25. PETROLOGY OF DOLERITES, HOLE 395A

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ABSTRACT

On the basis of variation of mineralogy, texture, and grain size, dolerites recovered at Hole 395A are divided into two cooling units. The lower unit is probably less than 15 meters thick.

In the lower unit, the texture of the matrix changes inward from glassy or intersertal to ophitic, probably reflecting slower cooling rate in the central part of the unit. Compositional variations of constituent minerals also become more pronounced inward. Fractionation of magma took place in small scale in this unit, however, and did not produce separate masses of late differentiates.

On the assumption that olivine megacrysts are comagmatic, the original magma composition was estimated from the compositions of glass inclusions in olivine megacrysts. It is also suggested that fractional crystallization of olivine, clinopyroxene, and plagioclase is necessary to derive the composition of the chilled margin from the estimated original magma. Experimental data indicate that this process probably took place at a depth of about 25 km.

INTRODUCTION

Doleritic rocks were recovered from a depth of about 610 meters below the sea floor at Hole 395A. These rocks are covered with hyaloclastite; no samples have been recovered from the contact, however. At the lower contact with aphyric pillow lavas, chilled-margin glass is observed. These doleritic rocks are divided into two units bounded by thin basalt breccia zone. In this report, the petrography of these two units of doleritic rocks is described.

PETROGRAPHY

Upper Unit

The two samples studied—61-1, 128-132 cm and 61-CC, 27-28 cm—are from the upper and the Lower part of the recovered unit, respectively. Their exact positions in the unit are uncertain, however, because the thickness of the unit is unknown.

395A-61, CC, 27-28 cm

Large anhedral olivine crystals are present, and their rims have been altered to aggregates of iron-rich smectite. Clinopyroxene and plagioclase form an ophitic texture. Opaque minerals, probably titanomagnetite, are confined to interstitial parts. Interstitial glass has been altered to aggregates of fine-grained clay minerals. Other secondary minerals are carbonates and perhaps zeolites.

395A-61-1, 128-132 cm

This sample is altered more intensely than Sample 61, CC, 27-28 cm. Olivine has been completely altered to carbonate or clay minerals or both. Plagioclase and clinopyroxene form an ophitic texture. Plagioclase and poikilitic clinopyroxene megacrysts are also present. The plagioclase megacrysts have very calcic narrow rims. Opaque minerals occur only in the interstitial parts.

Lower Unit

In the lower unit, the grain size of the matrix increases inward. The texture also changes regularly inward: samples from the marginal part show glassy intersertal texture, and those from the inner part show subophitic or ophitic texture.

395A-64-2, 127-130 cm

This sample is from the contact with the underlying aphyric pillow basalt, and represents the chilled margin. The texture is essentially porphyritic, and no ophitic texture is evident. Pale brown glass several milimeters wide is recognized at the very contact with the pillow basalt. The glass is partly palagonitized. In the outermost part of this glass, only olivine and plagioclase microphenocrysts are present; in the inner part, clinopyroxene is also recognized, suggesting that olivine and plagioclase crystallized before clinopyroxene, after the emplacement of the magma. In the main part of this sample, olivine, clinopyroxene, and plagioclase occur as megacrysts, phenocrysts, and groundmass minerals. The texture of the matrix is intersertal. All the megacrysts contain glass inclusions; some are fresh and pale brown, others are hydrated and opaque. Plagioclase megacrysts (up to 1 cm long) have irregularly shaped calcic cores, mantled with less calcic, remarkably zoned rims. The boundary between the calcić core and the sodic rim is very sharp. Olivine megacrysts are subhedral and have been partly altered to carbonates and clay minerals. Olivine microphenocrysts are subhedral and scattered in the matrix. Megacryst clinopyroxene includes plagioclase (An_{70}) crystals poikilitically.

395A-64-2, 50-53 cm

The matrix of this sample shows typical intersertal texture. Plagioclase megacrysts, similar to those of Sample 64-2, 127-130 cm, are present. Olivine and clinopyroxene occur as phenocrysts and groundmass minerals. Clinopyroxene phenocrysts often include plagioclase crystals. Groundmass clinopyroxene shows wavy extinction.

395A-64-1, 95-100 cm

This sample shows typical ophitic textures. Some olivine crystals include aggregates of clay minerals which are alteration products of glass inclusions. Unusually large plagioclase crystals, with calcic cores mantled by less calcic rims, are present, and resemble plagioclase megacrysts of Samples 64-1, 127-130 cm and 64-2, 50-53 cm. The clinopyroxenes are strongly zoned. Opaque minerals are confined to the interstitial part. Interstitial glass has been altered to clay minerals. Hornblende occurs in the interstitial parts, and has often been replaced by chlorite.

395A-63-1, 20-23 cm

This sample shows typical ophitic textures, and is similar to Sample 64-1, 95-100 cm, except that pigeonite is common in Sample 63-1, 20-23 cm. Pigeonite occurs as irregularly shaped inclusions in, or as the rims of, augite crystals. The boundaries between augite and pigonite are diffuse. Olivine is uncommon. Opaque minerals occur only in the interstitial parts. Clay minerals are probably alteration products from interstitial glass.

395A-62-1, 70-73 cm

Glomerocrysts of olivine and plagioclase and phenocrysts of olivine, plagioclase, and clinopyroxene are set in the intersertal or intergranular groundmass. Anhedral glomerocrystic olivines are very magnesian (Fo_{87-90}), and plagioclases are very calcic (An_{80-86}); both contain glass inclusions. Phenocryst olivine is subhedral and less magnesian than glomerocrystic olivine.

MINERALOGY

Analyses were carried out using the JEOL JXA-5 type microanalyzer of the University of Tokyo. Conditions and correction methods are the same as described by Nakamura and Kushiro (1970). Descriptions refer mainly to the minerals of the lower unit.

Olivine

Olivine in the lower dolerite unit occurs as megacrysts and phenocrysts or microphenocrysts. Chemical compositions are shown in Table 1 and Figure 1. Olivine microphenocrysts from the chilled margin (Sample 64-2, 127-130 cm) range from Fo_{85} to Fo_{86}, and olivine phenocrysts from the inner part of the unit (Sample 64-1, 95-100 cm) show wider compositional variation (from Fo_{83} to Fo_{87}), indicating that olivines crystallized after the emplacement of magma are less magnesian than Fo_{86}, and also that differentiation was more intensive in the slowly cooled parts. The relatively small compositional variations of the phenocryst olivines from Sample 62-1, 70-73 cm indicate that this sample may have come from a zone near the upper chilled margin of the lower unit, as is also suggested by the texture of matrix (intersertal and/or intergranular).

