21. PETROCHEMISTRY OF BASALTS D/V *GLOMAR CHALLENGER*, LEG 45 HOLES 395, 395A, AND 396

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INTRODUCTION

This paper deals with the chemical composition of basalts recovered in Holes 395, 395A, and 396, during Leg 45 of D.V. *Glomar Challenger*. For this purpose variation diagrams were compiled for the main rock-forming oxides and for some petrochemical coefficients. These diagrams show that several varieties of basalts can be recognized within the two major types of basalt, aphyric and porphyritic, recovered on Leg 45. At the same time significant distinctions between the chemical compositions of aphyric and porphyritic basalts were recorded. These chemical differences are mainly the result of different degrees of melting in the mantle, as also shown by Bougault et al. (this volume) and Rhodes et al. (this volume). These differences may also be connected in part with accumulation of the porphyritic crystals.

ANALYTICAL PROCEDURE

Chemical analyses of oceanic basalts for the principal set of elements were carried out in the chemical-analytical laboratory of the Geological Institute of the USSR Academy of Sciences. The following components were identified in the course of the analyses: SiO_2, Al_2O_3, Fe_2O_3, FeO, TiO_2, MnO, CaO, MgO, H_2O^+, H_2O^-, P_2O_5, Na_2O, K_2O, CO_2, and C_{org}.

Before analysis, the samples were crushed in a metal mortar and then powdered in agate mortars. In each case, the finely dispersed material was homogenized by quartering. Below are the amounts of material used in analyses for rock-forming components:

1) SiO_2, Al_2O_3, TiO_2, MnO, CaO, and MgO were estimated from a 0.5-g weight.

2) FeO and P_2O_5 were identified from weights of 0.5 g each.

3) CO_2 and C_{org} were singled out from a 0.5-g weight, using the wet-combustion method.

4) Moisture of samples was determined from a specimen weighing 0.2 to 0.5 g, and the total $H_2O\pm$ content was determined from a 0.2-g specimen.

5) The amount of alkaline elements was determined by flame photomety, after decomposition of 0.1 g of rock.

The oxide totals all fell within the range 99.5 to 100.5%.

Macroquanta of SiO_2 were estimated gravimetrically as silicic acid gel in muriatic solution; this determination was followed by supplementary photometry of subsequent filtrates, after separation of sesquioxides and determination of Ca, Mg, and Mn.

Al_2O_3, Fe_2O_3, CaO, and MgO were estimated by volumetric titration.

The methods of photometry of colored-complex compounds were used for identification of TiO_2 (through coloration of peroxide compounds in a sulfate medium) and MnO (in ammoniacal medium during formation of the complex with formaldoxime).

After a corresponding treatment of a specimen, the ferric iron was determined by volumetric titration of potassium bichromate.

Phosphorus was recognized photometrically from a weight after repeated treatment of a specimen with an admixture of nitric and hydrofluoric acids and subsequent leaching by means of diluted nitric acid as a colored complex, with an admixture of molybdenum-acid and vanadium-acid ammonium in nitric acid.

The laboratory reproducibility of the results was checked by analyses of five rock samples already analyzed onboard *Glomar Challenger* by X-ray fluorescence spectrometry (Bougault et al., this volume).

Results of repeated analyses carried out by various researchers, and compositions of similar specimens, determined through X-ray fluorescence, are presented in Table 1.

Comparison of the values shows that the most significant disagreements occur in estimates of the Fe_2O_3 content; this is related to errors in volumetric titration of iron in the presence of aluminum. The sum of Fe_2O_3 and Al_2O_3 is in satisfactory agreement for all the pairs of researchers.

RESULTS AND DISCUSSION

The petrographic and geochemical study of volcanic rocks carried out onboard the ship showed that at Hole 395A the drilling penetrated a series of basaltic flows that differ not only in petrographic features (texture, structure, mineral composition), but in chemical composition as well. Ten types were distinguished among these, on the basis of fine geochemical differences: five types among aphyric basalts, and five among porphyritic basalts (Chapters 7 and 8, this volume).

Histograms of the distribution of the principal rock-forming oxides, based on this study (Table 2, Figure 1), show a significant geochemical peculiarity of volcanic rocks, i.e., the bimodal character of distribution of the TiO_2, Al_2O_3, MgO, CaO, and FeO contents, corresponding to the difference between aphyric and porphyritic basalts.

We have compiled two-component variation diagrams: Al_2O_3-TiO_2 (Figure 2), Al_2O_3-MgO (Figure 3), Al_2O_3-CaO (Figure 4), MgO-CaO (Figure 5). In all the

TABLE 1
Composition of Basalts Analyzed by the Classical Chemical and the XRF Methods

Hole	395									395A					
Core	11			17			20			14			16		
Section	1			1			1			1			1		
Interval (cm)	105-110		105-107	64-68		56-69	35-39		32-36	90-98		92-99	100-103		100-104
No. of Analysis	Chemical Anal. I	Chemical Anal. II	XRF	Chemical Anal. I	Chemical Anal. II	XRF	Chemical Anal. I	Chemical Anal. II	XRF	Chemical Anal. I	Chemical Anal. II	XRF	Chemical Anal. I	Chemical Anal. II	XRF
SiO_2	47.54	47.38	48.95	48.70	48.93	50.2	48.48	48.74	49.6	48.02	48.52	49.2	48.15	48.69	49.5
Al_2O_3	16.06	15.96	15.93	17.53	17.37	17.71	18.12	17.89	18.77	16.20	17.73	17.81	18.11	18.05	17.36
Fe_2O_3	5.51	5.51	12.83	0.38	0.85	6.52	3.00	3.56	9.52	3.85	1.89	9.43	4.63	3.06	8.67
FeO	6.77	6.43		3.60	3.45		4.46	4.44		6.59	6.88		5.01	5.20	
MgO	5.53	5.83	6.79	8.95	8.61	12.2	7.22	6.66	6.1	6.69	6.85	7.1	6.97	6.74	7.8
CaO	11.44	11.21	11.01	10.92	11.34	9.32	12.08	11.81	12.05	12.55	12.07	11.97	12.94	13.04	12.57
Na_2O	3.42	3.42		4.21	4.21		2.95	2.95		2.88	2.88		2.40	2.40	
K_2O	0.33	0.33	0.22	0.45	0.45	0.20	0.22	0.22	0.30	0.17	0.17	0.11	0.27	0.27	0.12
TiO_2	1.70	1.53	1.70	0.48	0.47	0.39	1.20	1.36	1.28	1.25	1.28	1.36	1.18	1.11	1.07
MnO	0.19	0.21		0.12	0.11		0.15	0.13		0.15	0.13		0.14	0.14	
P_2O_5	0.23	0.23		–	–		0.11	0.11		0.11	0.11		0.10	0.10	
H_2O^+	0.84	1.12		3.38	3.21		0.71	0.75		0.57	0.57		0.09	0.43	
H_2O^-	0.60	0.94		0.71	0.92		0.99	1.30		0.59	0.59		0.30	0.60	
CO_2	0.35	0.35		0.07	0.07		–	–		–	–		–	–	
l.i.			0.9			4.9			1.5			1.6			
	100.51	100.45	98.33	99.5	99.99	100.4	99.69	99.92	99.2	99.62	99.67	98.6	100.29	99.83	97.5

diagrams, the plotted points are grouped into three fields: a field of aphyric basalts and two fields of prophyritic basalts. The various chemical types of basalt (five aphyric and five porphyritic) occupy different positions within these three fields. These diagrams therefore illustrate the distinct chemical character of each of the basalt types. In this way we see that the aphyric basalts were formed from more "primitive" melts than the porphyritic basalts. If we assume that primitive melts were similar in composition to fresh aphyric basalts (characterized by relatively high contents of MgO and TiO_2 and low concentrations of Al_2O_3 and CaO), the evolution of this melt was characterized by an increase in Al_2O_3 and CaO, the result of high concentrations of plagioclase phenocrysts in the porphyritic basalts.

