

5. PETROLOGY OF THE BASALTS: LEGS 45, 46

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The numerous analyses of layer 2 basalts in dredge samples and DSDP holes from mid-oceanic ridges have shown that they are, for the most part, oceanic tholeiite and that the range of compositions is very narrow. I infer from this that the physical conditions of the final magmatic stages accompanying ocean crust formation are stable and uniform for long periods of time.

However, the data obtained from DSDP holes penetrating more than 50 meters (Legs 24, 26, 30, 31, 34, 37, 45, 46) indicate the existence of magmatic episodes with significant differences in lava compositions. This allows us to assume that there are deviations from these average conditions. These deviations could result from differences in the composition of the upper mantle source of basaltic magma, or from changes in tectonic processes or the dynamics of the magmatic processes.

Quantitative estimation of these deviations is necessary to create a petrologic and dynamic model of oceanic crust development. However, the first step to obtain this universal model should be the development of more simple petrological models for the most typical variations of the oceanic tholeiites. The data of Legs 45 and 46 are useful for the generation of this more realistic model.

Sites 395 of Leg 45 and 396 of Leg 46 are located on either side of the axis of the Mid-Atlantic Ridge at about 23°N latitude (60 miles to the west and 80 miles to the east, respectively). The upper part of the geological section in Hole 395A (to a depth of 362 m) and the entire section of Hole 396B (to a depth of 315 m) are very similar. Both holes cored basaltic complexes consisting of aphyric units at the top and porphyritic units at the bottom. The two units are separated by thin layers of lithified sediments and brecciated basalt. The chemical variations of basalts from both holes are also very similar.

The two holes differ only in the thicknesses of the basaltic units, but this does not appear to be significant.

In general, the data from the two holes indicate that the tectonic and physical conditions of basaltic magmatism on the western and eastern slopes of the Mid-Atlantic Ridge were similar 9 to 13 million years ago.

There are 57 shipboard major element analyses for Hole 395A (Bougault in press). These include 20 analyses of aphyric basalts from 117 to 173 meters sub-bottom (chemical type "B"), 9 analyses of plagioclase-olivine pyritic basalts from 181 to 210 meters (type "D"), and 28 analyses of plagioclase-olivine-clinopyroxene pyritic basalts from 210 to 362 meters (types C-1, C-2, and C-3).

For the basalts of Leg 46, there are 66 analyses of unaltered rocks: 34 conducted aboard ship (Site 396 Report, this volume) and 32 incorporating classical methods at the Vernadsky Institute of Geochemistry, USSR Academy of Sciences. In all, these include 27 analyses of sparsely pyritic

basalts from 150 to 235 meters sub-bottom (lithological Units 1 and 2; chemical Units A₁, A₂, and A₃), 7 analyses of the dolerite cooling unit from 235 to 245 meters (chemical Unit A₃), and 32 analyses of plagioclase-olivine pyritic basalts from 245 to 315 meters (lithological Unit 4, chemical Units B₁ and B₂).

Table 1 presents averages of the shipboard analyses and our analyses. The analyses of the Leg 46 interlaboratory standards are in Table 2.

Figure 1 presents histograms for TiO₂, Al₂O₃, and iron as FeO for Sites 395 and 396 and for mid-ocean ridge basalts from dredge samples (Dmitriev et al., 1976). These histograms show that the compositional variation of the basalts from Sites 395 and 396 lie within the limits of mid-ocean ridge basalts compositions. SiO₂, MnO, CaO, Na₂O, and K₂O in both the aphyric and porphyritic basalts do not differ from these of mid-ocean ridge basalts and correspond to the positions of maximum on the histograms. At the same time, the aphyric and porphyritic basalts differ significantly in TiO₂, Al₂O₃, and (FeO)*¹ (see Figure 1). The (FeO) and TiO₂ maxima for mid-ocean ridge basalts is between the maxima for the aphyric and porphyritic basalts from both Sites 395 and 396. The positions of two Al₂O₃ maxima for the mid-ocean ridge basalts correspond to the aphyric and porphyritic basalts from Legs 45 and 46, and are asymmetrical in the same way.

This distribution of TiO₂, Al₂O₃, and (FeO) in both basalt types indicates the absence of intermediate varieties and implies relatively stable conditions during the origination of the basalt.

The existence of two separate magmas, corresponding to the aphyric and porphyritic basalts formed under different conditions of differentiation, is confirmed by petrochemical study. Figures 2 and 3 demonstrate the wide variation in (FeO) and TiO₂ and relatively constant Al₂O₃ in the aphyric basalts, and the wide variation in Al₂O₃ and limited range of (FeO) and TiO₂ in the porphyritic basalts.

Figure 4 shows the positive correlation between (FeO) and TiO₂ in the porphyritic basalts, and the relatively constant TiO₂ independently of (FeO) in the aphyric basalts. The difference between aphyric and porphyritic basalts is illustrated in the S-Al₂O₃ diagram (Figure 5).

$S = \text{SiO}_2 - [(\text{FeO}) + \text{MgO} + \text{TiO}_2 + \text{MnO}]$ and is one of two parameters of the A-S diagram used for petrochemical investigations of various compositions (Dmitriev, 1972, 1974). Parameter A = Al₂O₃ + CaO + Na₂O + K₂O. A and S, therefore, include all the major elements of an igneous system. Because of this, points in A-S coordinates are invariant relative to the major elements in the rocks

* $(\text{FeO}) = 0.9 \times \text{Fe}_2\text{O}_3 + \text{FeO}$.

