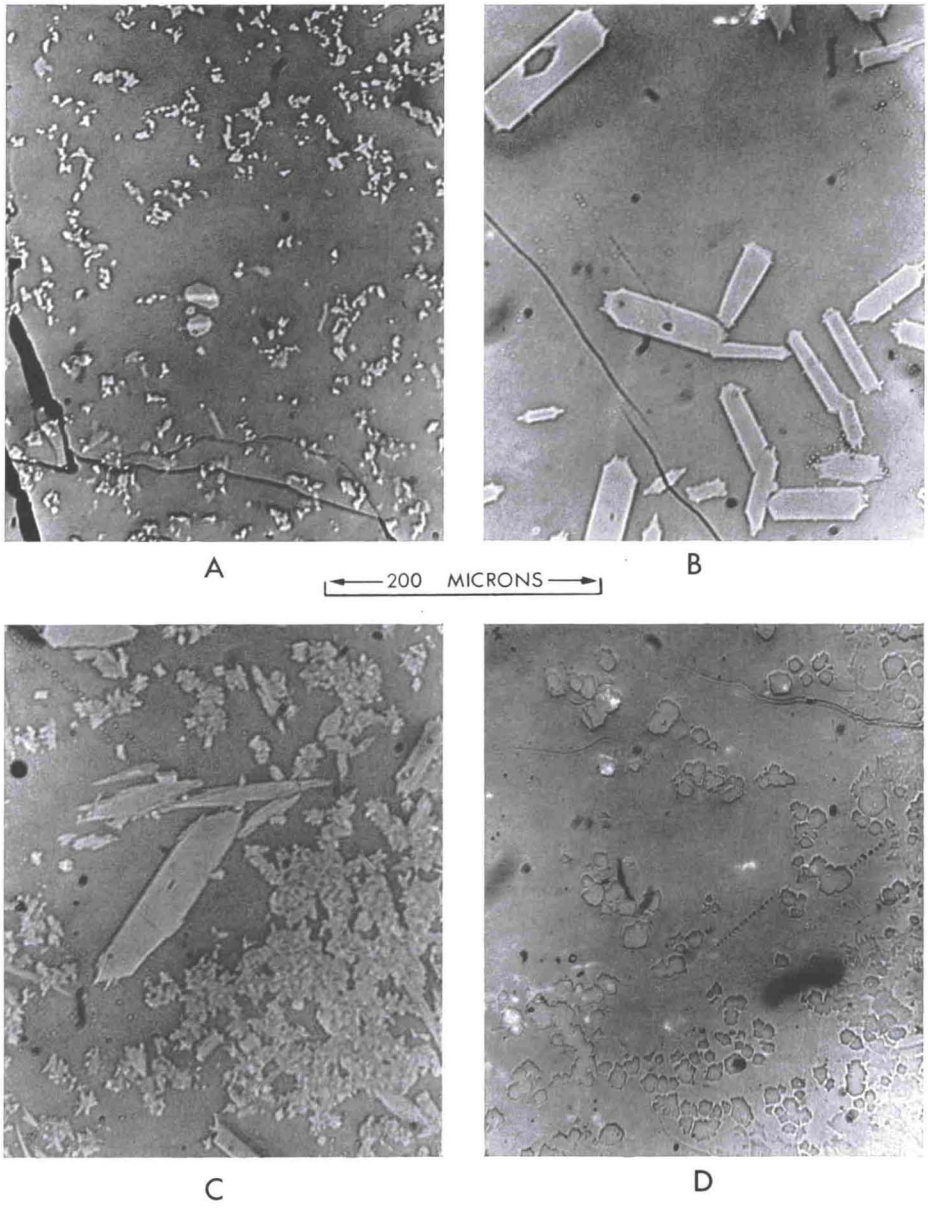

Fig. 2 A—D. Polished mounts for electron microprobe analyses showing crystalline phases in glass at various pressures. A. Olivine (small, highly reflecting grains) and orthopyroxene (larger, lath-shaped) crystals in glass. Olivine tholeiite at 9 kb, 1,290° C. White trace across larger orthopyroxenes shows path of electron beam during microprobe analyses. B. Orthopyroxene crystals in glass. Olivine tholeiite at 13.5 kb, 1380° C. Incipient nucleation of quench clinopyroxene particularly at corners of orthopyroxene. C. Large orthopyroxene and fine aggregates of quench clinopyroxene. Olivine basalt at 13.5 kb, 1,320° C. D. Garnet crystals and patchy aggregates of finegrained quench clinopyroxene (right hand side of picture) in 27 kb, 1,450° C run

either due to loss of iron to the platinum capsule or, in some cases, to splitting of the sample capsule during the run. The liquidus of the olivine tholeiite is at approximately 1,340° C and that of the alkali olivine basalt at about 1,260° C. In both compositions plagioclase is the second phase to appear (at 1,260° C in the olivine tholeiite and at 1,240° C in the alkali olivine basalt). Clinopyroxene appears at a similar temperature (1,220 ± 10° C) in both compositions and thus, in the olivine tholeiite composition there is a temperature interval of about 30° C over which precipitation of olivine and plagioclase together will determine the fractionation trend.

