SOURCE REGION CONSTRAINTS FOR LUNAR BASALT TYPES INFERRED FROM TRACE ELEMENT CHEMISTRY. A.R.Duncan,M.K.Sher,Y.C. Abraham,A.J.Erlank,J.P.Willis and L.H.Ahrens. Geochemistry Dept., University of Cape Town, Rondebosch, South Africa, 7700.

We have previously commented (1,2,3) on inter-element relation ships between the"incompatible" elements that we believe to be of particular importance in considering the petrogenesis of lunar lavas.New analytical data for 10 mare basalts are given in Table 1 We have now obtained major and trace element data for 24 mare basalt samples (including representatives from all 10 compositional groups defined by Rhodes et al.,4)thus providing us with an adequate dataset for assessing constraints on lunar basalt source regions.

The elements K,Ba,Zr,Nb,Y and Ti whose ratios are depicted in Fig.1 are essentially excluded from major lunar mineral phases other than ilmenite or armalcolite.Thus,with the exception of the high-Ti basalts there is no real possibility of these ratios being significantly modified by crystal fractionation processes at or near the lunar surface.Duncan et al.(3)also concluded that the effect of shallow fractionation of ilmenite or armalcolite in the high-Ti A-17 basalts could not account for observed inter-element ratios.This suite of elements is thus particularly well suited to the comparison of source region compositions for all lunar basalts. Conclusions drawn from Fig.1 are as follows:- (a)Inter-element ratios for A-12 and A-15 basalts fall close to "average" lunar crustal ratios.(b) A-11 low-K basalts show the same significant perturbations of many ratios which have been interpreted for the A-17 basalts (3) as indicative of a two-stage origin involving partial melting of a pre-existing ilmenite-rich cumulate.However differences in the Zr/Nb ratio suggest that the proportions of cumulate phases in the two source regions are somewhat different. (c) A-11 high-K basalts do not show the same ratio perturbations as other high-Ti basalts and are therefore most unlikely to be derived from the same source region as Shih et al.(5)have suggested. The data are compatible with derivation of A-11 high-K basalts as a low-volume partial melt from the same source region(s) that produced the A-12 and A-15 basalts (6).(d) KREEP-rich materials, and to a lesser degree the A-14 basalt (14053),show ratio perturbations that are complementary to those shown by low-K,high-Ti basalts (e.g.Ba/Zr,Ba/Y). KREEP-rich materials also show an extraordinarily low Ti/Zr ratio. We infer that the high-Ti cumulates forming the source region for some of the high-Ti basalts are complementary to the source region for KREEP.Significant separation of ilmenite from a magma which subsequently crystallised to form the KREEP source region could also explain the high Mg/Fe ratio of KREEP.

The ratio variations shown in Fig.1 and their implications

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for the compositional inter-relationships of mare basalt source regions are compatible with the Taylor-Jakěs model of lunar evolution (7).

References: (1)Willis et al.(1972),The Apollo 15 Lunar Samples, 268. (2)Duncan et al.(1973),Proc. 4th Lunar Sc.Conf.,1097. (3) Duncan et al.(1974),Proc. 5th Lunar Sci.Conf.,1147.(4) Rhodes et al.(1975),Proc.Mare Basalt Conf.,135. (5) Shih et al.(1975),Proc. 6th Lunar Sci.Conf.,1255. (6) Ringwood and Green (1974), Lunar Science V,636. (7) Taylor and Jakěs (1974), Proc. 5th Lunar Sci. Conf., 1287.

