DRAFT

72320

Partially Shadowed Soil (portion frozen)

106.31 grams

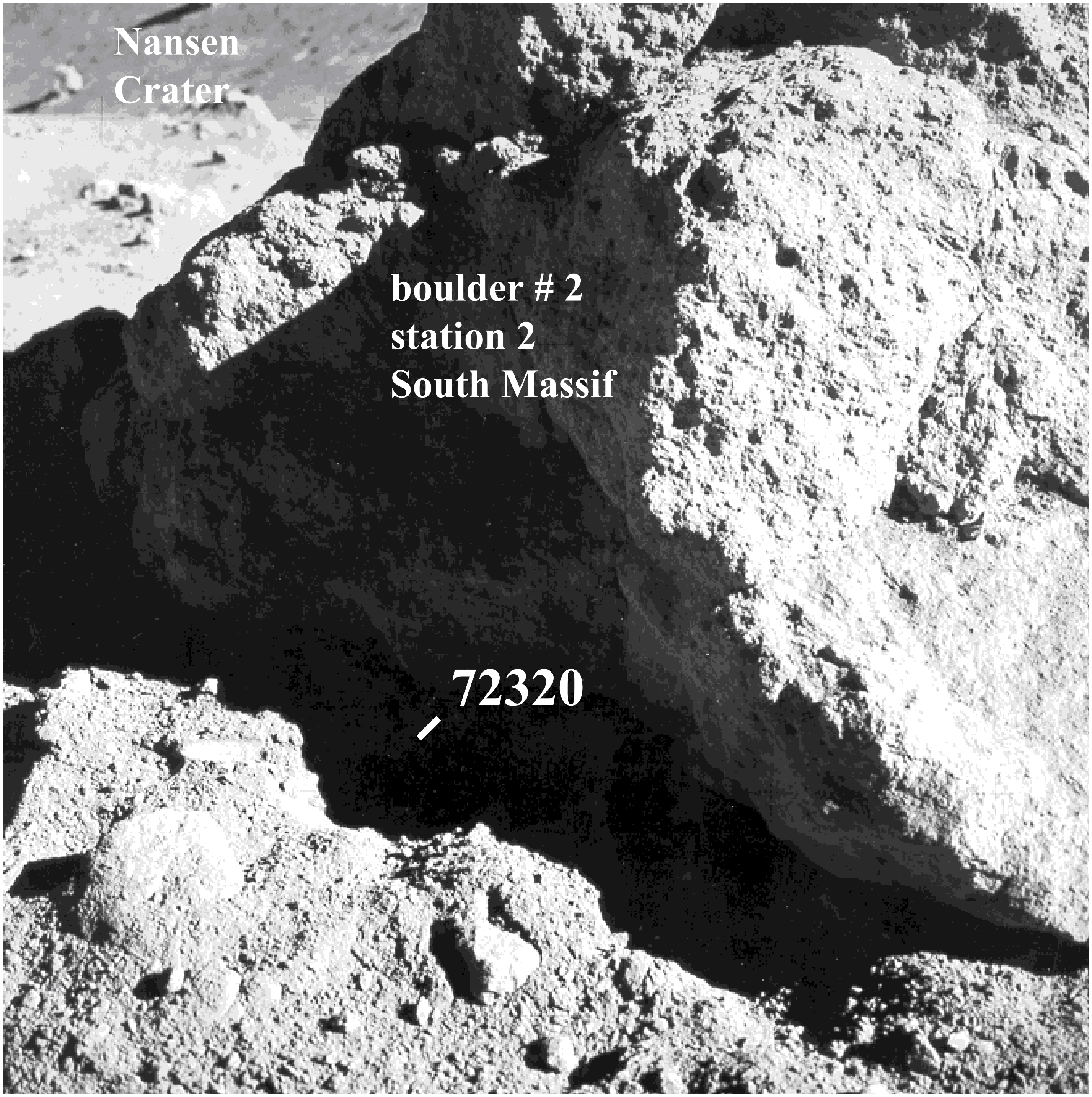

Figure 1: Location of soil sample 72320 in shadow of boulder 2, at station 2, Apollo 17. NASA photo #AS17-137-20925.

Introduction

72320 is a partially-shadowed soil sample collected about 20 cm. under the east – west overhang on the south side of a 2 meter diameter boulder (#2) at station 2, near the base of the South Massif (figure 1). It has a maturity index $I_s/FeO = 73$ (mature) with about 45% agglutinates (Heiken and McKay 1974). McKay et al. (1974) reported a mean grain size of 47 microns. Although it is called a fillet sample (Ryder 1993), the high maturity index indicates that it is primarily a preexisting soil from before the boulder arrived.

