THE ORIGIN OF OLIVINE BOMBS AND RELATED INCLUSIONS IN BASALTS

by

James L. Carter
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ABSTRACT

The generation and differentiation of basaltic magmas and the chemical nature of the upper mantle is of considerable interest. A geochmeical investigation of ultramafic and mafic inclusions in basaltic rocks was initiated to ascertain if the chemical compositions of the several minerals present reflect fractionation or chemical homogeneity of the upper mantle.

Eight hundred and fifty modal analyses of olivine-bearing inclusions and two hundred and ninety modal analyses of feldspar-bearing inclusions were performed in the field. Mineral separates from fifty-seven inclusions and their host rocks from nine continental localities were analyzed for nineteen elements by atomic absorption spectrophotometry, colorimetry, and gamma spectrometry to a precision generally better than five per cent of the amount present. Forty-six of the inclusions were from Kilbourne Hole, New Mexico. One of these inclusions contained sufficient phlogopite for a potassium-40/argon-40 determination, yielding an age of 6.7 million years.

Three inclusion types were recognized in the field: Type-I olivine rich; Type-II, pyroxene rich; and Type-III, feldspar rich. Frequency diagrams of mineral percentages indicate a bimodal distribution with a continuous variation between Types I and II. A plot of the mineral percentages from the forty-six Kilbourne Hole inclusions against a differentiation index (fayalite content of the coexisting olivine) indicates (a) considerable dispersion from possible trend lines for Type-I inclusions, and (b) narrow dispersion from possible trend lines for Type-II inclusions. Plots of elemental values against the same differentiation index indicate close correlations in most cases.

These correlations indicate that (a) for major elements no discernible distinction between the minerals of the two types; however, there are significant differences from some minor and trace elements, especially nickel, chromium, and titanium; (b) Type-I olivines display a variation series from seven to twenty-four mole percent fayalite, and Type-II olivines display a variation series from about seven to nineteen mole percent fayalite; (c) spinel varies from magnesiochromite (40% Cr_2O_3) to hercynite-rich spinel (60% Al_2O_3); (d) in general, aluminum varies sympathetically with iron; (e) orthopyroxene is present in inclusions with fayalite contents less than nineteen mole percent; (f) variations in chromium and nickel are similar to those of the Skaergaard Intrusion; and (g) euhedral olivines were present in Type-I inclusions with fayalite contents greater than fourteen mole percent.

These correlations between chemical and mineralogic composition lead to the probable conclusion that these olivine inclusions were formed by fractional crystallization from a mafic (pictritic?) magma, which thus trended toward a basaltic composition. Variations in the generation and differentiation of such mafic magmas might give rise to local heterogeneities in the earth's upper mantle.