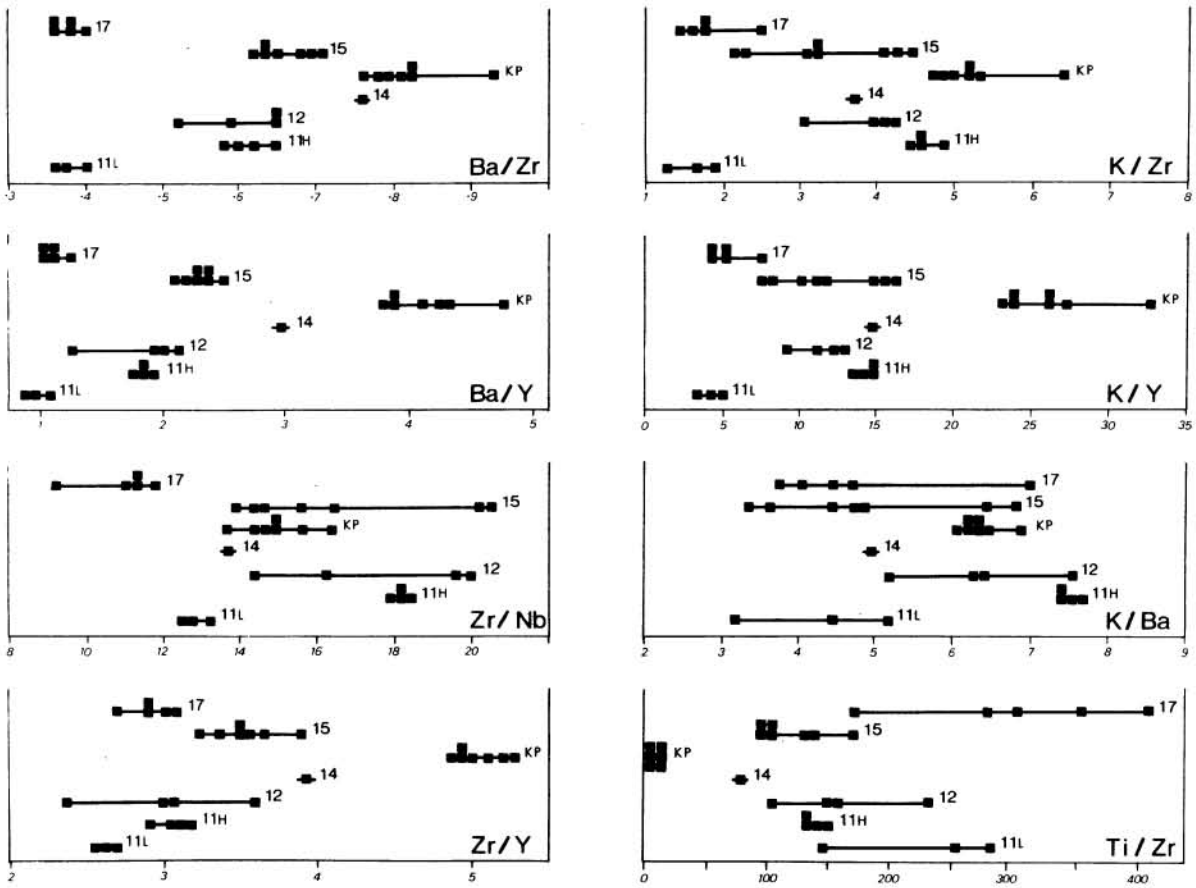

Fig. 1 Inter-element ratios in Lunar basalts. Numbers designate missions. 11L = A-11 low-K, 11H = A-11 high-K, KP = A-14 KREEP-rich breccias. All data from this laboratory.

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TABLE 1. ANALYSES OF APOLLO 11, 15, AND 17 BASALTS

MAJOR ELEMENTS (%)

	10020,179	10050,142	10057,82	10058,142	10069,20/69	10072,125	15485,17	15499,72	70135,41	75035,19
SiO_2	39.50	39.70	40.67	41.78	40.32	39.81	47.39	47.93	37.68	42.31
TiO_2	10.62	11.16	11.35	9.07	11.59	12.27	1.77	1.73	13.83	8.95
Al_2O_3	9.57	10.21	7.99	10.44	7.90	7.66	9.14	8.88	7.53	10.30
FeO	19.15	18.57	19.40	18.68	19.61	19.41	19.82	19.84	19.74	18.57
MnO	0.263	0.262	0.233	0.266	0.236	0.233	0.268	0.270	0.260	0.262
MgO	8.12	7.95	7.65	5.96	7.77	8.01	9.48	9.93	10.00	6.28
CaO	11.40	11.91	10.75	12.34	10.70	10.40	10.21	10.23	9.80	12.15
Na_2O	0.41	0.44	0.57	0.48	0.59	0.55	0.28	0.29	0.40	0.53
K_2O	0.034	0.052	0.287	0.085	0.286	0.269	0.031	0.028	0.051	0.061
P_2O_5	0.131	0.094	0.197	0.132	0.200	0.192	0.084	0.083	0.077	0.084
Cr_2O_3	0.396	0.363	0.347	0.205	0.364	0.388	0.575	0.617	0.636	0.207
S	0.176	0.143	0.260	0.190	0.259	0.254	0.064	0.066	0.191	0.219
O≡S	0.088	0.072	0.130	0.095	0.130	0.127	0.032	0.033	0.096	0.110
Total	99.68	100.78	99.57	99.53	99.70	99.32	99.08	99.86	100.10	99.81

TRACE ELEMENTS (ppm)

Nb	17.6	21.0	28.7	28.4	29.0	27.8	5.5	5.4	26.3	29.1
Zr	224	265	517	376	522	504	113	109	299	319
Y	84	103	170	147	169	161	32.2	31.1	103	118
Sr	142	172	166	208	166	160	104	100	165	223
Rb	1.7	<1.4	6.5	1.5	6.8	6.0	<1.4	1.4	<1.4	1.5
Zn	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Cu	<2	<2	<2	<2	<2	<2	4	3	<2	<2
Ni	<2	<2	<2	<2	3	3	22	19	<2	<2
Co	18	14	25	12	27	25	42	44	20	13
V	81	88	47	46	52	62	177	189	127	19
Ba	89	98	319	136	315	294	71	69	113	126

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