Boulder #2 is an impact breccia located on the "landslide" off of South Massif. Documented rock samples 72315, 72335, 72355, 72375 and 72395 were chipped off the sides and top of the boulder. Sample 72313 is from a clast observed in the breccia, 72335 represents the "contact" and 72355, 72375 and 72395 represent the normal boulder matrix. However, all five boulder samples are very similar in lithology (micropoikilitic) and chemical composition (figure 2).

A portion (20 g) of 72320 has been kept frozen since return to the Lunar Receiving Laboratory. Durrani et al. (1976) found that the thermoluminescence of this sample was not well preserved (figure 3), indicating that the sample may have only been partially shaded from the Sun.

Petrography

It is not clear which soils should be considered as a reference for this partially shaded sample – however, 72500 and 72700 were collected nearby.

Chemistry

Rhodes et al. (1974), Laul et al. (1974) and Morgan et al. (1974) have determined the chemical composition of 72320 (Table 1; figure 2). Table 2 provides an average for the composition of the boulder. Morgan et al. (1974) did not find high Cd, Br or Tl in this sample. The high Ni, Ge, Ir, Au can be attributed to the high maturity.

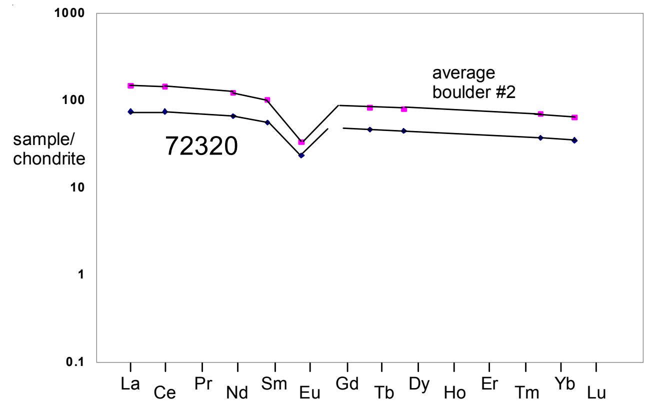

Figure 2: Noramalized rare-earth-element composition of 72320 compared with that of boutlder #2.

Cosmogenic isotopes and exposure ages

Leich et al. (1974) and Arvidson et al. (1975) find the age of the landslide to be about 45-55 m.y. ago (from samples of adjacent boulder (72255, 72275).

Other Studies

Durrani et al. (1976) found that the natural thermoluminescence of this "partially shaded" sample was not as preserved as would have been expected (figure 3). They interpret their data to mean that 72320 was not always shaded as seen in figure 1.

Processing

A portion (20 G) of this shadowed sample was placed in a freezer (~ January 30, 1973), but was removed on or about January 1974 (CO1637) to split a cold portion for SADurrani (details are important). The sample was delivered (cold) to Durrani March 22, 1974. The remainder has been in the freezer ever since (no further processing).

Modal content of soil 72321 (90-150 micron).
From Heiken and McKay 1974.

	72321	72501	72701
Agglutinates	45.3 %	48 5 %	43.6
Basalt	3	3.3	1.7
Breccia	28.2	29.6	34
Anorthosite	1.4	2.4	2.3
Norite	2	0.3	0.3
Gabbro	-		
Plagioclase	9.3	6.3	7.7
Pyroxene	3	5.3	3.7
Olivine	0.3	0.7	1.7
Ilmenite	tr.	0.3	-
Orange glass	tr	1	1
Glass other	5	2.7	3.7

