66041

Soil

570 grams

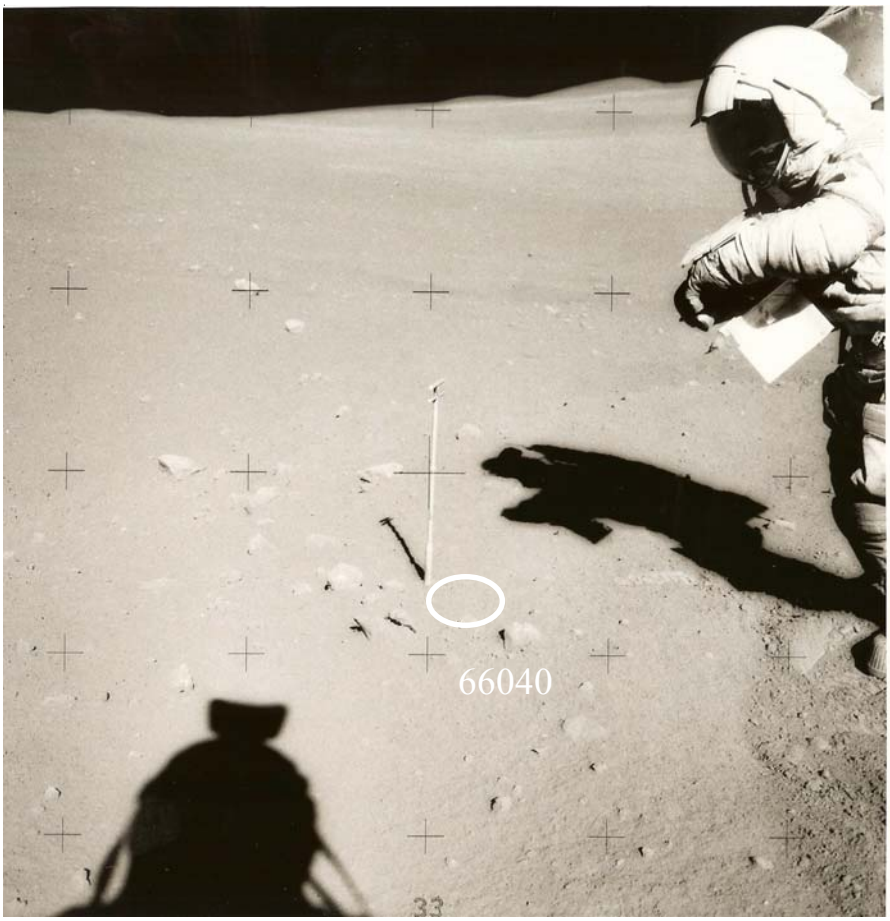
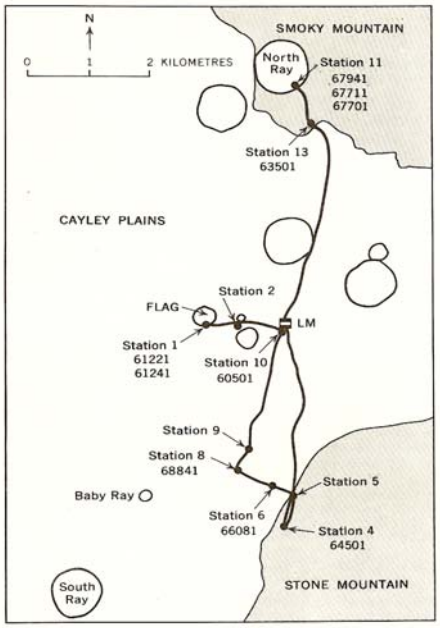
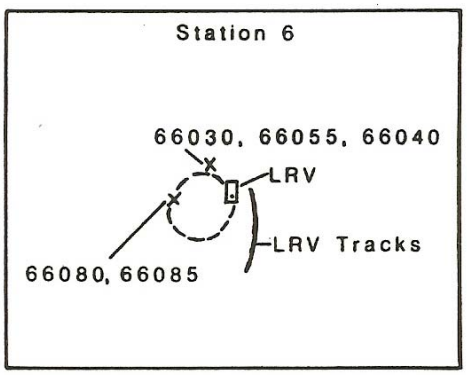


Figure 1: Astronaut preparing to collect sample 66040. AS16-108-17627





Figures 2 and 3: Maps of Apollo 16 site and station 6.

