CHEMISTRY AND ASSIGNED ORIGIN OF SOME ULTRAMAFIC NODULES FROM KIMBERLITE

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Table 1 contains new analyses of sixteen peridotites or pyroxenites from S. African kimberlites, grouped according to their postulated origin. Other analyses considered to belong to some of these groups are identified in the table.

A weight per cent plot of other oxides v MgO (after averaging and scaling to 100% water and CO_2 free) is shown in fig 1 (total iron is plotted as FeO). In fig 1 H = average harzburgite, GH = average garnet harzburgite, GLIK = averages of garnet lherzolite (ex table 1 and from Carswell and Dawson 1970) excluding MF most fertile looking garnet lherzolite 1032 (table 1) from Matsoku. A poor linear correlation between MgO and other oxides through these rocks is indicated. Dashed field P includes some possible primary picritic magmas, K, K', S being komatiite and Sandspruit ultramafic lavas (Viljoen and Viljoen 1969a); and B = Baffin Island picrite (Clarke 1970). M = a 'fertile' garnet-lherzolite nodule from Hawaiian basalt (Jackson and Wright 1970). Compositions in field P include known liquid magmas; while B is known to approximate to initial partial melt of garnet lherzolite at 30 kb, the best liquid extract to yield H, GH from GLIK appears to be komatiite, K. MF and M have chemistry of possible liquid extracts. If K, MF, M do represent liquids in equilibrium with olivine and orthopyroxene, the pressure of their derivation must have been much greater than 30 kb (they are high in olivine in the CIPW norm). Field E contains compositions of possible early eclogite extracts during high pressure fractionation (selected from O'Hara et al 1973, fig 2). Field T contains the compositions of the parental magmas of Hawaiian tholeiite suites (Macdonald and Katsura 1964). For each major oxide plot, the composition ranges of olivine and pure Mg-Fe orthopyroxene with Mg/Mg+Fe 100-85 are indicated.

Figure 2 illustrates for one pair of oxides how fig 1 might be used to play the currently popular petrogenetic guessing games, using real rock compositions, to obtain 15% primary magma, Lp, from a garnet-lherzolite source mantle, then to fractionate 50% early eclogite (mean composition E) from it, yielding residual liquid L which might still undergo 38.5% extraction of olivine (average $Fo_{87.5}$) in order to yield an eruptive parental tholeiite magma L_T (maximum enrichment factor for incompatible elements relative to source is ~20). Fe/Mg distribution between liquids and crystals at each step conform to known or plausible equilibrium relationships. (The games may be played for the other oxides as well, and in many other ways; anyone may join in, but subtract points if you have to use rock types not actually found in nature, or find the fit less good when the same calculation is made for the other oxides; stentorian Boanerges have a head start).

None of the commonly erupted magmas seen at the earth's surface can be the primary magma generated during the partial melting events which created the residual mantle types found in kimberlite. Komatiite and related ultramafic lavas, which appear to have been a relatively widespread lava type 3.45×10^9 years ago, might be the complementary liquid extracted when the principal chemical variation between the peridotites was created, constituting evidence for a widespread major thermal, tectonic and chemical upheaval in the upper mantle at that time. This interpretation