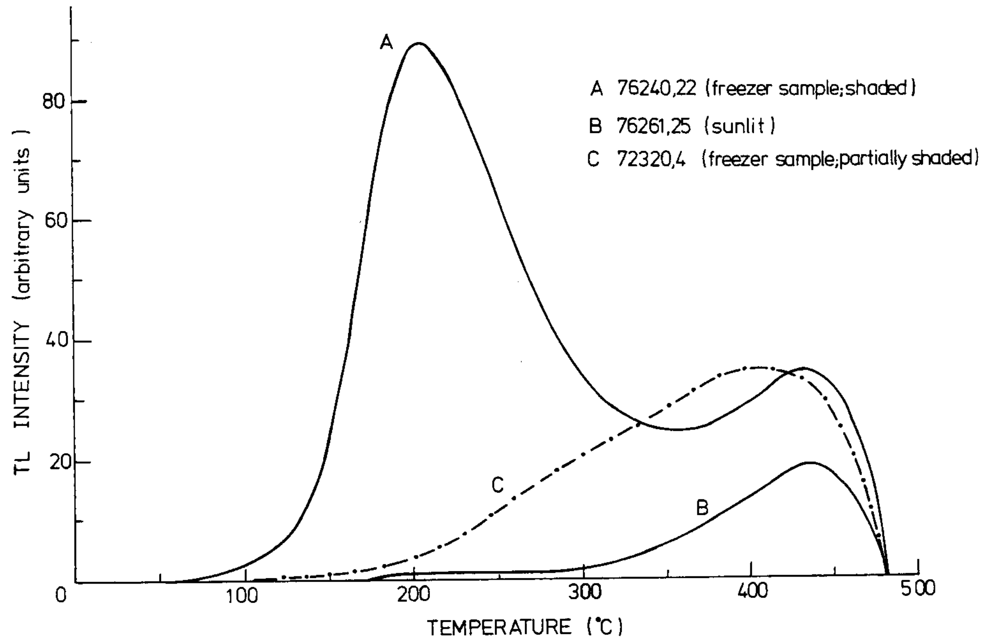

Figure 3: Natural thermolumenscence "glow curves" for three lunar soils with different radiation and thermal histories (Durrani et al. 1976). Frozen sample 72320 gives off less light and starts at a higher temperature than permanently shaddowed sample 76240 indicating that 72320 may have only been partially shaddowed on the Moon.

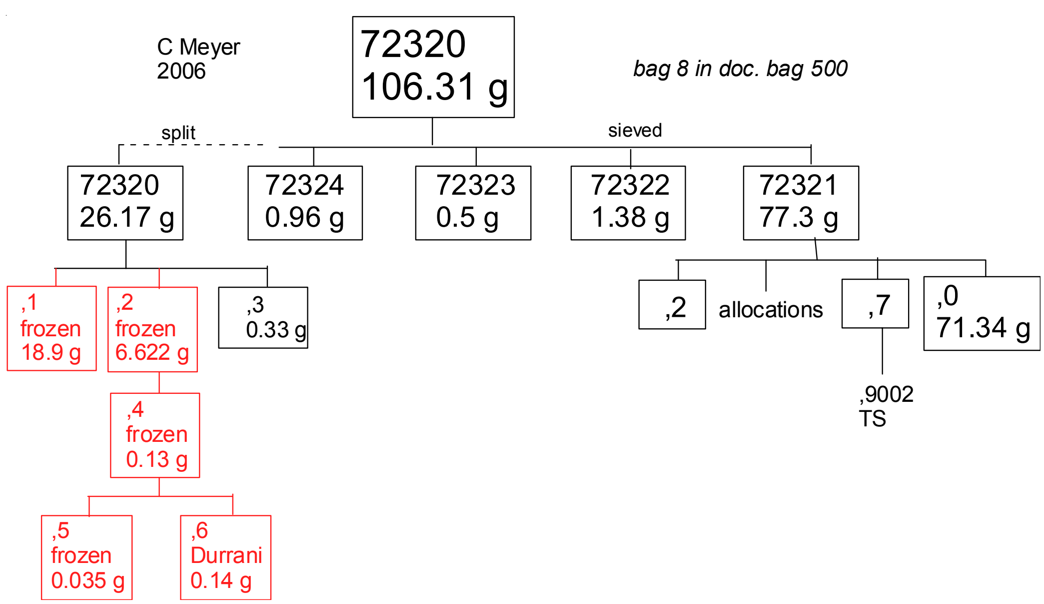

Table 1. Chemical composition of 72320.

