

33. PETROLOGY AND ORIGIN OF BASALTS OF THE MIDDLE AMERICA TRENCH, SOUTHERN MEXICO TRANSECT¹

Y. I. Dmitriev, Institute of Geology and Ore Deposits, Petrology, Mineralogy and Geochemistry, USSR Academy of Sciences, Moscow, USSR

INTRODUCTION

The volcanism of Central America, according to current theory (Pichler and Weyl, 1973; Stoiber and Carr, 1974; Hey, 1977), is related to the subduction of the Cocos Plate under the North American lithospheric plate and the melting of ocean crust material in the subduction zone (Green and Ringwood, 1968; Dickinson, 1970, Fitton, 1971).

Since Cocos Plate subduction occurs at the rate of more than 7 cm/y. (Hey et al., 1977), basalts underlying upper Miocene sediments of the Middle America Trench outer slope, penetrated in Hole 487 (Fig. 1) during Leg 66 (Moore et al., 1979), should have formed far from their present position if current theory is accurate.

Present manifestations of basaltic magmatism in adjacent areas of the Pacific derive from the axial part of the East Pacific Rise, the Galapagos spreading center, and transform fracture zones.

The question arises: Are there analogs of the Middle America Trench basalts among magmatic rock associated with these modern features, or do the trench basalts have some other origin?

HOLE 487 BASALTS

To answer this question, let us compare the petrological data of Hole 487 basalts, samples of which were provided by the Deep Sea Drilling Project repository at Scripps Institution of Oceanography, with my own and other scientists' published material on magmatic basic rocks of different structural elements in the Pacific segment of the Earth's crust.

Hole 487 was drilled 11 km from the axis of the Middle America Trench zone, at 15°51.21'N, 99°10.52'W and at a water depth of 4764 meters. They reached basalt at 172 meters sub-bottom, under a layer of hemipelagic gray green mud and pelagic brown clay. I studied Samples 487-20-1, 172–173.5 m and 487-20-2, 173.5–181.5 m.

Based on their petrographic and petrochemical characteristics, I subdivide Hole 487 basalts into two groups, olivine-plagioclase phyric and aphyric basalts (Samples 487-20-1, 2–9 cm, 29–32 cm, 73–78 cm; 487-20-2, 62–64 cm, 80–84 cm) and plagioclase phyric basalts (Samples 487-20-1, 15–19 cm, 113–115 cm; 487-20-2, 34–36 cm).

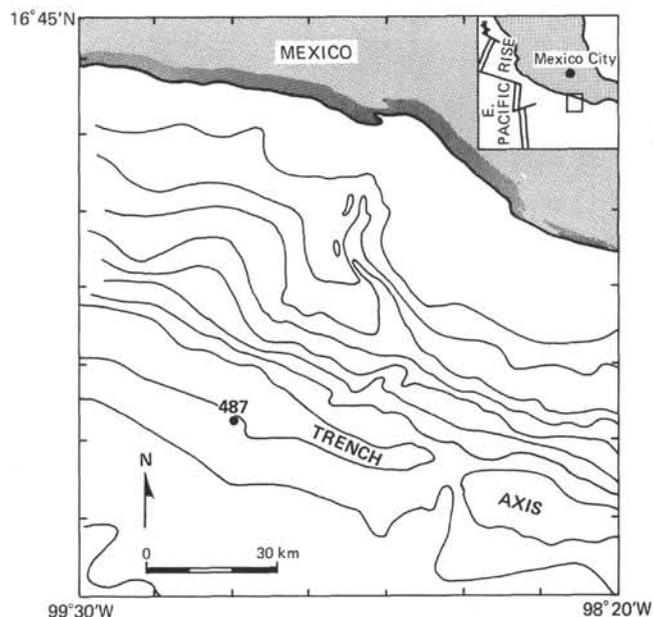


Figure 1. Location map for Hole 487.

Rocks of both groups, according to the ratio $\text{Na}_2\text{O} + \text{K}_2\text{O}/\text{SiO}_2$, derive from tholeiitic basalt magma.

Olivine-plagioclase phyric and aphyric basalts as well as plagioclase phyric basalts have a fine-grained groundmass consisting of a cryptocrystalline matrix, grains of plagioclase, clinopyroxene, olivine, titanomagnetite, spinel, and patches of such secondary minerals as calcite and smectite (Table 1).

The main mineralogical differences between the rocks studied are type and content of phenocrysts. Olivine-plagioclase phyric basalts contain as much as 11 to 12% plagioclase phenocrysts and olivine. Plagioclase phyric basalts contain only 2 to 3% plagioclase phenocrysts. Although aphyric basalts have no phenocrysts, or contain only a few grains, they are considered together with olivine-plagioclase phyric basalts because of their virtual identity in chemical composition.

The texture of the groundmass of basalts is mainly microplitic and pilotaxitic.

The comparison of rock-forming mineral compositions of olivine-plagioclase phyric and plagioclase phyric basalts (Tables 2–6) shows that plagioclase phyric basalts have more calcic plagioclase in the groundmass, somewhat more ferruginous clinopyroxene, clearly more ferruginous olivine, titanomagnetite with higher TiO_2

¹ Initial Reports of the Deep Sea Drilling Project, Volume 66.

Table 1. Modal composition of basalts, Hole 487 (vol. %).

