27. PETROCHEMISTRY OF BASALTS AND DISTRIBUTION OF ORGANIC GASES: HOLES 407, 408, 409, 410A, 411, 412, and 413, DSDP LEG 49

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INTRODUCTION

This paper considers the petrochemistry of basalts and distribution of organic gases in basalts recovered from Holes 407, 408, 409, 410, 410A, 411, 412A, and 413. For this purpose, we compiled variation diagrams for the major rock-forming elements and some petrochemical coefficients, then grouped the plotted values in all diagrams into three mutually overlapping fields corresponding to the three regions of the Mid-Atlantic Ridge in which the DSDP drilling was conducted.

Petrochemical differences of basalts developed in various regions of the Mid-Atlantic Ridge can be explained either by lateral heterogeneity of the composition of the mantle substratum, or by the various depths of magma generation. The absence of a discrete distribution of the major rock-forming elements (especially aluminum, magnesium, and titanium) in the basalts of each of the three identified groups testifies to a negligible role of crystallization differentiation. This does not contradict the petrographic characteristics of the basalts.

The distribution of organic gases in basalts is extremely diverse. We did not establish a distinct correlative dependence between the various gases and the chemistry of basalts in this study.

ANALYTICAL PROCEDURE

Chemical analyses of the samples were performed in the Chemical-Analytical Laboratory of the Geological Institute of the USSR Academy of Sciences, Moscow. In accordance with the previously described methods (Zolotarev et al., in press), the summary weight of the material taken for analysis was, as a rule, 3.5 grams. The results obtained were averaged from two parallel determinations in which the oxide sum composing the materials under study was 99.5 to 100.5 per cent.

To evaluate the reproducibility and accuracy of the results, the samples were analyzed simultaneously with samples recommended as interlaboratory standards by the French Scientific Center on Petrographic and Geochemical Studies (Roubault et al., 1970) and the National Association of Technical Studies of France (de La Roche and Govindaraju, 1973).

The results of analysis of the standard basalt samples BR and diorite DR-N, noted above, and the data obtained from our samples are presented in Table 1.

A comparison of the values obtained shows that the most significant disagreements in the results of the chemical analyses were Fe_2O_3 and the alkaline elements in basalt BR, and for the alkaline elements in diorite DR-N. The analytical results of the standard samples are in good agreement with the recommended values, and within the limits of relative deviations from the control analyses and from the average values of the element contents in the standard samples of basalt BR (Figure 1) and diorite DR-N (Figure 2).

The study of the composition of organic gases necessitates obtaining extracts from basalts. Gas extracts were obtained from small weights (1.25 to 3.5 g) that had been mechanically powdered in steel chambers filled with argon. This method of gas extraction proved efficient in previous studies (Zolotarev et al., in press). Nevertheless, there are limitations to this extraction method. Small volumes of gas extracted through powdering small rock weights repeatedly become diluted in an argon-filled chamber (25 cm³), so one cannot always accurately determine the content of a particular component of low-boiling gases (CO_2, first of all) by means of chromatographic analysis, owing to a limited sensitivity of the catarometer. This results from the amount of the component in the mixture studied being below the threshold response of the detector. The use of highly sensitive flame-ionization detectors for analysis of hydrocarbons eliminates these limitations. A second limitation of the gas extraction method is a lower gas output from powdered rocks

Figure 1. *Intervals of relative deviations of carbon percentage for basalt BR. Dotted line indicates relative deviations of interlaboratory results; continuous line shows relative deviations of control analyses performed in the chemical-analytical laboratory of the Geological Institute of the USSR Academy of Sciences.*

TABLE 1
Results of the Analyses of Standard Samples of Basalt BR and Diorite DR-N

Basalt BR

Components	Data of the "Centre de Recherches Petrographiques et Geochimiques" (C.R.P.G.). M. Roubault, H. de la Roche, and K. Govindaraju (1970).						Results of the chemical analyses of the standard sample performed by chemical-laboratory of the Geological Institute of the USSR Academy of Sciences					Deviation of the results of the analyses	
	Recommended Values	X	S	C%	X-S	X+S	X	S	C	X min	X max	X-R.V	C%
SiO_2	38.20	38.75	0.98	2.5	37.77	39.73	38.33	0.09	0.02	38.24	38.42	+0.13	0.3
TiO_2	2.60	2.61	0.17	6.5	2.44	2.78	2.72	0.0	0.0	2.72	2.72	+0.12	4.6
Al_2O_3	10.20	10.28	0.10	3.9	9.88	10.68	9.88	0.5	5.0	9.50	10.61	-0.32	3.1
Fe_2O_3	5.58	5.69	0.36	6.3	5.33	6.05	6.57	0.55	8.3	5.84	7.08	+0.99	17.7
FeO	6.57	6.32	0.26	4.0	6.26	6.78	6.56	0.12	1.8	6.44	6.68	-0.01	0.15
MnO	0.20	0.20	0.023	11.5	0.177	0.223	0.205	0.005	2.4	0.20	0.21	+0.005	2.5
MgO	13.28	13.20	0.42	3.2	12.78	13.62	13.53	0.155	1.1	13.38	13.69	+0.25	1.9
CaO	13.80	13.78	0.35	3.1	13.43	14.13	13.69	0.01	0.07	13.68	13.70	-0.11	0.8
Na_2O	3.05	3.12	0.25	8.0	2.87	3.37	3.49	0.14	4.0	3.35	3.63	+0.44	14.4
K_2O	1.40	1.42	0.14	9.9	1.28	1.56	1.59	0.08	5.0	1.51	1.67	+0.19	13.6
P_2O_5	1.04	1.05	0.06	5.7	0.99	1.11	1.025	0.005	0.5	1.02	1.03	-0.015	1.4
H_2O^+	2.30	2.31	0.29	12.6	2.02	2.60	1.81	0.04	2.2	1.77	1.85	-0.49	21.3
H_2O^-	0.50	0.46	0.19	41.3	0.27	0.65	0.59	0.03	5.0	0.56	0.62	+0.09	18
CO_2	0.86	0.84	0.11	13.1	.073	0.95	0.40	0.25	62.5	0.15	0.65	-0.46	53.5
	99.58	100.23	4.00	-	96.23	104.23	100.4	1.98	-	98.36	100.56	-	-
Fe_2O_3 (total)	-	12.88	0.53	4.1	12.35	13.41	13.85	-	-	12.0	14.5	+0.97	7.5

Diorite DR-N

Components	Data of "De L'Association Nationale de la Recherche Technique" H. de la Roche and K. Govindaraju (1973)						Results of the chemical analyses of the standard sample performed by chemical analytical laboratory of the Geological Institute USSR Academy of Sciences					Deviation of the results of the analyses	
	Recommended Values	X	S	C%	X-S	X+S	S	S	C	X min	X max	X-R.V	C%
SiO_2	52.75	52.91	0.86	1.6	52.05	53.77	52.13	0.20	0.38	51.93	52.33	-0.42	0.8
TiO_2	1.10	1.10	0.12	11.0	0.96	1.20	1.12	0.02	1.8	1.10	1.14	+0.02	1.8
Al_2O_3	17.52	17.41	0.64	3.7	16.77	18.05	17.39	0.45	2.6	16.94	17.84	-0.13	0.7
Fe_2O_3	3.77	3.91	0.48	12.3	3.43	4.39	3.55	0.52	14.6	3.03	4.07	-0.22	5.8
FeO	5.31	5.34	0.29	5.4	5.05	5.63	5.21	0.02	0.4	5.19	5.23	-0.10	1.9
MnO	0.21	0.21	0.026	12.6	0.18	0.24	0.215	0.005	2.3	0.21	0.22	+0.005	2.4
MgO	4.46	4.45	0.30	6.7	4.15	4.75	4.34	0.13	3.0	4.21	4.47	-0.12	2.7
CaO	7.07	7.04	0.24	3.4	6.80	7.28	7.17	0.03	0.4	7.14	7.20	+0.10	1.4
Na_2O	2.99	2.98	0.21	7.0	2.77	3.19	3.30	0.12	4.0	3.18	3.42	+0.31	10.4
K_2O	1.73	1.72	0.12	6.9	1.60	1.84	1.92	0.10	5.0	1.82	2.02	+0.19	11.0
P_2O_5	0.25	0.26	0.05	18.0	0.21	0.31	0.27	0.00	0.00	0.27	0.27	+0.02	8.0
H_2O^+	2.19	2.24	0.23	10.2	2.01	2.47	1.96	0.023	1.3	1.94	1.99	-0.23	10.5
H_2O^-	0.24	0.25	0.08	33.2	0.17	0.33	0.36	0.00	0.00	0.36	0.36	+0.12	50
CO_2	0.15	0.15	0.06	40	0.09	0.21	0.22	0.07	34	0.15	0.30	+0.07	47
	99.74	99.95	3.786	-	96.24	103.66	99.16	1.69	-	97.47	100.86	-	-
Fe_2O_3 (total)	9.67	9.73	0.29	3.0	9.44	10.02	9.34	0.54	5.8	8.79	9.88	-0.33	3.4

Note: R.V. = recommended values; X = average values; S = standard deviation; C = relative deviation.

