

Fig. 1. Results of high pressure experimental runs on the diorite composition.

Shaded area AB: Postulated  $P$ - $T$  conditions for the lower crust (BIRCH, 1955; CLARK, 1961, 1962; CLARK and RINGWOOD, 1964). Shaded area CD: Experimental determinations of the albite  $\rightleftharpoons$  jadeite + quartz equilibrium plot in this field (BIRCH and LECOMTE, 1961; BOETTCHER and WYLLIE, 1968; NEWTON and KENNEDY, 1968; NEWTON and SMITH, 1967).

EF: Kyanite-sillimanite equilibrium (RICHARDSON *et al.*, 1968). GH: Experimental determination of the anorthite  $\rightleftharpoons$  grossular + kyanite + quartz equilibrium (HAYS, 1966) — extrapolated.

Encircled points represent experiments where a low pressure assemblage has reacted to form a high pressure assemblage, or alternatively a high pressure assemblage has reacted to a low pressure assemblage after a two-stage run.

unstable at 4.3 and 6.6 kb but became stable at 7.7 kb. It first appeared at 10.1 kb in a single stage run, again pointing to the difficulty in nucleating garnet in experimental runs at temperatures as low as 900 °C. Only a trace of feldspar (probably *K*-feldspar) was present at 25 kb and higher pressures, but plagioclase was stable to 22.5 kb. At 1000 °C plagioclase disappeared between 25 and 27 kb. In a similar fashion to the diorite composition garnet, quartz and clinopyroxene appeared at the expense of plagioclase with increasing pressure at temperatures of 900–1200 °C. As reported previously (GREEN, 1967) kyanite occurred in some runs at 1200 °C but it was not positively identified at 900–1100 °C in the present work, though it may have been present in amounts of the order of 5%. Overlapping peaks on the diffractometer charts from other phases in the runs preclude definite identification of small amounts of

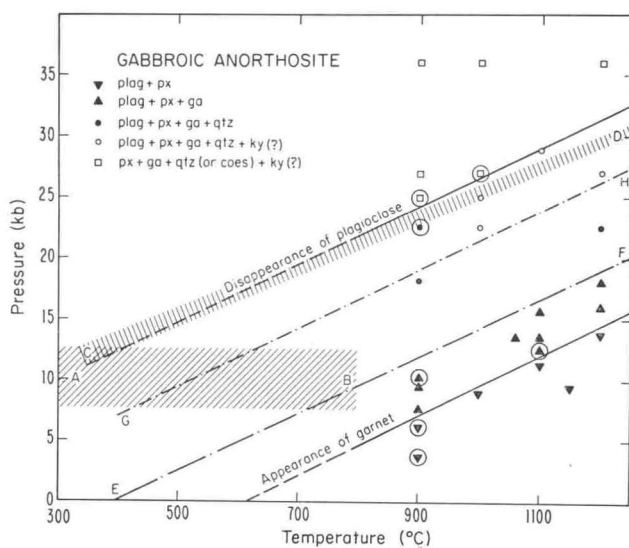


Fig. 2. Results of high pressure experimental runs on the gabbroic anorthosite composition.

Shaded area AB: Postulated  $P$ - $T$  conditions for the lower crust (BIRCH, 1955; CLARK, 1961, 1962; CLARK and RINGWOOD, 1964). Shaded area CD: Experimental determinations of the albite  $\rightleftharpoons$  jadeite + quartz equilibrium plot in this field (BIRCH and LECOMTE, 1961; BOETTCHER and WYLLIE, 1968; NEWTON and KENNEDY, 1968; NEWTON and SMITH, 1967).

EF: Kyanite-sillimanite equilibrium (RICHARDSON *et al.*, 1968). GH: Experimental determination of the anorthite  $\rightleftharpoons$  grossular + kyanite + quartz equilibrium (HAYS, 1966) — extrapolated.

Encircled points represent experiments where a low pressure assemblage has reacted to form a high pressure assemblage, or alternatively a high pressure assemblage has reacted to a low pressure assemblage after a two-stage run.

kyanite. The garnet cell size increased significantly with increasing pressure ( $a = 11.66 \text{ \AA}$  at 18 kb to  $a = 11.76 \text{ \AA}$  at 36 kb) reflecting a marked increase in grossular content (cf. GREEN, 1967).

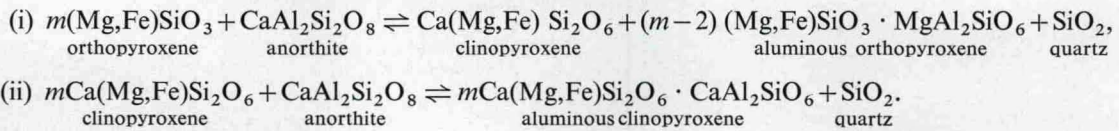
In the highest pressure runs the silica phase identified was coesite, rather than quartz.