Sample (interval in cm)	Olivine-Plagioclase Phyric and Aphyric Basalts							Plagioclase Phyric Basalts				
	487-20-1 2-9	487-20-1 29-32	487-20-1 ^a 45-49	487-20-1 73-78	487-20-2 50-56	487-20-2 62-64	487-20-2 80-84	Average of 7	487-20-1 15-19	487-20-1 113-115	487-20-2 34-36	Average of 3
Phenocrysts:												
plagioclase	4.5	2.9	—	1.8	1.7	4.7	11.6	3.9	2.3	1.6	0.6	1.5
olivine	2.3	0.9	—	0.7	r.g.	1.2	r.g.	0.4	—	—	—	—
spinel	r.g.	—	—	—	r.g.	—	—	r.g.	0.2	r.g.	—	0.1
Groundmass:												
plagioclase	40.4	39.4	37.9	34.7	28.3	26.6	31.5	34.1	34.7	44.6	26.0	35.1
clinopyroxene	49.6	3.3	2.8	3.2	63.1	3.4	2.5	22.6	2.1	50.0	4.1	18.7
olivine	—	—	—	—	0.4	—	—	0.1	—	—	—	—
titanomagnetite	3.1	in matrix		—	1.0	in matrix		0.6	in matrix		in matrix	
secondary minerals	1.8	—	—	—	5.5	—	—	1.0	—	—	—	—
matrix	—	53.5	59.3	59.6	—	34.1	54.4	37.4	60.7	3.8	69.3	44.6

Note: r.g. = rare grains.

^a Aphyric basalt.

Table 2. Plagioclase in basalts, Hole 487.

	Olivine-Plagioclase Phyric Basalts Sample 487-20-2, 50-56 cm			Plagioclase Phyric Basalts Sample 487-20-1, 113-115 cm	
	Phenocryst		Lath in Groundmass	Phenocryst	Lath in Groundmass
	Core	Fringe			
SiO ₂	49.4	47.1	49.6	45.2	47.8
TiO ₂	—	—	—	—	0.1
Al ₂ O ₃	33.9	32.8	30.3	36.2	34.3
FeO	0.38	0.34	0.64	0.35	1.5
MgO	0.17	0.28	0.36	0.25	0.12
CaO	18.0	17.5	15.4	17.1	16.1
Na ₂ O	1.1	1.7	2.4	1.5	2.2
Total	99.95	99.72	98.7	100.6	102.12
Cations on 8 Oxygen					
Si	2.138	2.175	2.298	2.068	2.158
Ti	—	—	—	—	0.004
Al	1.841	1.785	1.655	2.062	1.825
Fe	0.014	0.013	0.025	0.013	0.057
Mg	0.001	0.019	0.025	0.017	0.008
Ca	0.889	0.866	0.681	0.838	0.778
Na	0.098	0.152	0.215	0.133	0.193
% Ab	9.8	14.5	22.7	13.3	18.6
% An	90.2	85.5	77.3	86.7	81.4
Name	anorthite	bitownite	bitownite	bitownite	bitownite

Note: Chemical compositions of rock-forming minerals in basalts in Hole 487 were determined on an electron microprobe by G. N. Muravitskaya of the Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry of the USSR Academy of Sciences.

content, and spinel with relatively low Mg and Cr content.

As a whole, except for a higher anorthite content in the plagioclase groundmass, these data suggest a more differentiated character for plagioclase phyric basalts in relation to olivine-plagioclase phyric and aphyric basalts.

Other evidence for greater differentiation of the plagioclase phyric basalts is iron enrichment. The (FeO*/FeO* + MgO)/ × 100 ratio (FeO* is total Fe as FeO) in these rocks averages 51.1, whereas in olivine-plagioclase phyric basalts the mean value of this coefficient is 50.8. The main distinction of plagioclase phyric basalts, however, lies in the significantly higher Al₂O₃ content, which exceeds 17%; that is, plagioclase-phyric basalts are high-alumina rocks (Table 7). The high-alumina

Table 3. Clinopyroxenes in basalts, Hole 487.

	Olivine- Plagioclase Phyric Basalts Sample 487-20-2, 50-56 cm		Plagioclase Phyric Basalts Sample 487-20-1, 113-115 cm	
	SiO ₂	49.7	50.7	53.4
TiO ₂	0.83	0.85	1.0	1.0
Al ₂ O ₃	3.3	4.8	3.7	3.3
FeO	11.5	8.6	11.7	14.5
MnO	0.19	0.25	0.11	0.31
MgO	14.7	14.7	13.3	15.1
CaO	20.1	20.0	18.3	13.3
Na ₂ O	—	—	0.7	0.3
Total	100.32	99.9	102.21	99.11
Cations on 6 Oxygen				
Si	2.125	1.879	1.944	1.932
Ti	0.027	0.024	0.027	0.028
Al	0.166	0.210	0.159	0.147
Fe	0.411	0.266	0.356	0.456
Mn	0.007	0.008	0.003	0.010
Mg	0.937	0.812	0.721	0.847
Ca	0.921	0.794	0.714	0.536
Na	—	—	0.049	0.022
% En	37.9	42.6	36.5	42.8
% Wo	37.4	41.7	38.7	28.2
% Fs	24.6	15.7	24.8	29.0
Name	augite	augite	augite	augite

character of plagioclase phyric basalts is also evident in the chemistry of rock-forming minerals. A higher Al₂O₃ content is typical not only for feldspar of plagioclase phyric basalts but also for spinel, titanomagnetite, and even for olivine.

