

CHEMISTRY OF THE PRIMITIVE MANTLE, Don L. Anderson, Seismological Laboratory, California Institute of Technology, Pasadena, California 91125.

The composition of primitive mantle is estimated by a mass balance approach that does not make *a priori* assignments of basalt: peridotite ratios or LIL-contents of these components. Primitive mantle is treated as a five component system: crust, ultramafic rock (UMR), LIL-depleted basalt (MORB), orthopyroxene-rich rock (OPX) and an LIL-enriched component, Q. The Q component of mantle nodules and enriched basalts is similar, in LIL ratios, to kimberlite. Mantle magmas, in fact, can be modelled as mixtures of MORB and kimberlite. Kimberlite is similar in composition to KREEP except it has been in equilibrium with eclogite rather than plagioclase. In a large body, such as the Earth, a buried eclogite cumulate is the equivalent of the anorthositic crust on a small body such as the Moon. The components are combined to give chondritic ratios of the oxyphile refractory elements. In this way, one can estimate the volatile and siderophile content of the mantle. The calculated mixing ratios are UMR (32.6%), OPX (59.8%), MORB (6.7%), CRUST (0.555%) and Q (0.11%). The primitive mantle has K = 152 ppm, U = 0.020 ppm, Th = 0.078 ppm, K/U = 7724 and Rb/Sr = 0.025. The ratios are significantly less than previous estimates but, in general, there is good agreement with the cosmochemical model of Morgan and Anders (M & A, Ref. 1).

Table 1 gives the composition of the five components and the resulting primitive mantle (mantle + crust). The last two columns are primitive mantle normalized to 1.48 times the M & A values and to CI chondrites. As intermediate steps we have also estimated the composition of the picritic parent to MORB, the undepleted source region (UDS) and the upper and lower mantle. Table 2 gives critical element ratios for the various regions.

#### References

Morgan, J. W. and Anders, E., Proc. Natl. Acad. Sci. 77, 6973, 1980.

TABLE 2 : CRITICAL RATIOS

	CI	MORGAN ANDERS	UDS	UPPER MANTLE	LOWER MANTLE	MANTLE +CRUST	REL. TO M&A
RB/SR	.302	.039	.03	.028	.01	.024	.61
K/U	63571	10000	11429	8356	3552	7693	.77
K/NA	.11	.11	.10	.08	.04	.07	.69
TH/U	3.64	4.01	4.08	3.94	3.62	3.90	.97
MG/SI	.90	.92	.43	.84	.95	.92	1.00
CA/AL	1.08	1.09	.99	1.07	1.12	1.09	1.00
SM/ND	.325	.33	.315	.319	.318	.319	.97
LA/YB	1.48	1.66	2.18	1.85	1.43	1.77	1.07
YB/SC	.03	.02	.05	.04	.01	.02	.87
CE/ND	1.35	1.46	1.37	1.35	1.49	1.37	.94
EU/ND	.12	.11	.12	.13	.13	.13	1.10
YB/LU	6.53	5.07	6.26	6.10	4.77	5.00	.99
SR/BA	3.17	2.90	3.17	3.14	2.99	3.11	1.07
U/LA	.038	.036	.032	.035	.032	.034	.97
U/PB	.0039	.20	.20	.17	.13	.16	.82

Anderson, D. L.

