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## CRYSTALLIZATION OF BASALT AND ANDESITE UNDER HIGH PRESSURE HYDROUS CONDITIONS

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Experimental crystallization of synthetic high-alumina quartz tholeiite and basaltic andesite glasses at 9–10 kb under conditions of  $P_{\text{H}_2\text{O}} < P_{\text{load}}$  demonstrates that sub-silicic clinopyroxene, orthopyroxene and amphibole are the near-liquidus phases above 1000°C. Amphibole is the dominant phase at temperatures of about 960°C and less. Calcic plagioclase occurs nearer the solidus. In an andesite composition plagioclase and clinopyroxene are the near-liquidus phases at 940°C, joined by orthopyroxene, amphibole and garnet at lower temperatures. Electron microprobe analysis of phases crystallizing from the basalt allows calculation of the composition of liquid fractionates obtained under these conditions. The calculated liquid fractionate compositions follow the calc-alkaline trend and demonstrate that the calc-alkaline igneous rock suite may be derived by the fractional crystallization of basalt under hydrous conditions at 30–40 km depth ( $P_{\text{H}_2\text{O}} < P_{\text{load}}$ ) or alternatively by the partial melting of amphibolite under similar conditions. In both cases the crystalline residuum will consist dominantly of amphibole, with subordinate clinopyroxene and orthopyroxene, and possibly minor calcic plagioclase and garnet, depending on the degree of fractionation.

### 1. INTRODUCTION

In the course of an experimental investigation of the origin of the calc-alkaline series, an exploratory study of fractional crystallization of basalt, basaltic andesite and andesite under hydrous conditions at pressures of 9–10 kb ( $P_{\text{H}_2\text{O}} < P_{\text{load}}$ ) has been carried out. The preliminary results and implications of this study are reported in this communication. Preliminary results of an experimental investigation of an alternative hypothesis of origin of the calc-alkaline series viz. partial melting of quartz eclogite at depths of 100–150 km have already been reported [1]. The detailed experimental results and conclusions from both investigations will be given in a subsequent longer paper.

The hypothesis that the calc-alkaline series may be derived by hydrous fractional crystallization or par-

tial melting of mafic material near the base of the crust or in the upper mantle (e.g. at 30–40 km depth) has frequently been referred to in the literature [2-6], but so far there have been no experimental data directly applicable to the testing of this hypothesis. Yoder and Tilley [7] conducted pioneering work on the crystallization of a number of natural basalt compositions under controlled water vapour pressure conditions from 0–10 kb ( $P_{\text{H}_2\text{O}} = P_{\text{load}}$ ) using a gas apparatus. They demonstrated lowering of the liquidus of the compositions with increasing  $P_{\text{H}_2\text{O}}$ , together with a marked increase in the size of the field of crystallization of amphibole, but the composition of the amphibole was not known. The presence of such a large field of crystallization of amphibole from basalt under these conditions suggests that the composition of the amphibole may be a key factor in testing the hypothesis for the derivation of calc-alkaline rocks from a basic parent under hydrous conditions. Accordingly, in the present investigation the sequence of crystallization and the composition of the

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