Olivine megacrysts have relatively homogeneous cores mantled with narrow, zoned rims. The irregular shape of the cores may suggest that olivines were once resorbed. The core compositions of olivine megacrysts are more magnesian than of microphenocryst olivine from the chilled margin, and range from Fo_{86} to Fo_{89}. It is not clear whether megacryst olivines are pre-

TABLE 1
Selected Analyses of Olivines

	64-2* Meg-C	64-2* Mph-C	64-1 Ph-C	64-1 Ph-R	62-1 Meg-C	62-1 Meg-R	62-1 Mph-C	62-1 Mph-R
SiO_2	38.8	38.4	38.6	38.2	38.4	38.5	39.5	39.6
TiO_2	–	0.04	0.07	–	0.01	–	0.02	0.03
Al_2O_3	0.04	0.07	0.08	0.11	0.08	0.05	0.06	0.03
FeO*	12.4	14.2	14.4	15.8	10.9	12.9	13.7	14.0
MnO	0.22	0.24	0.23	–	0.17	0.16	0.16	–
MgO	48.0	47.0	47.4	43.9	48.6	46.2	46.3	45.6
CaO	0.32	0.34	0.31	0.36	0.33	0.33	0.33	0.35
Cr_2O_3	–	–	–	–	0.05	0.04	0.05	–
NiO	–	–	–	–	0.21	0.13	0.11	–
Total	99.8	100.3	101.1	98.4	98.5	98.3	100.2	99.6
Fo %	87.4	85.5	85.5	83.2	88.8	86.4	85.8	85.4

Note: Meg-C: core of megacryst, Mph-C: core of microphenocryst, Ph-C: core of phenocryst, Meg-R: rim of megacryst, Ph-R: rim of phenocryst, Mph-R: rim of microphenocryst. FeO*: total iron as FeO.

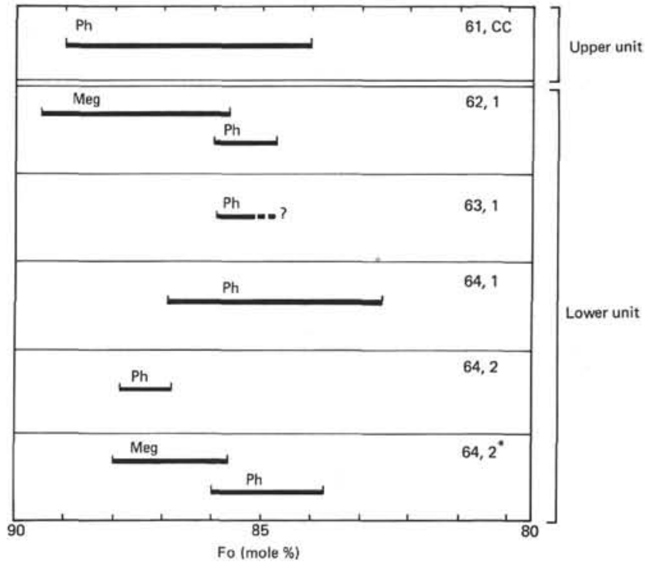

Figure 1. *Compositional ranges of olivines. Abbreviations: Meg, megacryst olivine; Ph, phenocryst and microphenocryst olivine. Section 64-2* is the chilled margin (Sample 64-2, 127-130 cm).*

emplacement phenocrysts or xenocrysts. The most magnesian olivines are observed at the upper part of the lower unit (Sample 62-1, 70-73 cm), where they form glomerocrysts with calcic plagioclase. This texture may suggest that such aggregates are xenoliths of olivine gabbro, and that some discrete megacryst olivines were derived from olivine gabbro xenoliths.

Plagioclase

Selected analyses of plagioclase are given in Table 2. Plagioclase megacrysts have broad homogeneous cores (more calcic than An_{80}) mantled with narrow, zoned, more sodic rims. The irregular shapes of the cores suggest that they might have been resorbed. The occurrence of glomerocrysts of plagioclase and olivine megacryrsts may indicate that some of the plagioclase megacrysts are xenocrysts. Compositions of the innermost parts of the zoned rims of plagioclase megacrysts (An_{78-80}) are identical to the most calcic cores of plagioclase phenocrysts. The core composition of microphenocrysts from the chilled margin (Sample 64-2, 127-130 cm) ranges from An_{68} to An_{75}, with a frequency maximum at about An_{70} core composition, suggesting that in situ crystallization of plagioclase took place from An_{70}. Compositions become more diverse toward the central part of the unit, reflecting the slow cooling rate in the inner part of the unit (Figure 2). The most sodic plagioclase in contact with interstitial clay minerals altered from interstitial glass is An_{33}.

Orthoclase contents of plagioclase are very low [K/(Ca+Na+K) is less than 0.01], reflecting the low potassium contents of the magma. A gradual increase of Or content with increasing of Ab content is recognized, however. FeO and An contents, in general, show reverse correlation, although the plots become considerably scattered with decreasing An contents (Figure 3). The FeO content of cores of plagioclase megacrysts (more than An_{80}) are lower than 0.4 wt per cent. The FeO contents are almost constant between An_{80} and An_{70}, and increase until about An_{50}.

Pyroxenes

Compositional variations of clinopyroxenes are smallest in the chilled-margin basalt (Sample 64-2, 127-130 cm) and in Sample 62-1, 70-73 cm, and most pronounced in Sample 63-1, 20-23 cm, (Figure 4). These variations reflect the slower cooling rate of the inner part of the unit (e.g., Section 63-1) compared with the marginal part. Consequently, that differentiation was more marked in the inner part. The crystallization of pigeonite is also recognized only in the inner part, for the same reason described above. The selected analyses of pyroxenes are given in Table 3.

Phenocryst clinopyroxene of Sample 64-2, 127-130 cm is more magnesian than Fs_{10}, and becomes slightly more Ca-rich toward the rim. The core composition of ophitic pyroxene in Sample 64-1, 95-100 cm, is about the same as that of phenocrysts in basalt of the chilled margin (Sample 64-2, 127-130 cm), indicating that the core composition represents the augite that crystallized before emplacement. The rims are enriched in Fs component and depleted in Wo. Compositions of the rims are variable, probably because they were crystallized from interstitial melts of variable composition. The Ca-rich clinopyroxene from Sample 63-1, 20-23 cm is almost the same as that of Sample 64-1, 95-100 cm. No pyroxene with composition similar to that of the phenocryst pyroxene of the chilled-margin basalt was detected in Sample 63-1, 20-23 cm. The absence of such pyroxenes in the inner part of the unit may indicate that all the pyroxene crystals suspended in the magma at the time of emplacement reacted with the melt and changed their compositions because of the slow cooling rate in the inner part of the unit. Alternatively, all the megacryst and phenocryst pyroxenes may have been concentrated near the margin of the unit as the result of flow differentiation, and all the pyroxenes in Sample 64-1, 95-100 cm, may have crystallized after the emplacement of magma.