											72700(reference)			Average
reference	Rhodes74		Laul74			Laul74			Morgan74		Korotev92			boulder2
weight (mg)			136	44		117	87		84		~50 mg			Table 2
SiO2 %	44.9	(a)												47
TiO2	1.56	(a)	1.6	1.6	(b)									1.6
Al2O3	20.57	(a)	21.4	21.1	(b)									18.6
FeO	8.65	(a)	8.7	8.7	(b)						8.85	9.04	(b)	8.85
MnO	0.13	(a)	0.11	0.11	(b)									0.11
MgO	9.84	(a)	10	10	(b)									11.7
CaO	12.82	(a)	11.8	12.1	(b)									11.1
Na2O	0.47	(a)	0.5	0.45	(b)						0.456	0.452	(b)	0.66
K2O	0.16	(a)	0.15	0.16	(b)									0.3
P2O5	0.15	(a)												0.3
S %	0.06	(a)												0.06
sum														
Sc ppm			18	18	(b)						19.1	18.7	(b)	16.5
V			50	50	(b)									50
Cr											1570	1577	(b)	
Co			30	28	(b)	28	28	(c)			34.2	39	(b)	30
Ni			250	260	(b)	250	260	(c)	550	(c)	341	350	(b)	270
Cu														3
Zn						18	18	(c)						2.4
Ga						4.7		(c)						4.3
Ge ppb									625	(c)				440
As														78
Se						240	240	(c)	240	(c)				116
Rb						3.9	4.7	(c)	4.1	(c)				6.8
Sr						155	145	(c)			158	181	(b)	156
Y														
Zr			200	220	(b)						250	280	(b)	462
Nb														
Mo														
Ru														
Rh														
Pd ppb														
Ag ppb						7.2	6.4	(c)	6.5	(c)				1
Cd ppb						36	37	(c)	37	(c)				6
In ppb						3	3	(c)						0.3
Sn ppb														
Sb ppb						2.2	4.8	(c)	1.81	(c)				2
Te ppb									24	(c)				
Cs ppm						0.18	0.22	(c)	0.17	(c)				0.27
Ba			190	190	(b)	180	170	(c)			194	193	(b)	318
La			17.7	18.3	(b)						17.8	17.1	(b)	34.7
Ce			45	45	(b)						46.8	44	(b)	87.7
Pr														
Nd			30	32	(b)						28	27	(b)	55
Sm			8.3	8.2	(b)						8.51	8.26	(b)	15.1
Eu			1.31	1.32	(b)						1.34	1.32	(b)	1.86
Gd														
Tb			1.7	1.6	(b)						1.65	1.69	(b)	3.03
Dy			11	11	(b)									19.4
Ho														
Er														
Tm														
Yb			6.1	6.2	(b)						6.16	6.08	(b)	11.3
Lu			0.85	0.84	(b)						0.853	0.849	(b)	1.55
Hf			6.2	6.4	(b)						6.65	6.36	(b)	11.7
Ta			0.84	0.84	(b)						0.85	0.79	(b)	1.55
W ppb														750
Re ppb							0.83	(c)	1.07	(c)				0.6
Os ppb														
Ir ppb			10	10	(b)	10	8.1	(c)	8.87	(c)	13	14.5	(b)	7.8
Pt ppb														
Au ppb			4	4	(b)	3.7	3.7	(c)	6.03	(c)	5	5.3	(b)	4.6
Th ppm			2.8	2.8	(b)						3.2	2.94	(b)	5.5
U ppm			1	1	(b)	0.91	0.83	(c)	0.9	(c)	0.76	0.73	(b)	1.8

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

Table 2. Chemical composition of boulder 2 samples.

	72315	72335	72355	72375	72395	72395	Average
reference	Laul74	Laul74	Laul74	Laul74	Laul74	Wanke75	boulder2
weight							
SiO2 %						46.9	47
TiO2	1.4	1.6	1.6	1.5	1.7	1.75	1.6
Al2O3	19.8	18.2	18.8	18.2	18.7	18.1	18.6
FeO	8.5	8.6	8.7	8.8	9.2	9.29	8.85
MnO	0.11	0.11	0.11	0.11	0.12	0.12	0.11
MgO	11	11	12	12	12	11.97	11.7
CaO	11.6	10.7	11.1	10.8	11	11.27	11.1
Na2O	0.61	0.61	0.7	0.67	0.67	0.69	0.66
K2O	0.32	0.27	0.33	0.27	0.32	0.29	0.3
P2O5						0.32	0.3
S %						0.056	0.06
sum							
Sc ppm	16	16	16	15	17	18.7	16.5
V	50	50	50	50	50		50
Cr							
Co	21	23	37	34	35	31	30
Ni	180	200	340	320	320	260	270
Cu						3.55	3
Zn	2.6		2.4	2.3	2.1	2.8	2.4
Ga						4.35	4.3
Ge ppb						440	440
As						78	78
Se	110		75	90	190		116
Rb	8.5		8	6.2	5.3	6.21	6.8
Sr	157		157	149	152	167	156
Y							
Zr	400	450	500	450	400	570	462
Nb							
Mo							
Ru							
Rh							
Pd ppb							
Ag ppb	1.1		0.87	0.82	1.4		1
Cd ppb	*8*		5.1	7.2			6
In ppb	0.4		0.2	0.2	0.2		0.3
Sn ppb							
Sb ppb	1.3		2.2	2.2	2.1		2
Te ppb							
Cs ppm	0.45		0.28	0.25	0.16	0.19	0.27
Ba	290	300	280	300	350	386	318
La	30	31.6	34	37	36	39.7	34.7
Ce	76	82	95	91	87	95	87.7
Pr							
Nd	50	54	54	57	55	61	55
Sm	12.8	14.1	15	16.6	15.2	16.8	15.1
Eu	1.82	1.84	1.92	1.82	1.81	1.93	1.86
Gd							
Tb	2.6	2.7	3.1	3.1	3	3.7	3.03
Dy	17	17	19	20	20	23.2	19.4
Ho							
Er							
Tm							
Yb	10	10.4	12	12	11	12.4	11.3
Lu	1.3	1.4	1.6	1.6	1.5	1.88	1.55
Hf	10		12	11	12	13.7	11.7
Ta	1.4	1.5	1.6	1.4	1.6	1.82	1.55
W ppb						750	750
Re ppb	0.43		0.73	0.84	0.79	0.2	0.6
Os ppb							
Ir ppb	4.3		7.3	8.5	8	11	7.8
Pt ppb							
Au ppb	2.8	4	4.9	5.3	5.8	4.7	4.6
Th ppm	5.2	4.6	6.1	5.7	5.5	6.05	5.5
U ppm	1.4	1.3	1.8	2	1.6	2.6	1.8
technique	*(a) INAA, RNAA*						