Miyashiro (1975) plotted (Na_2O/K_2O) versus (Na_2O+K_2O) for a number of basalt series, and revealed the peculiarities of distribution of alkaline elements. On this diagram (Figure 6), all basalts of the Mid-Atlantic Ridge occupy a part of the field of abyssal tholeiites. The arrangement of data points testifies to a slight inverse correlation between Na_2O/K_2O and the total alkalinity of rocks. In this case, some aphyric basalts are characterized by higher overall alkalinity, compared with porphyritic basalts (Figure 6) and approximate alkaline basalts of Iceland. However, all these basalts, by the normative classification, belong to the tholeiitic series.

De La Roche and Letterier (1973) suggested, for classification of basalts, use of an integral two-component diagram by Yoder and Tilley (1962), based on a transformation of their basalt tetrahedron. The basalts of the Mid-Atlantic Ridge, plotted on this diagram, are arranged rather compactly. Most of porphyritic basalts and dolerites lie in the field of high-alumina basalts. Roughly half of the aphyric basalts fall within the field of the alkaline series, and half is arranged between the fields of the alkaline and high-alumina basalts. None of the porphyritic and aphyric basalts occupy the position of the tholeiitic series (Figure 7).

On the whole, the arrangement of data points indicates a slight tendency toward alkaline composition of these Mid-Atlantic basalts. Perhaps this alkaline tendency is related to alteration processes. When the basalts are plotted on an (Al_2O_3-Na_2O)/TiO_2 versus TiO_2 variation diagram (Gottini, 1970), a distinct inverse correlation is apparent (Figure 8). In this case, the porphyritic basalts plus dolerites, and the aphyric basalts, form two isolated fields tending toward one direct line.

All the variation diagrams show that the several types of basalts differ in chemical composition. The strongest differences are between aphyric and porphyritic basalts. Aphyric basalts have higher contents of SiO_2, TiO_2, FeO^x, Na_2O, K_2O, and lower concentrations of Al_2O_3 and CaO, compared with porphyritic basalts (Table 3).

Dolerites of Hole 395A are by their chemical composition analogous to porphyritic plagioclase-olivine-cylinopyroxene basalts. The similar chemistry of these two groups of rocks enables us to deduce that both are derivatives of a single parental magma.

It is rather difficult to estimate the chemical composition of any primary magmatic melt, because all the basalt types have experienced some crystal fractionation (or accumulation).

In the two-component diagram suggested by Dmitriev (1972), which plots $(Al_2O_3 + CaO + Na_2O + K_2O)$ versus SiO_2 - $(Fe_2O_3 + FeO + MnO + TiO_2)$, basalts and peridotites of the Mid-Atlantic Ridge occupy two complementary fields (Figure 9). Also, aphyric basalts are rather distinctly separated from porphyritic basalts. The aphyric basalts plot closer to the peridotites.

All data points arrange compactly in the field of the basalts, but at the same time, these points agree with the chemical types distinguished on shipboard. In this case, aphyric basalts are close to the field of peridotites. It is possible to explain this by different degrees of partial melting of the mantle material at the time of original melting. From this diagram, we infer that the greatest degree of partial melting of the mantle is represented by the aphyric types of basalts.

Crystallization differentiation, too, influenced the chemical composition of all types of basalts, especially the porphyritic basalts. None of the variation diagrams used herein contradicts these conclusions.

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TABLE 2
Chemical Composition of Magmatic Rocks From Holes 395, 395A, 396

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hole	395													
Core	11	11	11	11	11	12	15	15	15	16	16	17	18	18
Section	1	1	1	2	2	2	1	1	2	2	3	1	1	2
Interval (cm)	50-55	150-110	130-133	67-72	102-107	110-115	12-14	119-124	121-125	41-46	4-7	64-68	92-96	39-41
SiO_2	48.19	45.54	48.67	48.03	48.80	48.61	46.12	49.03	48.60	48.08	48.98	48.70	41.54	47.68
TiO_2	1.65	1.70	1.74	1.53	1.47	1.53	1.55	1.55	1.54	1.57	1.50	1.48	0.17	1.03
Al_2O_3	15.32	16.06	14.49	14.54	14.68	14.51	14.91	15.08	14.49	15.30	14.75	17.53	1.02	17.14
Fe_2O_3	4.48	5.51	1.97	2.86	2.36	2.83	6.49	3.39	2.45	5.31	3.00	0.38	3.34	3.82
FeO	7.39	6.77	9.25	8.56	9.01	8.73	7.90	7.44	9.37	6.67	8.25	3.60	4.92	5.48
MnO	0.20	0.19	0.19	0.18	0.18	0.17	0.23	0.16	0.18	0.18	0.17	0.12	0.10	0.13
MgO	6.73	5.53	8.63	8.78	8.45	8.35	6.88	7.92	8.52	6.76	8.12	8.95	40.1	8.52
CaO	11.1	11.44	9.69	10.43	10.55	10.84	9.10	10.85	10.89	10.92	10.65	10.92	1.61	13.20
Na_2O	3.14	3.42	3.10	2.98	2.98	2.98	3.08	3.20	2.98	3.14	2.98	4.21	0.08	2.49
K_2O	0.37	0.33	0.38	0.29	0.20	0.24	0.44	0.17	0.33	0.31	0.27	0.45	0.08	0.18
H_2O^+	0.68	0.84	0.92	1.01	0.39	0.22	1.44	0.10	0.20	0.52	0.72	3.38	5.63	0.09
H_2O^-	0.46	0.60	0.48	0.54	0.46	0.48	1.92	0.54	0.44	0.56	0.48	0.71	0.73	0.26
P_2O_5	0.17	0.23	0.06	0.15	0.15	0.15	0.18	0.15	0.16	0.16	0.15	–	0.01	0.11
CO_2	0.30	0.35	0.12	0.75	–	0.45	–	–	–	0.65	0.10	0.07	0.30	0.10
Total			99.69									99.50		
b	2.37	5.55	2.13	2.13	1.74	1.85	3.97	1.88	1.96	2.34	1.77	3.78	–	1.52
t	7.38	18.0	6.55	7.58	7.96	7.52	7.61	7.66	6.47	7.77	7.87	27.75	5.53	14.3
a	29.84	31.3	27.66	28.3	28.4	28.2	27.5	29.30	28.6	29.7	28.70	33.09	2.79	33.0
s	27.74	25.8	26.89	26.0	27.3	26.9	29.12	28.57	26.5	27.48	27.88	33.20	7.09	28.8
y	1414	1820	1736	1830	1830	1850	1600	1844	1860	1800	1820	1950	1190	2170
x	1682	1380	1482	1780	1810	1800	1360	1759	1770	1680	1810	1542	2470	2000
k	0.10	0.10	0.12	0.09	0.09	0.09	0.10	0.10	0.09	0.09	0.09	0.12	0.008	0.07
A	16.20	17.85	15.05	14.10	13.97	14.09	14.58	15.47	14.14	15.93	14.56	26.47	0.33	13.28
F	52.72	55.83	47.64	48.02	48.90	49.37	56.92	48.16	49.47	52.86	49.06	22.48	14.46	44.36
M	31.07	26.32	37.31	37.88	37.13	36.54	28.50	36.36	36.39	31.21	36.38	51.06	83.21	42.37

Note: Hole 395: Variolitic basalts (Numbers 1, 2, 10); volcanic glass (3, 7); aphyric basalts (4-6, 8, 9, 11); gabbro (12); serpentinized peridotites (13, 15); porphyritic plagioclase-olivine basalts (14, 16, 17).

Hole 395A: Serpentinized peridotite (19); aphyric basalts (18, 20-23, 26, 64-72, 79-81); variolitic basalts (24, 25, 27-32); porphyritic plagioclase-olivine basalts (33-44, 60-61, 63); porphyritic plagioclase-olivine-clinopyroxene basalts (45-59, 62); volcanic glass (73); dolerites (75-78); variolitic brecciated basalts (82).