Pigeonite occurs as irregularly shaped inclusions in augite or as rims of augite in Samples 64-1, 95-100 cm and 63-1, 20-23 cm. Pigeonite in Sample 64-1, 95-100

TABLE 2
Selected Analyses of Plagioclases

	64-2* Meg-C	64-2* Mph-C	64-2* Gm-C	64-1 Core	64-1 Rim	62-1 Mph-C	62-1 Gm-C	62-1 Gm-R
SiO_2	46.2	50.1	51.4	51.2	59.3	50.8	47.2	54.8
Al_2O_3	32.8	30.7	30.3	29.8	24.4	29.9	32.9	27.8
FeO*	0.34	0.39	0.65	0.49	0.54	0.41	0.26	0.97
CaO	17.2	14.9	13.7	14.4	6.82	14.5	17.6	12.1
Na_2O	1.75	3.11	3.82	3.39	7.51	3.45	1.96	4.84
K_2O	0.03	0.02	0.02	0.01	0.09	0.01	0.01	0.04
Total	98.3	99.2	99.9	99.3	98.7	99.1	99.9	100.6
An	84.2	72.6	66.4	70.0	33.2	69.8	63.2	57.8
Ab	15.6	27.3	33.5	29.9	66.2	30.1	16.8	41.9
Or	0.17	0.12	0.10	0.07	0.55	0.05	0.05	0.25

Note: Meg-C: core of megacryst, Mph-C: core of microphenocryst, Gm-C: core of groundmass plagioclase, Core: core of plagioclase in doleritic rocks, Rim: rim of plagioclase in doleritic rocks.

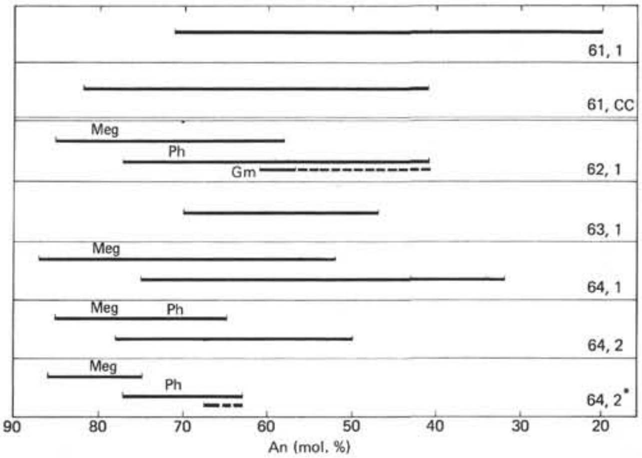

Figure 2. *Compositional ranges of plagioclases. Heavy solid lines with abbreviation Meg are the compositional ranges of megacryst plagioclases; those with Ph are the ranges of phenocryst and microphenocryst plagioclases; those with Gm are the core compositions of groundmass plagioclases; and those with no abbreviations are the compositional ranges of plagioclases in doleritic rocks.*

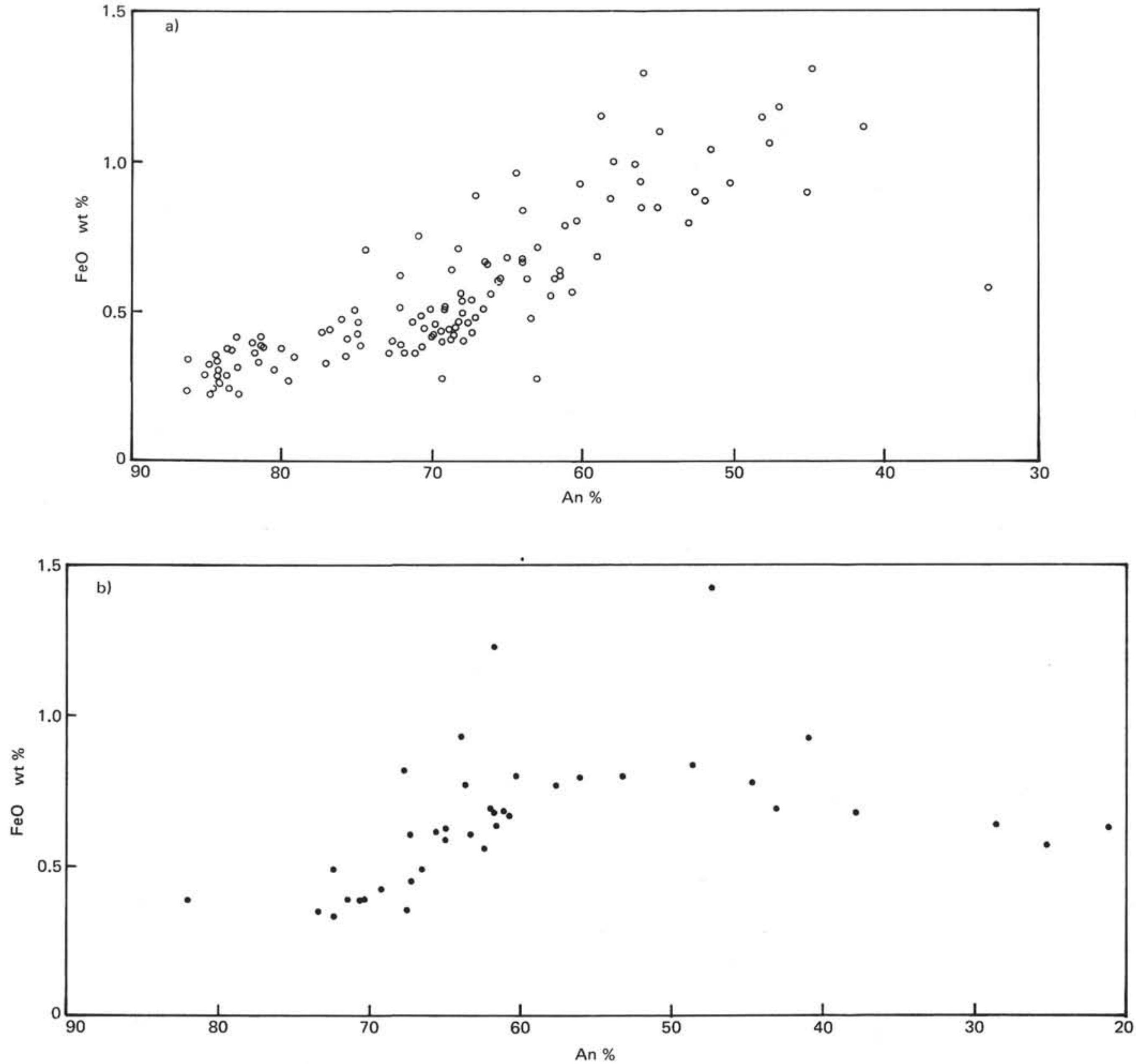

Figure 3. *The relations between An mole per cent and FeO wt per cent in plagioclase.* (a) *lower unit;* (b) upper unit.

cm was too small to analyze. The composition of pigeonite in Sample 63-1, 20-23 cm ranges from $Wo_9Fs_{26}En_{65}$ to $Wo_8Fs_{35}En_{57}$. As shown in Figure 4, there seems to be no crystallization break in either Ca-rich or Ca-poor pyroxenes, indicating that pigeonite and augite or subcalcic augite crystallized simultaneously.