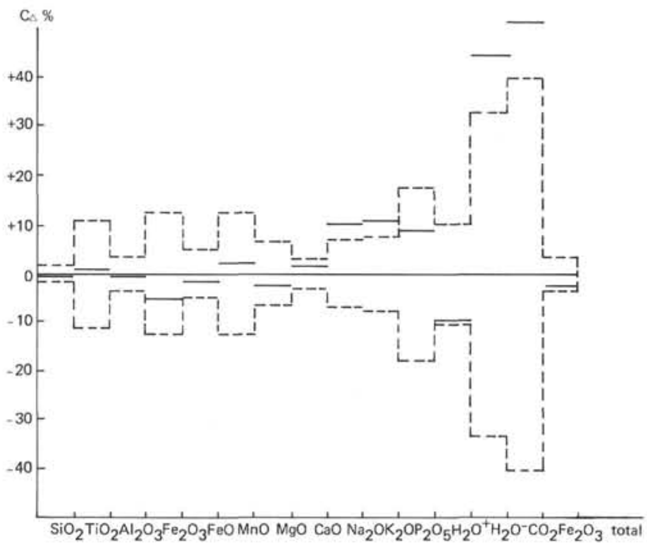

Figure 2. *Intervals of relative deviations for diorite DR-N. Symbols as in Figure 1.*

than could be obtained if the rocks were powdered under vacuum.

The data given on the chemical compositions and amounts of gases in the samples should be regarded as qualitative. A group of low-boiling gases (H_2,O_2,N_2,CO_2, and CH_4) was analyzed by means of a standard chromatograph LKHM-8D equipped with a catarometer. For determination of hydrocarbon gases up to C_5, including isomers C_4-C_5 and olefins C_2-C_4, we used the chromatograph "Geokhimik" equipped with a hydrogen flame ionization detector.

RESULTS AND DISCUSSION

Petrochemistry of Basalts

Petrographic study of basalts revealed that aphyric varieties are predominant and formed, as a rule, a series of flows overlapping one another. Among rare porphyritic basalts, the olivine-plagioclase microphyric varieties are the most common, whereas the plagioclase porphyritic basalts occur sporadically. All varieties of basalts were analyzed, and 85 complete silicate analyses (Table 2) were conducted. The differences in the chemical composition of the varieties of basalts are insignificant. Greater chemical differences occur, however, among basalts developed in various parts of the mid-oceanic ridge. Thus, all analyses were organized into three groups according to sample location.

The first group includes analyses of the Reykjanes Ridge at 62°N (Holes 407, 408, and 409). The second group of samples is from the Mid-Atlantic Ridge at 45°N (Holes 410 and 410A). The third group consists of samples from the Mid-Atlantic Ridge at 36°N (Holes 411, 412A, and 413).

Distribution histograms of the major-forming elements elucidate an important peculiarity of the basalt chemistry: every element is characterized by various modal values in each of the groups concerned. Some elements in basalts from the Reykjanes Ridge show bimodal (aluminum, calcium) and even three-modal (titanium) distributions (Figure 3). This peculiarity is interpreted as the result of differences in the composition of primary basaltic melts occurring in various parts of the Mid-Atlantic Ridge.

In the bicomponent variation diagram for Al_2O_3-TiO_2 (Figure 4) the ratio values are grouped in three fields and indicate pronounced reverse correlative dependence of these two components. The first field describes the Al_2O_3/TiO_2 ratio in basalts from the Reykjanes Ridge. The diagram shows that the younger the basalt the higher the Al_2O_3 concentrations and the lower the TiO_2 contents. In basalts from Hole 409, the ratios are the same as in abyssal tholeiites and similar to the ratios in basalts from the remaining holes of Leg 49 (Figure 4, fields 2 and 3). Basalts from Hole 407 are characterized by anomalously high TiO_2 contents with low concentrations of Al_2O_3.

In the variation diagrams for Al_2O_3-MgO (Figure 5), Al_2O_3-CaO (Figure 6), and CaO-MgO (Figure 7), one can see that the fields of values of basalts from various parts of the Mid-Atlantic Ridge partly overlap one another. On the basis of these components, basalts from Hole 407 (the oldest among the rocks studied) differ considerably from those of other holes. Basalts from Hole 409 (the youngest in the Reykjanes Ridge) are similar to abyssal tholeiites.

The distribution of K_2O contents was unexpected. First, an extremely wide interval of concentrations (0.14 to 2.41 wt.%) occurs and very high K_2O content are peculiar to Hole 410. In the variation diagram for K_2O-TiO_2 (Figure 8), the basalts developed in various regions of the Mid-Atlantic Ridge are characterized by various correlative ratios between these two components. A weak correlative dependence between K_2O and TiO_2 characterizes basalts of the Reykjanes Ridge; a stronger dependence typifies basalts of the Mid-Atlantic Ridge at 36°N. Basalts of the Mid-Atlantic Ridge at 45°N are characterized by weak reverse correlative dependence between K_2O and TiO_2. In this diagram, and in previous ones, the fields overlap one another within the diagram in a manner characteristic of abyssal tholeiites. Basalts from Hole 409 of the Reykjanes Ridge are most similar to tholeiites, whereas basalts from Holes 407 and 410 are different from tholeiites.

The variation diagram TiO_2-F/M (where F is the total Fe content recalculated to FeO, M represents MgO) shows that basalts of the Mid-Atlantic Ridge are characterized by a strong direct correlative dependence between TiO_2 content and the F/M ratio (Figure 9). The ratios for basalts from Holes 409, 410, and 412A are similar to those of abyssal tholeiites. Basalts from Hole 407 and part of Hole 408 differ considerably from abyssal tholeiites, according to this characteristic.

The Gottini (1970) coefficient (t) and that of TiO_2 are associated by parabolic dependence (Figure 10). Basalts from all holes, except Hole 407, occupy a position in the Gottini diagram peculiar to abyssal tholeiites.

In the Miyashiro (1975) variation diagram Na_2O/K_2O-($Na_2O + K_2O$), the Mid-Atlantic Ridge basalts plot very compactly (Figure 10). They lie almost entirely within the field of Icelandic tholeiites, a portion of which falls within the field of abyssal tholeiites, and the remaining part within the field of alkaline basalts of the Atlantic islands. The alkaline tendency is characteristic generally for basalts from Holes 410 and 410A (Figure 11). Noteworthy is that in this diagram all the basalts studied plot beneath the boundary line V-V separating the fresh rocks from those altered by epimagmatic processes.