From a chemical viewpoint, aphyric basalts are very similar to olivine-plagioclase phyric basalts, and what differences there are are in keeping with the mineralogical composition of the rocks and their position in cross section. For example, the lower CaO content in aphyric basalts as compared with olivine-plagioclase phyric basalts reflects the absence of plagioclase phenocrysts enriched with anorthite in the former. Aphyric basalts are also distinctive because of their higher MgO and Cr₂O₃

Table 4. Olivines in basalts, Hole 487.

	Olivine-Plagioclase Phyrice Basalts Sample 487-20-2, 50-56 cm		Plagioclase Phyrice Basalts Sample 487-20-1 113-115 cm
	Fringe	Core	
	SiO ₂	40.6	40.8
TiO ₂	—	—	0.11
Al ₂ O ₃	—	—	1.9
FeO	10.4	10.4	15.7
MnO	0.12	0.13	0.21
MgO	47.8	48.2	41.8
CaO	0.46	0.41	1.7
NiO	0.14	0.22	—
Total	99.52	100.16	99.73
Cations on 4 Oxygen			
Si	1.003	1.002	0.973
Ti	—	—	0.002
Al	—	—	0.057
Fe	0.215	0.213	0.333
Mn	0.002	0.003	0.005
Mg	1.761	1.764	1.581
Ca	0.012	0.011	0.046
Ni	0.003	0.004	—
% Fo	88.5	88.6	79.0
% Fa	11.5	11.4	21.0
Name	chrysolite		chrysolite

Table 5. Titanomagnetite in basalts, Hole 487.

	Olivine-Plagioclase Phyrice Basalts Sample 487-20-2, 50-56 cm			Plagioclase Phyrice Basalts Sample 487-20-1, 113-115 cm	
	SiO ₂	1.3	1.8	2.3	9.8
TiO ₂	16.3	16.1	16.1	17.5	17.5
Al ₂ O ₃	2.4	3.2	3.3	4.0	6.1
FeO	73.0	72.7	73.0	59.5	57.0
MnO	0.43	0.43	0.51	0.51	0.6
MgO	2.0	1.3	1.2	1.4	0.9
CaO	0.36	0.42	0.48	1.8	2.1
V ₂ O ₅	0.44	0.47	0.42	n.d.	n.d.
Total	96.11	96.88	97.63	94.51	93.4

Note: The determination of the unit cell dimension of magnetic ore mineral from Sample 487-20-1, 113-115 cm, performed by M. T. Dmitrieva, Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry of the USSR Academy of Sciences, shows that according to the value of this parameter, $a = 8.405 \pm 0.005 \text{ \AA}$, the mineral is almost pure magnetite ($a = 8.395\text{--}8.40 \text{ \AA}$).

content and their lower degree of iron oxidation. A genetic relation between aphyric, olivine-plagioclase phyrice, and plagioclase phyrice basalts is revealed by the relationship between their mineral and chemical composition and their position in the cross section of the hole (Fig. 2), though the latter may be significantly distorted

by displacement during drilling. In somewhat generalized form, the distribution of these varieties of basalt in the lower part of Hole 487 is as follows:

Core 20, Section 1	Depth from the Top of the Section (cm)
olivine-plagioclase phyrice basalt	0-15
plagioclase phyrice basalt	15-23
olivine-plagioclase phyrice and aphyric basalts	23-72
olivine-plagioclase phyrice basalt	72-110
plagioclase phyrice basalt	110-122
drilling breccia	122-150
Core 20, Section 2	
drilling breccia	0-26
plagioclase phyrice basalt	26-45
olivine-plagioclase phyrice basalt	45-90

The relationship between aphyric, plagioclase phyrice, and olivine-plagioclase phyrice basalts is clearest in the upper part of Core 20, Section 1, from 0 to 72 cm.

In this series (also bottom to top) one can see (1) an increase in phenocryst and CaO content, (2) enrichment of rocks in iron $[(\text{Fe}^*/\text{FeO}^* + \text{MgO}) \times 100]$, and (3) increase in the degree of iron oxidization in basalts $[(\text{Fe}_2\text{O}_3/\text{Fe}_2\text{O}_3 + \text{FeO}) \times 100]$.

It is possible that the variations of mineral and chemical composition are related to the differentiation processes inside the lava flow, or sheet. Flotation of plagioclase crystals and their accumulation in the upper parts of basaltic bodies have been discussed with relation to drilling in the Philippine Sea (Dmitriev et al., 1979).

The increased value of the ferruginity (fractionation) coefficient $[(\text{FeO}^*/\text{FeO}^* + \text{MgO}) \times 100]$ in the upper parts of differentiated basaltic bodies is a well-known

Table 6. Spinels in basalts, Hole 487.