Megacryst clinopyroxene in Sample 64-2, 127-130 cm is nearly the same in composition as phenocryst clinopyroxene. The former is, however, slightly more magnesian than the latter. Although the plagioclase enclosed poikilitically in the megacryst clinopyroxene is compositionally identical to the microphenocryst plagioclase (An_{70}), it is not so obvious whether the plagioclase inclusion crystallized simultaneously with microphenocryst plagioclase.

The Ti/Al ratios of all the clinopyroxenes are lower than 1/2, indicating that they have excess Al which cannot be explained by the $CaTiAl_2O_6$ component (Figure 5). Augites from the chilled-margin rock, of Sample 64-2, 127-130 cm and Sample 62-1, 70-73 cm, which is medium-grained basalt rather than dolerite, have the Ti/Al ratios less than 1/4. In the doleritic rocks from the inner part of the unit, Samples 63-1, 70-23 cm and 64-1, 95-100 cm, augites have cores with Ti/Al ratios less than 1/4 and rims with Ti/Al ratios larger than 1/4. These relations have been recognized both in terrestrial rocks (Nakamura and Coombs,

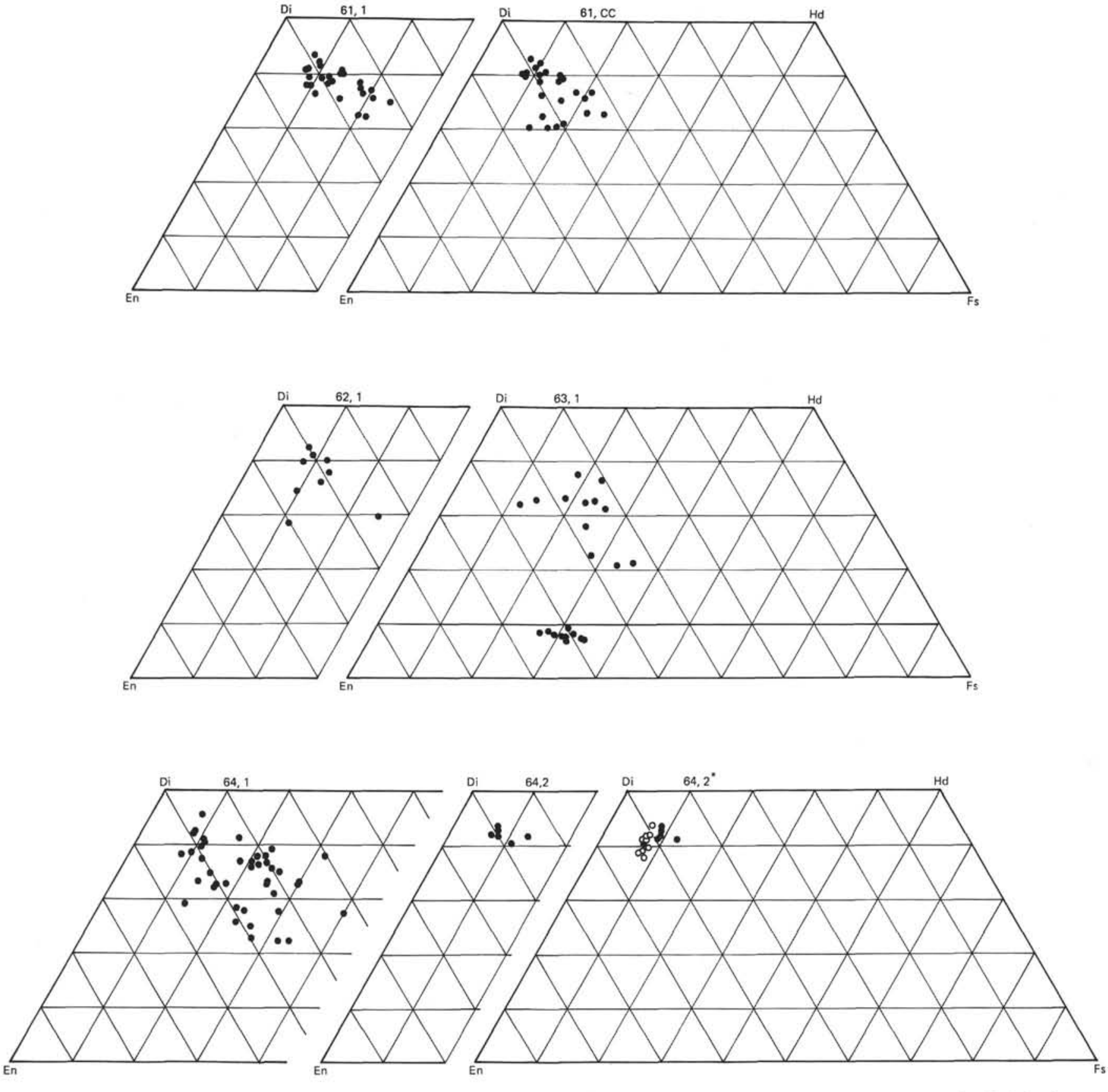

Figure 4. *Compositions of pyroxenes in Di-En-Fs-Hd diagrams. Open circles are megacryst pyroxenes and solid circles are phenocryst and microphenocryst pyroxenes.*

1973; Fujii, 1974) and in lunar samples (e.g., Bence, et al. 1970). Bence et al. (1970, 1971) suggested that the inner part and the rims of some Apollo 12 pyroxenes crystallized at depth and at the surface, respectively, whereas Hollister et al. (1971) suggested that low-(Ti/Al) pyroxene crystallized before plagioclase and high-(Ti/Al) pyroxenes subsequently crystallized simultaneously with plagioclase. In the case of the abyssal dolerite, the former explanation is preferable, because plagioclase crystallized before the emplacement, as is clear from petrographic description about the chilled margin, Sample 64-2, 127-130 cm.

The similarity of pyroxene compositions in Samples 62-1, 70-73 cm and 64-2, 127-130 cm confirms that Sample 62-1, 70-73 cm probably came from near the upper chilled margin.