#### 4. Discussion and application of results

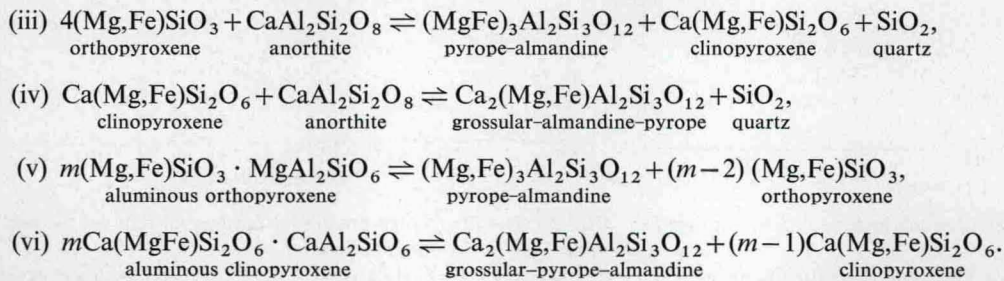
##### 4.1. Mineralogical changes and reactions

The mineralogical changes observed result from a series of pressure dependent reactions. These reactions are complex, involving members of feldspar, pyroxene and garnet solid solution series. Prior to the first appearance of garnet there is a small decrease in the proportion of plagioclase relative to pyroxene, particularly in the gabbroic anorthosite composition. This

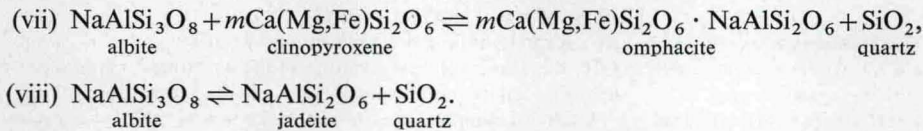
effect is attributed to reactions of the type (i) and (ii) resulting in the formation of aluminous pyroxenes and quartz, with the co-existing plagioclase becoming more sodic:



The first appearance of garnet, and its subsequent increase in amount with increasing pressure may result from the reaction of pyroxene with the anorthite component of plagioclase, and also in the later stages at higher pressure, from the breakdown of aluminous pyroxene, e.g.



The pyroxene content also increases from the breakdown of the albite component of the feldspar solid solution at moderately high pressures, according to reactions (vii) and (viii):



At intermediate pressures, where the anorthite molecule of plagioclase is involved in reactions with pyroxene, the pyroxene solid solution becomes rich in  $\text{CaAl}_2\text{SiO}_6$ . At higher pressures, the breakdown of aluminous pyroxenes to give garnet, combined with the breakdown of the albite component of the plagioclase to form jadeite and quartz will result in a pyroxene solid solution characterized by a high jadeite content, rather than a high  $\text{CaAl}_2\text{SiO}_6$  content.

At higher pressures than those at which final breakdown of plagioclase occurs, the only change in the pyroxene-garnet-quartz(-kyanite?) assemblage is in the gabbroic anorthosite composition where there is an increase in grossular content of the garnet, probably resulting from the further breakdown of  $\text{CaAl}_2\text{SiO}_6$ -rich pyroxene with increasing pressure.

#### 4.2. Comparison of results with natural rock mineralogies

As pointed out by GREEN and LAMBERT (1965) and RINGWOOD and GREEN (1966) the pressure-temperature

conditions under which basaltic compositions transform to eclogitic assemblages (garnet + clinopyroxene  $\pm$  quartz  $\pm$  kyanite, but no plagioclase) correspond to conditions at which clinopyroxene, garnet, quartz and sodic plagioclase form in more acid compositions. This holds for both the diorite and gabbroic anorthosite compositions investigated in the present work, since plagioclase is still stable above 25 kb at 1100 °C in these two compositions but it has disappeared by 25 kb at 1100 °C in each basaltic composition studied at high pressure (GREEN and RINGWOOD, 1967; GREEN, 1967).

The pyroxene-garnet-quartz-sodic plagioclase ( $\pm$  kyanite?) assemblage obtained at high pressure corresponds to some garnet granulites found in high grade metamorphic terranes. There are several recorded occurrences of assemblages analogous to those obtained in the experimental work in natural rocks of overall andesite or gabbroic anorthosite composition. Thus BUDDINGTON (1939, 1952) describes garnet-bearing gabbroic anorthosite (garnet moderately rich in grossular,