	Olivine-Plagioclase Phyrice Basalts Sample 487-20-2, 50-56 cm	Plagioclase Phyrice Basalts Sample 487-20-1, 113-115 cm
SiO ₂	0.6	5.3
TiO ₂	0.37	0.36
Al ₂ O ₃	30.7	34.8
FeO	15.8	15.0
MnO	0.14	—
MgO	17.6	14.4
CaO	0.27	1.2
Cr ₂ O ₃	32.8	30.2
Total	98.28	101.38
Cations on 12 Oxygen		
Si	0.053	0.443
Ti	0.025	0.023
Al	3.222	3.430
Fe	1.176	1.049
Mn	0.011	—
Mg	2.335	1.774
Ca	0.026	0.108
Cr	2.309	1.995
Fe/Fe + Mg	0.335	0.372

Table 7. Chemical composition of basalts, Hole 487 (wt. %).

Sample (interval in cm)	Olivine-Plagioclase Phyric and Aphyric Basalts					Plagioclase Phyric Basalts		
	487-20-1 2-9	487-20-1 45-49	487-20-2 50-56	487-20-2 80-84	Average of 7	487-20-1 15-19	487-20-1 113-115	Average of 2
SiO ₂	47.80	48.60	47.70	47.90	48.0	47.20	48.20	47.7
TiO ₂	0.86	0.93	0.86	0.88	0.88	0.89	0.87	0.88
Al ₂ O ₃	16.47	16.40	16.38	16.70	16.49	18.00	17.10	17.6
Fe ₂ O ₃	4.82	1.33	4.35	2.24	3.19	2.75	3.72	3.24
FeO	3.94	7.35	4.45	7.03	5.69	6.08	5.20	5.64
MnO	0.16	0.13	0.55	0.16	0.25	0.11	0.11	0.11
MgO	6.97	9.23	7.54	9.44	8.30	8.43	7.94	8.19
CaO	13.99	12.78	14.02	12.82	13.40	13.14	12.67	12.91
Na ₂ O	2.21	1.91	2.12	1.87	2.03	1.87	2.08	1.98
K ₂ O	0.19	0.10	0.18	0.074	0.14	0.10	0.10	0.10
H ₂ O ⁻	—	—	—	—	—	—	0.28	0.14
H ₂ O ⁺	2.21	0.98	1.44	0.87	1.38	1.01	1.72	1.37
CO ₂	—	0.15	—	—	0.04	0.39	—	0.28
P ₂ O ₅	—	0.07	—	0.09	0.04	0.03	0.04	0.04
Li ₂ O	n.d.	0.0016	n.d.	0.0013	0.0015	0.0013	0.0057	0.0035
Rb ₂ O	n.d.	0.0013	n.d.	0.0007	0.0010	0.0006	0.0004	0.0005
Cs ₂ O	n.d.	0.0006	n.d.	0.0004	0.0005	0.0004	0.0006	0.0005
F	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03
Cl	0.14	0.03	0.19	0.07	0.11	0.04	0.04	0.04
S	0.02	0.06	0.02	0.06	0.01	0.06	0.02	0.04
Cr ₂ O ₃	0.058	0.06	0.019	0.05	0.05	0.06	n.d.	0.06
V ₂ O ₅	0.046	0.04	0.02	0.01	0.03	0.05	n.d.	0.05
Total	99.90	100.17	99.86	100.27	100.04	100.24	100.29	100.40

Note: Chemical analyses of basalts in Hole 487 were carried out by Y. V. Dolinina, Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry of the USSR Academy of Sciences.
 a Aphyric basalt.

