melting of the ultrabasic upper mantle of the earth. He postulates on this evidence that the upper mantle has a particular composition, and "pyrolite" is the name he gives to the hypothetical rock. He further shows that primary melts derived from pyrolite can have different chemical compositions depending on the depth at which they were produced and the water content of the parent pyrolite — also, that each of these melts can change its composition through fractional crystallization. This will depend on the length of time that the melts remain at the various depths. Volcanic eruptions occur whenever some geological incident brings such melts to the surface.

THE ORIGIN OF BASALTIC AND NEPHELINITIC MAGMAS

by

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1. INTRODUCTION

Basaltic magmas are derived from the earth's mantle. Investigation of the origins of diverse magmas and deduction of the nature of the earth's upper mantle composition and mineralogy are two complementary problems. In this lecture, I will briefly review ideas on the nature of the Earth's upper mantle, as deduced from geological processes which sample the upper mantle and from constraints imposed on their source region by basalt magmas themselves. This will lead to derivation of a specific model composition for the upper mantle. The mineralogical variation with depth for this composition has been studied experimentally. The influence of a small (0.1 - 0.2%) quantity of water in the upper mantle source region is treated in some detail showing that this will lead to the formation of a low velocity zone within the upper mantle, characterized by very small degrees of partial melting.

The variations among natural basalts are briefly reviewed to select those magmas of direct mantle derivation. The experimental crystallization of such basaltic magmas under pressures and temperatures equivalent to upper mantle conditions and with various water contents, allows the recognition of conditions at which these magmas may be in equilibrium with olivine, enstatite, and possibly clinopyroxene, and spinel or garnet i.e. the residual phases of a source peridotite composition. In this way, an attempt is made to outline an internally consistent model of source composition, derivative liquids, peridotitic residues, and magmatic accumulates from the primary liquids under high and low pressure.

2. NATURAL PROCESSES SAMPLING THE UPPER MANTLE

(a) *Kimberlite Pipes* Kimberlite pipes transport xenoliths and xenocrysts of high-pressure type from depths of 80 kilometres or more. The dominance of peridotite xenoliths over rare eclogite (quartz-free), kyanite eclogite and grosspydite xenoliths has previously been noted (Ringwood 1966a). The peridotites themselves commonly consist of olivine + enstatite + rare chromite, olivine + enstatite + garnet, olivine + enstatite + clinopyroxene and olivine, enstatite, clinopyroxene and garnet. Magnesium-rich ilmenite, or phlogopite may occur as minor phases in some samples. The mineral assemblages of the peridotites indicate temperatures well below their solidus — this is apparent in the low Al_2O_3 content (1 - 2% Al_2O_3) of orthopyroxene coexisting with garnet and in the generally low degree of solid solution between orthopyroxene — clinopyroxene pairs (Boyd 1967, Green and Ringwood 1969). This is particularly important in evaluating attempts to use the olivine + orthopyroxene + garnet assemblage of some kimberlite inclusions to argue that residues from basalt magma extraction from the mantle source rock should be olivine + orthopyroxene + garnet $\pm$ clinopyroxene (O'Hara 1968, Carswell and Dawson 1970)