Hole 396: Porphyritic plagioclase-olivine basalts (83-98). Indexes A, F, M scaled to 100%.

$$b = \frac{(Na_2O + K_2O)^2}{SiO_2 - 43}$$

$$t = \frac{Al_2O_3 - Na_2O}{TiO_2}$$

$$a = Al_2O_3 + CaO + Na_2O + K_2O$$

$$s = SiO_2 - (MgO + Fe_2O_3 + FeO + TiO_2 + MnO)$$

$$y = 6\,Ca + 2Mg + Al$$

$$x = 4Si - 11\,(Na + K) - 2\,(Fe + Ti)$$

$$k = \frac{Na + K}{Al + Si}$$

$$A = Na_2O + K_2O$$

$$F = Fe_2O_3 \cdot 0.9 + FeO$$

$$M = MgO$$

TABLE 2 – *Continued*

15	16	17	18	19	20	21	22	23	24	25	26	27	28
	395							395A					
18	19	20	4	4	5	5	5	7	8	8	9	9	9
2	1	1	1	2	1	1	1	2	1	1	1	1	2
130-137	92-97	35-39	66-69	63-66	6-10	108-113	10-14	129-133	3-8	49-52	70-73	98-102	8-10
40.79	48.68	48.48	47.82	38.09	47.42	48.64	48.61	47.78	46.85	47.40	47.47	48.50	48.58
0.17	1.36	1.20	1.80	0.09	1.81	1.49	1.50	1.45	1.65	1.79	1.80	1.44	1.53
2.76	17.46	18.12	15.06	0.62	14.95	14.84	14.94	15.28	16.40	14.74	13.91	14.91	14.87
3.52	3.81	3.00	3.38	8.21	5.45	2.43	2.80	6.06	5.48	3.50	4.22	3.78	2.73
3.68	5.15	4.46	6.64	0.57	6.13	8.70	8.41	6.11	6.64	8.40	8.58	8.46	8.78
0.09	0.13	0.15	0.20	0.07	0.20	0.17	0.17	0.17	0.23	0.20	0.19	0.24	0.17
38.04	6.61	7.22	8.12	38.54	8.00	8.18	8.24	7.40	6.20	8.88	8.60	8.00	8.62
1.36	12.28	12.08	10.87	0.62	10.85	10.79	10.88	10.86	11.29	9.91	9.94	10.84	10.72
0.08	2.82	2.85	2.96	0.08	2.90	2.87	3.09	3.19	3.51	2.60	2.96	3.08	2.97
0.09	0.33	0.22	0.31	0.08	0.35	0.21	0.17	0.17	0.35	0.26	0.31	0.31	0.23
7.93	0.16	0.71	1.37	11.88	1.47	0.60	–	0.43	0.66	1.60	1.07	0.23	0.28
0.70	0.58	0.99	0.60	0.58	0.69	0.44	0.52	1.16	0.60	0.28	0.93	0.26	0.56
0.01	0.12	0.11	0.14		0.13	0.15	0.15	0.16	0.18	0.09	0.09	0.14	0.14
0.30	0.45	–	0.27	0.20	0.03	0.30	0.10	–	–	0.08	0.22	–	–
			99.54	99.63	100.48	99.87	99.58	100.22	100.04	99.73	100.29	100.19	100.18
–	1.75	1.82	2.29	–	2.39	1.68	1.89	2.52	3.87	1.86	2.39	2.09	1.83
15.7	10.7	12.7	6.73	6.0	6.60	8.03	7.93	8.69	7.82	6.78	6.08	8.19	7.78
4.29	32.9	33.4	29.20	1.4	29.05	28.71	29.1	29.5	31.6	24.63	27.12	29.2	28.8
4.71	31.7	32.5	27.68	9.39	25.83	27.67	27.5	26.5	26.7	27.51	24.08	26.6	26.8
2070	1970	2010	1854	1990	1846	1640	1860	1830	2830	1790	1760	1850	1870
2450	1910	1920	1770	2240	1704	1864	1810	1650	1460	1822	1668	1750	1800
0.008	0.08	0.08	0.09	0.009	0.09	0.09	0.09	0.09	0.10	0.08	0.09	0.09	0.09
0.38	17.18	18.06	15.52	0.34	14.58	13.91	14.53	15.05	17.85	12.28	13.48	14.58	13.83
15.18	46.78	40.80	45.94	17.06	49.53	49.16	48.73	51.79	53.49	49.59	51.05	51.01	48.74
84.42	36.04	41.14	38.54	82.60	35.89	36.93	36.74	33.15	28.66	38.13	35.46	34.41	37.38

TABLE 2 – *Continued*

No.	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Hole	395													
Core	9	9	11	11	13	14	14	14	15	15	15	15	15	16
Section	2	2	1	1	1	1	2	3	1	1	3	4	5	1
Interval (cm)	48-52	81-86	80-83	120-125	99-103	90-98	60-68	111-118	12-16	106-111	72-79	52-57	3-12	80-83
SiO_2	48.60	47.62	46.88	48.07	48.29	28.02	47.98	48.55	48.58	48.20	48.24	49.17	47.98	48.57
TiO_2	1.45	1.91	1.53	1.47	1.36	1.25	1.48	1.36	1.27	1.36	1.36	1.36	1.19	1.23
Al_2O_3	15.80	14.92	15.83	14.61	18.17	16.20	18.31	17.90	18.15	17.34	17.68	17.58	18.29	17.49
Fe_2O_3	3.44	5.54	7.91	2.53	3.69	3.85	2.87	3.05	1.41	3.84	3.30	3.64	3.50	3.71
FeO	8.47	7.25	5.17	8.75	5.11	6.59	4.73	5.41	6.70	6.01	6.67	5.61	5.91	4.71
MnO	0.20	0.21	0.20	0.22	0.14	0.15	0.13	0.13	0.11	0.11	0.11	0.11	0.14	0.16
MgO	8.79	7.11	6.16	9.12	6.99	6.69	6.60	7.33	7.15	7.09	7.34	7.34	7.57	6.46
CaO	10.40	10.03	11.13	10.82	12.22	12.55	11.40	11.78	12.20	11.71	11.43	11.81	11.84	12.25
Na_2O	2.95	3.16	3.19	2.99	2.83	2.88	2.96	2.89	2.76	2.82	2.98	2.82	2.76	3.22
K_2O	0.17	0.31	0.32	0.23	0.26	0.17	0.28	0.15	0.09	0.15	0.20	0.16	0.16	0.23
H_2O^+	0.04	1.46	0.60	0.57	–	0.57	1.26	0.17	0.06	0.41	0.64	0.47	0.65	0.65
H_2O^-	0.25	0.56	1.29	0.59	0.59	0.59	1.02	0.83	0.80	0.47	0.30	0.44	0.40	0.81
P_2O_5	0.13	0.11	0.19	0.14	0.12	0.11	0.10	0.11	0.11	0.11	0.11	0.10	0.09	0.14
CO_2	–	0.07	–	–	0.15	–	0.41	–	0.35	–	0.20	–	–	–
Total	100.64	100.26	100.40	100.11	99.92	99.62	99.53	99.96	99.74	99.62	100.56	100.61	100.48	99.63
b	1.74	2.61	3.18	2.05	1.81	1.85	2.11	1.66	1.46	1.7	1.93	1.44	1.71	2.14
t	8.9	6.16	8.26	7.89	11.29	10.6	10.37	11.0	12.1	10.68	10.8	10.9	13.0	11.6
a	29.3	28.42	30.47	28.6	33.48	31.9	32.17	32.7	33.3	32.02	32.4	32.4	33.0	33.2
s	26.3	25.58	25.91	26.1	31.00	29.6	32.95	1.4	32.0	29.79	29.5	31.2	29.7	32.2
y	1860	1712	1795	1900	1808	2000	1904	1960	2030	1744	1930	1960	2000	1970
x	1820	1622	1556	1770	1912	1830	1880	1910	1980	1906	1820	1970	1910	1790
k	0.08	0.10	0.10	0.09	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.08	0.08	0.09
A	13.29	15.21	15.98	13.78	16.64	15.40	18.89	16.41	15.86	15.21	15.77	15.51	14.94	19.21
F	49.28	53.64	55.97	47.20	45.54	50.81	42.62	44.04	44.35	48.49	47.82	46.28	47.36	44.82
M	37.44	31.16	28.05	39.02	37.76	33.79	38.48	39.56	39.79	36.30	36.41	38.21	38.72	35.97