TABLE 1
Composition of Basalts From Sites 395 and 396 (weight %)

	Hole 395A						Hole 396B										Dolerites "Cooling Unit" (235-245 m)		10	
	Aphyric Basalts (117-173 m)		Porphyritic Basalts (181-210 m)		Porphyritic Basalts (210-362 m)		1	2	3	4	5	6	7	8	9	X	S	X		S
	X	S	X	S	X	S														
SiO ₂	49.36	0.46	49.73	0.42	49.49	0.31	49.52	50.06	50.23	49.67	50.17	49.89	49.58	50.92	50.11	50.18	0.34	50.43	0.28	49.76
TiO ₂	1.62	0.03	1.35	0.04	1.11	0.07	1.59	1.43	1.49	1.59	1.58	1.43	1.47	1.65	1.66	1.52	0.09	1.63	0.02	1.24
Al ₂ O ₃	15.03	0.19	18.13	0.38	17.74	0.73	15.82	15.72	15.71	15.66	15.54	15.68	15.54	15.63	15.52	15.56	0.21	15.29	0.17	17.43
Fe ₂ O ₃	5.29	0.25	4.20	0.21	3.92	0.12	5.19	4.23	4.98	4.36	3.74	5.44	4.30	4.87	4.51	4.50	0.50	3.35	0.63	4.94
FeO	6.48	0.31	5.14	0.26	4.80	0.15	5.27	5.85	5.36	6.01	6.70	5.29	5.70	5.39	5.73	5.50	0.53	7.11	0.66	4.43
MnO	0.19	0.05	0.20	0.01	0.20	0.01	0.15	0.15	0.15	0.15	0.15	0.15	0.20	0.15	0.20	0.17	0.02	0.17	0.01	0.15
MgO	8.39	0.33	6.75	0.46	7.68	0.72	6.84	8.12	8.02	7.75	7.71	7.88	7.60	7.09	6.39	7.71	0.42	7.84	0.30	7.54
CaO	10.80	0.31	12.13	0.19	12.46	0.40	12.55	11.50	10.76	11.65	11.42	11.11	12.77	11.00	12.60	11.73	0.48	11.16	0.18	11.62
Na ₂ O	2.68	0.63	2.23	0.77	2.48	0.55	2.65	2.62	2.96	2.80	2.69	2.71	2.55	2.93	2.97	2.86	0.34	2.82	0.22	2.65
K ₂ O	0.16	0.07	0.14	0.07	0.12	0.05	0.36	0.26	0.31	0.31	0.25	0.36	0.25	0.33	0.25	0.27	0.05	0.20	0.07	0.20
S	27.39		32.09		31.78		30.46	31.11	30.28	29.79	30.26	19.68	30.28	31.75	31.59	30.78		30.33		31.43
A	28.67		32.63		32.80		31.40	30.22	30.24	30.44	29.91	19.88	31.12	29.91	31.36	30.42		29.47		31.91
(FeO)/(FeO) + MgO	0.57		0.57		0.52		59.27	56.18	56.14	56.20	56.62	56.37	55.74	57.94	60.52	0.57		0.58		54.08
Al ₂ O ₃ /CaO	1.39		1.49		1.42		1.26	1.37	1.37	1.34	1.35	1.41	1.21	1.42	1.23	1.33		1.37		1.50

Note: Hole 395A – XRF method, Bougault et al., 1978. Hole 396B – Shipboard analyses, Leg 46 Scientific Party, this volume; new analyses by classical methods, A. Lebedkova and L. Krigman, Vernadsky Inst. Geochemistry, USSR Acad. of Sciences. Fe₂O₃ and FeO analyses calculated from total iron by Fe₂O₃/FeO ratio for average unaltered basalt composition. Na₂O content for XRF analyses calculated as 100% minus sum of all other elements. X = average composition, S = standard deviation. (FeO) = 0.9 · Fe₂O₃ + FeO wt%. All data given as anhydrous compositions.

studied. The S parameter may be used as an independent quantitative measure of "basicity" or "acidity" of magmatic rocks. Moreover, S varies more than any single major element on the same scale.

Figure 5 shows that the basicity of the porphyritic basalts does not influence the Al₂O₃ content, while the positive S-Al₂O₃ correlation of the porphyritic basalts is clear. This difference confirms the existence of two separate melts. In terms of this result, we need to decide the origin of the two magmas and their possible genetic relationship.

The calculated average compositions of the aphyric and porphyritic basalts from both sites were plotted on the A-S diagram in Figure 6. Because this diagram is invariant for all the major elements, it can be used to calculate the proportions of any two compositions in a third. Figure 6 shows the straight lines joining the compositions of the aphyric porphyritic basalts and extending to the line joining plagioclase compositions. This diagram indicates that the average porphyritic basalt of Site 395 might be the sum of 100 parts of aphyric basalt and 19 parts of An₇₃ in weight per cent. Porphyritic basalts of Site 396 can be produced by combining 100 parts of aphyric basalts from 245 to 315 meters and 9 parts of An₈₆, or 100 parts of basalts from the Core 15 cooling unit and 12 parts of An₈₆.

Table 3 compares the true and calculated average porphyritic basalts for both sites. The numbers of the points on Figure 6 and the columns in Table 3 are the same.

The data of Table 3 indicate that both magmas mentioned above can be formed from a single parental melt by its separation into two parts. One of these must be enriched in plagioclase phenocrysts, another depleted in them.

