

oxene is the liquidus phase at 1,470° C and 27 kb, joined by garnet at lower temperature. With 2% H₂O, the liquidus is depressed to ~1,340° C, and olivine (minor) joined by orthopyroxene and then by clinopyroxene is the crystallization sequence. An analogy with Kushiro's data is suggested by the appearance of olivine at higher pressure in the hydrous runs but the important role of orthopyroxene is confirmed and is considered to be largely an effect of lowering the liquidus temperature and widening the pyroxene miscibility gap. Thus a magma, which at the high temperature of the anhydrous liquidus will crystallize a clinopyroxene with moderate CaO content, cannot precipitate this same phase as a single pyroxene at lower temperatures because of the wider pyroxene miscibility gap. Instead the magma may precipitate two pyroxenes, either of which may be the liquidus phase depending on bulk composition. The implication of these experiments to mantle melting is considered in a later section.

Kushiro *et al.*'s. (1968) experiments on the systems enstatite + water were in part repeated, and similar results were obtained on the roles of olivine + enstatite in the subsolidus and persistence of olivine in the melting interval. Unambiguous interpretation of the data is difficult owing to solubility of silica in the vapour phase and indeterminacy of liquid and vapour compositions. It is clear however that the total fluid phase (liquid + vapour) is silica-oversaturated and Kushiro *et al.*'s. experiments with low water contents provide evidence that in the vapour-absent region the liquid phase may also be silica-oversaturated. To test the applicability of the extrapolation from the simple system to natural basalt, experiments have been carried out in a quartz tholeiite composition (Green and Ringwood, 1967, Table 1, column 2) in the presence of 15% and 30% water at a load pressure of 22.5 kb. The quartz tholeiite contains 21% normative hypersthene and 2.5% normative quartz but olivine is the liquidus phase at atmospheric pressure — it is a typical basalt showing reaction between early-formed olivine and silica-oversaturated liquid. At 22.5 kb, with 15% water, the liquid is undersaturated with water (i.e. no vapour phase) and the liquidus is at 1,070 ± 15° C. The liquidus phase is clinopyroxene and garnet joins the clinopyroxene at about 1,050° C. With 30% water, the liquid is saturated with water (i.e. vapour phase coexists with liquid) and the liquidus lies between 1,000° C and 1,050° C. Clinopyroxene is the liquidus phase and garnet joins the clinopyroxene between 1,000° C and 970° C. Olivine does not appear in either the water-saturated or water-undersaturated runs, and the identification and presence of phases has been carefully checked with the electron microprobe. To further eliminate the possibility that absence of olivine was not due to nucleation difficulties, the quartz tholeiite was seeded with 6.4% olivine. This is sufficient to make the bulk composition exactly saturated i.e. with 26% normative hypersthene and no normative quartz or olivine. For this composition, the seed olivines entirely disappeared and clinopyroxene was the liquidus phase at 1,080° C (15% H₂O) and clinopyroxene and garnet appeared together in a near-liquidus run at 1,000° C (30% H₂O). The experiments show that olivine does not occur as a liquidus or near-liquidus phase in either a silica-oversaturated or exactly silica-saturated tholeiite at 22.5 kb either under water-saturated (30% H₂O) or water-deficient (15% H₂O) conditions. This pressure is within the range (up to 30 kb water pressure) in which Kushiro *et al.* (1968) report incongruent melting of enstatite to forsterite + silica-oversaturated liquid. Thus, at least at this pressure, the inference from the simple system study cannot be