TABLE 2 – *Continued*

43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
							395							
16	16	17	18	20	22	22	24	24	25	26	26	26	26	27
1	1	1	1	1	1	2	1	2	1	1	1	2	2	1
100-103	128-131	4-9	25-30	92-95	110-115	5-10	117-120	41-45	38-48	63-67	115-119	4-10	83-85	116-123
48.15	47.70	48.27	48.75	48.42	48.47	48.58	47.96	48.25	49.21	48.95	47.33	47.89	49.36	48.39
1.18	1.10	1.10	1.19	0.88	1.02	1.10	1.27	1.10	1.19	1.03	1.10	1.12	1.07	1.05
18.11	17.84	16.61	17.27	18.18	17.43	17.20	17.67	16.85	16.31	16.38	16.86	16.58	16.92	15.67
4.63	5.13	4.26	2.84	3.83	3.12	4.49	4.64	3.39	3.48	4.29	5.00	3.35	1.51	2.90
5.01	5.05	5.08	5.75	4.65	4.93	5.00	5.52	5.34	6.29	4.60	4.73	4.81	6.65	5.28
0.14	0.15	0.15	0.14	0.14	0.11	0.14	0.17	0.17	0.14	0.15	0.13	0.31	0.15	0.14
6.97	7.24	7.53	7.61	7.40	7.95	7.46	7.06	8.28	8.16	8.06	8.16	7.94	8.23	8.06
12.94	12.76	12.92	12.65	12.89	12.78	12.67	12.49	12.58	12.09	12.27	12.13	13.31	12.18	12.88
2.40	2.48	2.52	2.57	2.56	2.47	2.57	2.89	2.76	2.70	2.70	2.61	2.70	2.60	2.82
0.27	0.20	0.21	0.17	0.19	0.16	0.16	0.15	0.27	0.13	0.17	0.17	0.17	0.15	0.29
0.09	0.48	0.48	0.32	0.46	0.30	0.23	0.23	0.38	0.28	0.45	0.37	0.45	0.16	0.66
0.30	0.28	0.44	0.24	0.64	0.78	0.56	0.30	0.38	0.42	0.86	0.68	0.39	0.29	0.79
0.10	0.15	0.09	0.10	0.09	0.09	0.09	0.15	0.12	0.09	0.11	0.08	0.09	0.10	0.11
–	–	0.15	–	–	–	–	–	–	–	–	0.15	0.55	0.05	0.60
100.29	100.56	99.81	99.60	100.32	99.60	100.24	100.50	99.87	100.49	100.02	99.50	99.66	99.97	99.64
1.38	1.53	1.41	1.31	1.39	1.27	1.34	1.86	1.75	1.29	1.35	1.79	1.64	1.19	1.79
13.3	14.0	12.8	12.4	17.7	14.66	13.3	11.7	12.8	11.4	13.3	13.0	12.39	13.4	12.3
33.8	33.3	32.2	32.6	33.9	32.84	32.6	33.2	32.4	31.2	31.6	31.8	32.78	31.9	31.7
30.3	29.2	30.2	31.4	31.6	31.34	30.5	29.3	30.0	29.9	30.8	28.2	30.36	31.9	30.9
2080	2070	2090	2070	2090	2096	2050	2020	2070	2010	2030	2030	2138	2040	2080
2020	2010	2020	2080	2070	2106	2020	1840	1940	2030	2000	1910	1941	2070	1950
0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.07	0.08	0.07	0.08
14.19	13.68	14.24	14.68	15.08	14.36	14.20	15.35	15.38	13.87	14.80	13.78	15.40	14.48	16.32
48.78	49.36	46.48	44.53	44.35	42.25	47.03	48.99	42.59	46.15	43.64	45.76	42.00	42.18	41.40
37.04	36.96	39.28	40.78.	40.57	43.40	38.77	35.66	42.03	39.98	41.57	40.46	42.60	43.34	42.29

TABLE 2 – *Continued*

No.	58	59	60	61	62	63	64	65	66	67	68	69	70	71
Hole							395							
Core	27	27	28	30	31	32	37	47	50	51	53	54	55	56
Section	2	2	1	1	1	2	1	2	1	2	1	1	1	2
Interval (cm)	27-34	126-132	105-112	100-104	70-76	21-28	50-54	105-110	87-92	122-127	78-84	130-137	105-113	100-107
SiO_2	48.72	49.39	48.26	47.57	47.89	48.47	48.71	48.42	49.01	48.78	48.18	48.37	48.56	48.84
TiO_2	1.06	1.10	1.27	1.10	1.14	1.15	1.61	1.69	1.65	1.53	1.65	1.65	1.65	1.65
Al_2O_3	15.97	17.19	18.77	17.62	19.28	17.67	15.34	16.02	15.03	14.90	15.06	14.82	15.06	15.17
Fe_2O_3	3.34	2.02	3.66	4.55	4.11	3.24	3.94	4.03	3.05	4.63	4.90	5.29	4.57	4.38
FeO	5.30	6.25	5.50	5.09	4.53	5.18	6.12	6.33	7.50	6.42	5.57	5.51	5.85	6.02
MnO	0.23	0.16	0.18	0.14	0.16	0.13	0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.17
MgO	8.25	7.79	6.88	7.90	4.88	6.68	7.18	6.28	7.16	8.08	7.26	7.35	7.18	7.17
CaO	12.28	12.34	11.90	11.86	12.97	12.50	11.38	11.59	11.33	11.07	11.23	11.22	11.36	10.98
Na_2O	2.82	2.82	1.83	2.70	2.99	2.82	3.05	3.28	2.93	2.96	2.99	2.99	2.76	2.99
K_2O	0.27	0.21	0.29	0.16	0.21	0.28	0.29	0.36	0.23	0.31	0.29	0.29	0.24	0.25
H_2O^+	0.61	0.15	0.25	0.31	0.86	0.60	0.90	0.81	0.66	0.55	1.10	1.12	0.97	0.98
H_2O^-	0.80	0.24	0.41	0.76	0.54	0.69	0.93	0.73	0.48	0.74	1.08	1.12	1.11	0.94
P_2O_5	0.10	0.11	0.12	0.09	0.16	0.11	0.17	0.19	0.20	0.17	0.17	0.17	0.18	0.19
CO_2	0.20	0.25	–	–	0.50	0.40	0.10	–	–	0.05	–	–	0.10	0.10
Total	99.95	99.90	100.32	99.85	100.22	99.92	99.89	99.90	99.60	100.30	99.66	100.07	99.75	99.83
b	1.67	1.33	1.85	1.79	2.09	1.76	1.96	2.44	1.66	1.85	2.07	2.0	1.62	1.8
t	12.5	13.2	12.5	13.5	14.3	12.91	7.64	7.51	7.33	7.78	7.33	7.17	7.45	7.39
a	31.4	32.4	33.8	32.4	35.5	33.27	30.0	31.2	29.6	29.3	29.6	29.32	29.4	29.4
s	30.7	32.1	30.7	28.9	33.1	32.09	29.7	29.9	29.3	28.0	28.5	28.40	29.1	29.4
y	2030	2030	1980	2010	2000	2014	1870	1850	1860	1870	1850	1852	1860	1820
x	1950	2030	1910	1880	1830	1929	1820	1690	1870	1810	1800	1790	1910	1850
k	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
A	15.73	15.50	16.60	14.38	19.62	17.34	16.54	18.32	15.23	14.90	15.98	15.69	14.90	15.91
F	42.29	42.99	46.78	46.07	50.46	45.30	47.89	50.13	50.27	48.27	48.64	49.14	49.43	45.90
M	41.98	41.50	36.62	39.60	28.92	37.36	35.56	31.61	34.51	36.83	35.38	35.17	35.67	35.20