Table 1. Analyses of garnetiferous ultrabasic rock from kimberlite

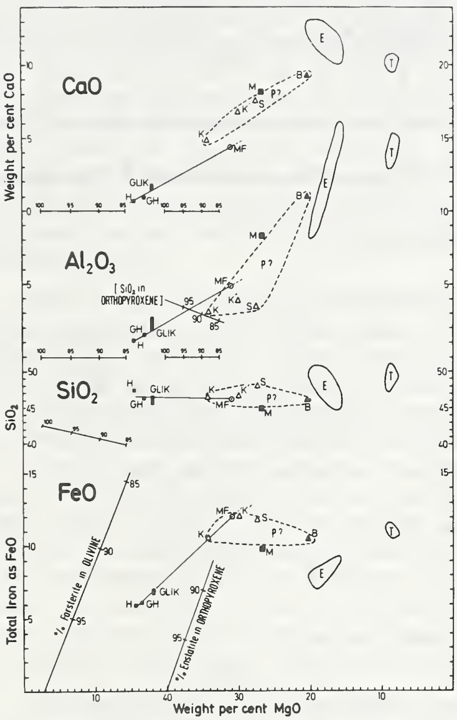
Type	No.	SiO_2	TiO_2	Al_2O_3	Cr_2O_3	Fe_2O_3	FeO	MnO	NiO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O+	CO_2	Class (O'Hara 1973) I(i) or V(i)
1. Gnt-lherzolite[1]	1032	45.52	.15	4.83	.58	1.61	10.40	.18	.22	30.34	4.26	.34	.04	.02	1.58		I(i)
2. " [2]	11093	45.19	.054	1.52	.39	0.92	4.74	.100	.26	41.8	1.04	.18	.16	.04	3.26	.10	
3. Gnt-harzburgite[3]	A6-10594	43.20	.02	3.13	.37	2.56	3.46	.10	.24	41.98	0.97	.10	.05	.04	3.64		
4. "	11083	45.37	.012	1.29	.42	0.84	4.76	.101	.27	42.5	0.65	.12	.06	.04	3.00	.04	II(i)
5. "	A5-10593	45.49	.080	1.01	.46	1.23	5.02	.106	.29	41.2	0.95	.14	.06	.06	3.13	.14	
6. Harzburgite[3]	A11-10586	44.36	.010	1.14	.34	0.62	5.35	.099	.30	44.3	0.53	.08	.06	.08	2.09	.15	
7. " [3]	A13-10587	44.46	.013	0.64	.34	0.98	5.10	.102	.30	43.8	0.67	.11	.06	.04	2.90	.18	
8. " [3]	A14-10588	46.58	.014	1.01	.45	1.20	4.37	.101	.26	40.6	0.77	.20	.20	.07	3.70	.26	III
9. "	11082	45.38	.007	1.18	.36	0.98	4.70	.094	.27	41.9	0.76	.10	.08	.02	3.76	.16	
10. "	11091	45.70	.024	1.19	.38	0.98	4.78	.097	.27	41.6	0.89	.11	.08	.04	2.97	.27	
11. Lherzolite[3]	A15-10589	44.77	.55	0.84	.14	1.70	3.99	.10	.27	40.03	1.76	.12	.94	nil	4.07		II(ii)
12. " [3]	A10-10591	45.23	.06	0.57	.35	2.47	3.54	.10	.26	40.70	2.59	.29	.09	.029	3.35		or
13. "	11089	41.61	.127	0.51	.31	1.42	4.88	.082	.27	44.5	1.39	.21	.14	.03	3.97	.20	II(iv)
14. "	1033	45.14	.06	0.48	.14	0.90	7.18	.11	.30	41.78	2.54	.12	.10	.05	1.17		
15. Pyroxenite[3]	A17-10597	51.82	.02	2.57	.68	1.84	2.94	.14	.093	25.90	11.04	.83	.12	.043	1.66		
16. " [1]	1031	51.84	.12	4.18	.44	0.89	6.31	.18	.12	27.00	6.66	.62	.05	.02	0.77		VII(i)
17. " [5]	1042	51.61	.11	4.24	.57	1.13	6.17	.18	.12	27.65	6.61	.63	.06	.01	0.94		

Notes (1) Garnet and two pyroxenes analysed (O'Hara et al 1973). (2) Average used in constructing fig 1 includes analyses of E11, E3 (Nixon et al 1963) A3-10596 (Holmes 1936) and KA 64.16 (Ito and Kennedy 1967). (3) Mineral data in O'Hara and Mercy (1963), Mercy and O'Hara (1965). (4) Average used in fig 1 includes A1-10585 (Holmes 1936). (5) 1042 is separate split of same rock as 1032.

supports hypothesis B of Viljoen and Viljoen (1969b).

So far as major element concentrations are concerned, it is possible to choose real rock compositions which permit a partial melting product of garnet-lherzolite to undergo substantial eclogite fractionation, followed by substantial olivine fractionation, in order to yield a residual magma similar to the parental magmas of oceanic island provinces. (Minor and trace elements have not been treated because of contamination problems in the source and residual peridotites).

Eclogite fractionation would have relatively little effect upon the major element composition of primary magmas similar to Baffin Island picrites (at say 30 kb). At higher pressures eclogite extraction will have increasingly dramatic effects, especially upon komatiite-like primary magmas, driving their residual liquids rapidly towards MgO, FeO-rich and CaO, Al_2O_3-poor compositions.



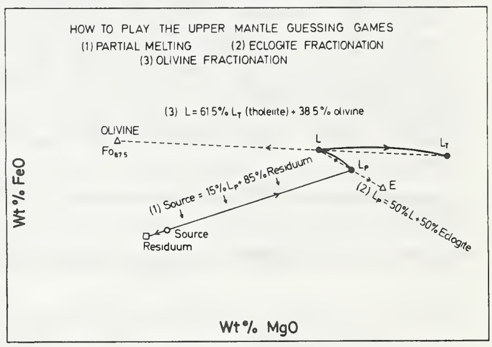


Fig 1. Wt% plot (volatile free) of oxides v MgO. See text.

Fig 2. Example of interpretation of fig 1. See text.

Reasons for rejecting the hypothesis that peridotites like MF represent the true source mantle include (i) scarcity among nodule suites, (ii) predicted relatively sow seismic velocity due to higher Fe/Mg ratio. If, however, material of this type were supposed to exist as source mantle at greater depths than commonly sampled by kimberlite ascending 'plumes' could apparently go some way towards explaining the generation of parental tholeiite as primary magmas in modern volcanic provinces. However, the FeO v MgO balance shown in fig 1 indicates that the common peridotite nodules in kimberlite (or basalt for that matter) could not possibly be residua from such a partial melting process (T, MF and GLIK are <u>not</u> colinear). The hypothesis is in any case unsatisfactory because the tholeiite magmas erupted over alleged mantle plumes in Hawaii and Iceland have the distinctive compositions, temperatures and phenocryst assemblages associated with liquids which have undergone fractional crystallization at low pressures (Jamieson 1970, O'Hara 1965, 1973b).

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