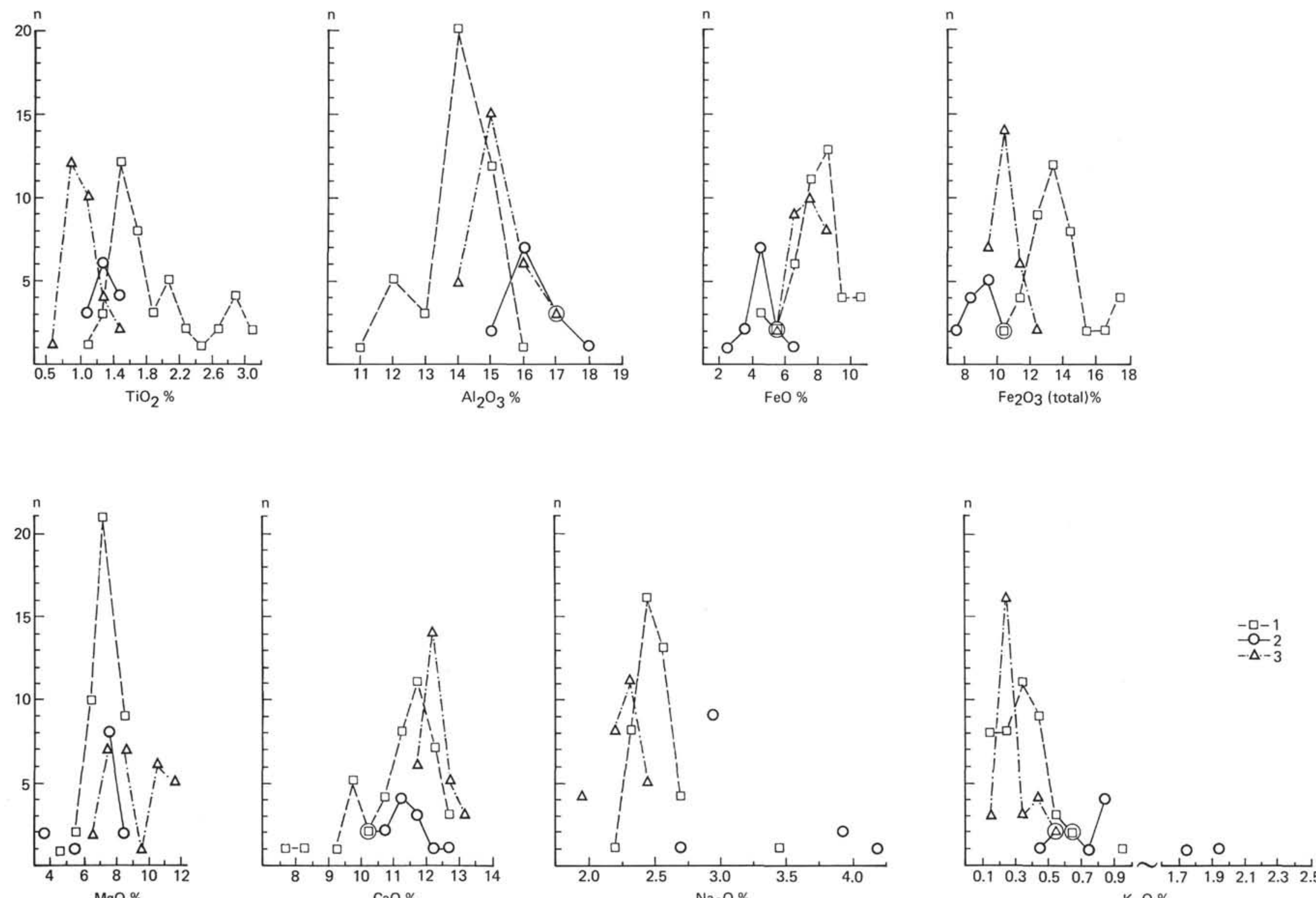

Figure 3. *Histogram of major-element distribution. 1 = basalts from Holes 407, 408, and 409; 2 = basalts from Holes 410 and 410A; 3 = basalts from Holes 411, 412A, and 413; n - number of determinations.*

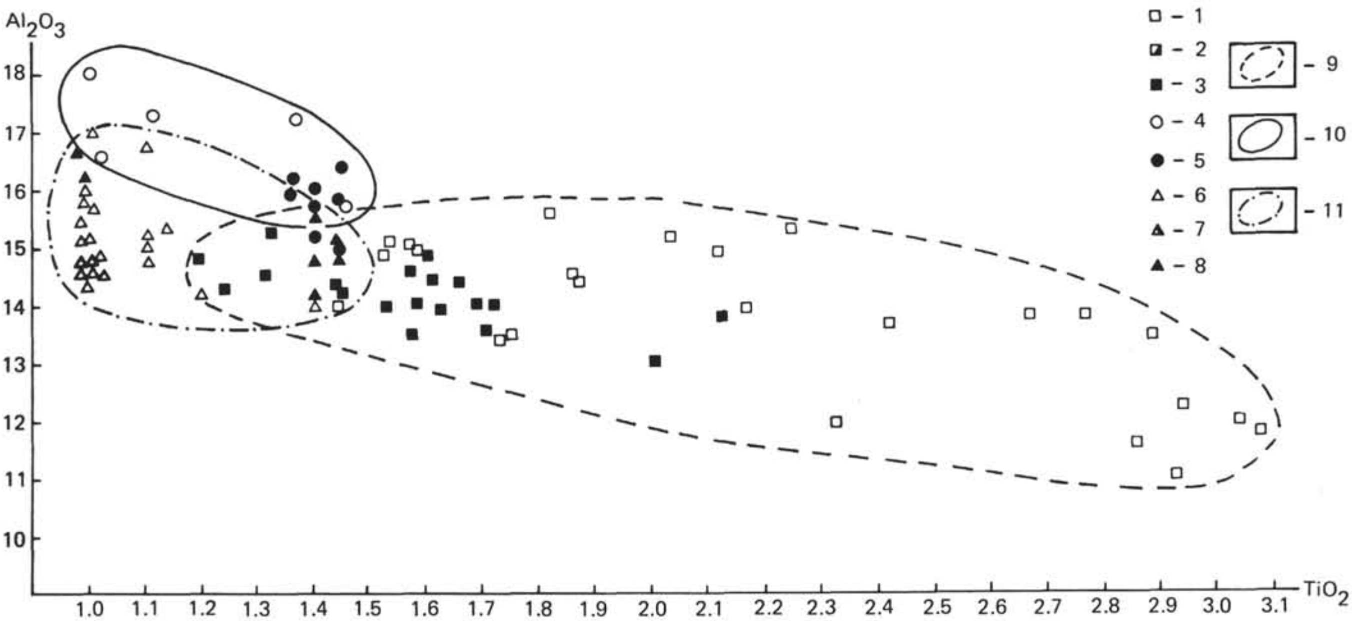

Figure 4. *Variation diagram Al_2O_3-TiO_2. Holes: 1 - 407, 2 - 408, 3 - 409, 4 - 410, 5 - 410A, 6 - 411, 7 - 412A, 8 - 413. Regions: 9 - the Reykjanes Ridge, 10 - the Mid-Atlantic Ridge at 45°N, 11 - the Mid-Atlantic Ridge at 36°N.*

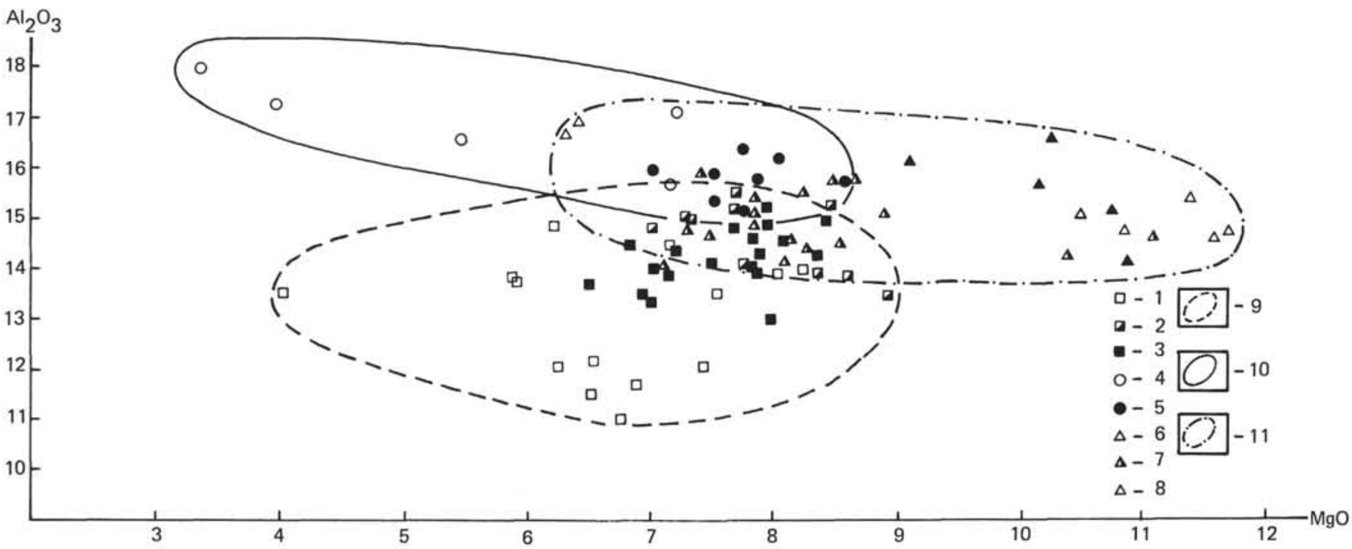

Figure 5. *Variation diagram Al_2O_3-MgO. Symbols as in Figure 4.*

Basalts of the mid-oceanic ridges are believed to be attributable to a series of abyssal tholeiites, but basalts penetrated during Leg 49 can be subdivided into three series according to Kuno (1966) classification. Holes 408, 409, 411, 412, and 412A shown in the three-component AFM diagram (Figure 12), fall within the field of the highly aluminous series. Basalts from Hole 407 occur within the field of the tholeiitic series. These two series form a single evolutionary row characterized by the Fenner trend of differentiation. Basalts from Holes 410 and 410A belong to the alkaline olivine-basaltic series, and are characterized by the Bowen differentiation trend (Figure 12).