TABLE 2 – *Continued*

72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
395												396		
56	58	59	61	61	63	64	64	65	67	67	14	15	15	16
3	2	2	2	3	3	1	3	1	2	2	6	2	4	2
55-64	57-64	43-47	65-70	5-10	108-114	45-54	62-67	81-84	47-50	138-143	44-49	92-99	27-33	120-127
48.39	46.94	47.48	48.94	48.60	47.86	48.35	47.26	47.39	47.72	46.71	48.88	47.70	47.84	48.35
1.67	1.45	1.49	1.02	1.06	0.87	1.02	1.49	1.53	1.53	1.49	1.45	1.36	1.15	1.25
15.21	14.48	14.56	17.11	15.83	17.35	16.88	14.87	15.18	16.11	15.01	17.10	17.10	16.95	17.36
3.63	3.18	4.65	2.56	2.01	3.94	3.21	4.59	4.23	4.93	2.54	3.06	5.63	3.93	3.26
6.82	7.31	6.95	5.64	5.66	3.76	5.15	5.87	6.99	5.63	8.04	6.31	3.66	4.74	5.47
0.15	0.17	0.17	0.13	0.14	0.13	0.15	0.17	0.20	0.17	0.18	0.16	0.16	0.15	0.16
7.25	8.18	8.10	7.50	8.60	7.23	8.27	8.26	7.72	6.14	8.18	6.24	4.98	8.07	6.57
10.82	19.18	11.29	12.65	12.33	13.14	12.39	11.39	11.65	11.67	10.79	12.04	13.01	11.93	12.49
2.93	3.36	2.90	2.77	2.65	2.60	2.60	2.90	2.90	2.90	3.03	2.90	3.10	2.77	2.77
0.33	0.66	0.38	0.14	0.14	0.20	0.18	0.25	0.31	0.29	0.40	0.32	0.31	0.26	0.25
1.21	2.41	0.87	0.67	1.73	1.26	1.05	1.07	0.42	0.96	1.28	0.50	0.95	0.51	0.74
1.02	2.65	1.11	0.68	0.44	1.08	0.58	1.52	0.92	1.42	2.06	0.74	1.59	1.28	0.64
0.19	0.14	0.15	0.10	0.11	0.08	0.11	0.15	0.16	0.16	0.15	0.15	0.15	0.12	0.13
0.10	0.20	–	–	0.20	0.20	–	–	–	–	0.50	–	0.35	0.05	0.10
99.72	100.31	100.10	99.91	99.50	99.64	100.04	99.79	99.60	99.63	100.36	99.85	100.05	99.75	99.54
1.97	4.11	2.41	1.43	1.39	1.61	1.44	1.48	2.35	2.16	3.17	1.77	2.47	1.9	1.7
7.37	7.66	7.65	14.0	12.5	16.95	14.0	7.99	8.04	8.63	8.04	9.79	10.3	12.3	11.7
29.3	27.7	29.2	32.7	31.0	31.93	32.1	29.5	30.0	31.0	29.23	32.3	33.5	31.9	32.8
29.0	26.6	26.2	32.1	31.1	33.29	30.6	26.8	25.2	29.4	26.28	31.6	31.8	29.9	31.5
1820	1660	1900	2070	2050	2102	2050	1910	1920	1860	1850	1930	1970	2000	1920
1810	1500	1710	1760	2060	1998	2010	1750	1720	1780	1646	1870	1740	1910	1940
0.09	0.11	0.09	0.08	0.07	0.08	0.07	0.09	0.09	0.09	0.10	0.09	0.09	0.08	0.08
15.83	17.97	14.56	15.86	14.79	16.15	14.56	14.71	14.77	16.55	15.65	17.39	19.92	15.63	16.79
48.98	45.46	49.47	43.27	39.61	42.16	42.12	46.71	49.70	51.91	47.02	48.92	50.99	42.72	46.69
35.19	36.57	35.97	40.87	45.60	41.70	43.32	38.58	35.53	31.65	37.33	33.69	29.09	41.64	36.52

TABLE 2 – *Continued*

No.	87	88	89	90	91	92	93	94	95	96	97	98
Hole						396						
Core	16	18	18	18	19	19	21	22	22	24	24	25
Section	4	1	1	2	1	2	1	4		2	3	1
Interval (cm)	120-127	52-60	140-150	27-33	110-116	20-27	62-70	55-62	100-107	65-72	67-73	124-130
SiO_2	47.54	47.15	47.56	48.65	48.31	47.38	48.06	48.26	48.92	47.21	48.72	48.77
TiO_2	1.25	1.23	1.25	1.25	1.23	1.23	1.39	1.35	1.27	1.36	1.19	1.27
Al_2O_3	17.33	16.94	16.97	16.43	16.41	17.69	16.46	16.47	16.42	16.07	16.51	15.66
Fe_2O_3	4.18	3.79	3.23	3.40	4.22	4.08	2.75	3.64	4.02	4.12	3.82	4.03
FeO	4.55	4.52	5.99	5.35	4.54	3.78	6.30	4.69	5.10	5.62	5.15	5.41
MnO	0.15	0.15	0.16	0.15	0.13	0.13	0.13	0.11	0.14	0.17	0.14	0.13
MgO	6.40	6.13	7.30	7.65	6.87	5.58	8.90	7.39	7.17	7.70	7.01	7.18
CaO	12.76	13.36	13.02	12.14	12.52	13.39	11.39	11.45	11.48	11.48	12.07	11.92
Na_2O	2.84	2.84	2.70	2.77	2.84	2.84	2.77	2.84	2.90	2.70	2.96	2.90
K_2O	0.28	0.36	0.26	0.32	0.28	0.36	0.26	0.33	0.25	0.33	0.26	0.22
H_2O^+	0.54	0.68	0.16	0.43	0.75	0.69	1.14	1.28	0.54	1.17	0.51	0.88
H_2O^-	1.41	1.11	0.78	1.16	1.62	1.59	0.52	1.36	1.14	1.17	0.93	0.94
P_2O_5	0.13	0.12	0.12	0.12	0.12	0.13	0.10	0.09	0.12	0.11	0.11	0.12
CO_2	0.55	1.00	0.40	–	0.25	0.92	0.25	0.27	–	0.37	0.15	0.15
Total	99.91	99.52	99.90	99.82	100.09	99.82	100.42	99.63	99.66	99.58	99.53	99.58
b	2.14	2.46	1.92	1.69	1.83	2.33	1.81	1.9	1.68	2.18	1.82	1.69
t	11.59	11.5	11.4	11.0	11.1	12.1	10.07	10.01	10.6	9.85	11.4	10.04
a	33.21	33.5	33.0	31.7	32.0	34.3	30.88	31.1	31.3	30.6	31.8	30.76
s	31.01	31.4	30.6	30.8	31.3	32.6	28.62	31.1	31.2	28.2	31.4	30.70
y	2020	2050	2080	2000	2000	2060	1970	1900	1930	1910	1630	1929
x	1870	1820	1880	1950	1910	1860	1418	1900	1910	1820	1890	1886
k	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.08	0.09	0.09
A	17.50	18.54	15.45	16.14	17.02	19.72	14.63	17.4	16.54	15.10	17.11	16.13
F	46.61	45.94	46.45	43.92	45.50	45.90	42.39	43.01	45.80	46.5	45.64	46.74
M	35.89	35.52	38.10	39.95	37.48	34.38	42.97	39.88	37.66	38.38	37.25	37.13