The reasonable enrichment in plagioclase and good agreement of the calculated plagioclase composition with that composition observed in the cores of the phenocrysts show this separation to be realistic.

The composition of the parental melt most likely is intermediate between the two magma compositions, although the possibility that it is more basic cannot be excluded. The only condition required is that its

composition must be on the straight line continuation (dashed lines on Figure 6).

Table 3 also indicates a small, but systematic excess of TiO₂, (FeO), and Na₂O, and a deficit of MgO and CaO in the calculated porphyritic basalts in comparison with the true average compositions. These deviations are probably due to the very simplified system of calculation, which does not include olivine or clinopyroxene. Also, the possibility the aphyric basalts are differentiated and the possible variation of the true parental melt composition are not taken into account.

In the first case, the aphyric basalts represent the residual magma after the plagioclase separation. In the second case, the origin of the aphyric basalts is less definite. These basalts could be the residual magma after the olivine separation from more basic parental melt or the magma from the intermediate zone between the upper part of a magma chamber enriched in plagioclase phenocrysts and a bottom enriched in olivine phenocrysts.

The petrological conditions of the basaltic complexes origin can be discussed in light of experimental data.

Kushiro and Thompson (1972) reported the results of melting experiments on two oceanic tholeiites described by Miyashiro et al. (1969). Both tholeiites have compositions similar to basalts of Legs 45 and 46. One is an Ol-tholeiite (T-87), similar to the average aphyric basalts; another is a Pl-tholeiite (T-89), similar to the average porphyritic basalt (see Table 3).

The author concludes that the Ol-tholeiite can be derived from a dry lherzolitic mantle from a depth up to 25 km at temperatures up to 1220°-1230°C, while the Pl-tholeiite can be derived from the same mantle under the wet condition (about 2 wt. % of H₂O) or from "pyroxenitic" mantle under dry condition (Figure 7).

These results cannot be accepted unconditionally and appear to be in conflict with the following observations.

1) It is hard to believe such sharp compositional and water saturation inhomogeneity are in a relatively narrow depth interval or mantle.

TABLE 1 – Continued

Hole 396B																				
Porphyritic Basalts (245-315 m)																				
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	X	S
49.63	49.83	49.75	50.27	49.49	49.94	50.25	50.25	49.74	50.44	50.11	50.19	49.58	49.63	50.57	49.49	50.13	49.42	49.81	49.95	0.30
1.29	1.26	1.36	1.25	1.23	1.20	1.23	1.17	1.12	1.15	1.04	1.06	1.01	0.99	0.98	1.01	0.99	0.93	0.91	1.13	0.12
17.63	17.52	17.51	17.29	17.60	16.74	17.43	16.95	17.22	16.99	17.18	17.06	18.20	17.74	17.36	18.96	17.95	18.24	17.52	17.44	0.50
6.33	5.71	5.43	4.99	4.93	4.31	4.40	4.70	4.08	3.92	4.44	4.12	4.15	3.68	3.97	3.76	4.04	3.36	3.63	4.45	0.68
3.53	3.89	4.51	4.60	4.36	4.79	4.51	4.38	4.49	4.62	4.21	4.20	4.36	4.27	3.97	4.32	4.13	4.53	4.31	4.31	0.33
0.20	0.20	0.20	0.20	0.20	0.20	0.18	0.14	0.17	0.12	0.15	0.33	0.24	0.14	0.17	0.11	0.16	0.37	0.30	0.19	0.06
5.11	6.07	5.79	7.83	7.14	8.00	6.90	7.97	8.16	8.09	7.74	8.42	7.85	8.44	7.86	7.62	7.19	8.44	9.35	7.68	0.83
13.29	12.62	13.60	10.63	12.29	12.20	12.91	12.27	12.41	12.03	12.44	11.93	11.94	12.54	12.46	12.11	12.58	12.35	12.03	13.38	0.52
2.71	2.62	1.56	2.57	2.49	2.36	1.92	1.92	2.34	2.38	2.46	2.41	2.38	2.34	2.45	2.36	2.50	2.06	1.92	2.25	0.34
0.22	0.24	0.25	0.32	0.22	0.22	0.22	0.20	0.22	0.21	0.19	0.20	0.23	0.17	0.17	0.20	0.29	0.26	0.18	0.22	0.03
33.14	32.67	32.44	31.37	31.60	31.42	33.01	31.87	31.70	32.52	32.51	32.01	31.94	32.08	33.60	32.64	33.60	31.76	31.28	32.19	
33.87	33.00	32.93	30.83	32.61	31.53	32.50	31.35	32.20	32.62	32.28	31.62	32.77	32.80	32.45	33.64	33.33	32.92	31.65	32.29	
64.38	59.80	61.87	53.72	55.23	52.00	55.12	51.96	50.03	50.21	51.47	48.33	50.77	47.32	48.97	50.29	51.93	47.22	44.80	0.52	
1.32	1.38	1.28	1.62	1.43	1.37	1.35	1.38	1.38	1.41	1.38	1.42	1.52	1.41	1.39	1.56	1.42	1.47	1.45	1.41	