Similar conclusions can be drawn after examining the diagram compiled by de La Roche and Letterier (1973). In this diagram (Figure 13), representing a chemical modification of the normative tetrahedron of Yoder and Tilly (1962), the basalts of the Mid-Atlantic Ridge also fall within three fields corresponding to different series: tholeiitic, highly aluminous, and alkaline-olivine-basaltic. A greater part of the basalts studied belong to the highly aluminous series, when judged by composition. In this case, rocks from Hole 407 exhibit a barely observable tendency towards a rhyolitic type of differentiation, whereas basalts from Hole 410 tend to the trachytic type (Figure 13).

The examination of petrochemical diagrams shows that basalts of the Mid-Atlantic Ridge penetrated during Leg 49 are slightly differentiated after SiO_2. According to classifications by Kuno (1966) and de La Roche (1973), they can be divided into three series: tholeiitic, high-alumina, and alkaline-olivine-basaltic, with the high alumina series in its quantitative ratio. We can conclude that there is a lateral geochemical heterogeneity of different ages of basalts that

TABLE 2
Chemical Composition of Magmatic Rocks From Holes 407, 408, 409, 410, 410A, 411, 412A, and 413, Leg 49

Hole								407						
Core	35	36	36	37	37	38	39	39	40	42	44	45	46	47
Section	1	1	3	1	2	2	2	3	1	2	1	1	2	3
Interval (cm)	30-33	20-25	95-97	112-117	109-111	15-17	100-105	25-30	70-75	35-40	60-65	55-60	0-5	77-80
SiO_2	53.91	47.67	47.35	47.15	47.66	47.95	47.78	48.09	48.07	48.37	46.27	45.88	46.25	47.20
TiO_2	2.88	1.73	1.75	3.07	2.92	2.94	2.85	2.76	3.04	2.66	2.12	2.32	1.86	1.87
Al_2O_3	13.59	13.98	13.50	11.78	11.09	12.24	11.57	13.85	12.25	13.88	14.96	12.04	14.58	14.04
Fe_2O_3	4.91	7.41	5.95	7.23	6.42	4.89	6.55	3.75	5.71	4.89	6.16	9.20	6.99	4.59
FeO	7.31	5.77	8.14	9.13	10.31	10.23	10.30	9.94	10.37	8.72	6.69	6.21	6.49	7.93
MnO	0.15	0.14	0.17	0.20	0.23	0.24	0.25	0.18	0.24	0.21	0.18	0.20	0.17	0.17
MgO	4.04	8.02	7.53	6.85	6.72	6.53	6.53	5.92	6.25	5.89	6.24	7.41	7.17	8.22
CaO	7.57	10.58	11.70	10.32	10.28	10.00	9.88	11.12	9.90	11.09	12.12	10.52	11.43	11.18
Na_2O	3.49	2.70	2.41	2.61	2.61	2.61	2.61	2.56	2.51	2.42	2.49	2.70	2.38	2.28
K_2O	0.99	0.31	0.20	0.34	0.41	0.54	0.61	0.39	0.58	0.46	0.28	0.61	0.28	0.15
H_2O^+	0.63	0.80	0.35	0.43	0.68	0.58	0.79	0.64	0.53	0.49	0.91	1.20	1.25	1.19
H_2O^-	0.49	0.97	0.73	0.86	0.59	0.56	0.42	0.84	0.47	0.69	1.23	1.58	1.09	1.36
P_2O_5	0.52	0.14	0.13	0.26	0.26	0.30	0.29	0.26	0.29	0.27	0.27	0.25	0.19	0.19
CO_2	-	0.20	-	0.30	0.10	-	0.15	-	0.25	-	-	0.20	-	-
Total	100.48	100.42	99.91	100.53	100.28	99.61	100.58	100.30	100.46	100.04	99.92	100.32	100.03	100.37
T	3.51	6.52	6.34	2.99	2.9	3.28	3.14	4.09	3.2	4.32	5.9	4.08	6.61	6.31
Y	1268	1756	1890	1670	1660	1630	1610	1760	1610	1650	1840	1720	1860	1870
X	17.64	1886	1834	1640	1640	1690	1600	1800	1700	1840	1750	1590	1850	1970
A	22.12	12.86	11.04	11.06	11.7	13.0	12.4	13.3	12.4	13.2	13.1	13.1	11.3	10.7
F	57.93	53.00	57.10	61.2	62.4	60.1	62.5	60.2	62.2	59.9	57.5	57.5	56.6	53.3
M	19.95	34.27	31.86	26.3	26.0	26.9	25.1	26.5	25.4	26.9	29.4	29.4	32.1	36.0

Hole														
Core	15	17	18	20	21	24	24	25	25	28	31	31	32	37
Section	2	1	1	1	3	2	3	2	4	1	1	2	1	1
Interval (cm)	80-85	130-135	90-95	10-15	120-125	130-135	145-150	60-65	40-45	120-125	70-75	45-48	85-98	85-90
SiO_2	47.17	47.37	47.15	47.11	47.83	48.82	48.16	47.87	47.27	47.34	47.56	47.73	48.57	50.48
TiO_2	1.53	1.57	1.65	2.07	1.57	1.44	1.69	2.12	1.70	1.62	1.58	1.61	1.57	1.45
Al_2O_3	13.99	15.04	14.38	13.02	14.66	14.41	14.01	13.79	13.59	13.91	14.07	14.43	13.50	15.77
Fe_2O_3	5.21	2.75	4.85	6.39	3.39	4.15	3.50	4.98	6.33	5.90	5.34	4.82	4.91	2.15
FeO	7.55	8.61	8.15	8.12	8.38	8.38	9.20	9.32	7.27	7.16	7.38	7.17	8.06	6.18
MnO	0.19	0.19	0.19	0.21	0.17	0.20	0.17	0.21	0.20	0.18	0.18	0.24	0.20	0.16
MgO	7.12	8.43	7.89	7.97	7.82	7.17	7.81	6.49	6.94	7.84	7.06	6.82	6.95	7.15
CaO	12.49	11.98	11.85	10.74	11.98	12.47	11.59	12.00	12.02	11.20	12.08	12.00	11.58	11.22
Na_2O	2.55	2.46	2.31	2.32	2.43	2.43	2.43	2.62	2.52	2.33	2.48	2.46	2.25	2.88
K_2O	0.43	0.20	0.33	0.24	0.31	0.27	0.22	0.39	0.39	0.46	0.35	0.37	0.37	0.83
H_2O^+	0.61	0.24	0.59	0.61	0.72	0.32	0.66	0.26	0.66	0.71	0.68	0.58	0.57	0.79
H_2O^-	0.64	0.56	0.70	0.74	0.62	0.16	0.48	0.39	0.94	1.34	0.97	1.16	0.95	0.48
P_2O_5	0.18	0.18	0.14	0.19	0.15	0.18	0.16	0.25	0.18	0.13	0.17	0.16	0.14	0.22
CO_2	0.45	-	-	-	-	-	0.10	-	0.40	0.05	0.25	-	-	-
Total	100.11	99.58	100.18	99.73	100.03	100.40	100.18	100.68	100.41	100.17	100.15	99.55	99.62	99.76
T	7.48	8.01	7.82	5.17	7.77	8.33	6.86	5.27	6.51	7.15	7.34	7.75	7.2	8.9
Y	1950	1982	1928	1800	1940	1970	1880	1870	1890	1870	1890	1900	1830	1870
X	1780	1900	1870	1850	1900	1970	1910	1760	1800	1860	1870	1900	2010	1890
A	13.3	11.0	11.4	10.5	12.2	12.3	11.6	12.9	12.8	12.1	12.8	13.4	11.9	19.5
F	54.8	50.0	54.4	56.7	52.1	55.0	54.1	59.2	56.8	54.0	55.3	54.5	56.7	42.7
M	31.9	39.0	34.2	32.8	35.7	32.7	34.3	27.9	30.4	53.9	31.9	32.1	31.4	37.8