TABLE 1 : CHEMICAL COMPOSITION OF MANTLE COMPONENTS

	MORB	UMR	KIMB	CRUST	PICR	OPX	UDS	MANTLE		MANTLE +CRUST	NORMALIZED M&A	C1
								UPPER	LOWER			
LI	9	1.5	25	10	7.13	1.5	7.48	3.49	1.50	2.09	.76	.87
F	289	7	1900	625	219		259	91	1	28	1.39	.31
NA	1.59	.24	.20	2.60	1.25		1.32	.60	.04	.2	1.10	.26
MG	5.89	23.1	16	2.11	10.19	21	9.80	18.67	21.31	20.52	1.00	1.46
AL	8.48	2.00	1.89	9.50	6.86	1.21	6.95	3.65	1.33	2.02	.97	1.57
SI	23.2	21.8	14.7	27.1	22.85	22.6	23	22.2	22.48	22.48	1.00	1.44
P	390	61	3880	1050	308		387	170	9	57	.02	.05
S	600	8	2000	260	452		458	158	1	48	.002	.003
CL	23	1	300	1074	17		79	27	.07	8	.27	.01
K	660	35	17600	12500	504	10	1356	475	14	151	.76	.17
CA	8.48	2.40	7.04	5.36	6.96	1.32	6.87	3.89	1.48	2.20	.96	1.58
SC	37.3	17	15	30	32	12	32	22	13	15	1.09	1.99
TI	5500	1000	11800	4800	4375	800	4477	2159	830	1225	1.01	1.86
V	210	77	120	175	177	60	176	110	63	77	.63	1.24
CR	441	2500	1100	55	956	2500	907	1969	2500	2342	.38	.67
MN	1000	1010	1160	1100	1063	1010	1066	1029	1010	1016	.91	.38
FE	6.52	6.08	7.16	5.83	6.41	6.08	6.39	6.18	6.08	6.11	.13	.22
CO	53	105	77	25	66	105	64	91	105	101	.08	.13
NI	152	2110	1050	20	642	2110	611	1610	2110	1961	.07	.13
CU	77	15	80	60	62	30	62	31	28	29	.62	.18
ZN	74	60	80	52	71	20	70	63	26	37	.34	.08
GA	10	4	10	10	14	3	15	7	3	4	.94	.31
GE	1.5	1.1	.5	1.5	1.4	1.1	1.4	1.2	1.1	1.13	.10	.02
SE	.101	.02	.15	.05	.14	.01	.14	.06	.01	.02	.002	.001
RB	.36	.12	.65	.42	.30	.04	3.32	1.19	.05	.39	.57	.11
SR	110	8.9	707	400	85	4.5	109	42	5	16.2	.94	1.42
Y	23	4.6	22	22	18	.02	19	9	.7	3.3	.84	1.57
ZR	70	11	250	100	55	5.5	60	27	6	13	1.18	2.20
NB	3.3	.9	110	11	2.7	.45	4.3	2	.5	.97	1.31	2.15
AG	.019	.003		.07	.01	.001	.02	.01	.001	.003	.05	.01
CD	.129	.026	.07	.2	.10	.01	.11	.05	.01	.02	1.03	.03
IN	.072	.002	.1	.1	.05	0	.06	.02	0	.01	2.13	.05
SN	1.36	.52	15	2	1.2	.52	1.34	.79	.52	.60	1.04	.24
CS	.007	.006	2.3	1.7	.01	.002	.13	.05	.003	.02	.68	.05
BA	5	3	1000	350	4.5	2	34	13	1.7	5	.88	1.45
LA	1.38	.57	150	19	1.2	.04	3.8	1.63	.12	.57	1.02	1.56
CE	5.2	1.71	200	38	4.33	.096	8.28	3.90	.34	1.40	.93	1.46
ND	5.61	1.31	85	16	4.54	.036	6.03	2.88	.23	1.02	1.00	1.43
SM	2.08	.43	13	3.7	1.67	.009	1.90	.92	.07	.32	.96	1.40
EU	.81	.19	3	1.1	.66	.002	.70	.36	.03	.13	1.10	1.48
TB	.52	.14	1	.64	.43	.002	.44	.241	.02	.09	1.09	1.51
YB	2.11	.46	1.2	2.2	1.70	.02	1.72	.88	.09	.32	.95	1.30
LU	.34	.079	.16	.3	.27	.007	.27	.14	.02	.06	.96	1.46
HF	1.4	.34	7	3	1.14	.17	1.30	.66	.20	.33	.98	1.96
TA	.1	.03	9	2	.08		.28	.11	.00	.04	1.10	1.24
RE	1.1	.23	1	1	.08	.00	.09	.45	.10	.21	.0023	.003
OS	.04	3.1	5	5	.01	3.1	1.08	2.43	3.10	2.90	.0022	.003
IR	.001	3.2	7	1	.00	3.2	.08	2.43	3.20	2.97	.0024	.003
AU	.34	.49	4	4	.30	.49	.62	.53	.49	.50	.0013	.002
TL	.01	.02	.22	.25	.01		.03	.02	.00	.01	1.28	.03
PB	.08	.2	10	7	.11		.60	.33	.03	.12	1.19	.03
BI	.007	.005	.03	.2	.01		.02	.01	.00	.003	.75	.02
TH	.035	.094	16	4.8	.05		.48	.224	.014	.077	.96	1.58
U	.014	.026	3.1	1.25	.02		.12	.057	.004	.02	.98	1.40