TABLE 2
Leg 46 Interlaboratory Standards

	Sample 1				Sample 2				Sample 3				Standard	
	Sample Determination		Average Results		Sample Determination		Average Results		Sample Determination		Average Results		Standard JB-1	Flanagan Data (1973)
	a	b	Large Container	Small Container	a	b	Large Container	Small Container	a	b	Large Container	Small Container		
SiO ₂	48.50	48.40	48.45	48.70	48.64	48.34	48.46	48.64	48.32	48.09	48.21	48.32	52.12	52.09
Al ₂ O ₃	15.75	15.72	15.73	15.63	15.29	15.29	15.29	15.20	17.72	17.82	17.77	17.77	14.75	14.53
Fe ₂ O ₃	3.11	3.14	3.13	3.16	3.38	3.08	3.23	3.17	2.83	2.94	2.89	2.97	2.15	2.30
FeO	6.85	6.80	6.83	6.70	7.24	7.35	7.30	7.34	5.25	5.15	5.20	5.20	6.16	6.06
MgO	7.95	7.99	7.97	8.04	7.78	7.99	7.99	8.00	8.00	8.15	8.07	8.08	7.86	7.70
CaO	11.54	11.45	11.50	11.45	10.52	10.45	10.48	10.40	11.58	11.72	11.65	11.78	9.15	9.21
Na ₂ O	2.65	2.65	2.65	2.69	3.02	3.03	3.02	2.95	2.52	2.53	2.52	2.52	2.65	2.69
K ₂ O	0.24	0.23	0.24	0.24	0.18	0.18	0.18	0.17	0.23	0.24	0.23	0.23	1.39	1.42
ΣH ₂ O	-1.20	1.20	1.20	1.10	1.88	1.73	1.80	1.84	1.81	1.78	1.80	1.81	1.85	1.80
TiO ₂	1.40	1.44	1.42	1.42	1.60	1.64	1.62	1.64	1.00	1.00	1.00	1.00	1.34	1.35
MnO	0.17	0.16	0.17	0.17	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.18
total	99.36	99.18	99.29	99.30	99.68	99.23	99.42	99.50	99.40	99.56	99.48	99.82	99.56	99.43

Note: Major elements except Na₂O and K₂O, determined by complexometry with trilon B; Na₂O and K₂O, determined by flame photometry. Analysis by A. V. Lebedkova, Vernadsky Inst. of Geochemistry, USSR Academy of Sciences.

2) Data on the homogenization of the glass inclusions in plagioclase phenocrysts of porphyritic basalts from Site 396 show that they crystallized at about 1230°-1260°C (see Table 4). Wet conditions in the experiments decrease the melting temperature to 1150°C (see Figure 7).

3) The basalts studied were most likely formed under dry conditions. However, it does not mean that parent magmas were not generated under water saturation in mantle.

Both compositions (T-87 and T-89) were also plotted on the A-S diagram (see Figure 6). The straight line joining them ends at An₆₅. The calculation indicates that plagioclase tholeiite (T-89) can be formed by addition of 9 weight per cent of An₆₅ to olivine tholeiite (T-87) (see Table 3).

4) The generalized model of this process is as follows. The composition of the single oceanic tholeiite parental melt corresponds to average oceanic tholeiite shown in Table 3 and Figure 6. Deviation from this composition depends

upon the variability in the composition of the lherzolitic mantle and its degree of water saturation. Variability of both the lherzolite composition and water saturation influence the plagioclase phenocrysts composition and, consequently, the composition of the aphyric residual magma.

For a fixed composition of the lherzolitic mantle, the decrease in anorthite in the plagioclase phenocrysts and lowering of SiO₂ in the aphyric residual basalts show the development of magmatic process under water saturation.

The abundance of the phenocrysts indicates a well-separated primary melt under relatively stable tectonic conditions.

The initial schematic model for the basaltic complexes of Sites 395 and 396 from the observed and experimental data is as follows.

1) The parental melt for both porphyritic and aphyric basalts was similar to olivine tholeiite (T-87) and also to average mid-ocean ridge basalt. This parental melt was

