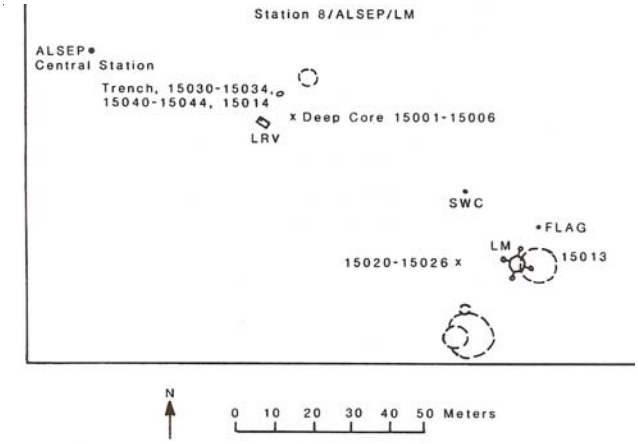
15020

Soil

607.5 grams



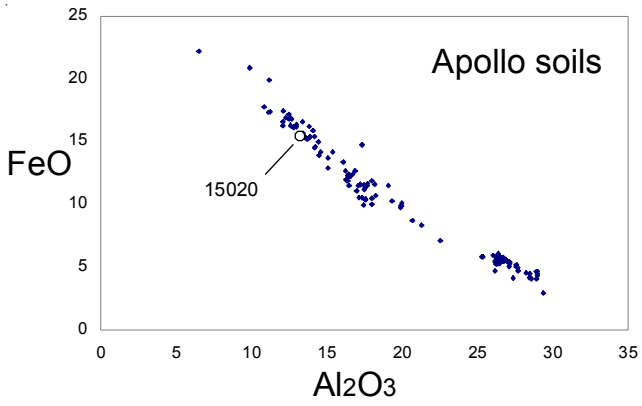


Figure 1: Composition of 15021 compared with other Apollo soils.

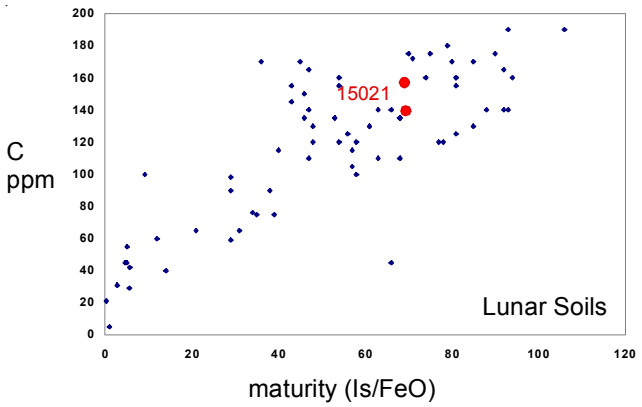


Figure 2: Carbon content and maturity index for 15021 compared with all other lunar soils.

Introduction

Lunar soil sample 15020 is the contingency sample returned from near the LM (compare with SESC sample 15013 from under LM). Two small rocks (15025 and 15026) were included.

Petrography

The maturity index (I_s/FeO) of 15021 is 70 (mature)(Morris 1978) and the % agglutinate is 55.5 (Basu et al. 1981). Carr and Meyer (1974) also give the mode (55% agglutinate). The average grain size is 54 microns (figure 3).

The coarse fines (4-10 mm) were cataloged by Powell (1972) and partially studied by Ryder and Sherman (1989). Meyer (1972, 1977) and Basu et al. (1981) described fragments of KREEP basalt from the coarse fines 15022-23.

Glass: Warner et al. (1972) and Reid et al. (1972) analyzed numerous glass particles in 15021 (figure 4).

Chemistry

Keith et al. (1972), Laul et al. (1972), Willis et al. (1972), Fruchter et al. (1973), Wanke et al. (1973) and Korotev (1987) reported analyses of 15021 (figure 5).

Holland et al. (1972) reported 135 ppm C and 122 ppm N and Moore et al. (1973) reported 150 ppm C (figure 2).

Hubbard et al. (1972) gave an analysis of a KREEP basalt fragment (15023). This soil had ~ 25 % KREEP (Walker and Papike 1981).

Cosmogenic isotopes and exposure ages

Finkel et al. (1973) used 15021 as a surface sample in their study of cosmic-ray bombardment of the moon.