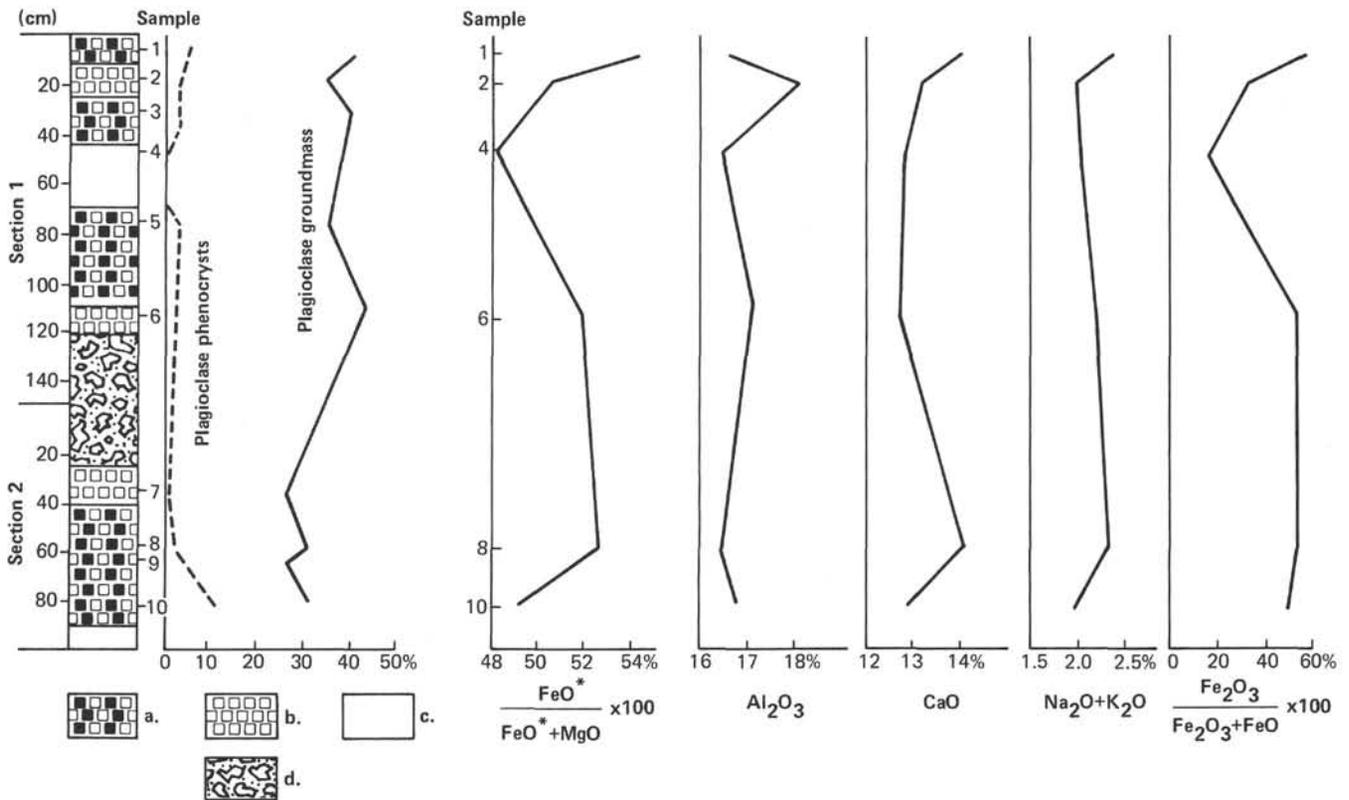


Figure 2. Variations of basalt composition in cross section in Hole 487. (a = olivine-plagioclase phyric basalts, b = plagioclase phyric basalts, c = aphyric basalts, d = basaltic breccia. Samples: 1 = 487-20-1, 2-9 cm; 2 = 487-20-1, 15-19 cm; 3 = 487-20-1, 29-32 cm; 4 = 487-20-1, 45-49 cm; 5 = 487-20-1, 73-78 cm; 6 = 487-20-1, 113-115 cm; 7 = 487-20-2, 34-36 cm; 8 = 487-20-2, 50-56 cm; 9 = 487-20-2, 62-64 cm; 10 = 487-20-2, 80-84 cm.)

fact, as is the enrichment of the same parts of basaltic sheets and sills by volatile components. With regard to the latter, the degree of iron oxidation increases beginning at the horizon of aphyric basalts and there are about 0.6% vesicles (former gas bubbles) in olivine-plagioclase phyric basalt in the top of the cross section. In the lower part of the cross section, plagioclase phyric, olivine-plagioclase phyric, and aphyric basalts contain no such vesicles.

The decrease in quantity of plagioclase phenocrysts and the absence of olivine phenocrysts in plagioclase phyric basalts in the upper part of the presumed basaltic body may be related to the dissolution of phenocrysts due to their disequilibrium with the more differentiated melt of this zone.

On the basis of these data we may conclude that aphyric, olivine-plagioclase phyric, and plagioclase phyric basalts are derivatives of a common tholeiitic melt, differentiated in the body of basaltic flow or sheet after eruption on the seafloor.

The interpretation of the sequence aphyric and olivine-plagioclase phyric basalts, olivine-plagioclase phyric basalts, and plagioclase phyric basalts as a series reflecting differentiation inside the basaltic flow or sheet is contradicted by the thickness (less than 1 m) of the presumed basaltic body, which should preclude significant differentiation.

In the lower part of the cross section one can also see the sequence (from top to bottom) olivine-plagioclase phyric basalts, plagioclase phyric basalts, and olivine-plagioclase phyric basalts (without aphyric basalts), but the regular variations in rock composition observed in the upper part of the cross section are absent. It is possible that the original relationship between rocks in the lower part of the cross section was disturbed during drilling, when a rather thick (54 cm) layer of basalt that had disintegrated during drilling (Samples 487-20-1, 122-150 cm and 487-20-2, 0-26 cm) was formed.

Thus the data seems to indicate that basalts in Hole 487 comprise at least two lava flows or sheets.

OTHER EASTERN PACIFIC OCEAN FLOOR BASALTS

To explain the genesis of basalts exposed in Hole 487, on the seaward side of the Middle America Trench, let us compare data about their composition with similar materials about basalts of other morphostructures in the Eastern Pacific.

Let us begin with a comparison between rock associations in the Middle America Trench, which consists of normal and high-alumina basalts, and those of tholeiitic basalts of different morphostructures in the Pacific; I omit consideration of basaltic series in ocean islands with an alkaline affinity.

In the Galapagos spreading center, according to my material on Holes 424 and 425 of Leg 54 (Dmitriev, in press) and the data of other investigators (Anderson et al., 1975; Rudnik, 1976; Yeats et al., 1973), the following rocks in the tholeiitic series occur: high-alumina basalts, normal basalts, Fe-basalts. There are also alkalic

basalts on seamounts in the Galapagos zone of spreading.

In the Siqueiros transform fracture zone, according to my study of samples from Hole 427, Leg 54 (Dmitriev, in press) and to other data (Batiza et al., 1977), there are high-alumina, normal, and Fe-basalts of tholeiitic series as well as alkalic basalts.