Hole														
Core	3	4	1	2	3	3	3	5	6	7	8	9	11	11
Section	1	1	1	1	1	2	3	1	1	2	1	1	2	3
Interval (cm)	143-145	84-88	16-20	71-75	47-50	45-50	42-45	35-40	85-90	130-135	90-95	130-135	140-145	3-5
SiO_2	49.76	49.81	49.79	49.19	49.95	49.70	49.11	49.77	49.70	50.45	49.82	50.51	49.70	50.06
TiO_2	1.10	1.02	1.19	0.98	1.02	0.93	1.40	1.02	1.10	0.99	0.98	1.10	0.89	0.94
Al_2O_3	16.70	16.98	14.12	15.92	14.66	14.30	14.07	14.45	14.86	14.69	14.69	15.19	15.14	15.83
Fe_2O_3	3.16	2.71	2.62	3.43	2.50	1.93	3.20	2.97	3.57	3.02	1.87	1.48	1.89	1.96
FeO	6.41	6.21	7.97	6.17	7.79	7.66	8.56	8.31	7.04	6.98	8.21	8.10	7.40	6.87
MnO	0.15	0.15	0.16	0.15	0.17	0.15	0.20	0.17	0.18	0.17	0.16	0.17	0.15	0.14
MgO	6.32	6.41	8.08	7.47	8.10	10.38	7.11	8.28	7.27	7.46	8.56	7.84	8.91	8.64
CaO	13.26	13.29	12.44	12.75	12.37	11.98	12.24	12.26	12.79	12.95	12.50	12.39	12.86	12.86
Na_2O	2.34	2.25	2.34	2.31	2.31	2.15	2.39	2.39	2.25	2.31	2.15	2.33	2.23	2.33
K_2O	0.41	0.37	0.29	0.28	0.28	0.27	0.27	0.27	0.56	0.33	0.27	0.26	0.20	0.26
H_2O^+	0.39	0.36	0.36	0.38	0.43	0.25	0.45	0.31	0.52	0.25	0.15	0.45	0.30	0.24
H_2O^-	0.10	0.12	0.24	0.52	0.32	0.30	0.40	0.34	0.28	0.24	0.50	0.24	0.30	0.36
P_2O_5	0.16	0.11	0.07	0.10	0.10	0.10	0.11	0.10	0.14	0.10	0.10	0.10	0.08	0.07
CO_2	-	-	-	0.60	-	-	-	-	0.05	0.10	-	-	-	-
Total	100.27	99.79	99.67	100.19	100.00	100.10	99.51	100.64	100.31	100.04	99.90	100.16	100.05	100.56
T	13.1	14.4	9.92	13.9	12.2	13.1	8.36	11.9	11.5	12.5	12.8	11.7	14.5	14.4
Y	2060	2060	2010	2030	2000	2060	1940	2000	2010	2030	2050	1990	2110	2110
X	2120	2220	2140	2140	2160	2240	2060	2120	2120	2190	2230	2210	2230	2210
A	14.9	14.9	12.5	13.6	12.6	10.9	12.5	12.1	13.8	13.3	11.6	13.1	11.9	13.0
F	50.3	48.9	49.0	48.0	48.3	42.3	53.8	50.0	50.5	49.0	47.3	47.6	44.6	43.4
M	34.8	36.2	38.5	38.4	39.1	46.8	33.7	37.9	35.7	37.7	41.1	39.3	43.5	43.5

Note: $T = \frac{Al_2O_3 - Na_2O}{TiO_2}$; y = 6Ca+2Mg+Al; X = 4Si - 11(Na+K) - 2(Fe+Ti); A = Na_2O+K_2O; F = $Fe_2O_3 \cdot 0.9+FeO$; M = MgO; Indices A.F.M. scaled to 100%.

TABLE 2 – *Continued*

36	36	36	36	37	37	37	38	38	38	7	9	10	10	11	12
1	2	3	5	1	2	3	1	2	3	6	2	1	4	3	1
121-124	83-85	7-10	34-37	74-77	89-91	33-35	66-68	38-40	95-97	135-140	95-100	50-55	95-100	70-75	120-125
45.85	47.08	46.76	47.24	48.61	46.54	47.05	45.93	45.81	45.90	48.61	49.99	49.21	49.17	49.19	48.86
1.71	1.53	1.52	1.57	1.44	2.03	1.82	2.41	2.16	2.24	1.60	1.45	1.32	1.31	1.23	1.19
14.07	15.07	14.89	15.04	14.01	15.21	15.61	13.67	13.90	15.32	14.90	14.23	15.30	14.54	14.37	14.87
7.60	5.06	6.01	6.15	3.11	5.36	4.03	5.88	6.68	4.77	5.11	3.51	1.90	2.95	2.73	3.39
5.29	4.85	4.90	4.71	7.05	6.45	6.87	7.83	7.06	6.79	8.13	8.01	8.53	8.46	8.61	7.77
0.15	0.11	0.14	0.13	0.11	0.09	0.16	0.18	0.21	0.19	0.17	0.20	0.17	0.17	0.17	0.18
7.78	7.32	7.03	7.30	8.37	7.68	7.69	8.92	8.59	8.46	7.67	7.49	7.94	8.08	8.37	7.92
11.28	12.58	12.55	11.96	11.60	9.77	11.36	8.16	9.12	9.68	10.86	11.08	12.27	11.85	12.14	12.74
2.51	2.42	2.35	2.49	2.35	2.70	2.49	2.70	2.41	2.51	2.41	2.51	2.55	2.31	2.39	2.39
0.58	0.41	0.48	0.48	0.26	0.41	0.20	0.41	0.24	0.24	0.17	0.37	0.14	0.16	0.20	0.20
0.84	1.17	1.26	1.12	0.90	1.48	1.31	1.62	1.57	1.71	0.67	0.44	0.52	0.43	0.43	0.39
1.54	1.77	1.70	1.62	1.02	2.03	1.45	1.64	2.02	1.57	0.45	0.22	0.32	0.52	0.42	0.36
0.17	0.14	0.13	0.18	0.11	0.23	0.18	0.29	0.24	0.24	0.11	0.14	0.10	0.09	0.09	0.08
0.45	-	-	0.05	-	-	0.10	-	-	-	-	-	-	-	-	-
99.83	99.51	99.72	100.12	99.84	100.03	100.32	99.64	100.01	99.62	100.13	99.64	100.27	100.04	100.34	100.34
6.74	8.3	8.22	8.03	8.13	6.16	7.2	4.56	5.32	5.71	7.81	8.07	9.7	9.31	9.79	10.5
1850	1990	1970	1920	1930	1720	1900	1580	1660	1750	1830	1820	2010	1940	2000	2050
1690	1890	1890	1860	2080	1680	1830	1580	1740	1770	1950	2040	2060	2100	2060	2070
13.4	14.5	14.1	14.4	12.4	14.1	12.9	12.4	10.9	12.3	11.2	13.3	12.9	11.4	11.8	12.2
52.6	48.2	51.7	50.0	47.4	51.1	50.3	52.1	53.7	49.9	55.5	51.9	49.0	51.2	50.3	50.7
34.0	37.3	34.2	35.6	40.2	34.8	36.8	35.5	35.4	37.8	33.3	34.8	38.1	37.4	37.9	37.1

