THE RELATIONSHIP BETWEEN GEOLOGY AND SOIL CHEMISTRY AT THE APOLLO 17 LANDING SITE. J. M. Rhodes[1], K. V. Rodgers[1], C. Shih[2], B. M. Bansal[1], L. E. Nyquist[3], and H. Wiesmann[1]. [1]Lockheed Electronics Company, Inc., Houston, Texas; [2]Lunar Science Institute, Houston, Texas; [3]NASA, Johnson Space Center, Houston, Texas.

Major and trace element data obtained by x-ray fluorescence analysis are presented for 19 soils (table 1) and 12 rocks (table 2) from the Apollo 17 landing site. These results, together with our previously published data for 17 soils and 13 rocks (1,2), and additional data obtained by isotope dilution for lithophile elements in several soils, are used to examine the compositional diversity of the Apollo 17 soils with respect to their spatial distribution, inferred stratigraphy, and the prevailing major rock types.

The rock data indicate that, with a few exceptions, three distinct, chemically defined, rock types have been sampled (1,2): sub-floor basalts from the valley floor, and KREEP-like noritic breccias and anorthositic gabbros from the North and South Massifs. In addition, there are aluminum, magnesium and iron rich variants of the noritic breccias (73235, 76055, 72275) a dunite clast (72415), a troctolite (76535), and the orange soils (74220).

The soils at the site have a wider compositional variation than those sampled at any previous landing site, ranging from soils that closely approach the sub-floor basalts in composition, to aluminous soils from the South Massif (Fig. 1). Within this range, three chemically distinct groups can be recognized, largely on the basis of minor and trace element data, each group relating to a specific spatial and geological feature of the landing site.

South Massif and Light Mantle Soils: Soils from stations 2 and 2a are remarkably uniform in composition and, apart from a small (5-10%) basaltic and orange glass component, are intermediate in composition between the KREEP-like noritic breccias and anorthositic gabbros (Fig. 1,2). If this material is representative of the South Massif, the massif should consist of almost equal proportions of noritic breccias and anorthositic gabbros. This is in conflict with the preponderance of noritic breccias in the returned sample collection and suggests that they have been sampled preferentially to more friable anorthositic material.

The uniformity of these soils contrasts markedly with the wide diversity of the valley floor soils, and is surprising in view of the substantial compositional differences between the two major rock types sampled at the South Massif. Such disparity between soil and rock variance appears to be a feature of the lunar highlands, and may be attributed to either (a) extensive and highly efficient mixing of soils early in lunar history, or (b) the derivation of the soils by ablation from rocks that have been intimately mixed, at the outcrop scale or larger, during periods of extensive impact and brecciation.

Valley Floor Soils: Soils collected at stations 1,4,5 and the ALSEP site form a coherent group, the chemistry of which is dominated by sub-floor basalts. The compositional variation within the group can be attributed to mixing comminuted basalt, and variable amounts of orange glass, with aluminous South Massif soils. The fact that this inferred aluminous component corresponds closely with the South Massif soils and not with any major rock

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type provides further evidence for the existence of a massif soil that was well-homogenized prior to basalt extrusion. The basaltic component of the soil is dominated by high titanium basalts similar in composition to 70017. In contrast, lower titanium, quartz normative basalts (e.g. 75055) do not appear to be volumetrically significant at the Apollo 17 site. Soils from stations 1 and 5 contain the largest basaltic component, whereas the gray soils from station 4 contain the highest proportion of massif material.

<u>North Massif and Sculptured Hills Soils</u>: Soils from stations 6,7, and 8 are broadly comparable in composition in that they are more aluminous than the valley floor soils, but contain a greater proportion of basalt than do the South Massif soils. Station 9 soils, although containing larger amounts of basalt, are chemically closer to this group than to any other. The compositional variations within this group cannot be accounted for by mixing basalt with South Massif soils. It is necessary to postulate a different, fairly uniform massif component, higher in aluminum and magnesium and lower in lithophile elements (K, Rb, P, Zr, Y, Nb) than the South Massif material (Fig. 2). Again this component does not correspond with any single dominant rock type, but may represent a well-mixed massif soil containing more anorthositic gabbro than noritic breccia (3), and also substantial amounts of troctolite similar in composition to 76535. It is therefore inferred that the lithologies of the North Massif and Sculptured Hills differ from those of the South Massif in that the former contain a higher proportion of anorthositic rocks, such as anorthositic gabbro and troctolite, and lesser amounts of KREEP-like noritic breccias.