Other Studies

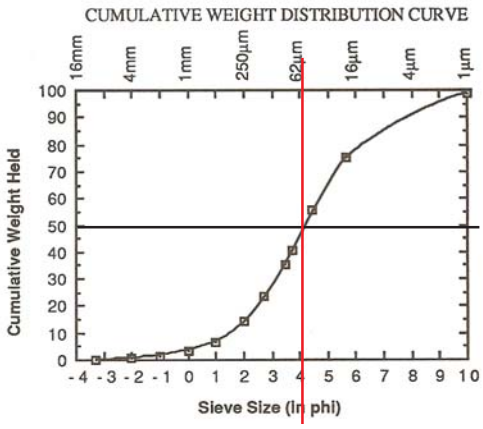
Kirsten et al. (1972), Frick et al. (1973), Jordan et al. (1974), Bogard and Nyquist (1973, 1974), Signer et al. (1977) and Wieler et al. (1980) determined the concentration and isotopic ratio of the rare gasses in 15021.

Modal content of soil 15020.
From Basu et al. 1981.

Agglutinates	55.5%
Basalt	8
Breccia	15
Anorthosite	0.3
Norite	
Gabbro	
Plagioclase	15
Pyroxene	3.6
Olivine	9.1
Ilmenite	2.3
Glass other	6

From Carr and Meyer 1974.

Agglutinates	55.2%
Basalt	5.7
Breccia	1
Plagioclase	9.3
Pyroxene	19.5
Olivine	0.6
Ilmenite	0.2
Glass other	8.5



Average grain size = 54 microns

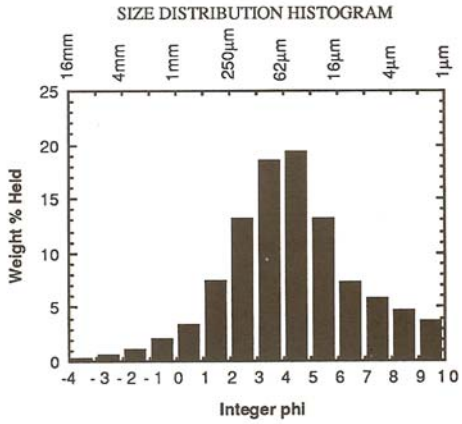


Figure 3: Grain size distribution for 15020 (Graf 1993).

Silver (1972), Fields et al. (1972), Nyquist et al. (1973), Birck and Allegre (1973), Thode and Reese (1979) and Epstein and Taylor (1972, 1973) measured various isotopes in 15021.

Adams and McCord (1972) and Gold et al. (1977) used 15021 to understand optical properties of lunar soils.

Processing

15020 was returned in the contingency sample bag and probably exposed to air in the LM, CSM and Pacific Ocean. It should be compared with 15013 which was returned and processed in a different manner.

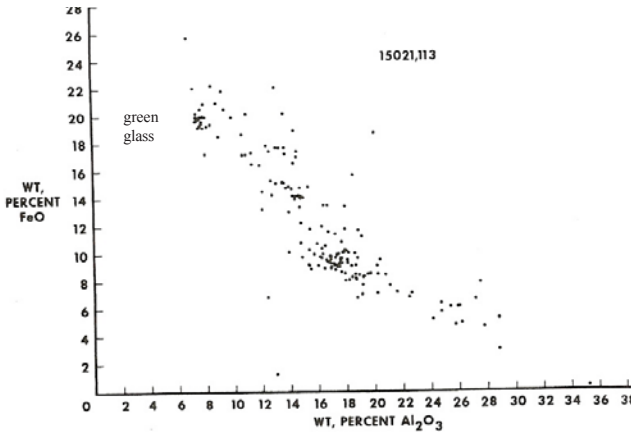


Figure 4: Composition of glass in 15021 (Reid et al. 1972).