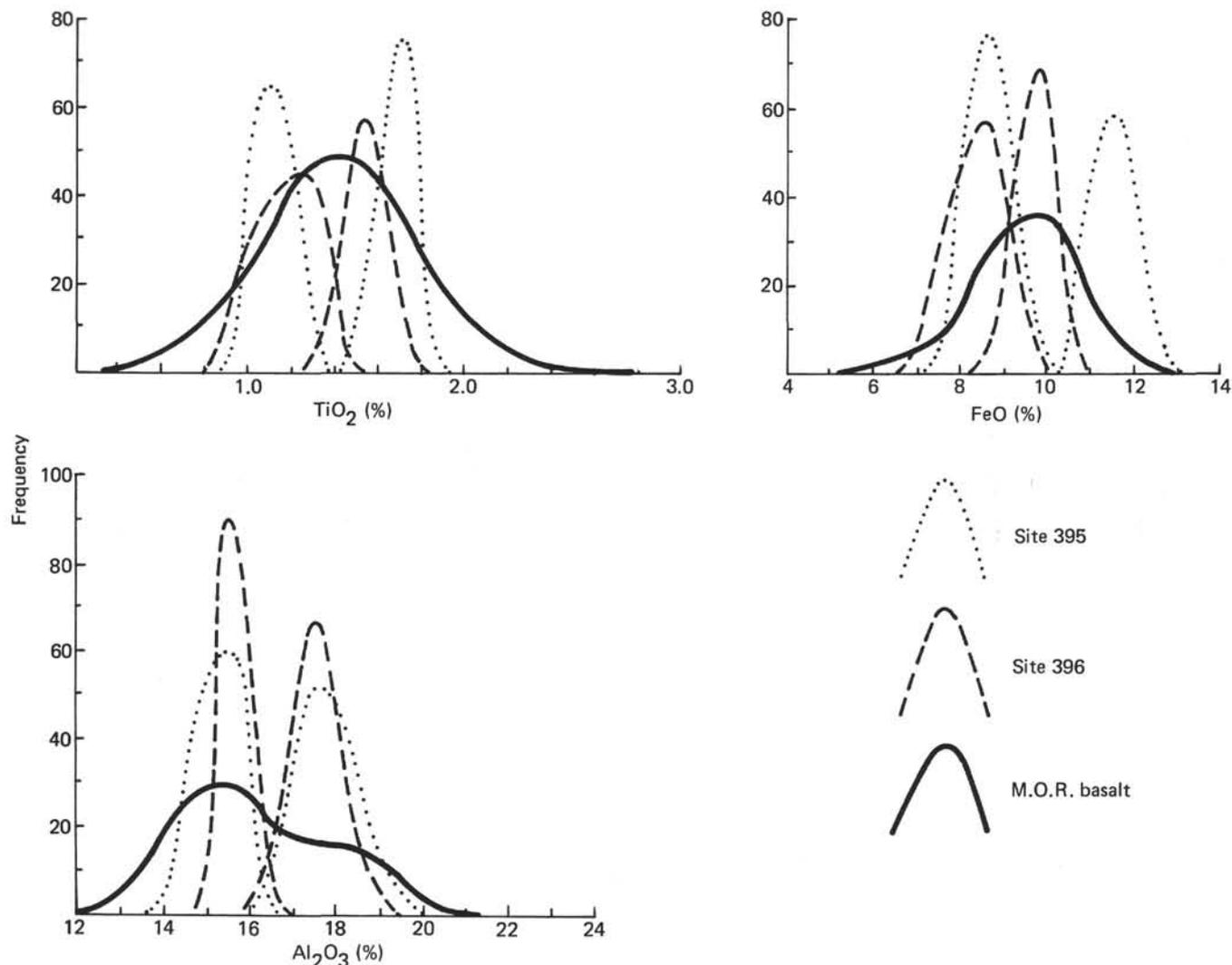


Figure 1. TiO_2 , (FeO) , and Al_2O_3 histograms for basalts from Sites 395 and 396 and for mid-oceanic ridge basalts (Dmitriev et al., 1976). $(FeO) = 0.9 \cdot Fe_2O_3 + FeO$.

derived from lherzolitic mantle under the dry condition.

2) The crystallization of this melt began with the temperature falling to about $1230^\circ C$. Plagioclase, olivine, and clinopyroxene crystallized at approximately 25 km depth. Rising of the melt up to 20 km was accompanied by clinopyroxene dissolution. Only plagioclase and olivine crystallized above 20 km depth.

3) The phenocryst paragenesis in the porphyritic basalts, Ol + Pl, or Ol + Pl + Cpx from Site 395, and Ol + Pl from Site 396, and also the relatively stable Ol/Pl ratio of about 1:6 indicates that parental melt was close to eutectic under 6-8 kbar pressure.

4) The formation of the porphyritic and aphyric basalts is due to gravity separation of the cooling parental melt into two parts in a magma body. The upper part is enriched in suspended plagioclase phenocrysts. Some amount of small crystals of olivine are also preserved in the upper zone. The crystallization of the phenocrysts leads to a change of the residual melt composition towards more basic composition. This process requires a considerable vertical dimension of

the magma chamber and a stable tectonic condition during separation.

5) The basaltic complex consisting of interlayered porphyritic and aphyric lavas forms as the result of eruptions from the different levels of the magma chamber. The eruption can be accompanied by crystallization of additional phases and dissolution of another owing to the change of pressure and temperature. The scale of this change depends upon the rate at which the magma rises.

ACKNOWLEDGMENT

We thank A.V. Sobolev, A.I. Sharaskin, N.M. Sushchevskaya, and A.V. Garanin for discussion and assistance.

REFERENCES

- Bougault, H., in press. X-ray fraction analyses of the basalts. In Melson, W.G., Rabinowitz, P.D., et al., *Initial Reports of the Deep Sea Drilling Project*, v. 45: Washington (U.S. Government Printing Office).

