	(a)				
Ta	0.93	(a)	1.1	(a)				
W ppb								
Re ppb								
Os ppb								
Ir ppb								
Pt ppb								
Au ppb								
Th ppm	3	(a)	6.5	(a)			3.57	(c)
U ppm							0.97	(c)

technique: (a) INAA, (b) "microchemical", (c) radiation counting

Table 2. Composition of coarse-fines.

15223	feroan anorthosite		impact melt		
reference	Simon87		Laul87		
weight	,50	,51	,45	,21	
SiO2 %					
TiO2	< 0.1	< 0.1	0.86	1.1	(a)
Al2O3	32.1	31.4	17.5	19.2	(a)
FeO	2.3	1.43	6.65	6.7	(a)
MnO	0.03	0.023	0.088	0.099	(a)
MgO	1.5	1	10.6	9	(a)
CaO	17.7	17.1	11.3	12	(a)
Na2O	0.28	0.25	0.61	0.6	(a)
K2O	0.012	0.007	0.16	0.088	(a)
P2O5					
S %					
sum					
Sc ppm	1.7	1.1	11	14.3	(a)
V			30	30	(a)
Cr					
Co			16	20.1	(a)
Ni	< 10	< 10	100	80	(a)
Cu					
Zn					
Ga					
Ge ppb					
As					
Se					
Rb					
Sr	150	150	160	170	(a)
Y					
Zr	< 10	< 10	110	70	(a)
Nb					
Mo					
Ru					
Rh					
Pd ppb					
Ag ppb					
Cd ppb					
In ppb					
Sn ppb					
Sb ppb					
Te ppb					
Cs ppm					
Ba	< 10	< 10	160	110	(a)
La	0.25	0.19	11	6.6	(a)
Ce	0.56	0.44	26	17	(a)
Pr					
Nd	< 1	< 1	17	12	(a)
Sm	0.084	0.074	4.5	3.4	(a)
Eu	0.76	0.75	1.5	1.5	(a)
Gd	< 1	< 1	5.9	4.2	(a)
Tb	0.02	0.017	1	0.74	(a)
Dy	<0.03	<0.03	6.6	4.8	(a)
Ho	<0.03	<0.03	1.5	1.2	(a)
Er					
Tm	< 0.1	< 0.1	0.6	0.5	(a)
Yb	0.58	0.55	4.2	3.2	(a)
Lu	0.009	0.0085	0.61	0.48	(a)
Hf	< 0.1	0.05	3.4	2.34	(a)
Ta	<0.02	<0.02	0.55	0.47	(a)
W ppb					
Re ppb					
Os ppb					
Ir ppb			3	< 1	(a)
Pt ppb					
Au ppb			< 2	< 1	(a)
Th ppm	< 0.05	< 0.05	2.12	1.2	(a)
U ppm	< 0.1	< 0.1	0.57	0.31	(a)

technique: (a) INAA



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