410				410A								411			
38	39	39	41	2	2	3	4	4	5	5	6	1	1	2	3
1	3	6	2	1	4	3	2	4	3	4	2	1	1	1	1
86-91	119-124	28-33	54-59	39-44	25-30	25-30	75-80	55-60	85-90	25-30	115-120	7-10	70-75	60-65	37-41
48.29	49.57	51.33	51.36	49.86	49.19	47.10	47.88	46.53	47.48	47.90	45.94	47.63	48.15	47.85	47.86
1.36	1.11	1.02	1.02	1.40	1.36	1.40	1.44	1.40	1.44	1.36	1.44	0.85	0.84	0.85	0.85
17.27	17.31	18.01	16.60	16.00	15.91	15.77	15.86	15.23	16.40	16.26	15.04	15.11	14.71	14.63	15.43
3.26	5.97	4.52	3.12	3.93	3.87	4.27	4.57	4.23	3.77	4.08	5.37	3.40	2.43	2.98	2.15
5.01	3.06	2.34	3.58	5.52	4.94	4.11	4.30	4.28	4.71	4.45	4.74	6.65	7.82	7.63	7.48
0.17	0.16	0.11	0.16	0.17	0.16	0.11	0.11	0.11	0.17	0.17	0.15	0.17	0.15	0.17	0.15
7.22	3.97	3.36	5.47	7.05	7.50	8.59	7.88	7.77	7.74	8.03	7.52	10.49	11.70	11.61	11.38
11.69	10.73	10.37	10.10	11.09	11.33	11.33	16.95	12.39	11.56	11.71	12.92	12.39	12.10	12.11	12.04
2.97	3.93	4.19	3.93	2.88	2.70	2.90	3.00	3.00	3.00	2.90	3.00	1.98	1.98	1.98	1.98
0.81	1.73	2.41	1.99	0.81	0.68	0.54	0.51	0.49	0.65	0.78	0.86	0.27	0.17	0.17	0.20
0.58	0.97	0.91	1.16	0.62	1.01	0.93	1.29	1.63	1.05	0.74	1.16	0.54	0.35	0.25	0.63
0.88	0.85	0.90	0.84	0.90	1.22	2.25	2.28	2.21	1.74	1.43	0.74	0.46	0.10	0.16	0.24
0.34	0.42	0.29	0.26	0.20	0.20	0.25	0.23	0.27	0.26	0.24	0.22	0.09	0.09	0.11	0.11
0.15	-	-	-	0.10	0.15	-	0.05	-	-	0.30	0.82	-	-	-	-
100.40	99.78	99.96	99.59	100.53	100.22	99.55	100.35	99.54	99.97	100.24	99.92	100.03	100.59	100.50	100.41
10.6	12.1	13.5	12.5	9.36	9.71	9.21	8.96	8.71	8.75	9.85	8.33	15.4	15.1	14.9	15.9
1940	1690	1610	1680	1830	1900	1930	1870	1990	1930	1970	2050	2130	2170	2150	2140
1730	1260	1220	1390	1840	1900	1750	1740	1700	1710	1770	1510	2160	2180	2170	2180
19.9	31.5	40.2	33.3	18.5	17.5	17.1	17.7	18.00	18.7	18.5	18.4	10.0	9.0	8.9	9.5
41.8	46.6	39.1	35.9	45.8	43.6	39.9	42.5	41.7	41.5	40.8	45.6	43.8	41.8	42.7	41.0
38.3	21.9	20.7	30.8	35.7	38.9	43.0	39.8	40.3	39.8	40.7	36.0	46.2	49.2	48.4	49.5

412A				413						
13	13	14	14	1	1	2	2	3	4	5
1	2	2	5	2	2	1	1	1	1	1
97-100	30-35	107-112	3-7	75-80	113-118	25-28	72-75	70-75	56-60	55-60
50.31	50.34	50.31	49.95	64.96	47.99	47.20	47.20	48.75	46.97	47.74
1.10	1.13	1.02	0.93	1.40	1.40	1.44	1.44	1.40	0.72	0.93
15.06	15.38	15.60	15.72	14.75	14.15	14.77	15.16	15.70	16.59	16.16
1.78	1.33	1.37	1.50	2.66	3.45	1.99	2.02	0.18	3.85	4.29
8.29	8.69	8.31	7.14	6.56	5.54	6.96	7.43	8.01	6.47	5.87
0.18	0.18	0.17	0.15	0.16	0.11	0.14	0.16	0.16	0.16	0.18
7.83	7.83	8.24	8.48	10.85	10.87	11.06	10.73	10.15	10.27	9.09
12.25	12.25	11.96	13.37	12.38	11.64	12.07	11.74	11.78	10.99	11.57
2.40	2.25	2.33	2.18	2.31	2.25	2.33	2.33	2.33	2.40	2.48
0.22	0.28	0.26	0.20	0.41	0.48	0.44	0.57	0.68	0.22	0.28
0.28	0.17	0.28	0.20	0.19	0.82	0.44	0.69	0.58	0.29	0.60
0.36	0.26	0.22	0.40	0.70	1.48	0.91	0.73	0.14	1.19	1.09
0.10	0.10	0.07	0.07	0.23	0.20	0.18	0.19	0.23	0.04	0.08
-	-	-	-	-	-	-	-	-	-	-
100.16	100.19	100.14	100.34	99.56	100.38	100.02	100.39	100.18	100.13	100.36
11.51	11.62	13.1	16.3	8.86	8.5	8.64	8.91	9.55	19.7	14.7
1990	1996	1983	2150	2140	2054	2118	2080	2062	1944	2000
2150	2238	2206	2270	1940	2060	1966	1930	2038	1930	1990
12.9	12.5	12.7	12.3	12.1	12.3	12.3	12.7	14.1	11.5	12.8
48.6	48.8	46.8	43.8	39.8	38.9	38.7	40.4	38.3	43.5	45.0
38.5	38.7	40.5	43.9	48.1	48.8	49.0	46.9	47.6	45.0	42.2