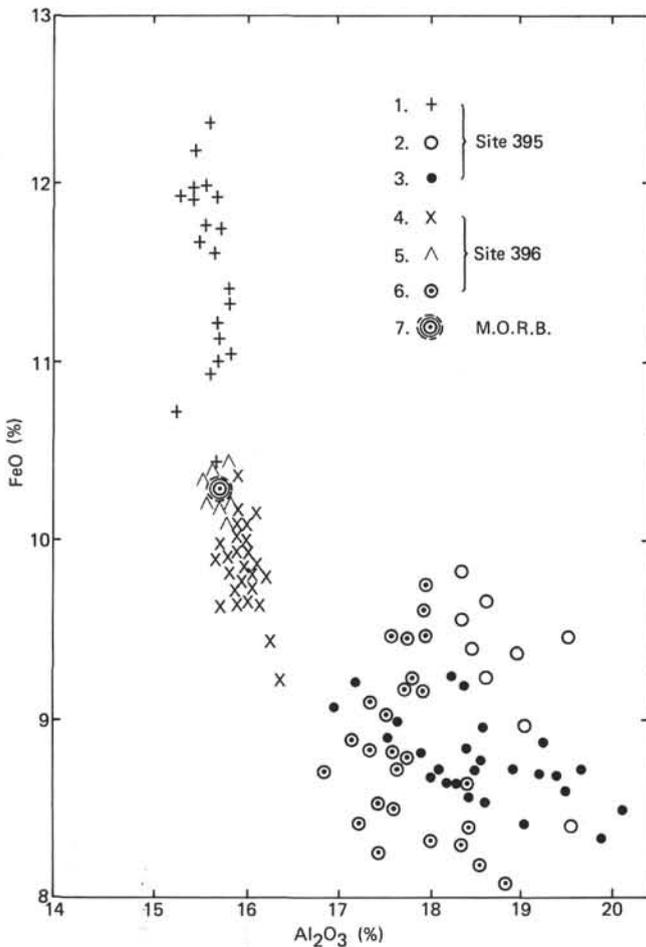


Figure 2. $Al_2O_3 - (FeO)$ diagram for basalts from Sites 395 and 396. Site 395: (1) aphyric basalt, 111 to 173 meters; (2) P1-01-phyric basalt, 181 to 210 meters; (3) P1-01-Cpx-phyric basalt, 210 to 362 meters; Site 396: (4) aphyric basalt, 150 to 235 meters; (5) dolerite, 235 to 245 meters; (6) P1-01-phyric basalt, 245 to 315 meters; (7) average oceanic tholeiite (Dmitriev, et al., 1976).

Dmitriev, L.V., 1972. Major elements chemistry of the solid rocks from mid-Indian Ocean Ridge and their geochemistry and petrology. *Investigation on the problem of the rift zones of the world ocean*, v. 1, Moscow (NAUKA), p. 115-145.

_____, 1974. Petrochemical study of the basaltic basement of the mid-Indian Ocean Ridge. In Fisher, R.L., Bunce, E.T., et al., *Initial Reports of the Deep Sea Drilling Project*, v. 24: Washington (U.S. Government Printing Office), p. 767-779.

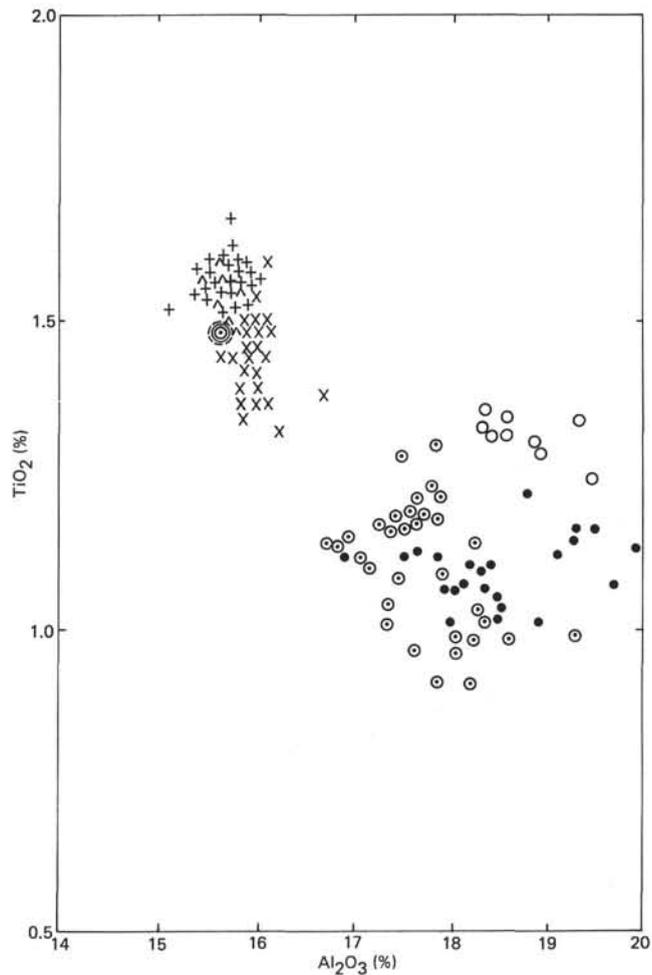


Figure 3. $Al_2O_3 - TiO_2$ diagram for basalts from Sites 395 and 396. Symbols as in Figure 2.

Dmitriev, L.V., Sharaskin, A.J., and Garanin, A.V., 1976. The main features of the ocean bottom magmatism, *Petrological Problems*: Moscow (NAUKA), p. 173-189.

Kushiro, I. and Thompson, R.N., 1972. Origin of some abyssal tholeiites from the mid-Atlantic Ridge. *Carnegie Inst. Year Book No. 71. Annual Report of the Director Geophys. Lab.* p. 403-406.

Miyashiro, A., Shido, F. and Ewing, M., 1969. Diversity and origin of abyssal tholeiite from the mid-Atlantic Ridge near 24° and 30° north latitude, *Contrib. Mineral. Petrol.*, v. 23, p. 38-52.

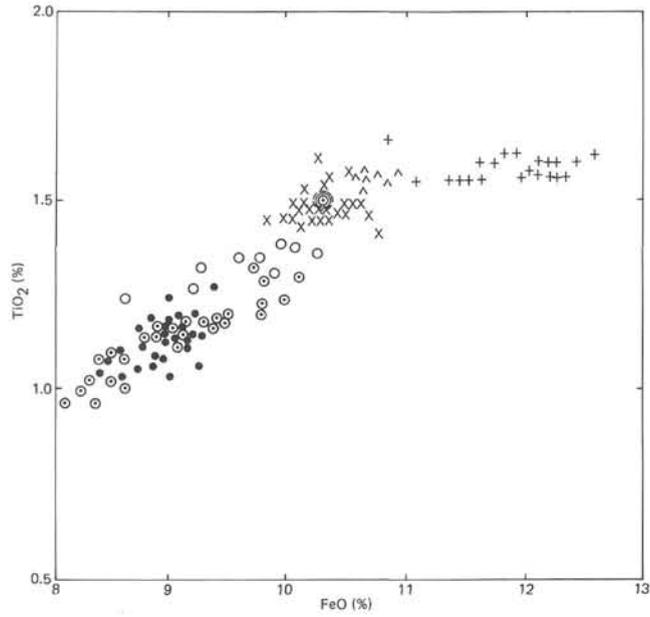


Figure 4. $(FeO) = TiO_2$ diagram for basalts from Sites 395 and 396. Symbols as in Figure 2.

