basaltic magma at 30—40 kms. depth (p. 112), and may also be applied in the reverse case of fractional melting of a basaltic composition at high pressure, where the sub-solidus assemblage consists mainly of amphibole, pyroxenes and plagioclase and possibly minor quartz and garnet. It is proposed that varying degrees of fractional melting or crystallization give rise to liquids comprising a typical calc-alkaline series. Thus for low degrees of melting the residuum will consist of amphibole, pyroxenes and plagioclase, and the liquid will be of dacitic or rhyodacitic composition with a high K/Na ratio. As the temperature increases the residuum becomes amphibole-pyroxene dominated and the liquid will be of andesitic composition, changing to basaltic andesite as the temperature rises further and melting of the mafic minerals of the residuum contributes significantly to the liquid. For $P_{H_2O} < P_{LOAD}$ temperatures necessary to produce calc-alkaline liquids would range from 900° C in the case of dacite and rhyodacite, to about 1000° C for basaltic andesite.

The crystallization of dacite at 27 kb under wet conditions where garnet not quartz is the liquidus phase, indicates that partial melting of eclogite at depths of 100—150 kms with in the earth, under wet conditions may give rise to dacitic or rhyodacitic liquids as the low melting fraction, rather than the andesitic low melting fraction obtained under dry conditions.

Table 25. *Electron microprobe analysis of plagioclase from a wet run on the high-alumina quartz tholeiite composition*

Conditions of run	10 kb, 920° C, $7^1/_2$ hrs
Co-existing phases	cpx[b], opx, amph[b]
SiO_2	52.9[a]
Al_2O_3	30.0
CaO	13.9
Na_2O	3.9
K_2O	0.1
	100.8
Mol prop.	
Or	0.6
Ab	33.4
An	66.0

[a] Denotes calculated content.
[b] Denotes co-existing phase analyzed.

Calculation of Fractionation Trends

The experiments carried out under wet conditions for 4—8 hours in platinum capsules are accompanied by the loss of significant amounts of iron (e.g. an average loss of about 2.3 % iron calculated as FeO — see Table 3) to the platinum capsule during the experiment. This results in the crystallization of phases possessing lower $\frac{100\ Mg}{Mg + Fe}$ ratios than would have occurred in runs without iron loss, and in turn, affects the calculated fractionation trend. However appropriate corrections may readily be applied to allow for this loss, and thus yield the true fractionation trend. Two independent methods have been used, leading to concordant results.

The average iron loss was determined by chemical analysis of two typical charges after the runs. Distribution factors for iron between the bulk composition (after the experiment) and crystallizing clinopyroxene, orthopyroxene and amphibole were determined using electron microprobe data, and the iron content of these three phases corresponding to the initial iron content of the bulk composition was obtained. The recalculated analyses of the phases were given in Tables 23

and 24. Corrections are comparatively small, e.g. clinopyroxene at 920° C is corrected from 7.0 to 9.0% FeO.

These corrections were verified subsequently by a series of wet runs in graphite capsules, preventing any iron loss (see Table 21 for details), and analyses of orthopyroxene, clinopyroxenes and amphibole from these runs have been obtained (Tables 23, 24). These analyses agree well, particularly the $\frac{100\ Mg}{Mg + Fe}$ values, with the corrected analyses of phases from platinum capsule runs. In making this comparison, phases from runs showing similar degrees of crystallization should be compared. Because of the difficulty in controlling water vapour pressure in these experiments, the runs in the graphite capsules show smaller degrees of crystallization than runs in the platinum capsules at the same temperature. Thus the run at 1040° C in platinum should be compared with the run at 940° C in graphite.

Using where necessary corrected analyses of phases as discussed above and their observed proportions, the fractionation trend of residual liquids obtained from the high-alumina quartz tholeiite under wet conditions has been calculated in Table 26. These liquids show marked silica and alkali enrichment, and also some alumina enrichment in the early stages. The $\frac{100\ Mg}{Mg + Fe}$ ratio obtained for varying degrees of crystallization follows that of the typical calc-alkaline trend, showing only minor enrichment relative to magnesium. The slight enrichment of iron relative to magnesium would have been decreased if the experiments had not been carried out under such reducing conditions, since under more oxidizing conditions a significant amount of iron in the trivalent state may be taken into the amphibole and pyroxene structures. For example amphiboles and pyroxenes from plutonic and effusive members of the calc-alkaline series contain a significant amount of ferric iron $\left(\frac{100\ Fe_2O_3}{FeO + Fe_2O_3}\right)$ ranges from 15.7—48.6 for amphiboles and from 19.1—32.8 for clinopyroxenes; Larsen et al., 1936; Aoki, 1961; Lipman, 1964; Deer, 1938). The most significant feature of this experimental investigation at 9—10 kb under wet conditions where $P_{H_2O} < P_{LOAD}$, is that the amphiboles and pyroxenes are sub-silicic, so that extraction of these phases provides a very efficient means of enriching liquid fractionates in silica. Thus the residuum in equilibrium with a liquid of basaltic andesite composition will consist of approximately equal proportions of pyroxene and amphibole, while amphibole and subordinate pyroxene will form the residuum left after an andesite composition is extracted (the residuum will be approximately 45% by weight of the initial basalt). Finally amphibole, plagioclase, pyroxene and possibly minor

Note to Table 26

[a] The orthopyroxene analysis obtained at 1,040°C, 9 kb has been used in calculations for other experimental runs since it could not be analyzed in these runs. Since only 2% of orthopyroxene is extracted, any variations in its composition will not seriously affect the compositions of the liquid fractionates or crystalline residua. Also 1% of ilmenite is extracted as part of the crystalline residua. This is because an accessory iron-titanium rich opaque mineral phase occurred in the experimental runs in graphite capsules where no iron loss took place. This phase could not be analyzed quantitatively and as a first approximation for these calculations was taken as ilmenite.