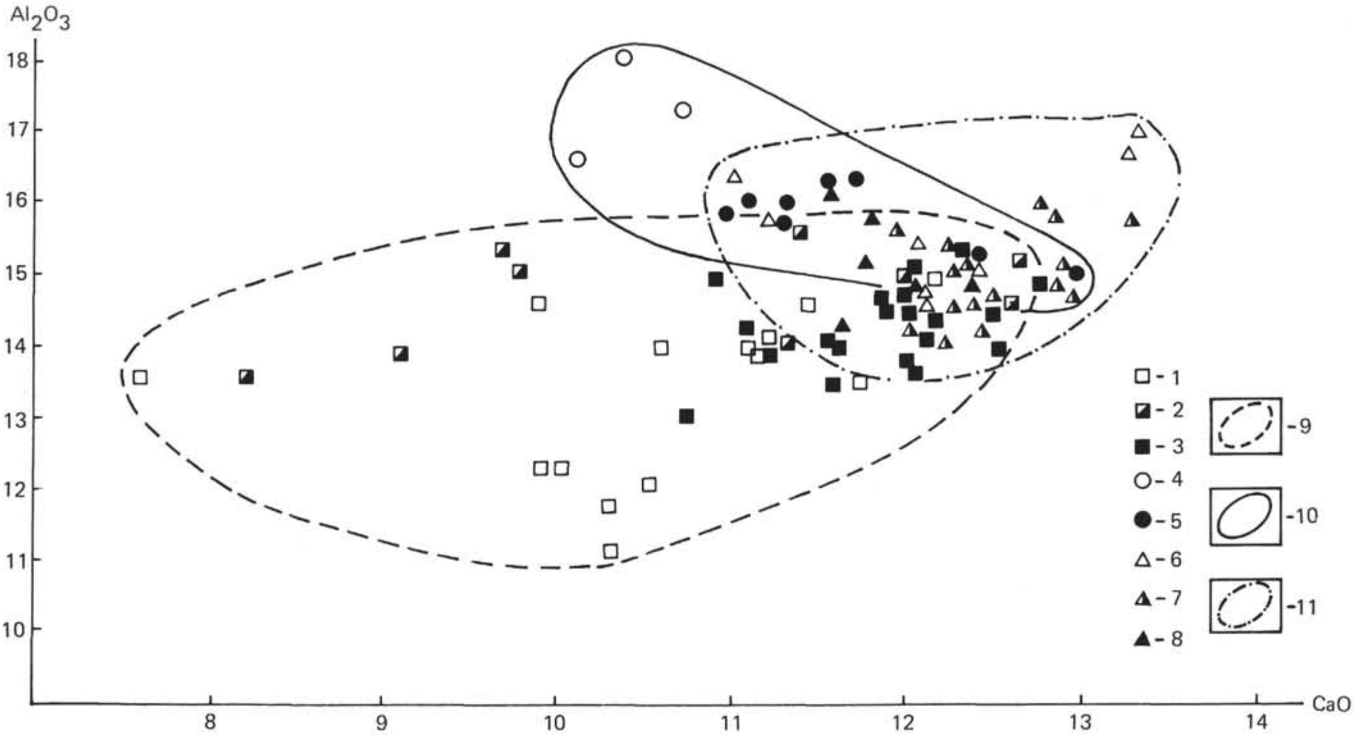

Figure 6. *Variation diagram Al_2O_3-CaO. Symbols as in Figure 4.*

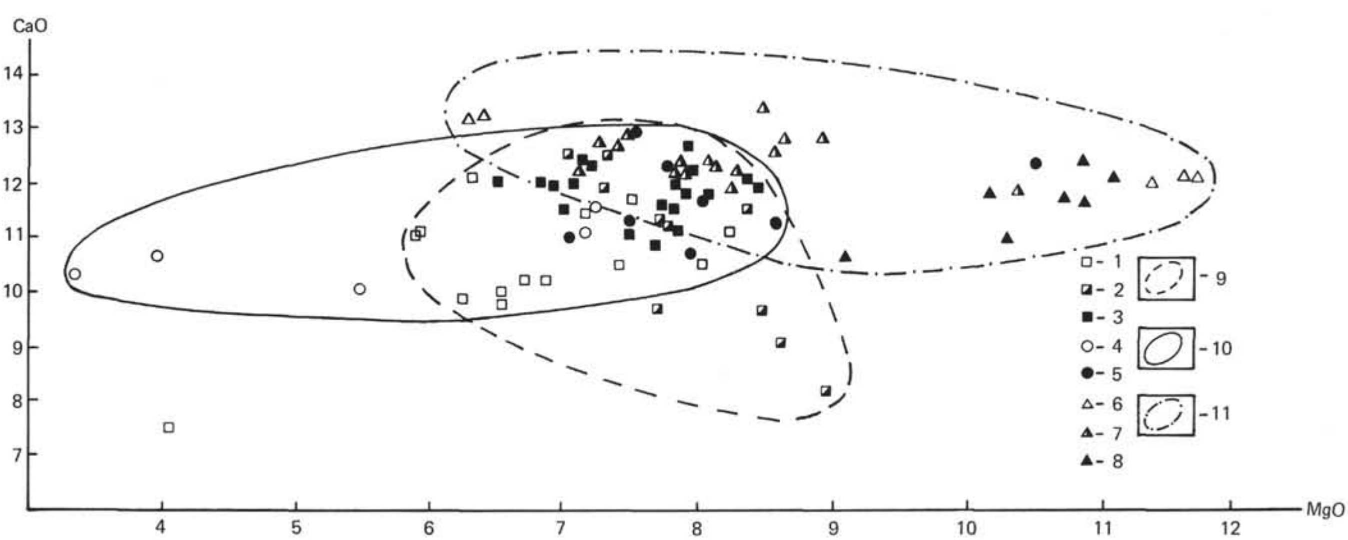

Figure 7. *Variation diagram CaO-MgO. Symbols as in Figure 4.*

have erupted in various parts of the Mid-Atlantic Ridge. Judged by most of the elements (TiO_2, Al_2O_3, MgO, CaO), maximum differences were established between basalts of the Mid-Atlantic Ridge and those of the Reykjanes Ridge. Rocks from Hole 407 and some from Hole 408 have an uncommon composition. Basalts from Hole 410 differ from rocks of other holes by their extremely high K_2O contents.

Table 3 gives average chemical composition of basalts formed in various regions of the Mid-Atlantic Ridge. The table shows that basalts of the Reykjanes Ridge differ significantly from rocks distributed in other regions of the Mid-Atlantic Ridge. The oldest basalts of the Reykjanes Ridge (Hole 407) are similar in composition to the effusives of Iceland, whereas more recent basalts (Hole 409) are analogous to common abyssal tholeiites. All Leg 49 basalts studied are characterized by an anomalously low Na_2O/K_2O ratio, as compared with abyssal tholeiites (in which the ratio value reaches 12 to 17). Noteworthy is that a portion of the basalts from Hole 407 is characterized by high concentrations of TiO_2, as in alkaline basalts of arched uplifts of the oceanic areas (Zolotarev, in press). However, basalts with high titanium contents from the Reykjanes Ridge contain low concentrations of alkaline elements, K_2O in particular. This makes them similar to the median composition of Icelandic basalts. Considering all other elements, except for Na_2O and K_2O, basalts with high titanium contents of the Reykjanes

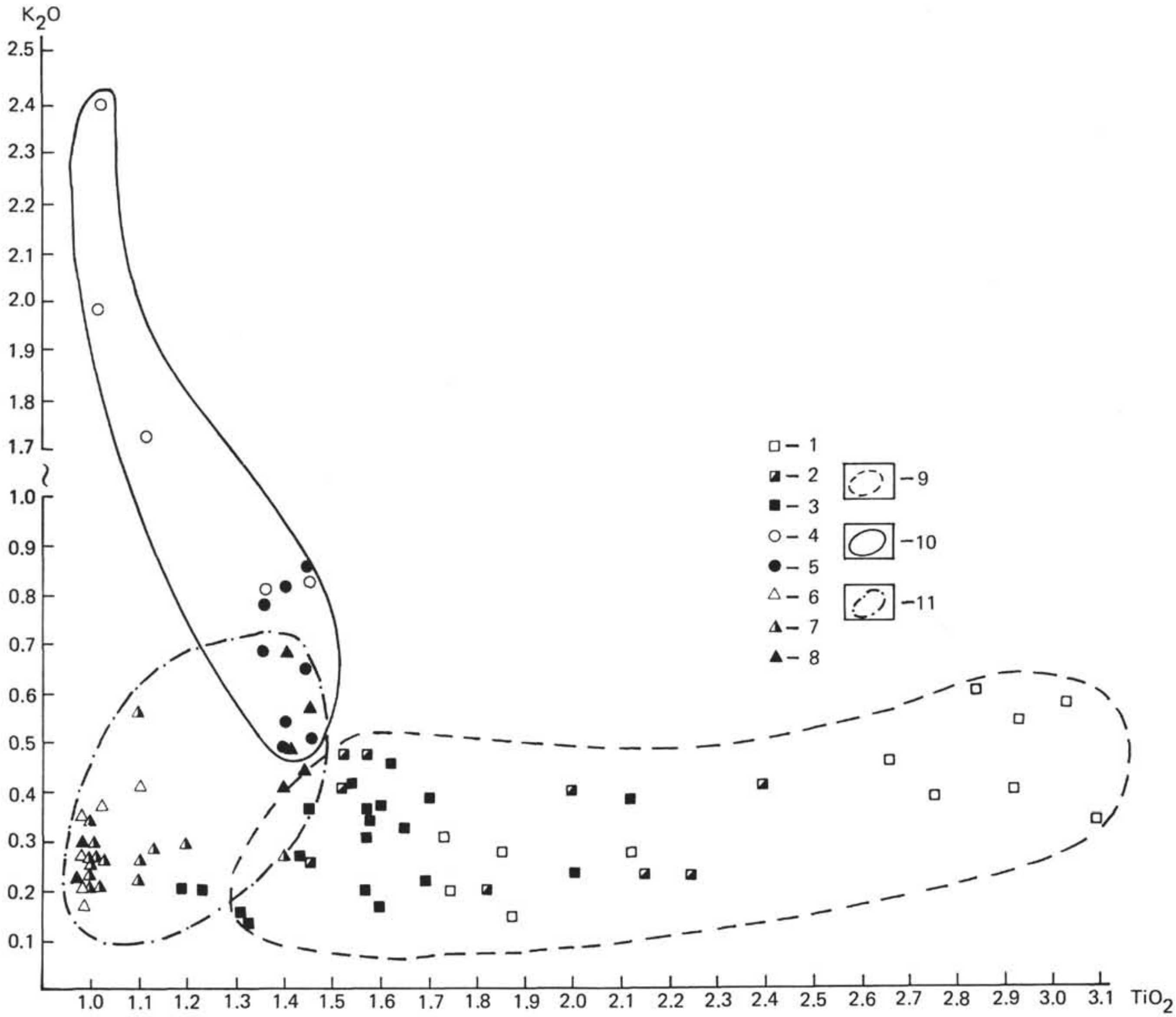

Figure 8. *Variation diagram K_2O-TiO_2. Symbols as in Figure 4.*

Ridge are surprisingly similar to lunar plagioclase basalts (Woods, 1975). Lower concentrations of alkaline elements in lunar plagioclase basalts may result from the specific character of lunar magmatic eruptions. Under vacuum, readily mobile alkaline elements disappear from the melt in the eruption process.

The basalt study has shown that in the northern part of the Atlantic Ocean (Reykjanes Ridge) there is an age-geochemical specialization of the effusive rocks. The formation of basalts at Site 407 appears to be related to melting of the primary liquid from the undifferentiated parts of the upper mantle. They are characterized by higher concentrations of titanium and iron, and are similar in composition to the undifferentiated lunar mantle. At later stages of magmatic activity (the remaining holes of Leg 49), the melting of basalts proceeded from a differentiated mantle with low levels of titanium and iron.

Another explanation for the established geochemical specialization of the basalts studied should consider the different depth of generation of primary melts. Varying degrees of differentiation of the mantle material constituting the asthenospheric levels play a determinative role.