References:

Baedecker P.A., Chou C.-L., Sundberg L.L. and Wasson J.T. (1974) Volatile and sidrophilic trace elements in the soils and rocks of Taurus-Littrow. Proc. 5th Lunar Sci. Conf. vol. 2, 1625-1644.

Blanford G., Fruland R.M., McKay D.S., Morrison D.A. (1974) Lunar surface phenomena: Solar flare track gradients, microcraters and accretionary particles. Proc. 5th Lunar Sci. Conf. vol. 3, 2501-2526.

Durrani S.A., Kazal K.A.R. and Ali A. (1976) Temperature and duration of some Apollo 17 boulder shadows. Proc. 7th Lunar Sci. Conf. vol. 1, 1157-1177.

Heiken G.H. and McKay D.S. (1974) Petrography of Apollo 17 soils. Proc. 5th Lunar Sci. Conf. vol. 1, 843-860

Hintenberger H., Schultz L., and Weber H.W. (1975) A comparison of noble gases in lunar fines and soil breccias: Implications for the origin of soil breccias. Proc. 6th Lunar Sci. Conf. vol. 2, 2261-2270.

Laul J.C.. Hill D.W. and Schmitt R.A. (1974) Chemical studies of Apollo 16 and 17 samples. Proc. 5th Lunar Sci. Conf. vol. 2, 1047-1066.

Laul J.C. and Schmitt R.A. (1974) Siderophile and volatile trace elements in Apollo 17 boulder-2 rocks and soils. (abs) LS V, 441-443.

McKay D.S., Fruland R.M. and Heiken G.H. (1974) Grain size and the evolution of lunar soils. Proc. 5th Lunar Sci. Conf. 887-906.

Morgan J.W., Ganapathy R., Higuichi H., Krahenbuhl U. and Anders E. (1974) Lunar basins: Tentative characterization of projectiles, from meteoritic elements in Apollo 17 boulders. Proc. 5th Lunar Sci. Conf. vol. 2, 1703-1736.

Morris R.V. (1977) Origin and evolution on the grain-size dependence of the concentration of fine-grained metal in lunar soil: The maturation of lunar soils to a steady-state stage. Proc. 8th Lunar Sci. Conf. 3719-3747.

Morris R.V. (1978) The surface exposure (maturity) of lunar soils: Some concepts and Is/FeO compilation. Proc. 9th Lunar Sci. Conf. 2287-2298.

Rhodes J.M., Rodgers K.V., Shih C.-Y., Bansal B.M., Nyquist L.E., Wiesmann H. and Hubbard N.J. (1974) The relationships between geology and soil chemistry at the Apollo 17 landing site. Proc. 5th Lunar Sci. Conf. 1097-1118.

Wolfe E.W., Bailey N.G., Lucchitta B.K., Muehlberger W.R., Scott D.H., Sutton R.L. and Wilshire H.G. (1981) The geologic investigation of the Taurus-Littrow Valley: Apollo 17 landing site. USGS Prof. Paper 1080