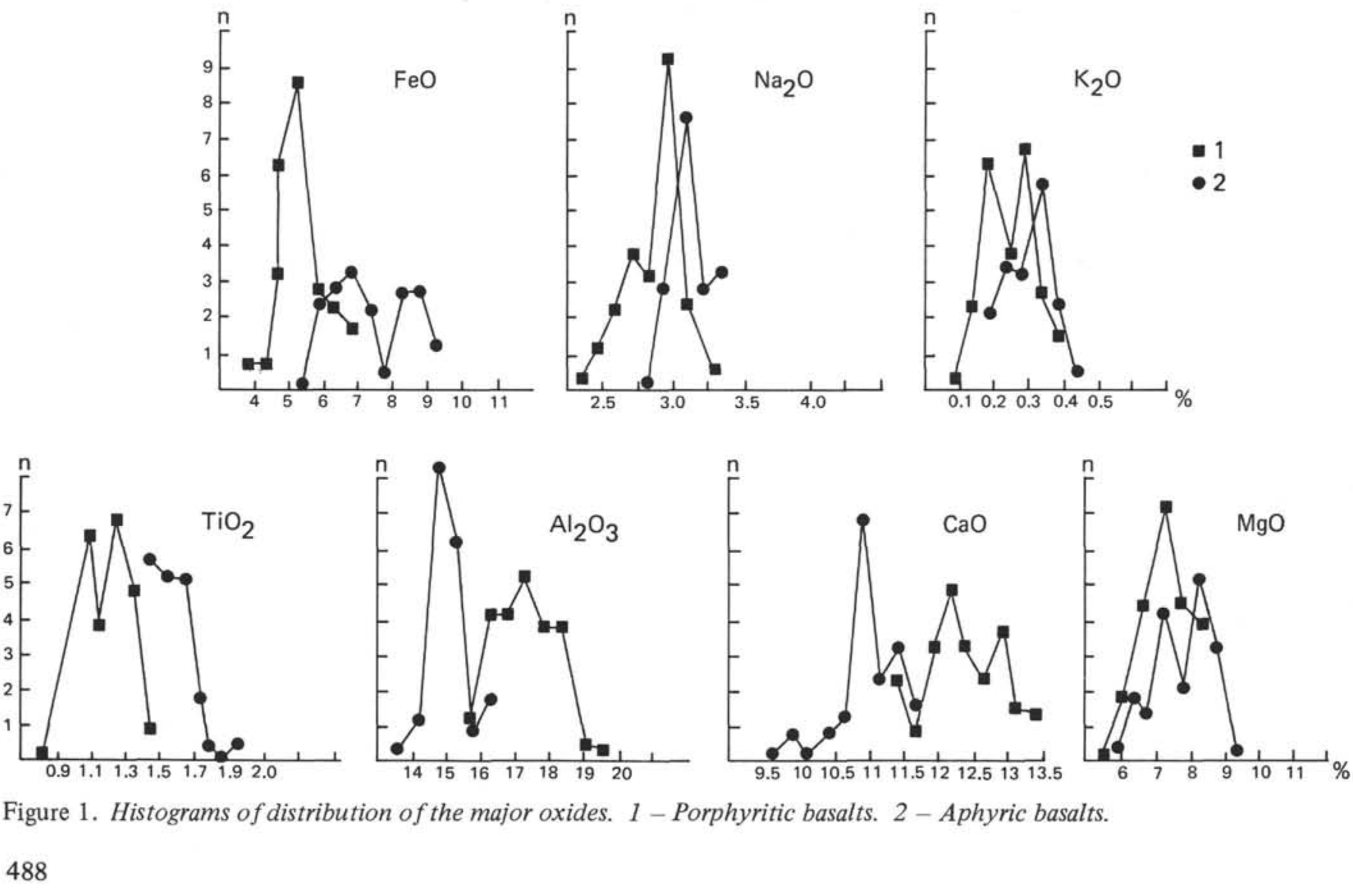

Figure 1. *Histograms of distribution of the major oxides. 1 – Porphyritic basalts. 2 – Aphyric basalts.*

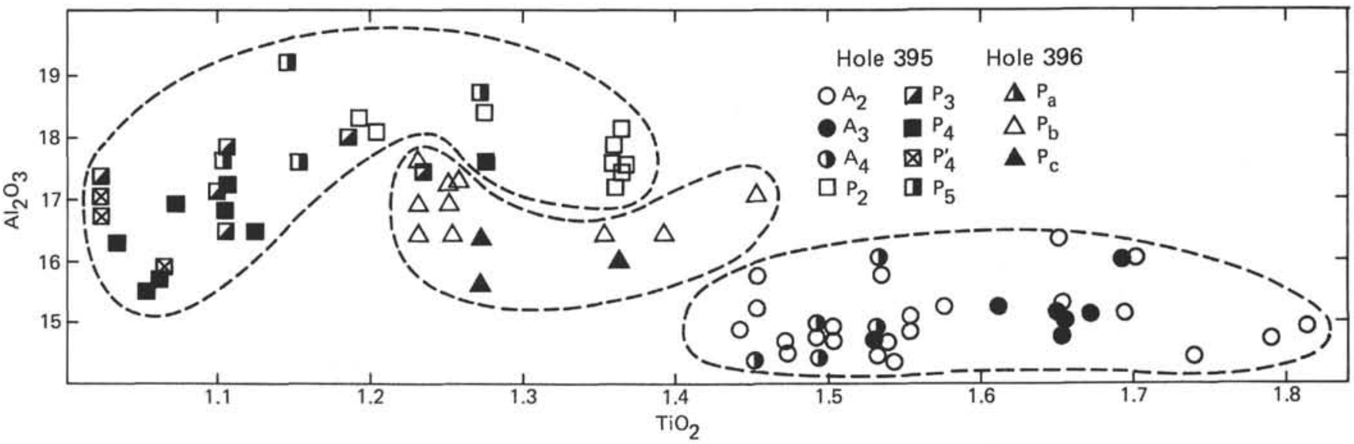

Figure 2. *Variation diagrams of Al_2O_3-TiO_2. A_2-A_4 – chemically distinct varieties of aphyric basalts of Holes 395, 395A; P_2-P_5 – chemically distinct varieties of porphyritic basalts of Holes 395, 395A; P_a, P_b, P_c – chemically distinct varieties of porphyritic basalts of Hole 396.*

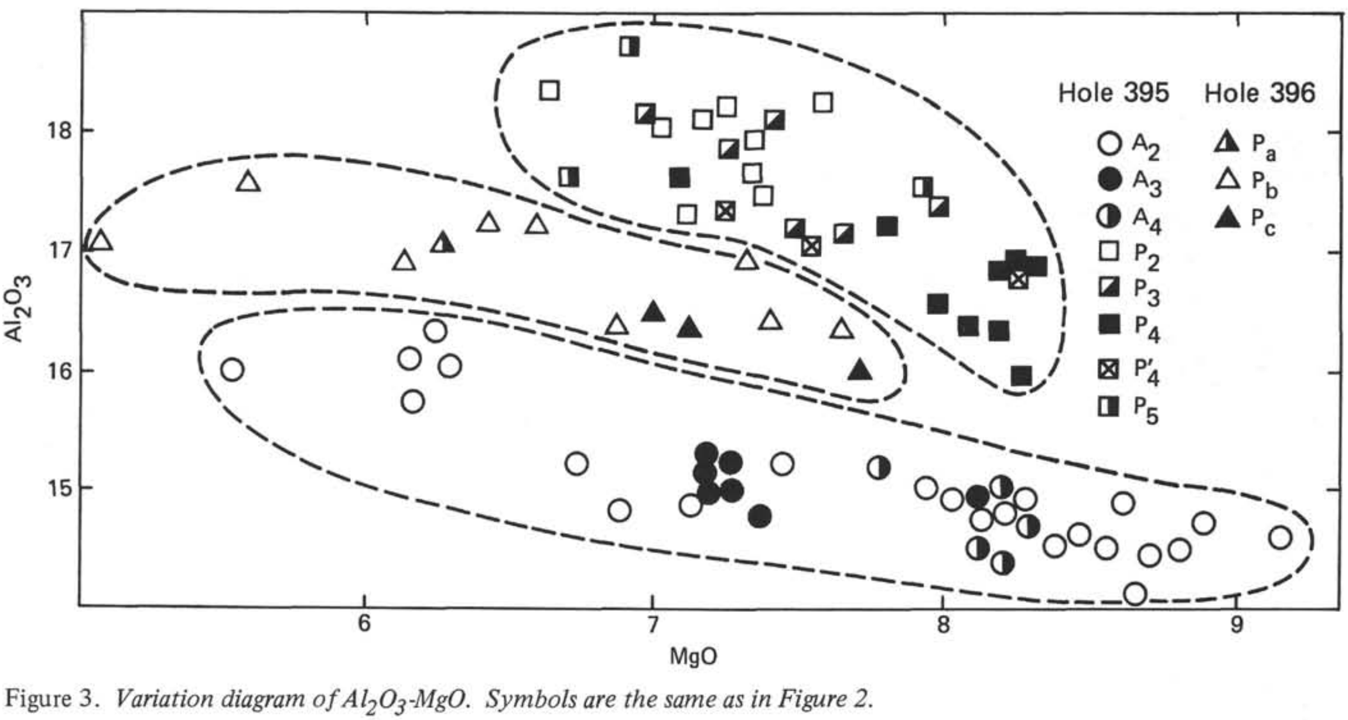

Figure 3. *Variation diagram of Al_2O_3-MgO. Symbols are the same as in Figure 2.*