On the flanks of the East Pacific Rise, according to my investigation (Dmitriev, in press) of Holes 419, 420, 422, and 428, Leg 54, and the results of Leg 16 (Yeats et al., 1973), only normal and Fe-basalts of tholeiitic series occur.

All these findings indicate that no direct correspondence exists between associations of rocks in Hole 487 and the basaltic associations of other morphostructures of adjacent regions of the Pacific. In zones of spreading and zones of transform fractures, basaltic associations are more diverse than in Hole 487, for they comprise along with normal and high-alumina basalts, tholeiitic Fe-basalts and alkalic basalts as well. On the flanks of the East Pacific Rise, on the other hand, high-alumina basalts were not observed; instead normal tholeiitic basalts associate with Fe-basalts.

The peculiarity of the associations of normal and high-alumina basalts in Hole 487 becomes more obvious when we compare their average chemical composition with corresponding data on normal and high-alumina basalts of the Galapagos spreading zone, Siqueiros transform fracture zone, and the western flank of the East Pacific Rise (Table 8).

There is a distinct difference between normal basalts of the Middle America Trench and other morphostructures of the East Pacific. As it is clear from Table 8, normal basalts of the Middle America Trench have significantly lower SiO₂, TiO₂, and Na₂O + K₂O content; a minimum value of (FeO*/FeO* + MgO) × 100; and higher concentrations of Al₂O₃ and CaO than normal tholeiitic basalts from other morphostructures.

Table 8. Average composition of normal and high-alumina tholeiitic basalts of the Middle America Trench, Hole 487, and other morphostructures of the East Pacific.

Components	Normal Basalts				High-Alumina Basalts		
	1	2	3	4	5	6	7
SiO ₂	49.78	49.51	49.52	48.0	47.67	49.20	47.7
TiO ₂	1.31	1.30	1.49	0.88	0.65	0.88	0.88
Al ₂ O ₃	15.77	14.83	14.76	16.49	18.44	17.7	17.6
Fe ₂ O ₃	9.70	2.17	10.39	3.19	2.08	1.09	3.24
FeO		7.55		5.69	5.83	6.75	5.64
MnO	0.16	0.17		0.25	0.13	0.14	0.11
MgO	7.33	8.69	7.71	8.30	9.61	8.84	8.19
CaO	12.33	12.25	11.81	13.30	12.64	12.57	12.91
Na ₂ O	2.62	3.00	2.46	2.03	2.12	2.47	1.98
K ₂ O	0.19	0.12	0.19	0.14	0.11	0.05	0.10
H ₂ O			1.24	1.38	0.32		1.37
P ₂ O ₅	0.12	0.16	0.15	0.04	0.07	0.10	
Total	99.31	99.75	99.72	99.79	99.63	99.79	
FeO*/(FeO* + MgO) × 100	57.0	52.1	60.0	50.8	44.6	46.75	51.1

Note: 1, 5—Galapagos spreading zone: 1—average of 19 analyses; 5—average of 4 analyses (on the basis of analyses from Anderson et al., 1975; Dmitriev, in press, analyst, Y. V. Dolinina; Rudnik, 1976; Yeats et al., 1973). 2, 6—Siqueiros Zone of transform fracture: 2—average of 17 analyses; 6—average of 2 analyses (on the basis of analyses from Batiza et al., 1977). 3—Western flank of the East Pacific Rise (9°-11°N, 105°-150°W): average of 16 analyses (on the basis of analyses from Dmitriev, in press, analyst, Y. V. Dolinina; Yeats et al., 1973). 4, 7—Middle America Trench, Hole 487: 4—average of 4 analyses; 7—average of 2 analyses.

The difference between high-alumina trench basalts and basalts of the same type from other ocean morphostructures is less distinct. High-alumina basalts of the Middle America Trench, like the normal basalts of this morphostructure, have a higher CaO and a lower $\text{Na}_2\text{O} + \text{K}_2\text{O}$ content, than high-alumina basalts of spreading zone, transform fault or flanks of the mid-oceanic ridge, but the main difference is a significantly higher $(\text{FeO}^*/\text{FeO}^* + \text{MgO}) \times 100$ value in trench basalts.

All these data on the chemistry of Middle America Trench basalts support the conclusion that these rocks are not entirely identical to rocks of the same kind in spreading zones, transform faults, and on the flank of the mid-oceanic ridge. Thus the question arises: Is it possible that Middle America Trench basalts originate in the formation of trench—that is, that they erupted locally rather than being brought into the trench zone mechanically by the movement of the lithospheric plates?

If this is the case, we expect that the composition of trench basalts will possess characteristics related to the specific geodynamic conditions of magmatism in these morphostructures which distinguish areas of oceanic tholeiitic magmatism from zones of island arc calc-alkaline magmatism.

Let us examine the position of Middle America Trench basalts in Hole 487 with regard to the chemical composition of oceanic tholeiitic basalts, including basalts of other deep sea trenches and island arcs of the Pacific. On the $\text{TiO}_2/(\text{FeO}^*/\text{FeO}^* + \text{MgO}) \times 100$ diagram (Fig. 3) one can see that basalts of the Middle America Trench, the Mariana Trench, and the Yap Trench occupy a position between basalts of oceanic spreading zones, zones of transform faults, and slopes of the East Pacific Rise on the one hand and basalts of island arcs on the other hand. It is also obvious from this diagram that whereas high-alumina basalts of zones of spreading and transform faults belong to the most primitive rocks of these morphostructures, high-alumina basalts of deep sea trenches, according to the value of $(\text{FeO}^*/\text{FeO}^* + \text{MgO}) \times 100$, are more differentiated members of the tholeiitic series.