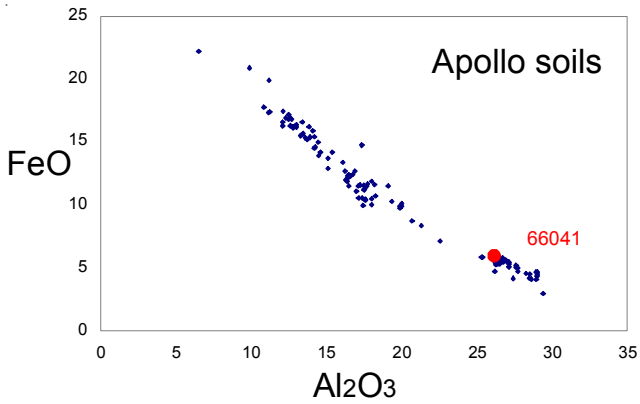


Figure 4: Composition of 66041 compared with Apollo soil samples.

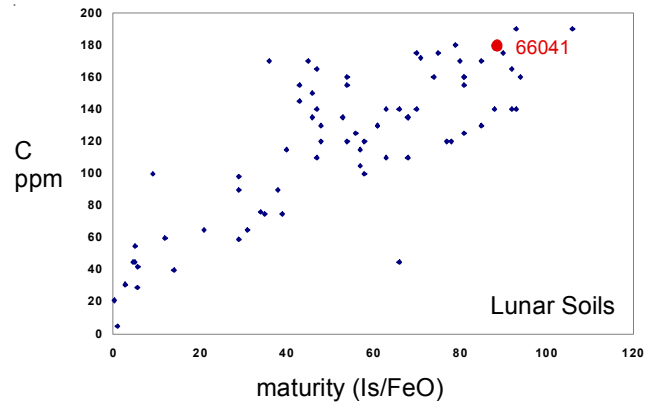


Figure 5: Carbon content and maturity index for 66041.

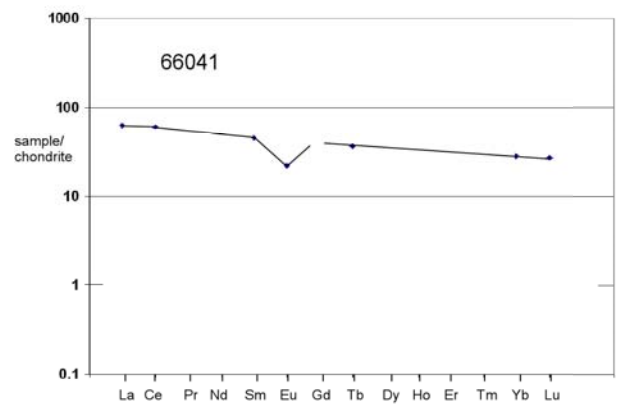


Figure 6: Normalized rare-earth-element diagram for 66041

Introduction

Soil sample 66030 – 66034 was collected with breccia samples 66035, 66036 and 66037. Both 66041 and 66031 were collected from the same location on the Cayley Plain near Stone Mountain (figures 1-3).

Petrography

66031 is a very mature soil with I_s/FeO = 102 (Morris 1987). It has an average grain size of 121 microns (figure 6). The mineral mode and agglutinate content are presumably like that for 66041.

Chemistry

Korotev (1982) determined an average for soils from each station at Apollo 16. The analysis by Brunfeldt et al. (1973) is similar (figure 5).