b) Crystallization at 9 kb

The liquidus phase in all three basalt compositions studied at 9 kb is olivine. In the olivine tholeiite composition olivine is the only phase crystallizing from the liquidus at 1,360 ± 10° C[3] down to 1,300° C. In the olivine basalt the liquidus was not accurately established but seems unlikely to be higher than 1,310° C and both orthopyroxene and clinopyroxene begin crystallizing with olivine between 1,260° C and 1,280° C. In the alkali olivine basalt composition, olivine occurs on the liquidus at 1,270 ± 10° C and co-exists with liquid alone down to 1,230 ± 10° C. At 9 kb, there is in all three compositions, a temperature interval of about 40° C or more in which separation of olivine alone will govern the early stages of fractionation of these basaltic liquids. It is of interest that the composition with the *lowest* normative olivine content (the olivine tholeiite) has the highest liquidus temperature at 9 kb and the largest temperature interval for the two phase olivine + liquid assemblage. This composition has the highest $Mg/Mg + Fe^{++}$ value and lowest $Na_2O + K_2O$ content and the liquidus temperatures show a dependence on alkali content and iron-enrichment closely analogous to that observed at atmospheric pressure by Tilley, Yoder and Schairer (1965).

In the 1.290° C run on the olivine tholeiite composition, olivine is joined by orthopyroxene (Plate IA) and the assemblage ol + opx + liquid is stable down to 1,260 ± 10° C. At this temperature the composition is less than 50% crystallized. However, the appearance of clinopyroxene as a primary phase in the 1,250° C run also results in greatly increased degree of crystallization. There is an apparent decrease in the abundance of olivine in the 1,210 to 1,250° C runs in comparison with runs at both higher and lower temperatures. The increase in olivine in going from 1,210° C down to 1,100° C may be attributed to decreasing solubility of Al_2O_3 in pyroxenes with decreasing temperatures — it is accompanied by an increase in spinel and in plagioclase (c.f. Green and Ringwood, 1967) and implies reactions

$$\text{olivine} + \text{plagioclase} \rightleftharpoons \text{aluminous pyroxenes}_{ss}$$
$$\text{spinel} + \text{plagioclase} \rightleftharpoons \text{aluminous pyroxenes}_{ss}.$$

The lower abundance of olivine in the interval 1,210° C—1,250° C in comparison with runs at higher temperatures implies a reaction relationship between olivine and liquid — this will be further discussed in a later section, but it may be noted that the precipitating phase, replacing olivine, is not enstatite or hypersthene but aluminous clinopyroxene.

Plagioclase may be present as a minor phase at 1,230° C, 9 kb, and is definitely present in the near-solidus run at 1,210° C. The very late appearance and small content of plagioclase in this composition at 9 kb contrast with the major role that this phase plays in the atmospheric pressure runs.

Olivine is again the liquidus phase in the olivine basalt at 9 kb. Both orthopyroxene and clinopyroxene begin crystallizing at similar temperatures (about 1,260° C) but the orthopyroxene is a very minor phase. The degree of crystallization shows a marked increase with the appearance of clinopyroxene. At a lower temperature (1,240° C) clinopyroxene increases in abundance at the expense of both orthopyroxene (no longer observed) and olivine.

In the alkali olivine basalt composition, orthopyroxene does not appear at 9 kb and olivine is joined by clinopyroxene in the 1,220° C run. Clinopyroxene in this run forms medium sized euhedra (up to 10—15 microns), not distinguishable optically from olivine but clearly identifiable with the microprobe. In this composition the first appearance of clinopyroxene is apparently not accompanied by an abrupt increase in the degree of crystallization. At 1,180° C, a near-solidus run contains mainly clinopyroxene with a moderate amount of plagio-

[3] The uncertainty in temperature reflects the spacing of runs at 10° C—20° C intervals and does not include the estimated precision or absolute accuracy of temperature measurement (see page 114).