Table 1a. Chemical composition of 15021.

reference	LSPET72		Korotev87		Wiesmann75			Fruchter73		Janghorbani73	Wanke73		Laul72		15023,2,5 Wiesmann75 Hubbard72	
weight																
SiO2 %	46.56	(c)								50	47	(b)				
TiO2	1.75	(c)	1.8	(b)				1.75	(b)	2	1.83	(b)	1.8	(b)	2.13	(a)
Al2O3	13.73	(c)	14.1	(b)				13.4	(b)	14.8	14.1	(b)	14.1	(b)		
FeO	15.21	(c)	15.1	(b)				14.9	(b)	15.8	15.2	(b)	15	(b)		
MnO	0.2	(c)								0.19	0.18	(b)	0.19	(b)		
MgO	10.37	(c)	10.5	(b)		10.3	(a)			10.3	10.5	(b)			8.6	(a)
CaO	10.54	(c)	10.5	(b)		10.5	(a)				9.1	(b)	10.8	(b)	9.4	(a)
Na2O	0.41	(c)	0.42	(b)	0.4	0.39	(a)	0.51	(b)	0.4	0.42	(b)	0.434	(b)	0.82	(a)
K2O	0.2	(c)			0.213	0.21	(a)				0.2	(b)	0.22	(b)	0.53	(a)
P2O5	0.18	(c)														
S %	0.06	(c)														
sum																
Sc ppm			30.4	(b)				30	(b)		26.6	(b)	28	(b)		
V													114	(b)		
Cr			2790	(b)				2529	(b)		2500	(b)	2737	(b)		
Co			44.6	(b)				44	(b)		42	(b)	40	(b)		
Ni	288		232	(b)							210	(b)				
Cu																
Zn																
Ga																
Ge ppb																
As																
Se																
Rb	6.1	(c)			5.91	5.85									13.2	(a)
Sr	135	(c)	130	(b)	131	131									177	(a)
Y	91	(c)														
Zr	410	(c)	380	(b)				310	(b)				350	(b)		
Nb	24	(c)														
Mo																
Ru																
Rh																
Pd ppb																
Ag ppb																
Cd ppb																
In ppb																
Sn ppb																
Sb ppb																
Te ppb																
Cs ppm			0.27	(b)												
Ba			263	(b)		276	(a)	260	(b)				320	(b)	683	(a)
La			25	(b)		26.7	(a)	27	(b)		26.6	(b)	26	(b)	69.8	(a)
Ce			67	(b)	69.9	68.1	(a)	69	(b)		58	(b)	73	(b)	193	(a)
Pr																
Nd			38	(b)	43.1		(a)	50	(b)		38	(b)			114	(a)
Sm			12	(b)	12.5		(a)	13	(b)		12	(b)	12.9	(b)	32	(a)
Eu			1.325	(b)	1.4		(a)	1.49	(b)		1.34	(b)	1.4	(b)	2.6	(a)
Gd					14.9		(a)									
Tb			2.39	(b)				2.4	(b)		2.3	(b)	2.3	(b)		
Dy					17.2		(a)				16.5	(b)			44	(a)
Ho											3	(b)				
Er					10.1		(a)								28.3	(a)
Tm																
Yb			8.8	(b)	8.9		(a)	8.8	(b)		8.3	(b)	9.5	(b)	21.5	(a)
Lu			1.22	(b)	1.35		(a)	1.39	(b)		1.2	(b)	1.3	(b)	3.1	(a)
Hf			9.9	(b)				9.1	(b)		8.8	(b)	9.9	(b)		
Ta			1.18	(b)				1.7	(b)		1.2	(b)	1.2	(b)		
W ppb																
Re ppb																
Os ppb																
Ir ppb			8.2	(b)												
Pt ppb																
Au ppb			3.8	(b)												
Th ppm	3.8	(c)	4.3	(b)				4.6	(b)				4.9	(b)		
U ppm			1.09	(b)	1.3	1.27	(a)						1.5	(b)	3.09	(a)

technique: (a) IDMS, (b) INAA, (c) XRF

Table 1b. Chemical composition of 15021.