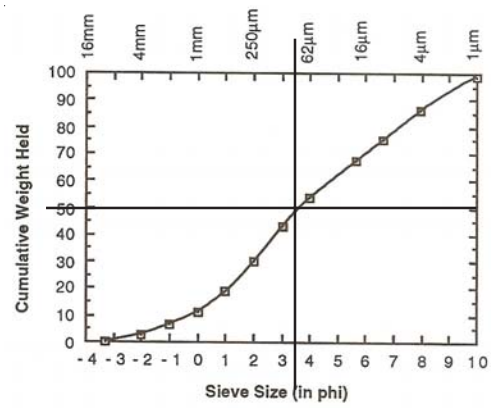
Cirlin and Housley (1981) determined 71 ppb Cd and 20.5 ppm Zn.

Cosmogenic isotopes and exposure ages

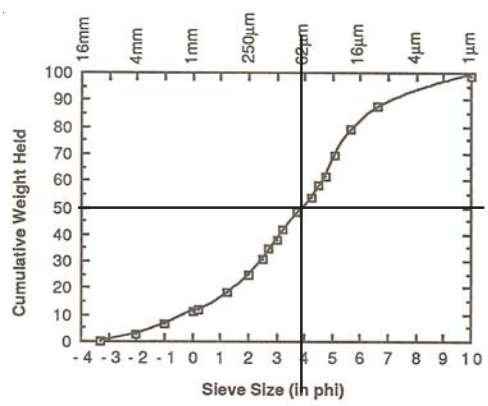
Eldridge et al. (1973) determined the cosmic-ray-induced activity of ^{26}Al = 208 dpm/kg and ^{22}Na = 52 dpm/kg.

Mineralogical Mode

From Butler	74-53 microns
Olivine	1.9 %
Pyroxene	3.5
Plagioclase	12.4
Glass	9
Rock fragments	30
Welded fragments	43



average grain size = 63 microns



average grain size = 79 microns

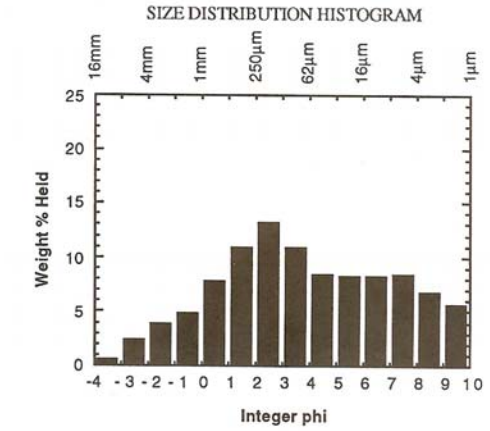


Figure 7a: Grain size distribution (Graf 1993, from data by Engelhardt)

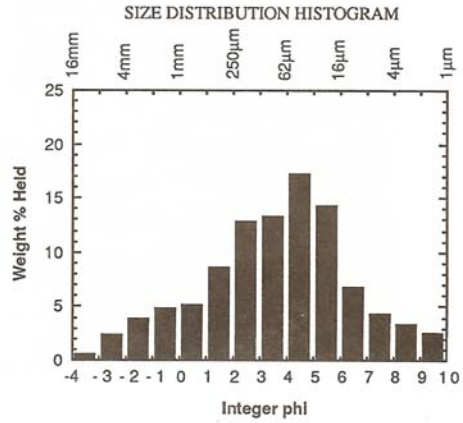


Figure 7b: Grain size distribution (Graf 1993, from data by Butler et al.)