Glass Inclusions in Megacrysts

Most glass inclusions in olivine and clinopyroxene megacrysts are brown and transparent and include bubbles of gas. The inclusions in plagioclase megacrysts are completely devitrified to aggregates of small clinopyroxene and plagioclase. Microprobe traverses across the glass inclusion indicate that there is no

TABLE 3
Selected Analyses of Pyroxenes

	64-2* Meg-C	64-2* Ph-C	64-2* Gm-C	64-1 Core	64-1 Rim	64-1 Rim	63-1 Core	63-1 Rim
SiO_2	51.0	51.4	51.5	51.9	49.3	50.8	48.2	50.3
TiO_2	0.35	0.39	0.60	0.85	1.33	0.87	1.22	1.14
Al_2O_3	2.88	3.48	3.42	2.98	2.93	1.42	4.56	1.65
FeO*	4.63	4.99	5.80	7.07	14.1	20.3	11.5	20.5
MnO	0.13	0.10	0.16	–	–	–	–	–
MgO	18.6	18.1	19.3	16.5	13.5	15.0	14.9	15.9
CaO	20.5	20.6	18.7	19.3	17.3	10.5	18.1	10.0
Na_2O	0.26	0.22	1.44	–	–	–	–	–
Total	98.4	99.3	100.9	98.6	98.5	98.8	98.5	99.5
Ca	40.9	41.4	37.3	40.5	36.7	22.2	37.8	20.8
Mg	51.8	50.7	53.6	48.0	39.9	44.1	18.7	46.0
Fe	7.2	7.9	9.0	11.5	23.4	33.7	43.4	33.2
	63-1 Core	63-1 Rim	62-1 Mph-C	62-1 Gm-C	61-1 Core	61-1 Rim	61,CC Core	61,CC Rim
	51.9	51.9	53.1	51.3	52.9	50.0	51.9	53.2
	0.35	0.39	0.35	0.91	0.41	1.21	0.38	0.63
	0.62	0.56	1.79	3.47	1.83	1.99	1.95	1.36
	18.1	21.0	5.99	7.75	5.50	14.9	5.42	11.3
	0.47	–	0.30	–	–	–	0.24	0.36
	24.3	21.5	19.9	17.6	18.5	14.0	18.4	17.6
	4.54	4.14	17.3	17.4	19.5	16.7	19.8	14.7
	0.18	–	–	–	–	–	–	–
	100.5	99.5	98.7	98.4	98.6	98.8	98.1	99.2
	8.7	8.2	34.8	36.4	39.3	34.9	39.9	30.6
	64.5	59.4	55.7	51.0	52.0	40.7	51.5	51.0
	26.9	32.4	9.4	12.6	8.7	24.3	8.5	18.4

Note: Meg-C: core of megacryst, Ph-C: core of phenocryst, Gm-C: core of groundmass augite, Mph-C: core of microphenocryst, Core: core of clinopyroxenes in doleritic rocks, Rim: rim of clinopyroxenes in doleritic rocks.

significant compositional variation within an inclusion. Five analyses of the inclusions in olivine and two in clinopyroxene are listed in Table 4. The CaO and TiO_2 contents of the inclusions in clinopyroxene are higher than those in olivine. It is probable that these compositions do not represent the compositions of liquids when they were trapped in the crystals as fluid inclusions, because additional crystals might have crystallized from the trapped liquid and consequently the compositions were changed (Watson, 1976). In order to estimate the original composition of trapped liquid, MgO variation diagrams were used (Figure 6 and 7). In these diagrams, fractionation lines are shown for glass inclusions in olivine and clinopyroxene. The liquid compositions (FeO) that could coexist with olivine megacrysts (Fo_{88}) are also shown in Figure 6 (Roeder and Emslie, 1972). The olivine fractionation line intersects with the liquid line at about MgO = 10.1 wt per cent (Figure 6). Then the original liquid composition can be estimated graphically (Figure 7); the intersection of the olivine fractionation line in each oxide variation diagram and the line for MgO = 10.1 wt per cent gives composition of original melt. The estimated original composition of trapped melt is also shown in Table 4.

As is clear from Figure 7, the fractionation lines for liquids in clinopyroxene do not intersect the olivine fractionation lines at the same MgO value; this indicates that the original composition of trapped liquid in clinopyroxene was different from that in olivine. The original composition of inclusions in clinopyroxene cannot be estimated, because the constant partitioning

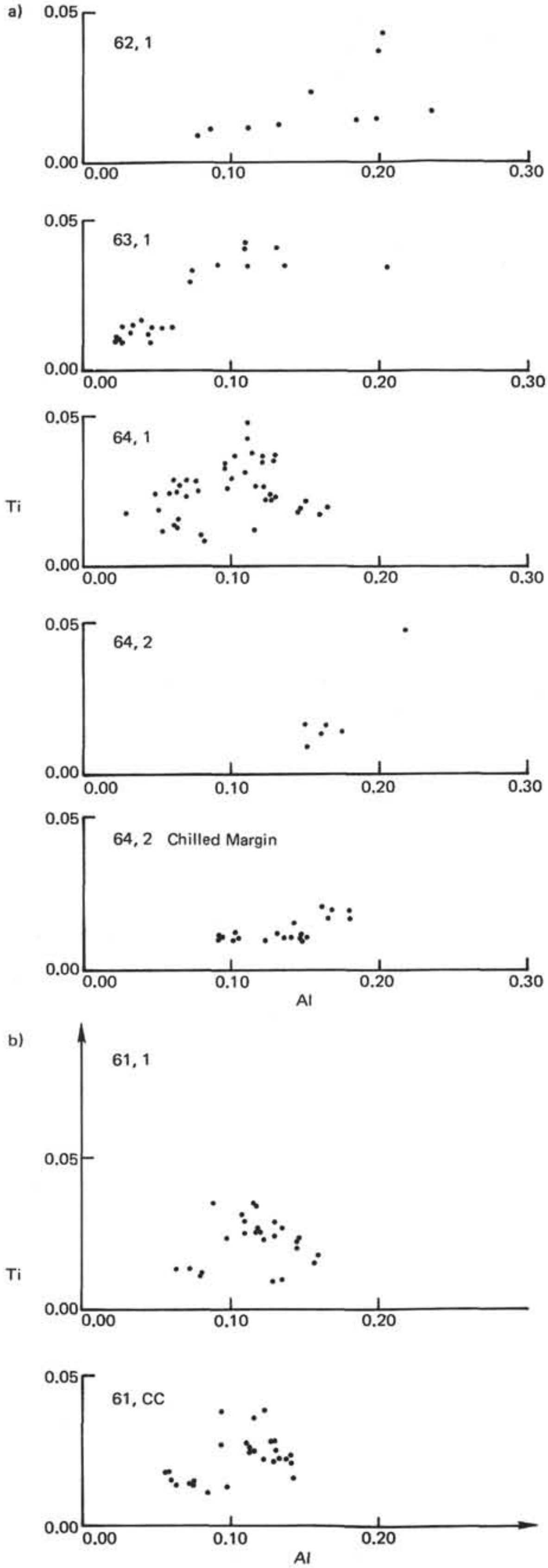

Figure 5. *Ti/Al relations of pyroxenes.* (a) *lower unit;* (b) *upper unit.*

TABLE 4
Chemical Compositions of Glasses

	1	2	3	4	5	6	7	8	9
SiO_2	51.0	51.2	51.4	51.5	51.6	59.9	51.0	50.3	50.8
TiO_2	1.32	1.36	1.30	1.31	1.42	1.46	1.46	1.2	1.61
Al_2O_3	15.6	15.7	15.8	15.7	16.0	15.6	15.7	14.5	15.1
FeO*	8.64	8.42	8.54	8.53	8.34	9.97	9.93	8.8	9.60
MnO	0.14	0.13	0.12	0.17	0.15	0.15	0.16	0.16	0.16
MgO	7.48	7.36	7.30	7.21	6.31	7.79	7.53	10.1	7.65
CaO	13.0	13.0	12.8	12.9	13.5	11.2	11.2	12.1	12.1
Na_2O	2.73	2.76	2.65	2.64	2.58	2.74	2.86	2.5	2.80
K_2O	0.07	0.08	0.08	0.07	0.06	0.09	0.11	0.05	0.09

