

EXPERIMENTAL STUDY OF AMPHIBOLITE AND ECLOGITE STABILITY

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The amphibolite-eclogite transition is often observed in metamorphic rocks and may be expected to occur in the lower crust or upper mantle if $P_{\text{H}_2\text{O}} \approx P_s$. Many simple amphiboles become unstable at high water pressures due to backbending of dehydration reactions or to solid-solid transitions involving sheet silicates. Contrary to YODER and TILLEY (1962), eclogite is expected to be stable relative to amphibolite at sufficiently high water pressures because of the formation of dense garnet and the high compressibility of water vapor. Experiments in progress on several basaltic compositions have produced eclogite at the expense of amphibolite at high water pressures. Seeding has been found to be important as hornblende crystallizing from glass will persist at least

4 kb above its stability field defined by reversals with garnet-pyroxene-amphibole mixtures. In reconnaissance experiments on a quartz tholeiite and an alkali olivine basalt, hornblende disappears at high water pressures between 15–25 kb and 700–900°C. Biotite appears to be stable in the alkali olivine basalt to at least 40 kb at these temperatures.

Basaltic amphibolites do not appear to be stable very far into the low-velocity zone even at $P_{\text{H}_2\text{O}} = P_s$ confirming LAMBERT and WYLLIE'S (1968) earlier experiments. Biotite however seems to be stable deeper in the mantle (at least for potassic basalts) than previously considered possible if $P_{\text{H}_2\text{O}} \approx P_s$ and may be a source of water for magmas when partially melted.

1. Introduction

Eclogite and amphibolite relationships have long been of interest to the petrologist as both rocks are closely associated in metamorphic terranes. The classical petrological studies of HEZNER (1903), BRIERE (1920), ESKOLA (1921) and TILLEY (1936, 1937) showed that early-formed eclogites have often become partially hydrated to amphibolites. ESKOLA (1939) originally placed the eclogite facies at the highest pressures and temperatures, but it is now recognized that eclogites may form at relatively low pressures as well. If eclogites form at relatively low temperature and low $P_{\text{H}_2\text{O}}/P_T^*$ then increase of water pressure could hydrate the eclogites to amphibolites (or glaucophane schists) as suggested by SAHLSTEIN (1936), BEARTH (1959), GREEN and RINGWOOD (1967) and others. For $P_{\text{H}_2\text{O}} \ll P_T$, either other gases must be very abundant to keep $P_F \approx P_T$, or there can be no vapour phase as in the water-deficient region (YODER, 1955). A third possibility is that the thermodynamic properties of intergranular films of impure water are markedly different from those of pure water. Most eclogites (except for rare scapolite-

bearing varieties) show little evidence of abundant gases other than water, though of course they need not be evident in the preserved solid phases. One may also question the possibility of crystallizing a coarse-grained eclogite from an initial olivine-pyroxene-feldspar rock in the absence of a vapour phase without leaving traces of the original basaltic minerals, though BEARTH (1959, 1965) has observed all steps of the basalt-eclogite transition for some unusual eclogites. The possibility that the partial pressure of impure water is considerably lower "in solution" along grain boundaries than pure water vapour at the same P - T cannot be properly evaluated at present. To avoid the apparent difficulties in these explanations ESSENE and FYFE (1967) postulated that eclogites are stabilized relative to amphibolites at high water pressures and showed that density data alone confirm this prediction. Similarly, GREEN and RINGWOOD (1967, p. 805–6) showed that amphiboles, including the simple end member tremolite, will break down to anhydrous products and water vapour at sufficiently high $P_{\text{H}_2\text{O}}$ and argued that this would considerably restrict the stability of amphibole in the upper mantle. Experiments are clearly needed to resolve the role of water pressures in the formation of eclogites.

* The notation used is $P_T = P_{\text{Total}}$, $P_F = P_{\text{Fluid}}$, $P_s = P_{\text{Solid}}$.