Table 1a. Chemical composition of 66041.

reference	LSPET72		Clark73			Baedecker72			Rose73		Laul73				ave. st. 6 Korotev81
weight															
SiO2 %	45.07	(a)							44.99	(d)					45.2
TiO2	0.64	(a)							0.63	(d)	0.75	0.65	0.7	(e)	0.67
Al2O3	26.39	(a)							26.12	(d)	26.8	26.6	26.7	(e)	26.4
FeO	6.08	(a)							5.8	(d)	6.1	6.1	5.6	(e)	5.95
MnO	0.08	(a)							0.08	(d)	0.072	0.072	0.073	(e)	0.077
MgO	6.14	(a)							6.07	(d)	7	7	7	(e)	6.25
CaO	15.29	(a)							15.32	(d)	16.9	15.7	16	(e)	15.7
Na2O	0.38	(a)							0.41	(d)	0.449	0.449	0.456	(e)	0.44
K2O	0.12	(a)	0.115	0.122	(b)				0.16	(d)	0.11	0.11	0.11	(e)	0.12
P2O5	0.15	(a)							0.13	(d)					
S %	0.09	(a)													
sum															
Sc ppm									10	(d)	10	10	9.6	(e)	10.4
V									22	(d)	25	25	25	(e)	24
Cr	820	(a)							821	(d)	807	807	718	(e)	795
Co									21	(d)	38	33	32	(e)	33.5
Ni	362	(a)				455	476	(c)	330	(d)			550	(e)	460
Cu									7.9	(d)					
Zn						25	23	(c)	22	(d)					
Ga						4.8	5.1	(c)	3.4	(d)					
Ge ppb						1070	1000	(c)							
As															
Se															
Rb	3	(a)													3
Sr	169	(a)							145	(d)					163
Y	44	(a)							40	(d)					44
Zr	197	(a)							130	(d)			155	(e)	182
Nb	12	(a)													
Mo															
Ru															
Rh															
Pd ppb															
Ag ppb															
Cd ppb						89	77	(c)							
In ppb						17	17	(c)							
Sn ppb															
Sb ppb															
Te ppb															
Cs ppm															
Ba									120	(d)		130	130	(e)	142
La											13.7	13.7	14.5	(e)	13.7
Ce											35	35	36	(e)	
Pr															
Nd															
Sm											6.6	6.6	6.6	(e)	6.95
Eu											1.24	1.24	1.23	(e)	1.27
Gd															
Tb											1.2	1.2	1.3	(e)	1.32
Dy											8.2	8.2	8.4	(e)	
Ho															
Er															
Tm															
Yb											4.6	4.6	4.6	(e)	4.65
Lu											0.71	0.71	0.66	(e)	0.73
Hf											4.4	4.4	4.6	(e)	4.7
Ta											0.64	0.64	0.6	(e)	0.6
W ppb															
Re ppb															
Os ppb															
Ir ppb						15	15	(c)					15	(e)	
Pt ppb															
Au ppb						11.6	5.9	(c)					10	(e)	
Th ppm	2.6	(a)	2.5	2.2	(b)						2.1	2.1	2.6	(e)	2.4
U ppm			0.66	0.74	(b)						0.7	0.7	0.7	(e)	0.67

technique: (a) XRF, (b) radiation count. (c) RNAA, (d) 'microchem.' (e) INAA

Table 1b. Chemical composition of 66041.

reference	Boynton75	
weight		
SiO2 %		
TiO2		
Al2O3		
FeO	6.05	(a)
MnO	0.08	(a)
MgO		
CaO	16.5	(a)
Na2O	0.5	(a)
K2O		
P2O5		
S %		
sum		
Sc ppm	10.5	(a)
V		
Cr	760	(a)
Co	38	(a)
Ni		
Cu		
Zn		
Ga		
Ge ppb		
As		
Se		
Rb		
Sr		
Y		
Zr		
Nb		
Mo		
Ru		
Rh		
Pd ppb		
Ag ppb		
Cd ppb		
In ppb		
Sn ppb		
Sb ppb		
Te ppb		
Cs ppm		
Ba	190	(a)
La	12.1	(a)
Ce	36	(a)
Pr		
Nd		
Sm	7.1	(a)
Eu	1.3	(a)
Gd		
Tb	1.3	(a)
Dy	9.6	(a)
Ho		
Er		
Tm		
Yb	4.6	(a)
Lu	0.77	(a)
Hf	4.9	(a)
Ta	0.61	(a)
W ppb		
Re ppb		
Os ppb		
Ir ppb		
Pt ppb		
Au ppb		
Th ppm	2.2	(a)
U ppm		
technique:	*(a) INAA*	

References for 66041.