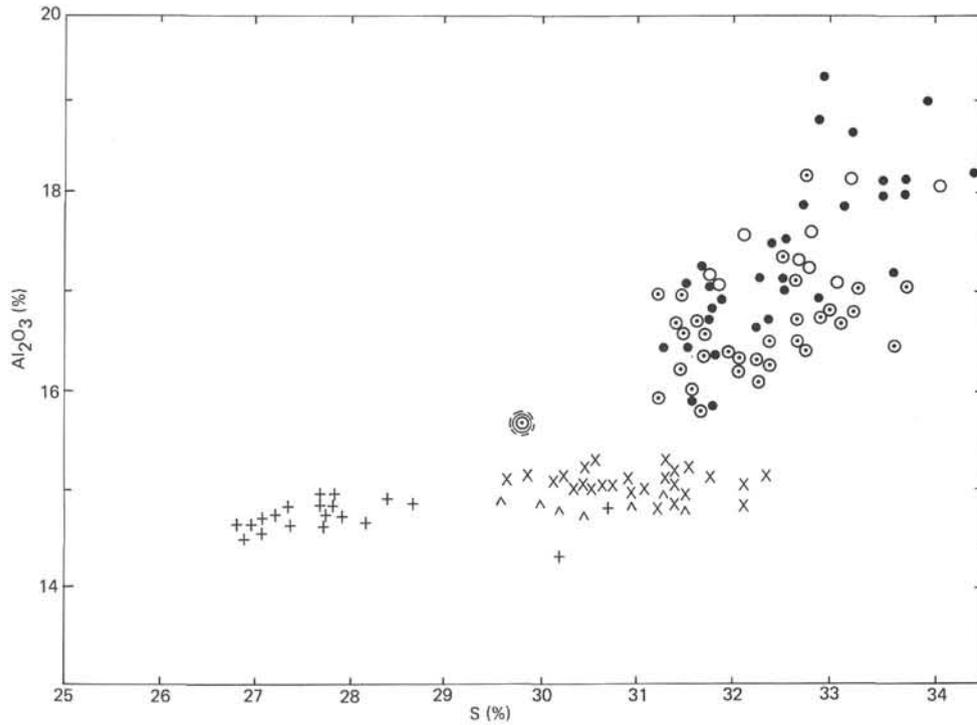


Figure 5. $S = Al_2O_3$ diagram for basalts from Sites 395 and 396. $S = SiO_2 - [(FeO) + MgO + TiO_2 + MnO]$ weight %. Symbols as in Figure 2.

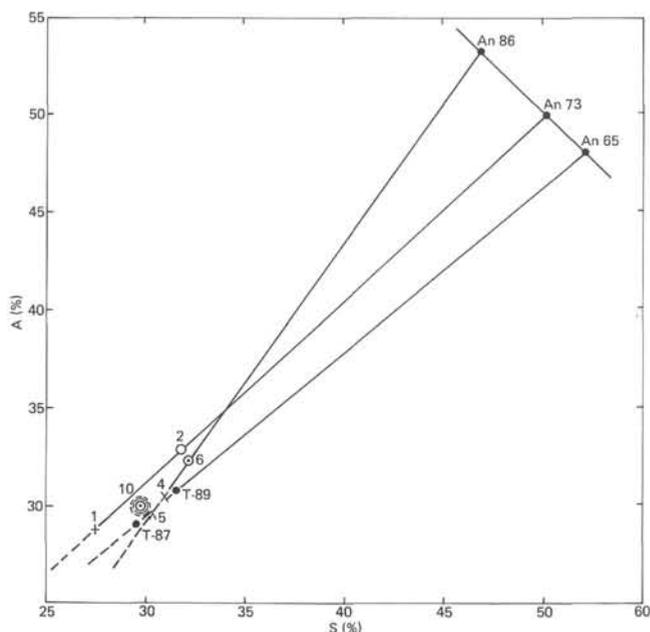


Figure 6. Variation lines for basalts from Sites 395 and 396 and for Ol- and Pl-tholeiites by Miyashiro, et al. (1969) in A-S coordinates. $A = Al_2O_3 + CaO + Na_2O + K_2O$; $S = SiO_2 - [(FeO) + MgO + TiO_2 + MnO]$ weight %. Point numbers correspond to column numbers in Table 3. Symbols as in Figure 2. See text for explanation.

