COMPOSITIONAL VARIABILITY OF THE APOLLO 15 REGOLITH

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The Apollo 15 soils exhibit considerable compositional variability which can be related to selenographic position within the area sampled. A number of previous authors (e.g. (1),(2),(3),(4),(5)) have discussed various aspects of soil composition at the Apollo 15 landing site, but no unified interpretation of major and trace element data for soil samples from all sampling stations has yet been made. Multiple samples taken at any given sampling station have essentially identical compositions for the elements we analyse (see 15261 & 15271, 15501 & 15511, in Table 1), and we therefore consider individual soil samples as representative of overall soil composition at the stations from which they were collected. We have analysed soils from six stations (Table 1 and (6)) and have taken data for soils from two additional stations from (1). As can be seen from Fig.1 all the Apollo 15 soils contain a significant proportion of Fra Mauro or KREEP type materials (using Zr as an indicator element). Many soils must also contain an ultramafic component such as the Green Glass (7) in order to explain their slightly higher MgO content relative to the Basalts. The plots in Fig.1 also suggest that relatively little Anorthositic Gabbro (e.g. 15418) or Anorthosite is present in most soils.

In order to make a more coherent interpretation of both the major and the trace element data available we have used R-mode factor analysis and compositional mixing models to express soil characteristics. Fig.2 shows clear separation between stations at the Appenine Front (2,6,7) and those on the mare surface, indicating a significant overall chemical difference that was not shown in Fig.1. Fig.2 also illustrates that the relatively high Zr abundances at station 9 and the LM site must be largely due to the presence of a KREEP component, rather than a low-K Fra Mauro component, at these stations.

In the mixing model calculations shown in Table 2 we have included those components which are known to be present in the soils from studies of soil particles and glasses (3),(5). Both low-K Fra Mauro and Anorthositic Gabbro decrease in abundance, with a corresponding increase in the basalt component, as one goes from stations at the Front to those on the Mare. KREEP is not a ubiquitous component in Front soils (it is absent at station 2) which, together with its higher relative abundance at the LM site and stations 6,7 and 9 strongly suggests that it may be derived from the Aristillus or Autolycus ray crossing these stations (3),(5). Neither the abundance of Green Glass, nor the relative proportions of the two mare basalt types appear to vary systematically with position in the area sampled.

References: (1) LSPET (1972), Science,175,363. (2) Schonfeld,E. and Meyer,C.E. (1972), Proc. Lunar Sci. Conf. 3rd.,p.1397-1420. (3) Reid,A.M. et al. (1972), Meteoritics,7,395. (4)Fruchter,J.S. et al. (1973), Proc. Lunar Sci. Conf.4th., p.1227-1237. (5) Carr,M.H. and Meyer,C.E. (1974), Geochim. Cosmochim.Acta,38, 1183. (6) Willis,J.P. et al. (1972), in "The Apollo 15 Samples",p.268. (7) Ridley,W.I. et al. (1973), Phys. Earth Planet. Interiors,7,133.

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TABLE 1. CHEMICAL ANALYSES OF APOLLO 15 SOILS AND BASALTS

MAJOR ELEMENTS (%)

	15071,83 Soil	15081,21 Soil	15085,34 Basalt	15085,39 Basalt	15261,52 Soil	15271,66 Soil	15301,73 Soil	15471,25 Soil	15476,9 Basalt	15501,22 Soil	15511,8 Soil
SiO_2	46.95	46.50	46.61	47.73	46.35	46.62	46.12	46.26	47.84	46.46	46.06
TiO_2	1.60	1.58	2.63	1.96	1.50	1.50	1.18	1.55	1.82	1.78	1.80
Al_2O_3	12.70	13.60	7.13	9.92	16.40	16.57	14.67	13.22	10.02	12.54	12.14
FeO	16.29	15.28	24.38	19.69	12.28	12.14	13.83	15.96	19.79	16.61	16.79
MnO	0.217	0.200	0.297	0.259	0.159	0.157	0.179	0.204	0.261	0.212	0.215
MgO	10.75	10.86	7.90	8.84	10.71	10.66	12.20	11.19	8.35	10.98	10.89
CaO	10.49	10.66	9.68	10.63	11.15	11.24	10.71	10.46	10.74	10.31	10.20
Na_2O	0.33	0.34	0.26	0.33	0.39	0.41	0.35	0.35	0.35	0.36	0.35
K_2O	0.092	0.130	0.059	0.035	0.190	0.196	0.134	0.11	0.043	0.158	0.153
P_2O_5	0.130	0.157	0.107	0.064	0.219	0.222	0.158	0.136	0.081	0.184	0.193
Cr_2O_3	0.465	0.441	0.613	0.521	0.343	0.344	0.375	0.472	0.467	0.458	0.463
S	0.070	0.079	0.137	0.068	0.084	0.084	0.068	0.072	0.067	0.080	0.080
O≡S	0.03	0.04	0.07	0.03	0.04	0.04	0.03	0.04	0.03	0.04	0.04
Total	100.05	99.79	99.73	100.01	99.73	100.10	99.94	99.95	99.80	100.09	99.29

TRACE ELEMENTS (ppm)