Deep sea trench basalts occupy the same intermediate position on the $\text{Al}_2\text{O}_3/(\text{FeO}^*/\text{FeO}^* + \text{MgO}) \times 100$ diagram (Fig. 4), but whereas on the previous diagram the distinction of trench basalts is the lower TiO_2 content as compared with spreading zone basalts of a similar stage of differentiation, transform fault zones, flanks of the East Pacific Rise, in Figure 4 the distinguishing feature of trench basalts is a higher Al_2O_3 concentration.

CONCLUSIONS

By plotting the chemical analyses of basalts belonging to different morphostructures on the $\text{MgO}/\text{FeO}^*/\text{Na}_2\text{O} + \text{K}_2\text{O}$ diagram (Fig. 5) one can obtain a general notion about the place of normal and high-alumina basalts in deep sea trenches in the basic processes of oceanic tholeiitic magma evolution.

Evidently, the tholeiitic basalts of all Pacific morphostructures form a single trend of evolution in the direc-

tion of iron enrichment, which is typical of the tholeiitic basaltic magma in general.

Normal and high-alumina basalts of the Middle America Trench, as well as of the Yap and Mariana trenches, occupy a transitional position between normal tholeiitic basalts and the point at which iron-rich differentiates (Fe-basalts) begin to dominate.

Points reflecting the chemistry of trench basalts are in the right portion of the diagram, which is evidence of an alkali deficit in these rocks as compared with basalts of other oceanic morphostructures.

It is necessary to note that the high-alumina basalts of island arcs even more advanced in the evolutionary series of oceanic tholeiitic magma than high-alumina basalts of the deep sea trenches. This fact confirms the transitional position of tholeiitic trench basalts between basalts of typical oceanic morphostructures and island arc basalts.

The higher Al_2O_3 content in deep sea trench basalts and in island arc basalts cannot be the result of the common differentiation of tholeiitic basaltic magma, because in the process of differentiation Al_2O_3 content decreases and, accordingly, on the $\text{MgO}/\text{FeO}^*/\text{Na}_2\text{O} + \text{K}_2\text{O}$ diagram the high-alumina basalts of spreading zones and zones of transform faults are in association with the least differentiated rocks with the highest MgO content.

Thus parental melts of deep sea trench basalts, and in an even larger degree island arcs, evidently are derivatives of oceanic tholeiitic magma, which evolved under conditions resulting either in fractionation and accumulation of Al_2O_3 -rich phases in some parts of the magma chamber or in assimilation by magma of the aluminous crust material.

The transitional (to judge by the number of features) chemical composition of normal and high-alumina basalts in Hole 487 from typical ocean basalts to island arc basalts indicates, from my point of view that the basalts in Hole 487 were formed in the transitional zone between the ocean and the island arc volcanic belt of the American Cordilleras—that is, in the Middle America Trench.

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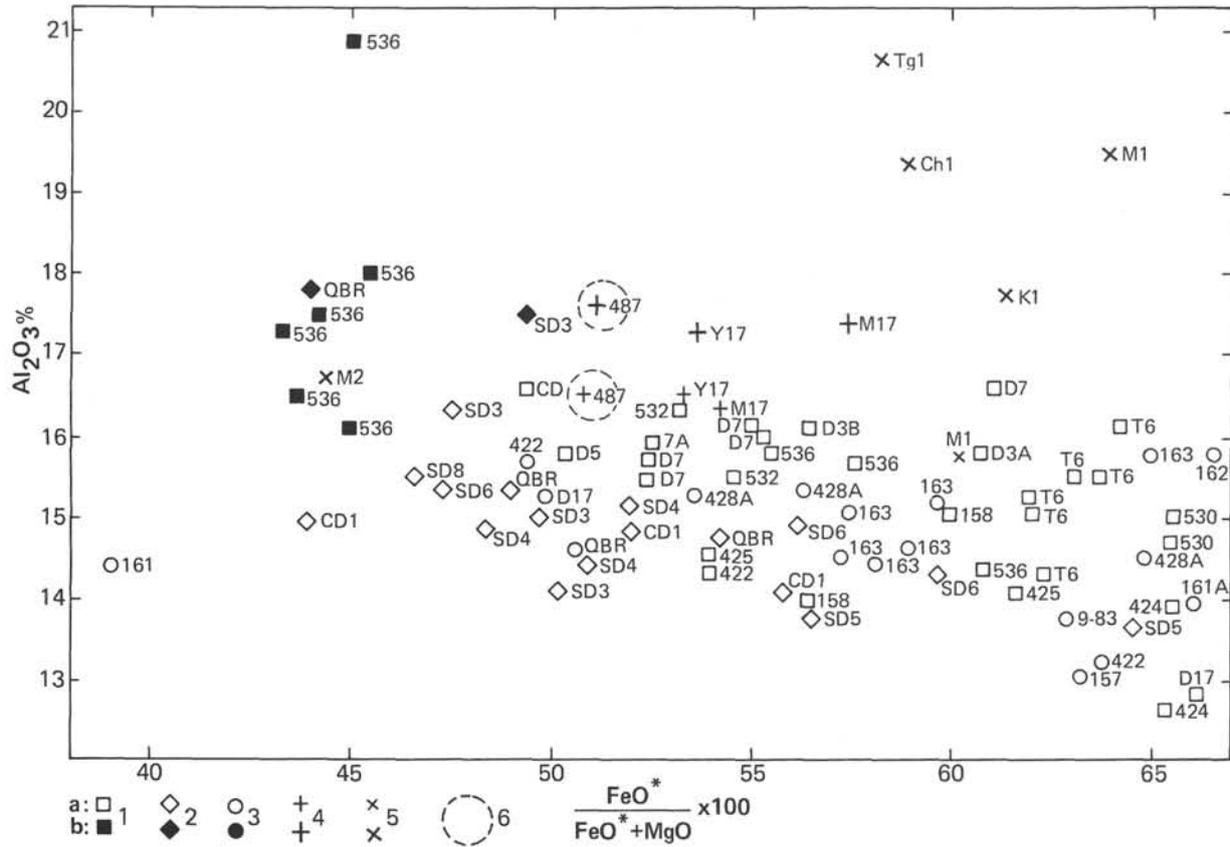