TABLE 3
Comparison of the Average and Calculated Compositions of Aphyric and Porphyritic Basalts From Sites 395 and 396 (weight %)

	1	2	3	4	5	6	7	8	T-89	9	T-87	2-2
SiO ₂	49.36	49.49	49.50	50.18	50.43	49.95	49.90	50.03	49.89	49.88	49.68	49.9
TiO ₂	1.62	1.11	1.20	1.52	1.63	1.13	1.39	1.45	1.35	1.42	1.55	1.5
Al ₂ O ₃	15.03	17.74	17.85	15.56	15.29	17.44	17.16	17.32	16.70	16.73	15.49	15.6
Fe ₂ O ₃	5.29	3.92	4.08	4.50	3.35	4.45	4.14	2.99	1.55	0.84	0.92	2.4
FeO	6.48	4.80	5.00	5.50	7.11	4.31	5.03	6.35	7.75	7.58	8.25	8.1
MnO	0.19	0.20	0.20	0.17	0.17	0.19	0.17	0.17	0.19	0.18	0.18	0.2
MgO	8.39	7.68	7.36	7.71	7.84	7.68	7.10	7.00	7.44	8.42	9.17	7.9
CaO	10.80	12.46	12.14	11.73	11.16	12.38	12.23	11.82	10.90	10.81	10.61	11.4
Na ₂ O	2.68	2.48	2.53	2.86	2.82	2.25	2.63	2.69	3.01	2.98	2.88	2.7
K ₂ O	0.16	0.12	0.13	0.27	0.20	0.22	0.25	0.18	0.23	0.10	0.11	0.2
(FeO)	11.24	8.33	8.67	9.55	10.13	8.32	8.76	9.04	9.14	8.61	9.08	10.3
(FeO)+MgO	19.63	16.01	16.03	17.26	17.97	16.00	15.86	16.04	16.59	17.03	18.25	18.2

Note: 1. Aphyric basalt, Hole 395A, depth interval 117 to 173 meters, 20 analyses. 2. Porphyritic basalt, Hole 395A, 210 to 362 meters, 28 analyses. 3. Calculated composition for porphyritic basalt: composition (1) + 19% An₁₃ wt %. 4. Aphyric basalt, Hole 396B, 150 to 235 meters, 26 analyses. 5. Dolerites, Hole 396B, cooling unit from 235 to 245 meters, 7 analyses. 6. Porphyritic basalt, Hole 396B, 245 to 315 meters, 32 analyses. 7. Calculated composition for porphyritic basalt: composition (4) + 9% An₈₆ wt %. 8. Calculated composition for porphyritic basalt: composition (5) + 12% An₈₆ wt %. 9. Calculated composition for Pl-tholeiite: T-87 + 9% An₆₅ wt %. 10. Average Mid-Oceanic-Ridge tholeiite, 200 analyses (Dmitriev et al., 1976). T-89. Plagioclase-tholeiite (Miyashiro et al., 1969). T-87. Olivine-tholeiite.

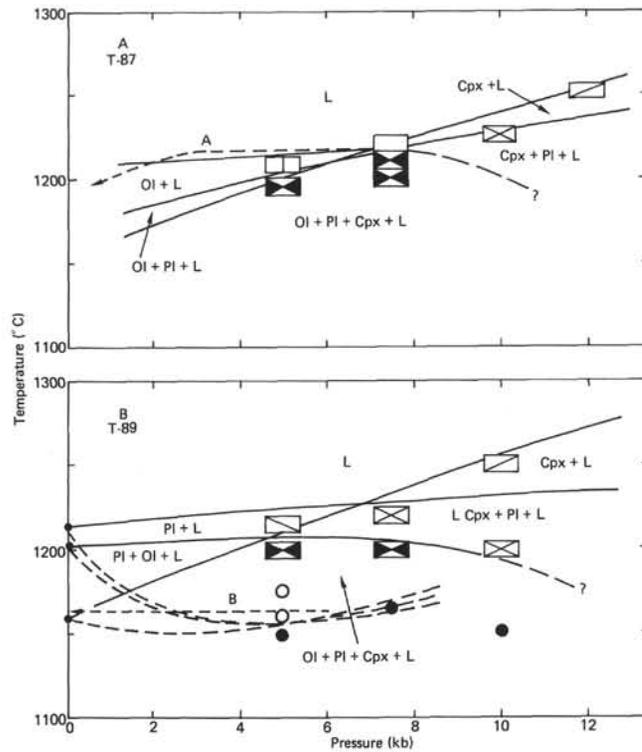


Figure 7. Results of experiments on abyssal tholeiites of (A) Ol-tholeiite (T-87) and (B) Pl-tholeiite (T-89). Circles indicate the runs made with 1.5 to 2.3 wt. % H_2O (open circles, glass; solid circles, crystals and glass). Abbreviations; Cpx, Ca-rich clinopyroxene; L, liquid; Pl, plagioclase; Ol, olivine. Dashed lines A and B are possible ascending paths of magmas of the Ol and Pl tholeiites respectively. The field for Ca-poor pyroxene crystallization in (A) has not been determined. (After Kushiro and Thompson, 1972).

TABLE 4
Temperature of the Glass
Microinclusions Homogenization
in Plagioclase Phenocrysts of
Porphyritic Basalts From Site 396

Sample (Core-Section, Piece no.)	T° C
16-5 #7	1240 ± 10
17-1 #7b	1250 ± 10
17-3 #1	1250 ± 10
17-4 #9	1240 ± 10
18-2 #1c	1220 ± 10
20-3 #2	1250 ± 10
20-5 #11a	1250 ± 10
21-1 #7	1250 ± 10
22-1 #4	1240 ± 10
22-2 #4	1250 ± 10
22-3 #1a	1240 ± 10

Note: Temperature is determined by a quenching method. Produced by V. E. Karpuchin, Vernadsky Institute of Geochemistry, USSR Academy of Sciences.