	15071,83 Soil	15081,21 Soil	15085,34 Basalt	15085,39 Basalt	15261,52 Soil	15271,66 Soil	15301,73 Soil	15471,25 Soil	15476,9 Basalt	15501,22 Soil	15511,8 Soil
Nb		16.3	10.0	6.6	24.8	24.6	17.3	14.0	5.6	19.5	19.9
Zr		273	156	92	382	390	268	228	110	312	319
Y		60.8	44.0	28.6	80.7	81.5	58.9	51.4	31.4	67.9	68.7
Sr		120	120	112	136	137	110	115	115	115	115
Rb		4.2	1.8	<1.5	6.0	5.9	4.2	3.2	1.5	4.8	4.9
Zn		33	<1.5	17	26	20	29	12	<1.5	13	16
Cu		36	9	29	11	4	4	5	4	3	10
Ni		209	20	23	250	231	234	179	15	224	197
Co		46	43	41	42	40	51	46	38	50	47
V		116	172	165	81	80	97	128	160	129	131
Ba		186	111	62	261	266	188	163	74	218	212

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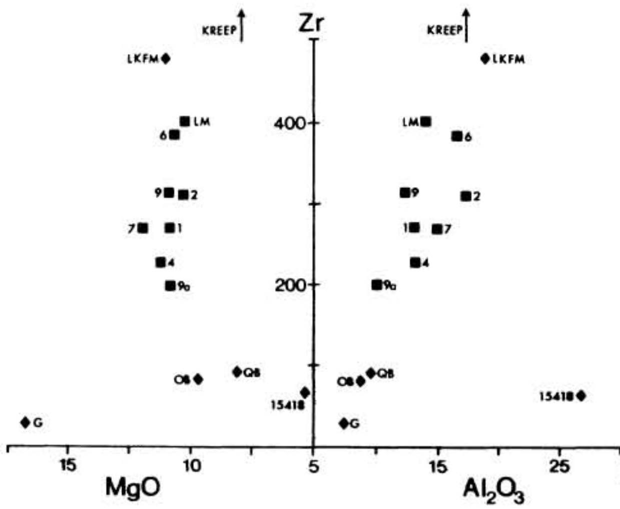

Fig.1 Plot of %MgO and %Al_2O_3 against Zr (ppm) for Apollo 15 soils and major rock types.
■ soil samples with station numbers
◆ rock types, coded as follows:-

LKFM = low-K Fra Mauro
OB = Olivine normative Basalt
QB = Quartz normative Basalt
G = Green Glass
15418 = Anorthositic Gabbro (15418)

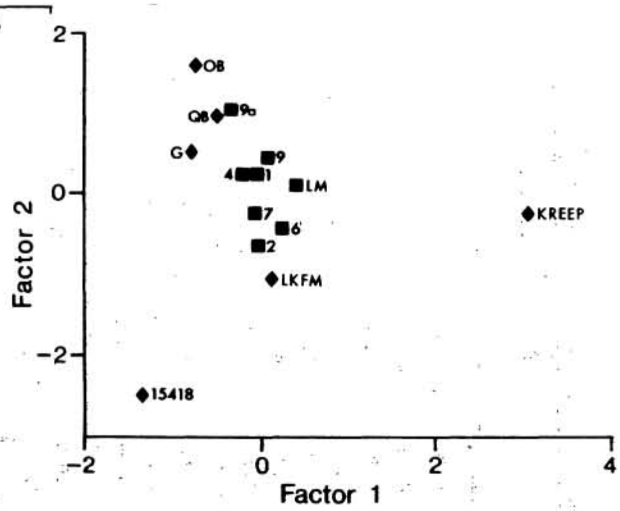

Fig.2 Plot of factor scores on the first two factors obtained by R-mode factor analysis of soil and rock data for 20 elements (major elements + Nb, Zr, Y, Sr, Rb, Ni, Co, V, Ba). 80% of the total variance is accounted for by the first two factors

Symbols and codes are the same as in Fig.1.

TABLE 2. CALCULATED MIXING MODELS FOR APOLLO 15 SOILS

	Front Sta. 6	Spur Sta. 7	St. George Sta. 2	Elbow Sta. 1	Dune Sta. 4	LM	Scarp Sta. 9	Rille Sta. 9a
Quartz⁺ Basalt	5.7	16.5	0.8	30.6	20.5	5.7	18.3	0.6
Olivine⁺ Basalt	18.3	5.6	19.0	20.0	27.4	34.7	32.4	68.3
15418	11.6	12.4	16.4	1.5	9.5	-	-	-
Low-K Fra Mauro	48.4	28.9	59.3	35.7	21.5	46.4	26.5	19.1
Green Glass	5.3	29.0	5.6	9.3	15.3	-	11.2	8.0
KREEP	9.9	8.0	-	3.0	5.7	11.5	10.7	3.5
CC-1 Meteorite	1.3	1.2	1.4	1.1	0.9	1.8	1.2	0.9
Total Basalt	24.0	22.1	19.8	50.6	47.9	40.4	50.7	68.9

⁺Quartz and Olivine normative.

Data for soil compositions are from Table 1, LSPET (1), and published data as collected in the Lunar Sample Database.

Data for mixing components are from (2) and the Lunar Sample Database.