Note: 1-5: Glass inclusions in olivines from Sample 395A-64-2, 127-130 cm; 6, 7: Glass inclusions in clinopyroxenes from Sample 395A-64-2, 127-130 cm; 8: Estimated original composition of trapped liquid in olivine from Sample 395A-64-2, 127-130 cm; 9: Chilled-margin glass from Sample 395A-64-2, 127-130 cm.

[a]All the analyses are recalculated to 100 per cent total.

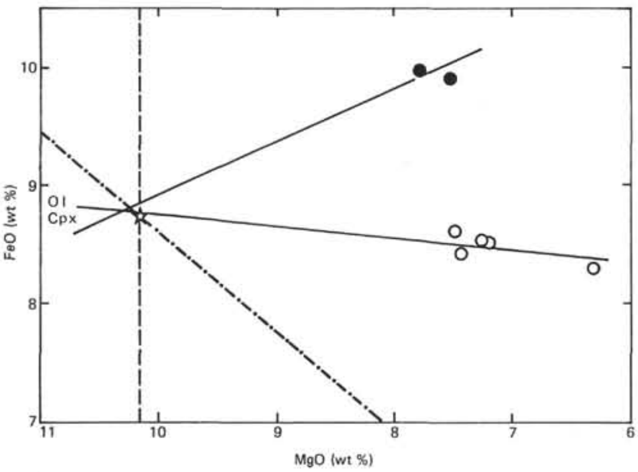

Figure 6. *Compositions of glass inclusions in megacrysts. Open circles are glass inclusions in olivines and solid circles are those in pyroxenes. Solid lines with abbreviations Ol and Cpx are olivine and clinopyroxene fractionation lines, respectively. Broken dotted line shows the composition of liquid which could coexist with megacryst olivine, assuming that* $K_D \frac{Fe\text{-}Mg}{ol\text{-}melt}$ *equals 0.30. Star is the possible original composition of trapped melt in olivine megacryst.*

of elements between clinopyroxene and melts are not known, and because the quantity of clinopyroxene that precipitated from these liquids after entrapment is unknown.

CHEMICAL COMPOSITIONS OF ROCKS

Two samples from the lower unit were analyzed (Table 5). Their H_2O contents and Fe_2O_3/FeO ratios are higher than those of fresh oceanic tholeiites (Miyashiro et al., 1969; Moore, 1970), and probably reflect the moderate alteration of the samples. The CIPW norms in Table 5 were, therefore, calculated on the basis of the recalculated analyses, assuming that Fe_2O_3 contents were 1.5 wt per cent and that the rest of the iron was all FeO (Kay et al., 1970). The results show that these two samples are in the olivine tholeiite field of the simple basalt system of Yoder and Tilley (1962).

These two compositions were plotted as a function of stratigraphic position with the other available analyses from this unit (Bougault, this volume; Graham et al., this volume; Rhodes et al., this volume) (Figure 8). The antipathetic variations of MgO and total FeO contents and Al_2O_3 content suggest that compositional variations within this unit result mainly from the difference in proportion of olivine and plagioclase phenocrysts and megacrysts. Although MgO and total FeO contents are lower and Al_2O_3 contents are higher in the inner part than in the marginal parts, the variation is not systematic, indicating that simple gravitational sorting after emplacement of magma may not be the main cause of the compositional variation. The compositional difference between the upper and the lower chilled-margin basalts (Samples 62-1, 70-73 cm and 64-2, 127-130 cm) suggest that distribution of intratelluric crystals may have been heterogeneous at the time of emplacement. Consequently, it is suggested that crystal sorting took place before or at the time of emplacement.

The composition of liquid when the magma was emplaced is estimated by the analyses of glass from contact with the underlying pillow basalt. The results are also shown in Table 4. As the glass contains somewhat skeletal microphenocrysts of olivine and plagioclase, the composition may be different from the liquid composition at the time of emplacement of this magma. The difference is probably very small, however, because the crystals are rare.

DISCUSSION

On the basis of the texture and grain size of matrix in Section 62-1, it is suggested that Section 62-1 is from the rapidly cooled part of the dolerite. Consequently, dolerite recovered at Hole 395A (from Section 64-2 to Section 61-1) is composed of two cooling units. It is impossible to estimate the thickness of the upper cooling unit because its marginal parts were not recovered. The compositional variations of constituent minerals in Sample 62-1, 70-73 cm are small, as in the lower chilled margin (Sample 64-2, 127-130 cm), indicating that this sample probably came from near the upper chilled margin of the lower unit. It is possible, therefore, to estimate the maximum thickness of the lower unit at about 15 meters.

The petrography of the chilled margin (Sample 64-2, 127-130 cm) suggests that magma that formed the lower unit was emplaced with intratelluric crystals of olivine (5 wt %), clinopyroxene (1 wt %), and plagioclase (17 wt %). Considering the variation of bulk chemical compositions through this unit (Figure 8), it may be suggested that intratelluric crystals were heterogeneously distributed and no simple crystal sorting took place after emplacement of magma.