REFERENCES

(1) LSPET (1973) Science 182, 659-672

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TABLE 1. CHEMICAL COMPOSITION OF APOLLO 17 SOILS

	70019, 28†	70051, 24	72141, 9	72161, 6	72321, 5	72441, 3	72461, 3	72501, 22	72701, 21	73121, 6
MAJOR ELEMENT DATA (wt %)										
SiO_2	40.66	42.05	43.11	42.12	44.91	45.03	44.98	45.17	44.96	44.60
TiO_2	8.26	5.04	4.37	5.21	1.56	1.55	1.50	1.55	1.53	1.42
Al_2O_3	12.38	16.15	16.10	14.22	20.57	20.51	20.87	20.63	20.55	20.83
FeO	16.38	12.81	13.45	14.86	8.65	8.85	8.58	8.74	8.94	8.59
MnO	0.24	0.19	0.19	0.22	0.13	0.13	0.12	0.13	0.13	0.13
MgO	9.50	10.25	10.25	10.54	9.84	9.89	9.69	9.87	9.98	10.00
CaO	11.03	11.87	11.83	11.17	12.82	12.83	12.97	12.84	12.83	12.87
Na_2O*	0.47	0.43	0.40	0.41	0.47	0.46	0.47	0.46	0.51	0.44
K_2O	0.09	0.10	0.12	0.11	0.16	0.17	0.17	0.17	0.17	0.15
P_2O_5	0.07	0.06	0.10	0.08	0.15	0.17	0.16	0.15	0.14	0.13
S	0.10	0.08	0.09	0.08	0.06	0.07	0.06	0.06	0.07	0.07
Cr_2O_3	0.43	0.33	0.37	0.42	-	0.22	0.21	0.23	0.23	0.22
TOTAL	99.61	99.36	100.38	99.44	99.32	99.88	99.78	100.00	100.04	99.45
TRACE ELEMENT DATA (ppm)										
Sr	-	150	153	156	-	155	155	153	153	150
Rb	-	1.8	2.2	1.9	-	4.3	4.2	4.5	3.9	3.5
Y	-	49	53	55	-	64	61	63	60	55
Zr	-	169	197	207	-	278	265	293	267	232
Nb	-	14	15	16	-	19	18	18	18	17
Zn	-	34	50	58	-	21	20	21	19	18

	73141, 7	74241, 50	75081, 56	76241, 14	76261, 15	76281, 4	76321, 7	76501, 42	77531, 3
MAJOR ELEMENT DATA (wt %)									
SiO_2	44.91	41.55	40.00	43.20	43.64	43.56	44.08	43.34	43.07
TiO_2	1.24	7.45	9.40	3.31	3.38	3.83	3.00	3.15	3.91
Al_2O_3	21.42	13.35	11.18	17.85	17.96	17.80	18.41	18.41	17.16
FeO	8.14	14.89	17.30	10.92	10.93	11.26	10.53	10.39	11.70
MnO	0.12	0.22	0.25	0.16	0.16	0.16	0.15	0.15	0.17
MgO	9.94	9.19	9.42	11.05	10.75	10.55	10.82	11.08	10.19
CaO	13.06	11.54	10.87	11.97	12.11	12.18	12.23	12.24	11.93
Na_2O*	0.44	0.48	0.38	0.43	0.45	0.43	0.46	0.40	0.44
K_2O	0.15	0.12	0.08	0.12	0.12	0.11	0.13	0.11	0.11
P_2O_5	0.12	0.10	0.07	0.09	0.11	0.09	0.09	0.09	0.09
S	0.06	0.12	0.11	0.07	0.07	0.07	0.07	0.07	0.08
Cr_2O_3	0.21	0.41	0.45	-	0.28	0.29	0.26	0.27	0.31
TOTAL	99.81	99.42	99.51	99.17	99.96	100.33	100.23	99.70	99.15
TRACE ELEMENT DATA (ppm)									
Sr	151	154	159	-	151	150	151	145	153
Rb	3.8	2.5	1.3	-	2.7	2.3	3.2	2.6	2.7
Y	55	74	73	-	52	48	54	43	52
Zr	238	232	211	-	197	174	204	168	198
Nb	15	19	19	-	15	13	15	13	15
Zn	19	96	31	-	26	33	25	32	31

*Na_2O by atomic absorption

†Soil Breccia

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TABLE 2. COMPOSITION OF APOLLO 17 ROCKS

