PARAGENESES OF ULTRAMAFIC NODULES IN BASALTS CONTRASTED WITH THOSE OF NODULES IN KIMBERLITES

M.J. O'Hara, Grant Institute of Geology, University of Edinburgh.

The average composition of ultrabasic nodules in basalts differs slightly but significantly from those of peridotite nodules in kimberlite, the former having persistently higher olivine/orthopyroxene ratios (fig 1) and higher Fe/Mg ratios (fig 2). Nodules in basalt persistently have higher diopside/enstatite ratios also (O'Hara 1970).

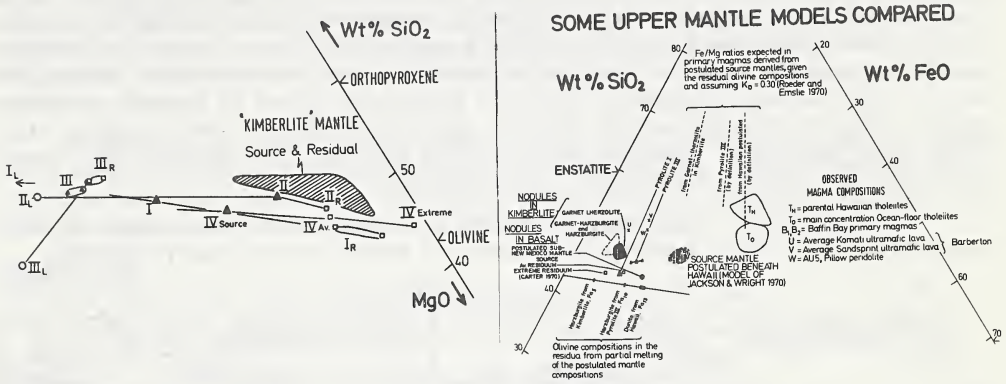

Fig 1. Diopside projection into $CaOAl_2O_3$-MgO-SiO_2 (see O'Hara 1968, Jamieson 1970a for method) showing nodules from kimberlite (shaded field) in relation to nodules from basalt in Hawaii (Jackson and Wright 1970; I, II, III=<u>their proposed</u> source mantle; I_R, II_R, III_R=actual nodules, interpreted as residuals of partial melting; I_L, II_L, III_L=<u>their</u> proposed primary magmas) and New Mexico (Carter 1970; IV source=<u>his</u> putative source mantle, IV_{av}, $IV_{extreme}$ = <u>his</u> putative average and extreme residual mantle).

Fig 2. MgO-FeO-SiO_2 projection (see Ford <u>et al</u> 1972, fig 7) of same data as in fig 1 comparing various nodule compositions from basalt and kimberlite with other upper mantle models and possible or proposed magmas related thereto.

The mineral assemblage of nodules in kimberlites also indicates higher pressures of equilibration (O'Hara 1967, O'Hara <u>et al</u> 1971) than does that of nodules in basalt, as well as generally lower temperatures - briefly, nodules from kimberlite appear to have equilibrated at subsolidus temperatures close to those of plausible sub-continental geotherms in the 20-60 kb range whereas nodules in basalt appear to have equilibrated at near solidus temperatures in the less than 25 kb range. The chemical differences prove that the nodules in basalt are not merely kimberlite nodules in a different mineral facies, and prove that they cannot be partial melt residua from kimberlite nodules, NOR VICE VERSA (see geometry of figs 1, 2 and in O'Hara 1970).

If nodules in kimberlite sample upper mantle with little alteration, what then do nodules in basalt represent?

Peridotite nodules from basalts tend to show positive correlation between high Al_2O_3 contents in spinel and pyroxene, high mutual solubility

in the pyroxenes (as judged say by the Ca/Ca+Mg+Fe in the coexisting pyroxenes), and low Mg/Mg+Fe ratios in the minerals. (O'Hara and Mercy 1963, Frechen 1963).