The crystallization sequences after emplacement of magma are olivine and plagioclase →clinopyroxene→ titanomagnetite. The compositional variations of constituent minerals becomes pronounced toward the center of the unit, reflecting the slow cooling rate of the

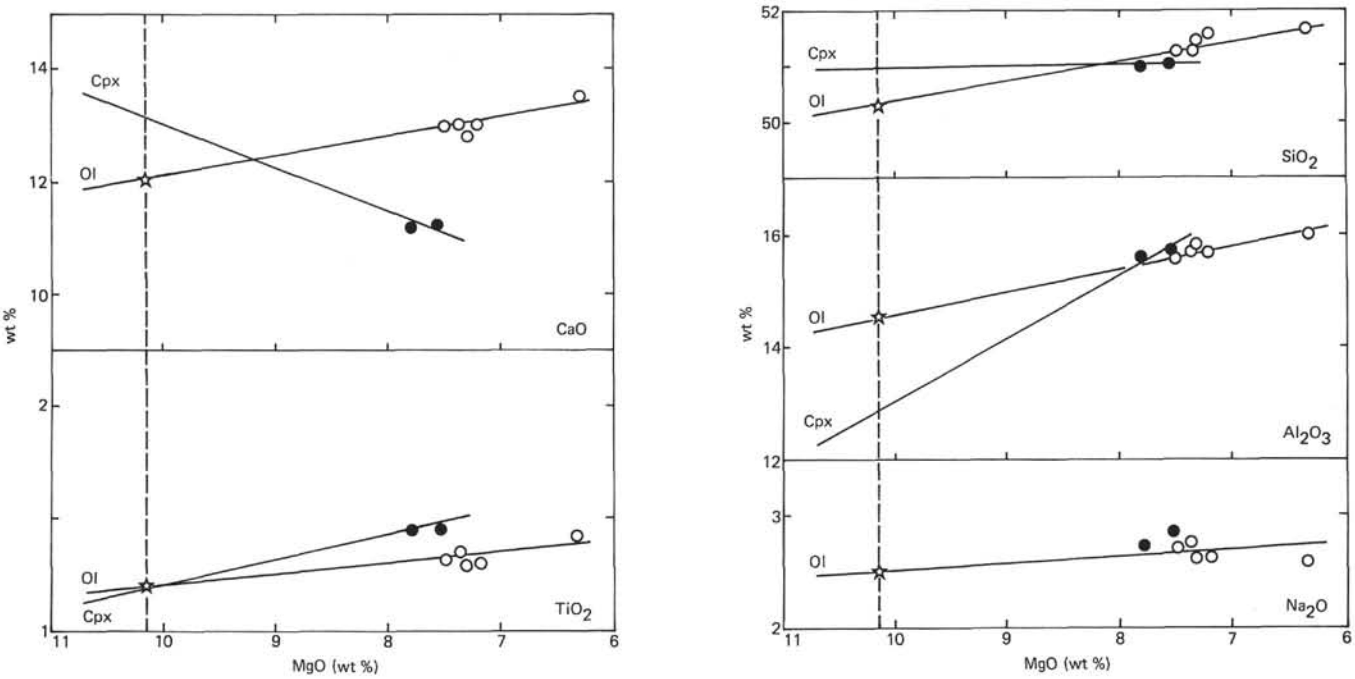

Figure 7. *Compositions of glass inclusions in megacrysts. Symbols are the same as those in Figure 6.*

inner part. The alteration of interstitial glass prevented an estimation of the composition of fractionated melts. It is probable, however, that TiO_2, FeO, and Na_2O were enriched in successively differentiated melts, as judged by compositional variations of minerals.

Analyses of glass inclusions in olivine and clinopyroxene megacrysts suggest that original trapped melt in olivine megacrysts is different from that in clinopyroxene megacrysts. If it is assumed that these two minerals are comagmatic with this dolerite magma, the liquid should have been trapped at different stages of fractionation of this magma. Although clinopyroxene megacrysts include poikilitically small plagioclase laths which have a composition identical to microphenocryst plagioclase, the difference in compositions of trapped melt and chilled marginal glass suggest that those plagioclase laths may have formed at different conditions from that of the microphenocryst plagioclase. The irregular shapes of megacryst olivine and plagioclase suggest resorption of these minerals, and may indicate that they were formed under different conditions from this magma (pre-emplacement phenocryst), or that they were formed by crystallization from a different magma (xenocryst). If it is assumed that the megacrysts are pre-emplacement phenocrysts, the estimated composition of trapped melt in olivine megacrysts could represent the composition of melt at the early stage of fractionation of this magma. As shown in Figure 9, it is probable that fractional crystallization of olivine, clinopyroxene, and plagioclase took place in the process to derive the chilled-margin glass from the estimated original magma. Experimental data on abyssal tholeiites (Kushiro, 1973; Fujii et al., this volume) suggest that fractional crystallization of clinopyroxene with olivine and plagioclase is most likely at about 8 kbar.

TABLE 5
Chemical Composition of Dolerite[a]

		Sample 63-1, 20-23 cm	Sample 64-1, 95-100 cm
	SiO_2	48.85	49.12
	TiO_2	1.17	1.12
	Al_2O_3	16.72	16.66
	Fe_2O_3	3.65	2.12
	FeO	4.36	5.89
	MnO	0.14	0.14
	MgO	7.74	8.45
	CaO	12.19	11.48
	Na_2O	2.67	2.44
	K_2O	0.15	0.10
	H_2O+	1.83	1.89
	H_2O-	0.25	0.10
	P_2O_5	0.22	0.21
	NiO	0.0076	0.0085
	Cr_2O_3	0.043	0.045
	Total	99.99	99.77
		CIPW norm	
	or	1.11	0.56
	ab	23.07	20.97
	an	33.93	35.05
di	wo	11.38	10.22
	en	4.92	4.42
	fs	6.46	5.80
hyp	en	7.13	11.24
	fs	1.19	2.24
ol	fo	5.42	4.15
	fa	0.92	0.92
	il	2.28	2.12
	mt	2.32	2.32
	ap	0.67	0.67

[a]Analyst: H. Haramura.