Figure 4. $Al_2O_3 + FeO^*/FeO^* + MgO \times 100$ in Pacific basalts of various morphostructures. (Legend and analyses same as in Fig. 3.)

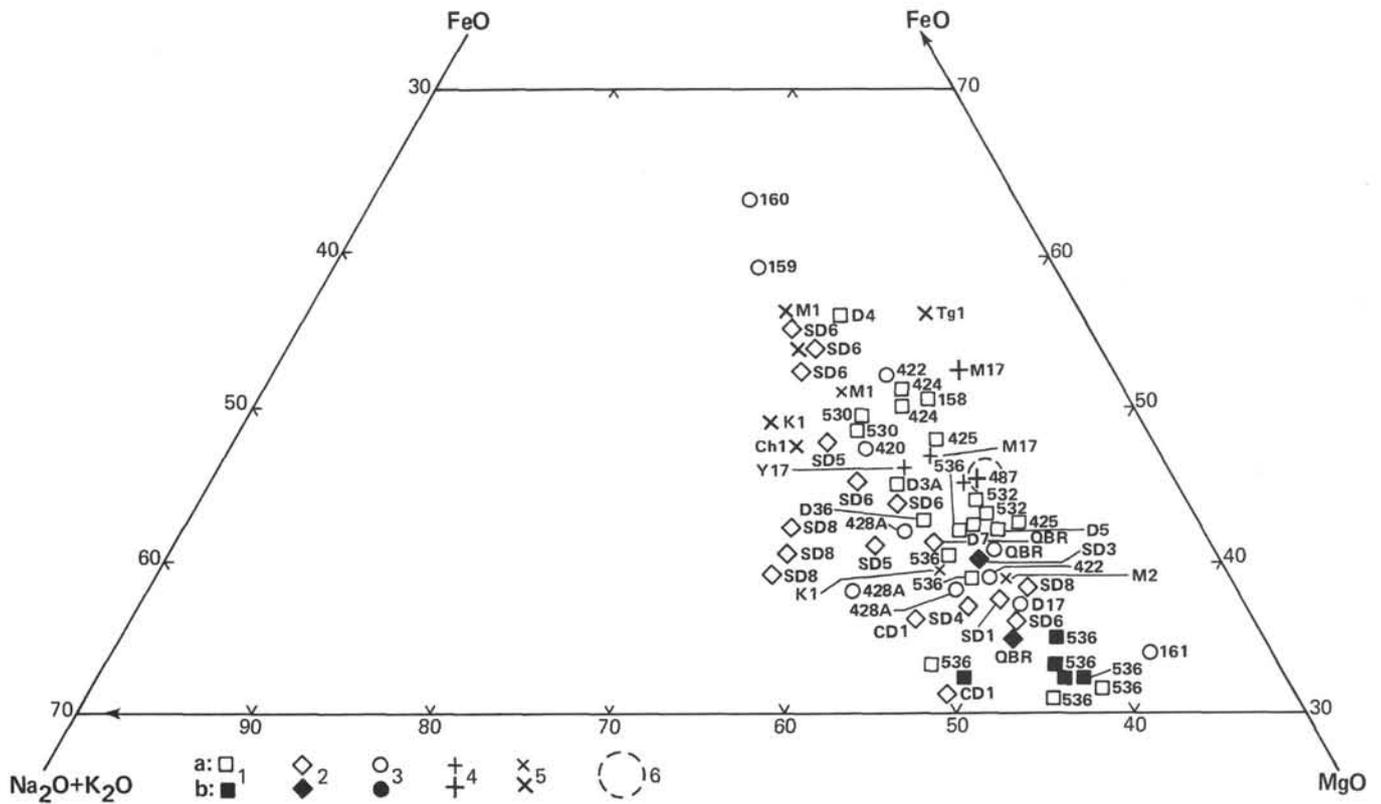


Figure 5. $MgO/FeO^*/Na_2O + K_2O$ in Pacific basalts of various morphostructures. (Legend and analyses same as in Fig. 3.)