reference	Baedecker73		Keith72		Willis72	
weight			132 g			
SiO2 %					47.23	(c)
TiO2					1.73	(c)
Al2O3					13.92	(c)
FeO					15.11	(c)
MnO					0.196	(c)
MgO					10.3	(c)
CaO					10.57	(c)
Na2O					0.37	(c)
K2O			0.194	(b)	0.205	(c)
P2O5					0.23	(c)
S %					0.095	(c)
sum						
Sc ppm						
V						
Cr						
Co						
Ni	283	(a)				
Cu						
Zn	13.9	(a)				
Ga	4.3	(a)				
Ge ppb	470	(a)				
As						
Se						
Rb					6.3	(c)
Sr					135	(c)
Y					86.2	(c)
Zr					402	(c)
Nb					25.3	(c)
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb						
Cd ppb	41	(a)				
In ppb	3.7	(a)				
Sn ppb						
Sb ppb						
Te ppb						
Cs ppm						
Ba					289	(c)
La						
Ce						
Pr						
Nd						
Sm						
Eu						
Gd						
Tb						
Dy						
Ho						
Er						
Tm						
Yb						
Lu						
Hf						
Ta						
W ppb						
Re ppb						
Os ppb						
Ir ppb	8.9	(a)				
Pt ppb						
Au ppb	7.2	(a)				
Th ppm			5	(b)		
U ppm			1.32	(b)		

technique: (a) RNAA, (b) radiation counting, (c) XRF

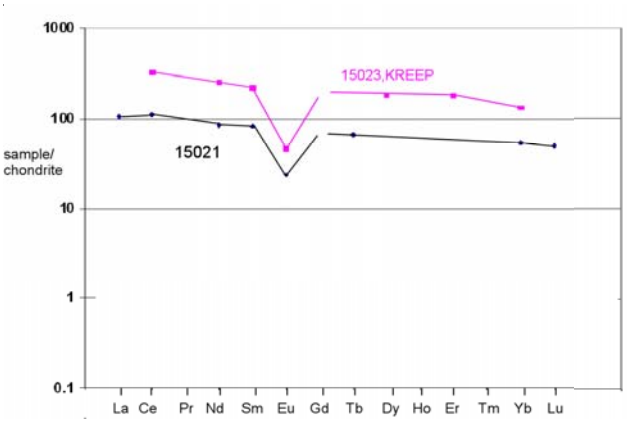


Figure 5: Normalized rare-earth-element diagram for 15021 (see table for data).

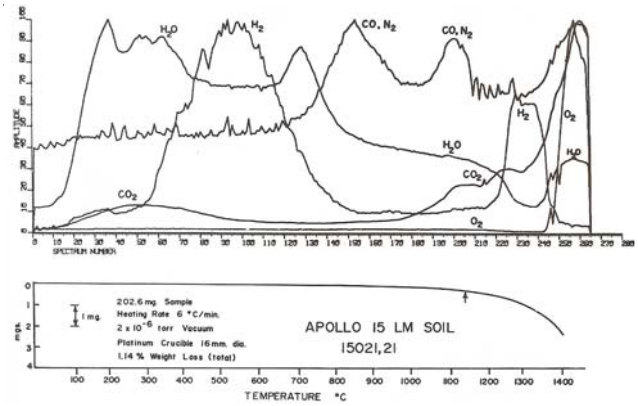
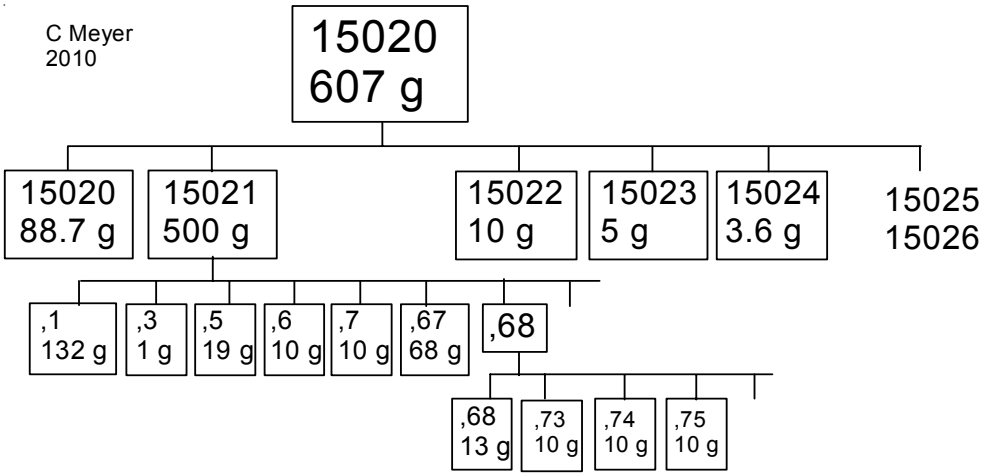


Figure 6: Thermal outgassing of 15021 (Gibson and Moore 1972).



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