Baedecker P.A., Chou C-L., Sunberg L.L. and Wasson J.T. (1972) Extralunar materials in Apollo 16 soils and the decay rate of the extralunar flux 4.0 GY ago. *Earth Planet. Sci. Lett.* **17**, 79-83.

Becker R.H. and Clayton R.N. (1975) Nitrogen abundances and isotopic compositions in lunar samples. *Proc. 6th Lunar Sci. Conf.* 2131-2149.

Boynton W.V., Baedecker P.A., Chou C.-L., Robinson K.L. and Wasson J.T. (1975a) Mixing and transport of lunar surface materials: Evidence obtained by the determination of lithophile, siderophile, and volatile elements. *Proc. 6th Lunar Sci. Conf.* 2241-2259.

Butler P. (1972) Lunar Sample Information Catalog Apollo 16. Lunar Receiving Laboratory. MSC 03210 Curator's Catalog. pp. 370.

Butler J.C., Greene G.M. and King E.A. (1973) Grain size frequency distribution and modal analysis of Apollo 16 fines. *Proc. 4th Lunar Sci. Conf.* 267-278.

Clark R.S. and Keith J.E. (1973) Determination of natural and cosmic ray induced radionuclides in Apollo 16 lunar samples. *Proc. 4th Lunar Sci. Conf.* 2105-2113.

Delano J.W., Bence A.E., Papike J.J. and Cameron K.L. (1973) Petrology of the 2 -4 mm soil fractions from the Descartes region of the moon and stratigraphic implications. *Proc. 4th Lunar Sci. Conf.* 537-551.

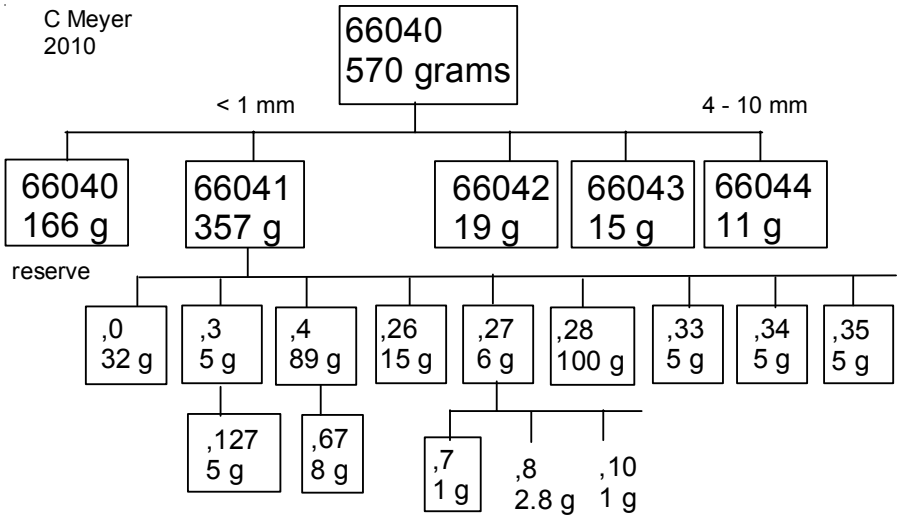
Delano J.W., Zellner N.E.B., Barra F., Olson E., Swindle T.D., Tibbetts N.J. and Whittet D.C.B. (2007) An integrated approach to understanding Apollo 16 impact glasses: Chemistry, isotopes and shape. *Meteorit. & Planet. Sci.* **42**, 993-1004.

von Engelhardt W., Hurrle H. and Luft E. (1976) Microimpact-induced changes of textural parameters and modal composition of the lunar regolith. *Proc. 7th Lunar Sci. Conf.* 373-392.