	BASALTS			NORITIC BRECCIAS							ANORTHOSITIC GABBRO & TROCTOLITE	
	70017,35	70215,56	75075,58	73235,55	73275,30	76315,30M Matrix	76315,30,3 Clast	76315,35 Matrix	76315,52 Clast	77135,5	76315,62 Clast	76535,21
Major Element Data (wt %)												
SiO_2	38.07	38.46	37.64	46.20	46.16	45.64	46.45	46.21	48.57	46.17	45.10	42.88
TiO_2	13.10	12.48	13.45	0.67	1.43	1.50	1.43	1.50	0.32	1.53	0.36	0.05
Al_2O_3	8.79	9.01	8.20	21.28	18.49	17.53	18.18	18.14	17.91	17.83	26.37	20.73
FeO	18.07	19.40	18.78	7.32	9.05	9.53	8.83	8.95	7.66	9.14	5.29	4.99
MnO	0.27	0.29	0.28	0.11	0.13	0.13	0.13	0.12	0.13	0.13	0.07	0.07
MgO	9.81	7.91	9.49	11.05	11.54	12.50	12.34	12.02	13.84	12.39	7.46	19.09
CaO	10.30	10.94	10.29	12.55	11.30	10.97	11.30	11.32	10.36	11.08	15.12	11.41
Na_2O*	0.40	0.42	0.40	0.48	0.67	0.70	0 64	0.60	0.47	0.69	0.47	0.23
K_2O	0.04	0.05	0.05	0.20	0.27	0.26	0.22	0.26	0.15	0.27	0.10	0.03
P_2O_5	0.05	0.10	0.05	0.20	0.26	0.30	0.29	0.29	0.12	0.30	0.06	0.03
S	0.15	0.17	0.16	0.04	0.08	0.08	0.07	0.07	0.00	0.07	0.04	0.00
Cr_2O_3	-	0.39	0.57	-	-	0.19	0.20	0.19	-	0.21	-	0.11
TOTAL	99.05	99.62	99.36	100.10	99.38	99.33	100.08	99.67	99.53	99.81	100.44	99.62
Trace Element Data (ppm)												
Sr	-	123	166	-	-	174	172	177	-	174	-	111
Rb	-	0.9	0.5	-	-	6.7	3.6	6.2	-	6.2	-	0.2
Y	-	69	81	-	-	113	107	111	-	111	-	4.4
Zr	-	185	208	-	-	506	478	522	-	508	-	12
Nb	-	21	21	-	-	33	32	33	-	33	-	1.2
Zn	-	6	5	-	-	3	2	4	-	4	-	1

* Na_2O by atomic absorption

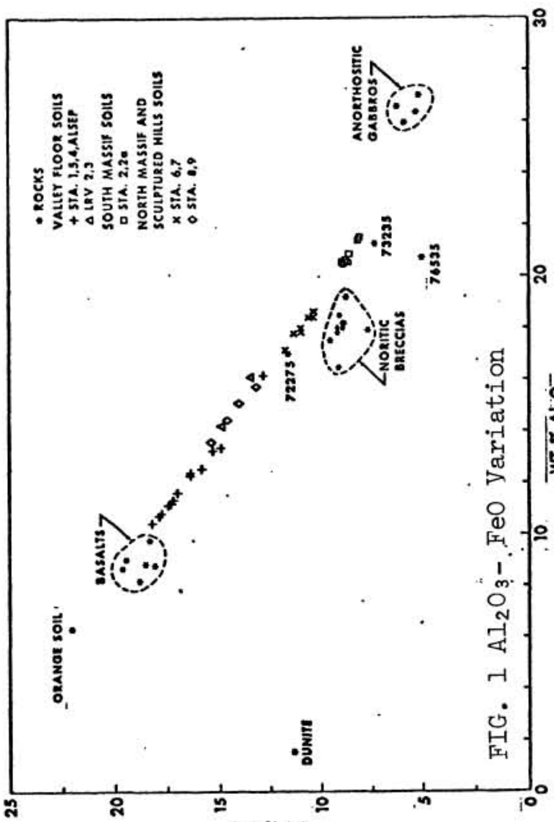

FIG. 1 Al_2O_3 - FeO Variation

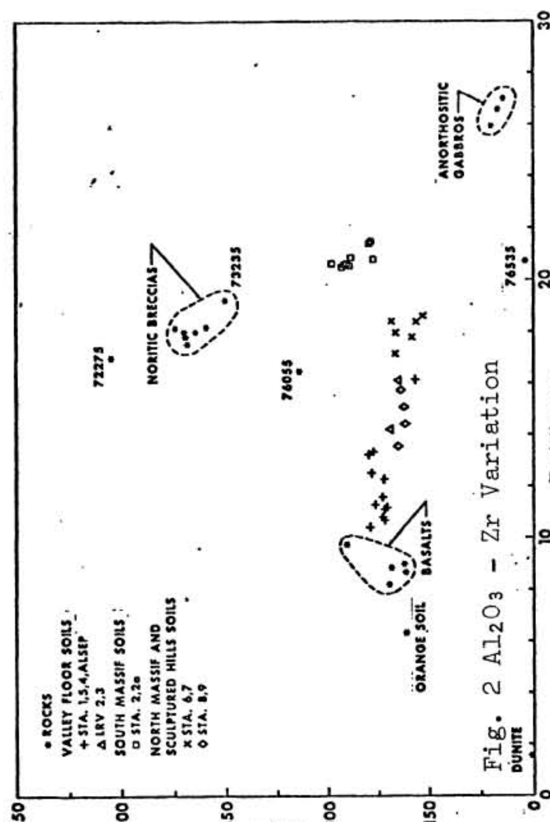

Fig. 2 Al_2O_3 - Zr Variation