Fig 3A illustrates the solidus, and temperature interval of coexistence of olivine (ol), clinopyroxene (cpx), orthopyroxene (opx), spinel (sp) and liquid (lq) just above the solidus of a natural spinel lherzolite (pressure range c 10-20 kb). Within the solidus to spinel-out interval, the Cr/Al ratio in the diminishing amount of spinel increases (because Al is preferentially taken by the liquid). Fig 3B illustrates the variation in Al_2O_3 substitution in the pyroxene with pressure and temperature within and on either side of this interval. Above the solidus, Al_2O_3 substitution decreases sharply with rising temperature due to formation of more and more Al-rich liquid. Fig 3C illustrates the rising mutual solubility of the coexisting pyroxenes, which is little affected by change of pressure. Fig 3D illustrates the way in which Mg/Mg+Fe of the minerals will rise from some near constant level in the solidus once melting has begun (because the liquid formed has low Mg/Mg+Fe).

In each figure the heavy line X-Y illustrates the only type of P-T variation which will produce the observed mineralogical correlations.

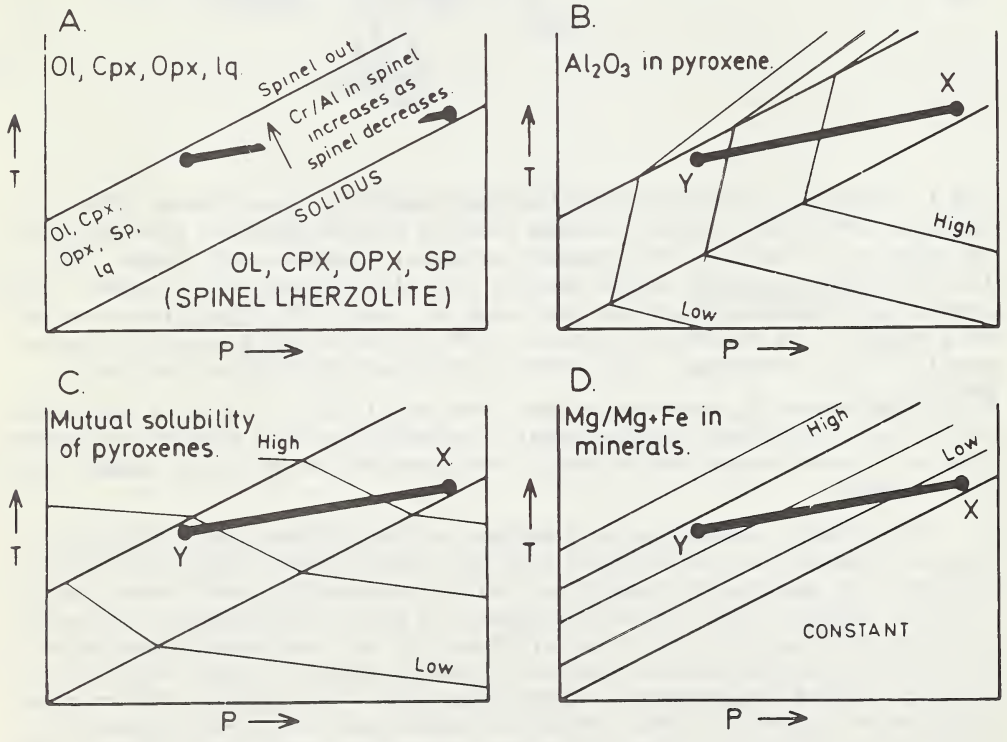

Fig 3. Mineral parageneses in spinel-lherzolite near the solidus. Explanation in the text.

X-Y cannot represent parageneses in an isobaric partial melting sequence. X-Y represents a possible adiabatic decompression path for an ascending basic magma or an ascending peridotite diapir. Because the nodules in question are carried by a basic magma which has manifestly

ascended along such a path and because the existence of peridotite diapirs and mantle plumes lacks any direct observational confirmation, the origin of mineral parageneses in these nodules is ascribed to precipitation on the side walls of a conduit through which basic magma was ascending, followed by break-up of the skin and incorporation in the magma during more rapid or violent eruption. Under these conditions polybaric fractional crystallization occurs and high olivine/orthopyroxene and high clinopyroxene/orthopyroxene ratios are expected in the precipitates (O'Hara 1968, Jamieson 1970b).

Nodules in kimberlite, on the other hand, show the positive correlations of Mg/Mg+Fe with increased Cr/Al ratio and depletion of diopside component which is expected to be created in isobaric partial melting processes and these nodules are more acceptable as models of upper mantle composition.

Whatever the choice of interpretation, the chemical and mineralogical differences between peridotite nodules in basalt and kimberlite are real and preclude the bracketing of these two rock types together without due consideration of the reasons for those differences.

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