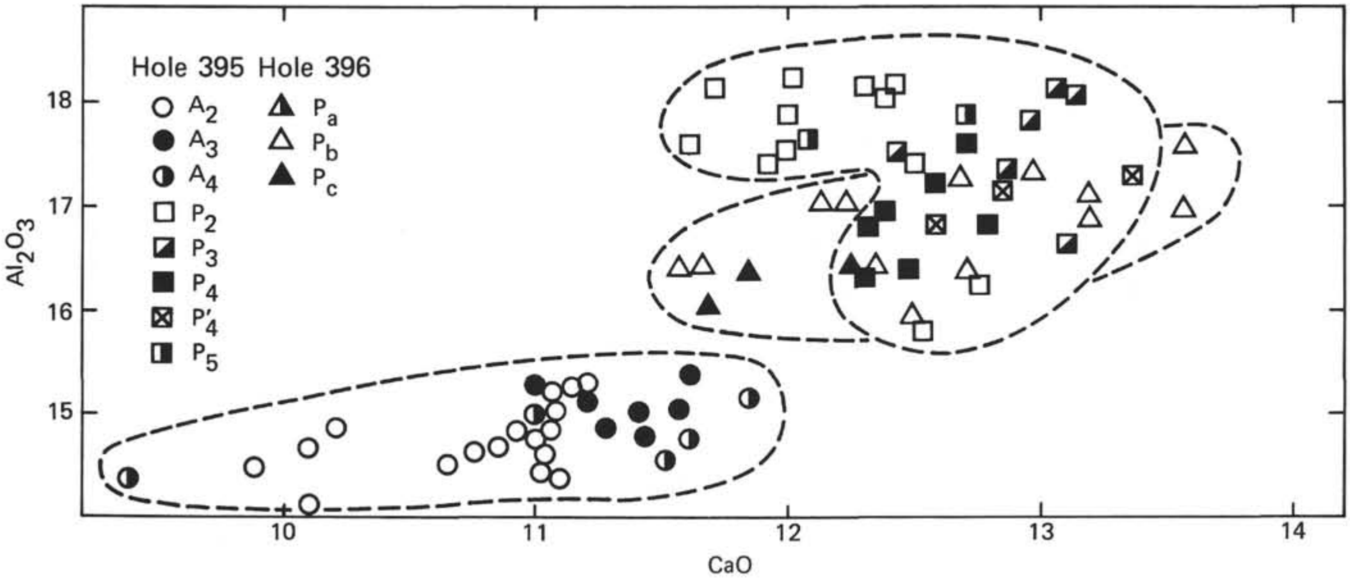

Figure 4. *Variation diagram of Al_2O_3-CaO. Symbols are the same as in Figure 2.*

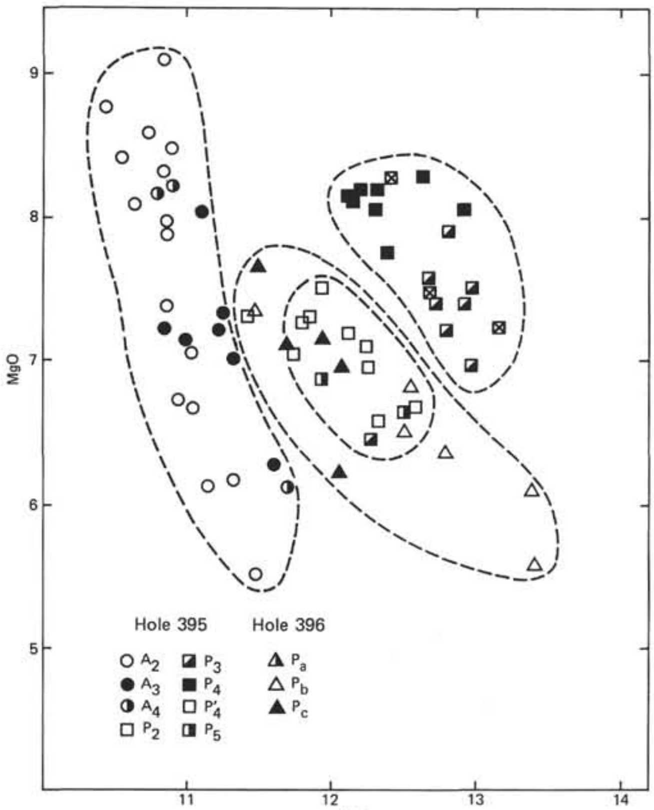

Figure 5. *Variation diagram of MgO-CaO. Symbols are the same as in Figure 2.*

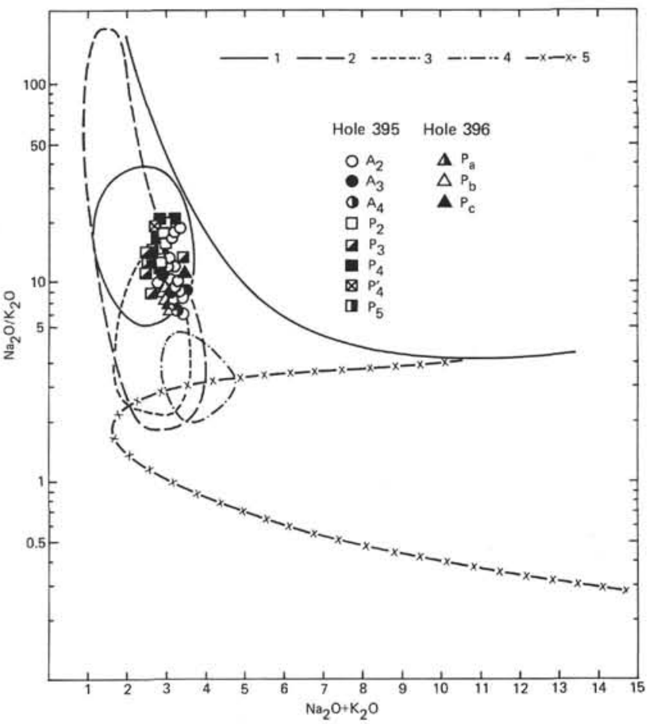

Figure 6. *Variation diagram by A. Miyashiro (1975). 1 – field of abyssal oceanic tholeiites; 2 – field of tholeiites of the Icelandic islands; 3 – field of tholeiites of the Hawaiian Islands; 4 – field of alkaline basalts of the Atlantic Ocean (except for the Icelandic islands); 5 – field of alkaline basalts of the continent. V-V – a line separating the field of altered rocks. The rest of the symbols are the same as in Figure 2.*

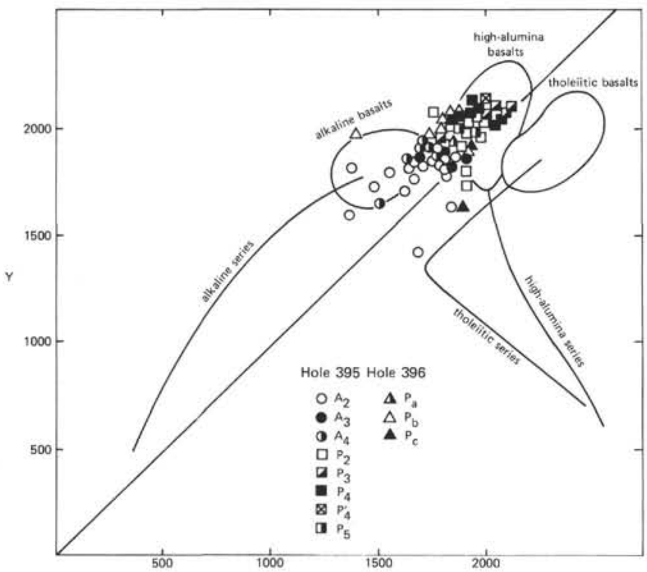

Figure 7. *Variation diagram by De La Roche and Letterier (1973). $X = 4Si - 11\ (Na+K) - 2\ (Fe+Ti)$, $Y = 6Ca - 2Mg - Al$; elements are given in atomic amounts. The rest of the symbols are the same as in Figure 2.*