Graf J.C. (1993) Lunar Soils Grain Size Catalog. NASA Pub. 1265

Heiken G.H., McKay D.S. and Fruland R.M. (1973b) Apollo 16 soils – grain size analysis and petrography. *Proc. 4th Lunar Sci. Conf.* 251-266.

Laul J.C. and Schmitt R.A. (1973b) Chemical composition of Apollo 15, 16, and 17 samples. *Proc. 4th Lunar Sci. Conf.* 1349-1367.



Laul J.C. and Schmitt R.A. (1973a) Chemical composition of Luna 20 rocks and soil and Apollo 16 soils. *Geochim. Cosmochim. Acta* **37**, 927-942.

LSPET (1973) The Apollo 16 lunar samples: Petrographic and chemical description. *Science* 179, 23-34.

LSPET (1972) Preliminary examination of lunar samples. Apollo 16 Preliminary Science Report. NASA SP-315, 7-1—7-58.

Marvin U.B. (1972) Apollo 16 coarse fines (4-10 mm): Sample classification, description and inventory. JSC Catalog.

Moore C.B., Lewis C.F. and Gibson E.K. (1973) Total carbon contents of Apollo 15 and 16 lunar samples. *Proc. 4th Lunar Sci. Conf.* 1613-1923.

Moore C.B. and Lewis C.F. (1975) Total nitrogen contents of Apollo 15, 16 and 17 lunar fines samples. *Lunar Sci.* **VI**, 569-571.

Morris R.V., Score R., Dardano C. and Heiken G. (1983) Handbook of Lunar Soils. Two Parts. JSC 19069. Curator's Office, Houston

Morris R.V. (1978) The surface exposure (maturity) of lunar soils: Some concepts and Is/FeO compilation. *Proc. 9th Lunar Sci. Conf.* 2287-2297.

Nunes P.D., Tatsumoto M., Knight R.J., Unruh D.M. and Doe B.R. (1973b) U-Th-Pb systematics of some Apollo 16 lunar samples. *Proc. 4th Lunar Sci. Conf.* 1797-1822.

Papike J.J., Simon S.B. and Laul J.C. (1982) The lunar regolith. *Rev. Geophys. Space Phys.* 20, 761-826.

Rose H.J., Cuttitta F., Berman S., Carron M.K., Christian R.P., Dwornik E.J., Greenland L.P. and Ligon D.T. (1973) Compositional data for twenty-two Apollo 16 samples. *Proc. 4th Lunar Sci. Conf.* 1149-1158.

Schaeffer O.A. and Husain L. (1973b) Early lunar history: Ages of 2 to 4 mm soil fragments from the lunar highlands. *Proc. 4th Lunar Sci. Conf.* 1847-1863.

Simkin T., Noonan A.F., Switzer G.S., Mason B., Nelen J.A. and Thomson G. (1973) Composition of Apollo 16 fines 60051, 60052, 64811, 64812, 67711, 67712, 68821 and 68822. *Proc. 4th Lunar Sci. Conf.* 279-289.

Sutton R.L. (1981) Documentation of Apollo 16 samples. In Geology of the Apollo 16 area, central lunar highlands. (Ulrich et al.) U.S.G.S. Prof. Paper 1048.

Taylor G.J., Drake M.J., Hallam M.E., Marvin U.B. and Wood J.A. (1973b) Apollo 16 stratigraphy: The ANT hills, the Cayley Plains and a pre-Imbrian regolith. *Proc. 4th Lunar Sci. Conf.* 553-568.

Walton J.R., Lakatos S. and Heymann D. (1973) Distribution of inert gases in fines from the Cayley-Descartes region. *Proc. 4th Lunar Sci. Conf.* 2079-2096.

Woodcock M.R. and Pillinger C.T. (1978) Major element chemistry of agglutinate size fractions. *Proc. 9th Lunar Planet. Sci. Conf.* 2195-2214.