LHERZOLITE-BEARING LAVAS AND THE NATURE OF THE UPPER MANTLE BENEATH BRITISH COLUMBIA, CANADA

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Quaternary volcanic activity has produced scattered cinder cones and lava flows between the Snake River Plain, U.S.A. and the British Columbia-Yukon border; a region 2000 km long and 500 km wide (Fig. 1). The rock types are alkali olivine basalts, basanites, trachybasalts, ankaramites , nephelinites and iron-rich lavas lacking pyroxene. The basalts and trachybasalts are strikingly similar in chemistry to rocks from the mid-Atlantic islands (Fig. 2). Associated with the lavas are xenoliths of lherzolite and gabbro and xenocrysts of plagioclase, olivine, and augite. The lherzolites are confined to the basalts, basanites, and nephelinites, indicating that these rocks represent melts which have come from the mantle with little or no modification.

Geophysical data provide an estimate of 30 to 50 km for the crustal thickness beneath the region (Fig. 1) with the low velocity zone near the Moho. These data indicate a minimum pressure of 15 to 25 Kb in the source region of the magmas.

The lherzolite xenoliths are remarkably uniform in mode, mineral chemistry (e.g. Fo 90 - Fo 92; see also Fig. 3) and texture across the entire region. In contrast the mantle-derived lavas show a range in chemistry which is reflected in the diversity of rock types (Fig. 2 and 4). One interpretation of these data is that the lherzolite xenoliths represent samples from a uniform layer or lid to the mantle whereas the lavas represent melts from the slightly deeper low velocity zone; the diversity in composition of the lavas being the result of either different degrees of partial melting of a uniform source or the result of melting of source materials of different compositions.

Given a source of uniform composition (e.g. pyrolite) the maximum amount of partial melting can be calculated (Fig. 5). The residua from these postulated melting episodes can then be recalculated as equilibrium lherzolite mineral assemblages. Finally, the P-T conditions for equilibrium between melt and residual mineral assemblage can be calculated. With pyrolite as the postulated source material, the results of the calculations are: 1) Maximum amounts of partial melting range between 4% and 20%; 2) The residua from the partial melting episodes would be non-uniform in composition; and 3) The melts, with rare exceptions, could not have been in equilibrium with these residua at the pressures prevailing near the top of the mantle.

Given a pressure and temperature, the composition of the olivine that would be in equilibrium with each melt can be calculated. With pressures estimated from the geophysical data and assuming a temperature of 1400°C, the calculated range in residual olivine compositions is Fo 77 to Fo 91 (Fig. 6); a range much greater than that of the xenolith olivines. One interpretation of these calculations is that the source materials for the lavas were not uniform in composition in the mantle beneath British Columbia.

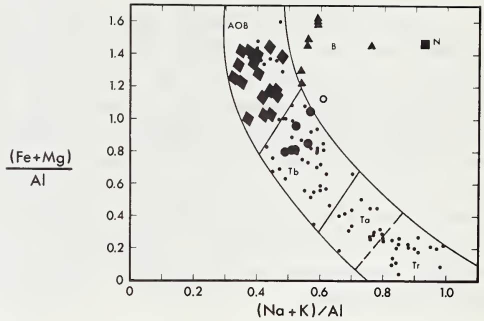
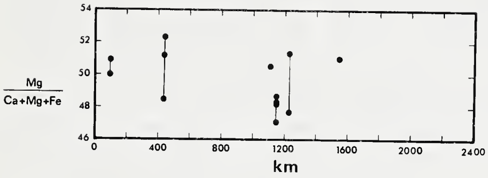


Fig. 1: Recent volcanic centres studied and depths to the Moho in British Columbia and adjacent U.S.A. Circles are studied volcanic centres and squares are locations of Moho depth determinations in km. Present plate boundaries shown for reference.

Fig. 2: Molecular (Fe + Mg)/Al versus (Na + K)/Al for rocks from North America and Atlantic Islands. Small dots are the Tristan da Cunha and Gough Island basalt-trachyte series. Large symbols this study: Filled diamonds-alkali olivine basalt; filled circles-trachybasalts; filled triangles-basanites; filled square-nephelinite; and open circle-iron-rich alkali olivine basalt.



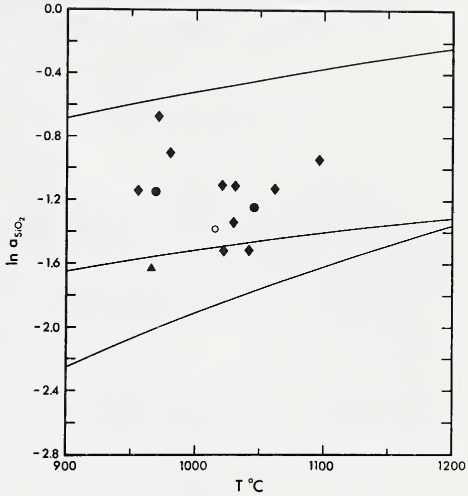
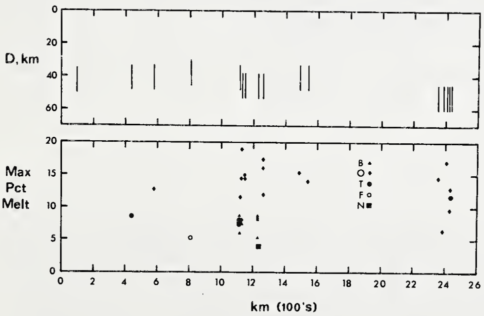


Fig. 3: Mg/(Mg+Ca+Fe) in clinopyroxenes from spinel lherzolites. Location of occurrences projected into a NW-SE section from NW British Columbia to SE Idaho. Distance along section in km.

Fig. 4: Natural logarithm of silica activity versus temperature. Curves are defined by the reaction relations: Upper curve-forsterite, enstatite; Middle curve-albite, nepheline; Lower curve-sphene, perovskite. Tholeiites and associates plot above forsterite-enstatite; Alkali olivine basalts and associates below. Nepheline-bearing rocks fall near and below the middle curve. Feldspar-free rocks below lower curve. Symbols as in Fig. 2.



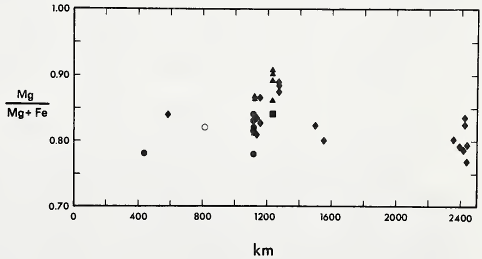


Fig. 5: Upper diagram. Depths to Moho and estimated minimum depths to low velocity zone (lower end of lines).
Lower diagram. Maximum amounts of partial melting of a uniform pyrolite source which can produce magmas of the same composition as the rock types in this study. Locations projected onto section as in Fig. 3.

Fig. 6: Calculated compositions of olivines in equilibrium with the magmas at Moho pressures + 10 kb and 1400°C. Same projection of locations as Fig. 3.