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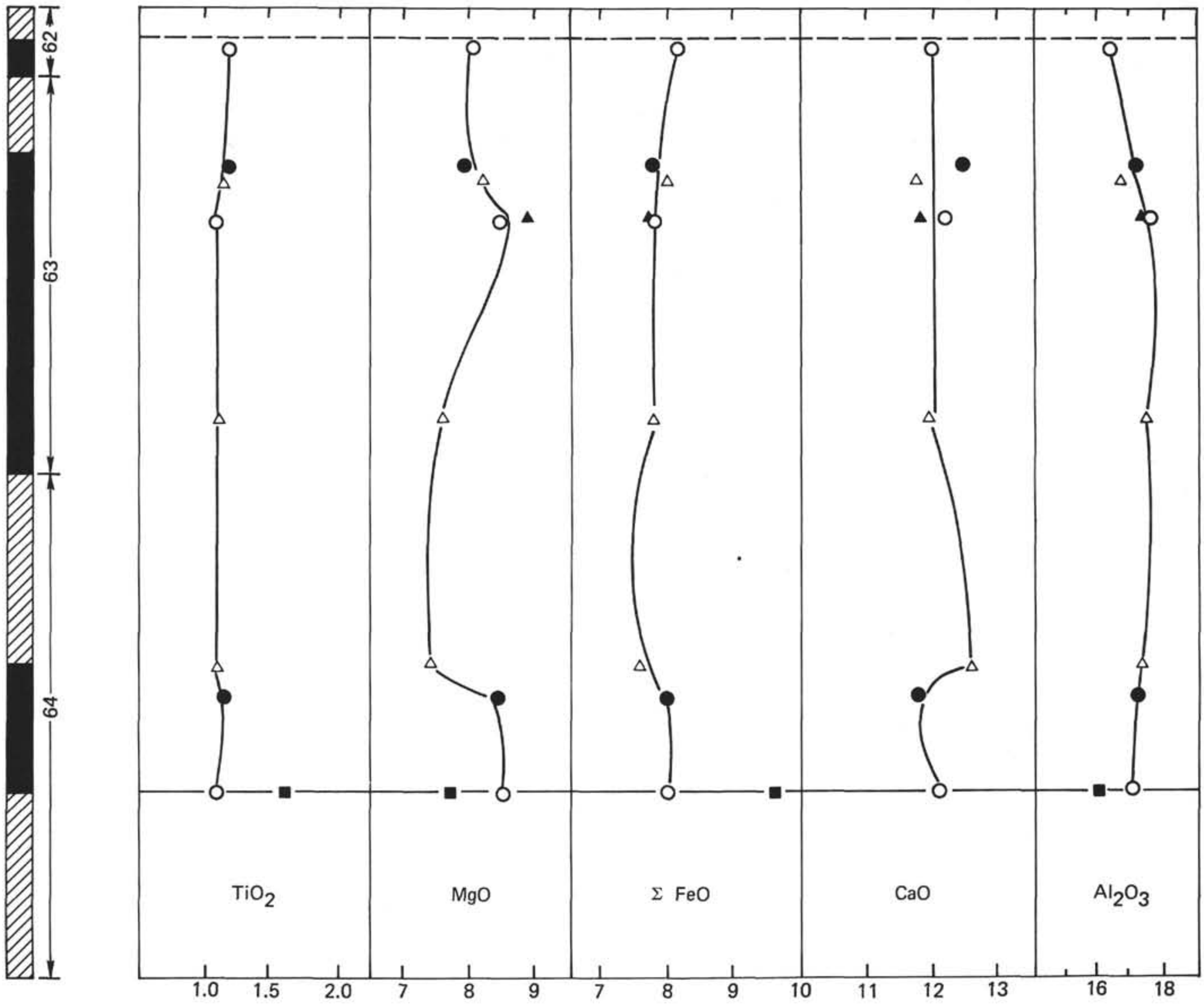

Figure 8. *Compositional variations of doleritic rocks through the lower unit. Solid areas of the left column show the recovery of doleritic rocks and shaded area show the recovery of aphyric rocks. Numbers besides the column are core numbers. Solid circles are from this study, open circles are from Bougault (this volume), open triangles are from Rhodes et al. (this volume), solid triangles are from Graham et al. (this volume), and squares represent the composition of chilled-margin glass.*

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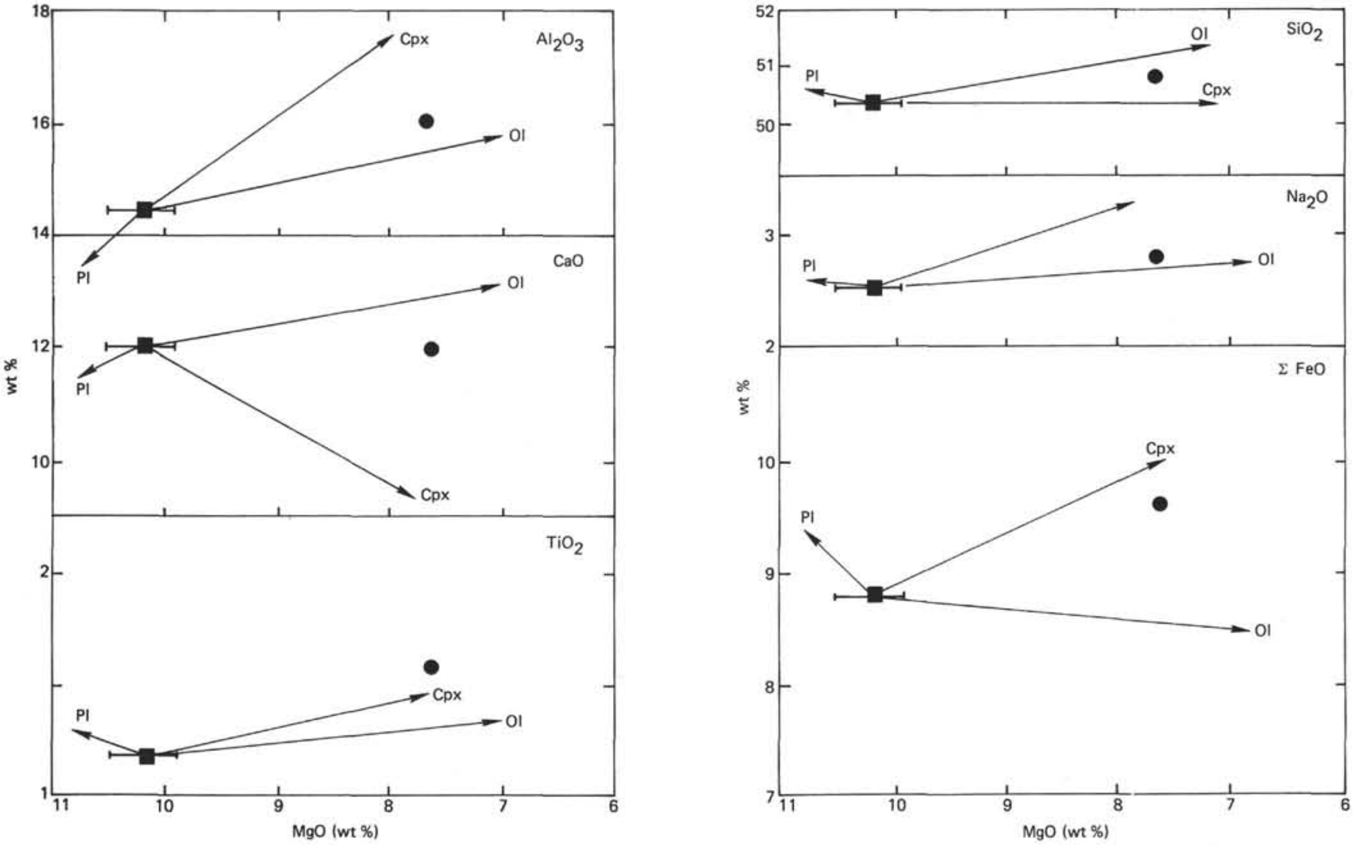

Figure 9. *Composition of the chilled marginal glass and the estimated original composition of trapped melt in megacryst olivine. Square is for trapped melt and circle is for chilled-margin glass. The arrows with abbreviations Ol, Cpx, and Pl are the fractionation trends of the trapped melt by the separation of olivine, clinopyroxene, and plagioclase, respectively.*

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