3. ANALYTICAL PROCEDURE

Direct quantitative analysis of amphibole, pyroxene and plagioclase crystals has been carried out using an electron microprobe. Prepared synthetic glasses of approximate amphibole, pyroxene and plagioclase compositions have been used as standards. Because of similarity in composition between standards and unknowns no correction procedures have been followed. The accuracy of analysis obtainable is sufficient for the purpose of indicating fractionation trends of major elements under certain P–T conditions, which is the main aim of this experimental project.

4. RESULTS

In the high-alumina quartz tholeiite composition clinopyroxene is the liquidus phase at about 1100°C and it is joined by orthopyroxene and amphibole at lower temperatures. Amphibole is the dominant phase at temperatures of about 960°C and less. Orthopyroxene is only present in minor quantities. Plagioclase joins the ferromagnesian phases at about 920°C. Accessory pseudo-brookite (?) needles are also present. A similar sequence of crystallization is observed in the basaltic andesite, and again amphibole is the dominant phase below 960°C. Plagioclase is present at 900°C. In contrast to these two compositions where plagioclase does not appear until temperatures are well below the liquidus, in the andesite composition under hydrous conditions at 10 kb, plagioclase and clinopyroxene are the near-liquidus phases at 940°C. These phases are joined by garnet, amphibole, orthopyroxene and accessory pseudo-brookite (?) by 900°C. A few runs conducted on the high-alumina quartz tholeiite using graphite capsules showed a similar sequence of crystallization to the runs in platinum capsules, but due to the difficulty in achieving equivalent P_{H_2O}, there are different degrees of crystallization in graphite and platinum capsule runs at corresponding temperatures.

5. ANALYTICAL DATA

Analyses of clinopyroxene, orthopyroxene, amphibole and plagioclase from runs on the high-alumina quartz tholeiite are given in tables 2–4. The pyroxenes show high alumina content in tetrahedral co-ordination and correspondingly low silica contents. The amphiboles correspond to aluminous edenitic hornblendes with a significant alumina content in tetrahedral co-ordination and a low silica content. Since H_2O could not be analyzed using the electron microprobe, the structural formula has been calculated on an anhydrous basis. The Mg/(Mg + Fe) ratio is significantly lower in the amphibole than in the co-existing pyroxenes. The plagioclase crystallizing well below the liquidus is noteworthy for its high anorthite content, when compared with plagioclases crystallizing from a similar basalt under dry conditions [12].

In summary the important features of these experimental results are the large field of crystallization of sub-silicic amphibole, subordinate crystallization of aluminous sub-silicic pyroxenes and, nearer the solidus, crystallization of calcic plagioclase from the basaltic composition. Similar crystallization occurs in the basaltic andesite.

6. CALCULATION OF FRACTIONATION TRENDS

Knowing the compositions of the crystallizing phases, and estimating their proportions, the composition of the residual liquid fractionates can be calculated, and the fractionation trends determined. There is a significant amount of iron loss to the platinum capsules in the 4–8 hour wet runs (e.g. an average loss of about 2.3% FeO, iron calculated as FeO). This results in crystallization of phases possessing higher 100 Mg/(Mg + Fe) ratios than would have occurred in runs without iron loss, and in turn affects the calculated fractionation trends. Appropriate corrections have been applied for this loss as discussed previously (section 2) thus yielding the true fractionation trend. The corrections have been verified by analyses of pyroxenes and amphiboles from runs in graphite capsules where no iron loss occurred.

The calculated residual liquid compositions are given in table 5. These liquids show marked silica and alkali enrichment, and also some alumina enrichment in the early stages. The 100 Mg/(Mg + Fe) ratio obtained for varying degrees of crystallization follows that of the calc-alkaline trend, showing only minor iron enrichment relative to magnesium. The slight

Table 2
Electron microprobe analyses of clinopyroxenes and orthopyroxenes from selected wet runs.

on	High alumina quartz tholeiite									
of	10 kb 920°C 7½ hr WET	10 kb 960°C 4 hr WET	9 kb 1040°C 4 hr WET	9 kb 1040°C 4 hr WET	10 kb 920°C 7½ hr WET	10 kb 960°C 4 hr WET	9 kb 1040°C 4 hr WET	9 kb 1040°C 4 hr WET	10 kb 960°C 4 hr WET	10 kb 940°C 6 hr WET
	Runs conducted in platinum capsules				Analyses adjusted for iron loss				Runs conducted in grap	
	amph *, opx, plag *	amph *, opx	amph *, opx *	amph *, cpx *	amph *, opx, plag *	amph *, opx	amph *, opx *	amph *, cpx *	opx *, ilm	amph *, opx, ilm
	47.2	48.0	47.3	47.5	46.7	47.5	46.8	46.3	51.7	52.0
	1.6	1.6	1.7	0.8	1.6	1.6	1.7	0.8	1.2	0.9
	10.0	10.6	8.6	7.5	9.9	10.5	8.5	7.3	9.2	11.3
	7.0	6.1	5.8	11.8	9.0	7.9	7.6	15.4	6.4	8.3
	11.6	11.9	14.9	26.6	10.5	10.9	13.9	24.5	13.6	13.8
	21.6	18.7	20.1	1.7	21.4	18.5	19.9	1.7	19.7	19.8
	0.7	0.7	0.6	–	0.7	0.7	0.6	–	0.1	0.2
	99.7	97.6	99.0	95.9	99.8	97.6	99.0	96.0	101.9	106.3
	74.7	77.7	82.1	80.1	67.5	71.1	76.5	73.9	79.1	74.8
[0]										
	1.7543	1.7922	1.7567	1.7722	1.7500	1.7888	1.7532	1.7588	1.8430	1.790
	0.2457	0.2078	0.2433	0.2278	0.2500	0.2112	0.2468	0.2412	0.1570	0.209
	0.1921	0.2585	0.1330	0.1018	0.1874	0.2586	0.1283	0.0857	0.2295	0.249
	0.0447	0.0448	0.0475	0.0224	0.0450	0.0453	0.0480	0.0228	0.0321	0.023
	0.2176	0.1905	0.1801	0.3682	0.2822	0.2490	0.2382	0.4892	0.1909	0.238
	0.6428	0.6626	0.8252	1.4800	0.5867	0.6122	0.7765	1.3878	0.7231	0.708
	0.8600	0.7479	0.7998	0.0679	0.8593	0.7465	0.7985	0.0692	0.7525	0.730
	0.0505	0.0507	0.0433	–	0.0509	0.0512	0.0437	–	0.0068	0.013
	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	2.01	1.96	2.03	2.04	2.01	1.96	2.03	2.05	1.94	1.96
	37.4	41.4	45.7	77.3	34.0	38.1	42.8	71.3	43.4	42.2
	12.6	11.9	10.0	19.2	16.3	15.5	13.1	25.1	11.5	14.2
	50.0	46.7	44.3	3.5	49.7	46.4	44.1	3.6	45.1	43.6

existing phase analyzed.