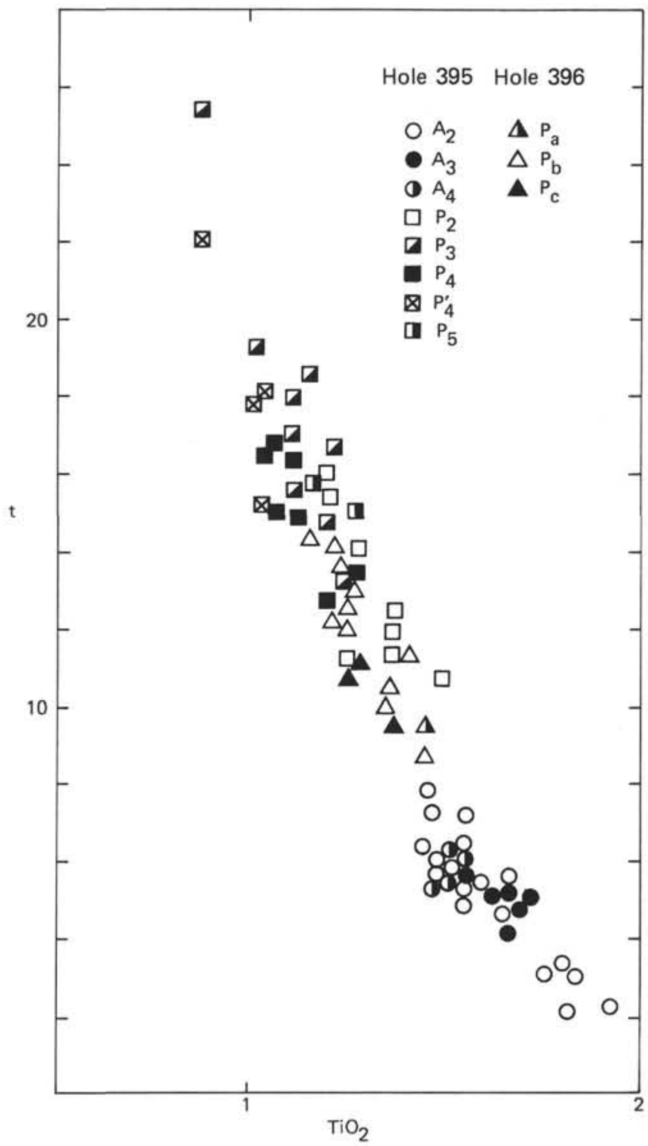

Figure 8. *Variation diagram by A. Gottini (1970).*

$$t = \frac{Al_2O_3 - Na_2O}{TiO_2}$$

The rest of the symbols are the same as in Figure 2.

TABLE 3
Average Chemical Compositions of Basalts and Dolerites

Rock, Region	Number of Analyses	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	FeO^a	$\frac{Na_2O}{K_2O}$	$\frac{FeO^a}{MgO}$
Aphyric basalt, Hole 395A	29	48.00	1.60	15.10	4.80	7.10	0.18	7.70	10.90	3.00	0.30	10.90	10.0	1.5
Porphyritic basalt, plagioclase-olivine, Hole 395A	15	48.25	1.27	17.81	3.60	5.55	0.13	7.08	12.08	2.81	0.20	8.80	14.0	1.2
Porphyritic basalt, plagioclase-olivine-clinopyroxene, Hole 395A	16	48.49	1.10	16.40	3.59	5.29	0.16	7.68	12.59	2.69	0.19	8.50	14.1	1.1
Dolerite, Hole 395A	4	48.44	0.99	16.79	2.93	5.05	0.14	7.90	12.63	2.66	0.17	7.70	15.6	0.9
Dolerite of the Hess depression[b]	15	48.17	1.03	16.49	3.03	7.02	0.16	6.86	11.35	2.49	0.13	9.75	19.1	1.4
Basalts of the East-Pacific Rise[b]	5	48.80	1.65	16.85	–	–	0.16	7.77	11.74	3.06	0.22	9.85	13.9	1.2
Basalts of mid-oceanic ridges of the Indian Ocean	30	49.09	1.44	16.68	2.30	6.49	0.17	7.47	10.79	2.95	0.17	8.56	17.4	1.1
Traps of old platforms[b]	258	49.22	1.48	15.18	3.18	9.32	0.20	6.22	10.47	2.22	0.75	12.18	2.96	1.9

[a]Summary content of Fe_2O_3 and FeO scaled to FeO.
[b]Analyses were taken from the works by G.B. Rudnik (1976).

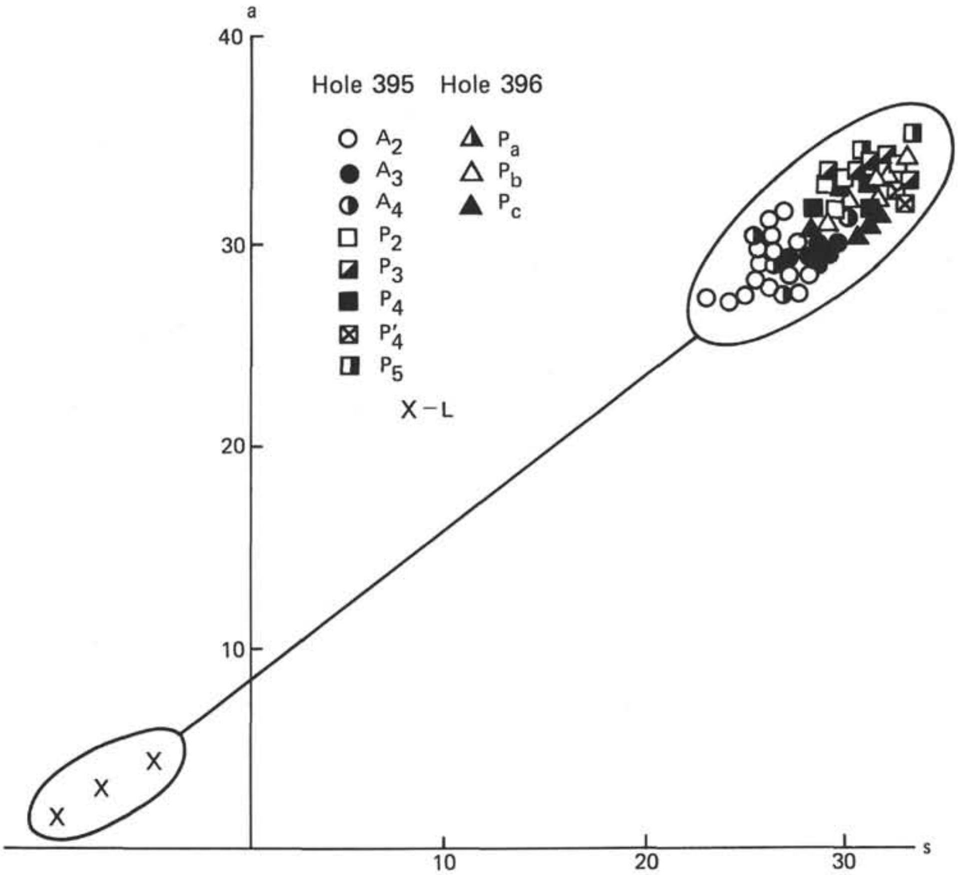

Figure 9. *Variation diagram by L. Dmitriev (1972). $a = Al_2O_3 + CaO + Na_2O + K_2O$, $S = SiO_2 - (MgO + Fe_2O_3 + FeO + TiO_2 + MnO)$. The rest of the symbols are the same as in Figure 2.*