TABLE VI

Electron microprobe analyses of clinopyroxenes from selected runs on the high-alumina basalt composition in the pressure range 13.5–18 kb

Conditions of run	13.5 kb 1300 °C 1 hr dry		13.5 kb 1280 °C 1 hr dry		13.5 kb 1240 °C 2 hrs wet		18 kb 1340 °C 1 hr dry		18 kb 1320 °C 1 hr dry		18 kb 1300 °C 1 hr dry		18 kb 1260 °C 2½ hrs wet		18 kb 1230 °C 2 hrs wet	
SiO_2	49.6		49.7		51.0		50.0		49.0		48.3		50.9		51.3	
TiO_2	0.8		1.2		1.2		0.7		0.9		0.9		1.1		1.9	
Al_2O_3	9.9		12.2		10.6		9.4		10.8		12.0		10.2		13.6	
FeO	6.2		8.1		6.0		5.4		5.7		5.4		4.8		8.0	
MgO	16.0		12.8		14.8		15.9		14.2		14.0		14.6		10.4	
CaO	16.6		15.3		16.8		16.2		16.0		15.9		17.1		15.9	
Na_2O	0.8		1.1		0.8		1.3		1.3		1.3		1.1		1.5	
	99.9		100.4		101.2		98.9		97.9		97.8		99.8		102.6	
$\frac{100\,Mg}{Mg+Fe}$	82.1		73.9		81.5		84.0		81.6		82.1		84.4		69.9	
Si	1.7980	2.00	1.7956	2.00	1.8171	2.00	1.8233	2.00	1.8059	2.00	1.7796	2.00	1.8324	2.00	1.8087	2.00
Al	0.2020		0.2044		0.1829		0.1767		0.1941		0.2204		0.1676		0.1913	
Al	0.2211	2.00	0.3150	1.95	0.2621	1.96	0.2275	2.00	0.2750	1.98	0.3004	1.98	0.2651	1.96	0.3736	1.91
Ti	0.0218		0.0326		0.0321		0.0193		0.0251		0.0250		0.0299		0.0504	
Fe	0.1880		0.2447		0.1788		0.1648		0.1756		0.1665		0.1445		0.2358	
Mg	0.8649		0.6896		0.7863		0.8647		0.7806		0.7692		0.7839		0.5469	
Ca	0.6446		0.5921		0.6413		0.6330		0.6317		0.6275		0.6595		0.6005	
Na	0.0562		0.0769		0.0552		0.0921		0.0930		0.0930		0.0766		0.1026	
Mg	50.9		45.2		48.9		52.0		49.1		49.2		49.4		39.5	
Fe	11.1		16.0		11.1		9.9		11.1		10.7		9.1		17.0	
Ca	38.0		38.8		40.0		38.1		39.8		40.1		41.5		43.5	

TABLE VII

Electron microprobe analyses of plagioclases from selected runs on the high-alumina basalt composition in the pressure range 13.5–18 kb

Conditions of run	13.5 kb 1280 °C 1 hr, dry	13.5 kb 1240 °C 2 hrs, wet	18 kb 1230 °C 2 hrs, wet
SiO_2	54.3* (53.0)	53.7*	57.5* (56.0)
Al_2O_3	28.8	29.0	26.3
CaO	10.9	11.6	9.0
Na_2O	5.4* (4.7)	5.0*	6.5* (6.1)
K_2O	0.08	0.08	0.08
	99.5	99.4	99.4
Mol. Prop.			
Or	0.5	0.5	0.5
Ab	46.9	43.5	56.3
An	52.6	56.0	43.2

*Denotes calculated values; measured values are shown in parentheses.

TABLE VIII

Electron microprobe analyses of garnets from selected runs on the high-alumina basalt composition at 18 kb

Conditions of run	18 kb 1260 °C 1 hr, dry	18 kb 1230 °C 2 hrs, wet
SiO_2	41.3	41.0
TiO_2	0.8	1.8
Al_2O_3	22.8	22.0
FeO	9.1	17.7
MnO	0.4	0.4
MgO	17.9	12.6
CaO	6.7	7.8
	99.0	103.3
$\frac{100\,Mg}{Mg+Fe}$	77.8	55.9
Mol. Prop.		
Ti-andradite	2.1	4.7
Grossular	15.0	15.1
Pyrope	63.9	44.4
Almandine	18.2	35.0
Spessartine	0.8	0.8

separates of plagioclase can be obtained from crystallization of a parent gabbroic anorthosite magma, and the low melting liquid fractionate will be of an alkali-rich basic composition, as calculated in Table X, based on measured crystal compositions and their estimated proportions. At pressures of 27–36 kb there is a large field of crystallization of aluminous clinopyroxene which results in liquid fractionation trends away from more aluminous (or anorthositic) liquids at these pressures. This trend may be seen from the calculated liquid fractionates given in Table X.

High-alumina Basalt

At 13.5–18 kb the large field of crystallization of clinopyroxene with an alumina content less than that of the starting composition, indicates that crystallization of this phase will result in alumina-enrichment in the low melting liquid fractionate. However, the appearance of aluminous phases, garnet and plagioclase, as the next phases to crystallize after pyroxene, prevents the alumina-enrichment trend from reaching the alumina content of a gabbroic anorthosite magma. This is clearly illustrated in the calculated compositions of the liquid fractionates given in Table XI. The most aluminous liquid obtained contains 19% Al_2O_3 compared with greater than 22% Al_2O_3 generally found in gabbroic anorthosite compositions. At lower pressures (e.g. 9 kb) there is also an alumina-enrichment trend, but this is terminated by the crystallization of plagioclase, and the most aluminous compositions possible at 9 kb contain 18% Al_2O_3 (T. H. Green *et al.* 1967; T. H. Green 1967*b*). At higher pressures (e.g. 27 kb) garnet becomes more abundant in the partial melting field and appears closer to the liquidus, so that at these pressures a trend towards alumina-enrichment is prevented.

Experiments at 13.5–18 kb with low but significant water fugacity showed some suppression of crystallization of plagioclase, and hence some alumina-enrichment. With increasing water fugacity plagioclase may be further suppressed, but it is likely that amphibole will appear as a major crystallizing phase, and fractionation trends will be towards silica, alkali, and minor alumina enrichment of a typical calc-alkaline series, rather than towards gabbroic anorthosite compositions (cf. results at 9–10 kb; Green and Ringwood 1968).

Geological Applications

Origin of Anorthositic Complexes

As indicated in the introductory section, this experimental work has been carried out in order to determine the relative merits of the two main hypotheses of magmatic origin of anorthosites involving derivation from either (1) a gabbroic anorthosite parent magma or (2) a quartz diorite parent magma.

(1) Gabbroic Anorthosite Parent Magma

The experimental work on the gabbroic anorthosite composition showed that the crystallization is dominated by plagioclase to pressures