Distribution of Organic Gases in Basalts

Eighty extracts of natural gases were analyzed and identified as a mixture of nitrogen, hydrogen, and hydrocarbons up to C_5 (Table 4). According to the adopted classification, they can be attributed to the group of nitric gases. However, this conclusion does not seem to be well founded because the chosen recovery methodology does not exclude sample contamination with nitrogen in the air. Contamination seems most probable, because all the extracts of gases contained various amounts of free oxygen. If one excludes surface atmosphere gases (O_2 and N_2) from consideration, the gases contained in the sample basalts are hydrogenous, based on their chemical composition. The CO_2 content in the extracts under study are, as a rule, below sensitivity of the catarome-

TABLE 3
Average Chemical Composition of Basalts From the Mid-Atlantic Ridge, Iceland, and Effusive Lunar Rocks (wt. %)

Components	1	2	3	4	5	6
SiO_2	47.71	48.67	49.05	47.72	47.10	47.33
TiO_2	1.93	1.32	1.06	2.96	3.17	2.35
Al_2O_3	13.98	16.26	15.17	11.78	18.20	15.09
FeO	12.33	8.06	9.47	16.15	17.40	11.18
MnO	0.18	0.14	0.18	1.28	0.24	0.20
MgO	7.35	6.86	99.01	6.55	6.80	6.89
CaO	11.17	11.33	12.33	10.76	11.40	11.19
Na_2O	2.49	3.17	2.26	2.60	0.64	2.61
K_2O	0.35	1.01	0.31	0.49	0.07	0.57
FeO/MgO	1.68	1.18	1.05	2.46	2.56	1.62
Na_2O/K_2O	7.10	3.14	7.30	5.20	9.10	4.58

Note: 1 – basalts from Holes 407, 408 and 409 (43 analyses); 2 – basalts from Holes 410 and 410A (13 analyses); 3 – basalts from Holes 411, 412A and 413 (29 analyses); 4 – titanium-rich basalts from Hole 407 (5 analyses); 5 – plagioclase basalt from the Moon ("Apollo-12" J. A. Wood, 1975); 6 – basalts from Iceland (17 analyses, B. P. Zolotarev, in press).

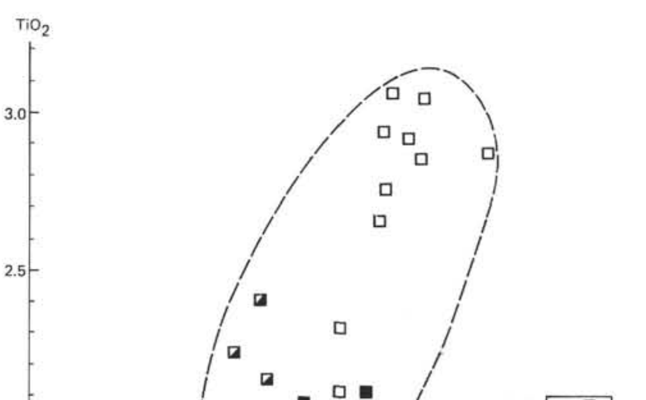

Figure 9. *Variation diagram TiO_2-(F/M). F = iron total recalculated to FeO; M = MgO. Other symbols as in Figure 4.*

ter (0.05%). CO_2 was recognized in the gas of only one sample.

Hydrocarbons, including a set of the components up to C_5, were recorded in 5 of the 80 basalt samples. The usual components of the gases studied were CH_4 and C_2H_6, since they are the most stable hydrocarbons of the alkanes.

The total average gas content in the basalts studied (nitrogen excluded) is not large: tentatively, 1.0 to 1.2 cm³/kg. They consist of H_2, 1.0 to 1.2 cm³/kg; CH_4 0.025 cm³/kg; and C_2H_8 0.012 cm³/kg. However, the interval of values of these gases is significant, i.e., H_2 0.1 to 3.3 cm³/kg; CH_4, 0.007 to 0.08 cm³/kg; C_2H_2, 0.0008 to 0.008 cm³/kg; and C_2H_8, 0.0006 to 0.008 cm³/kg. The variability of all individual gas contents is greatest in samples from Holes 407, 408, and 409. This range is somewhat narrower in samples from Holes 411, 412A, and 413, and the narrowest in basalts of Holes 410, and 410A. The average contents of all individual gases (except for hydrogen) change respectively in the same way (Table 5).

Histograms of distribution of gas contents compiled according to regional features show no observable changes in the contents or concentrations of gases (Figure 14). By composition and content, these gases are similar to those from basalts of the Kuril island arc of the southwestern sector of the Pacific Ocean (Zolotarev et al., 1976), Iceland (Zolotarev et al., in press b), and the Mid-Atlantic Ridge (Zolotarev et al., in press a).

The chemical composition of gases contained in basalts does not depend on the chemical composition of the primary melt. The gas saturation of basalts appears to depend only on the form of volcanism manifested (effusive, aerial, effusive underwater, or intrusive), and the degree of epimagmatic changes of the rocks.

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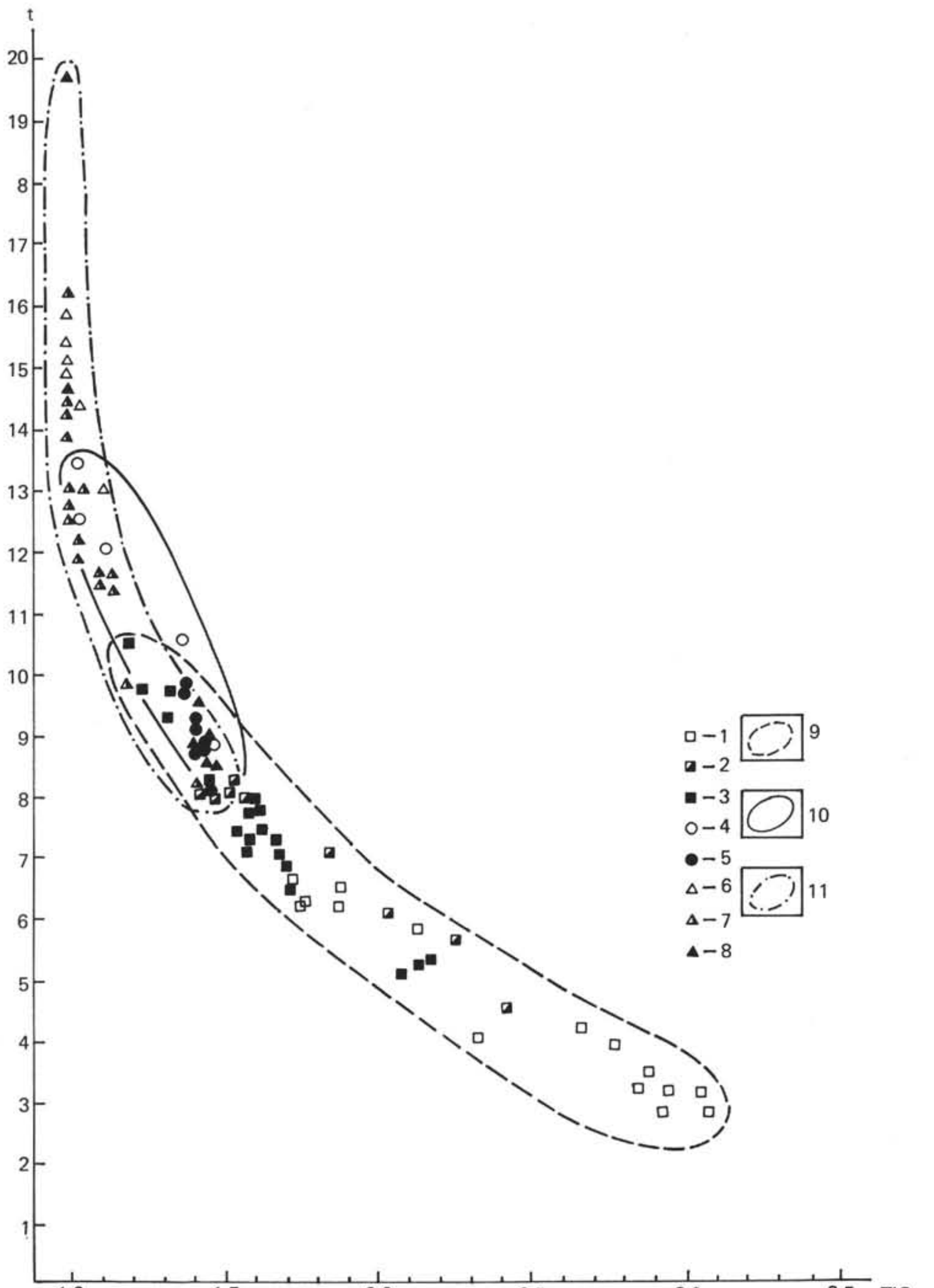

Figure 10. *Gottini variation diagram.* $t = \frac{Al_2O_3\text{-}Na_2O}{TiO_2}$. *Other symbols as in Figure 4.*

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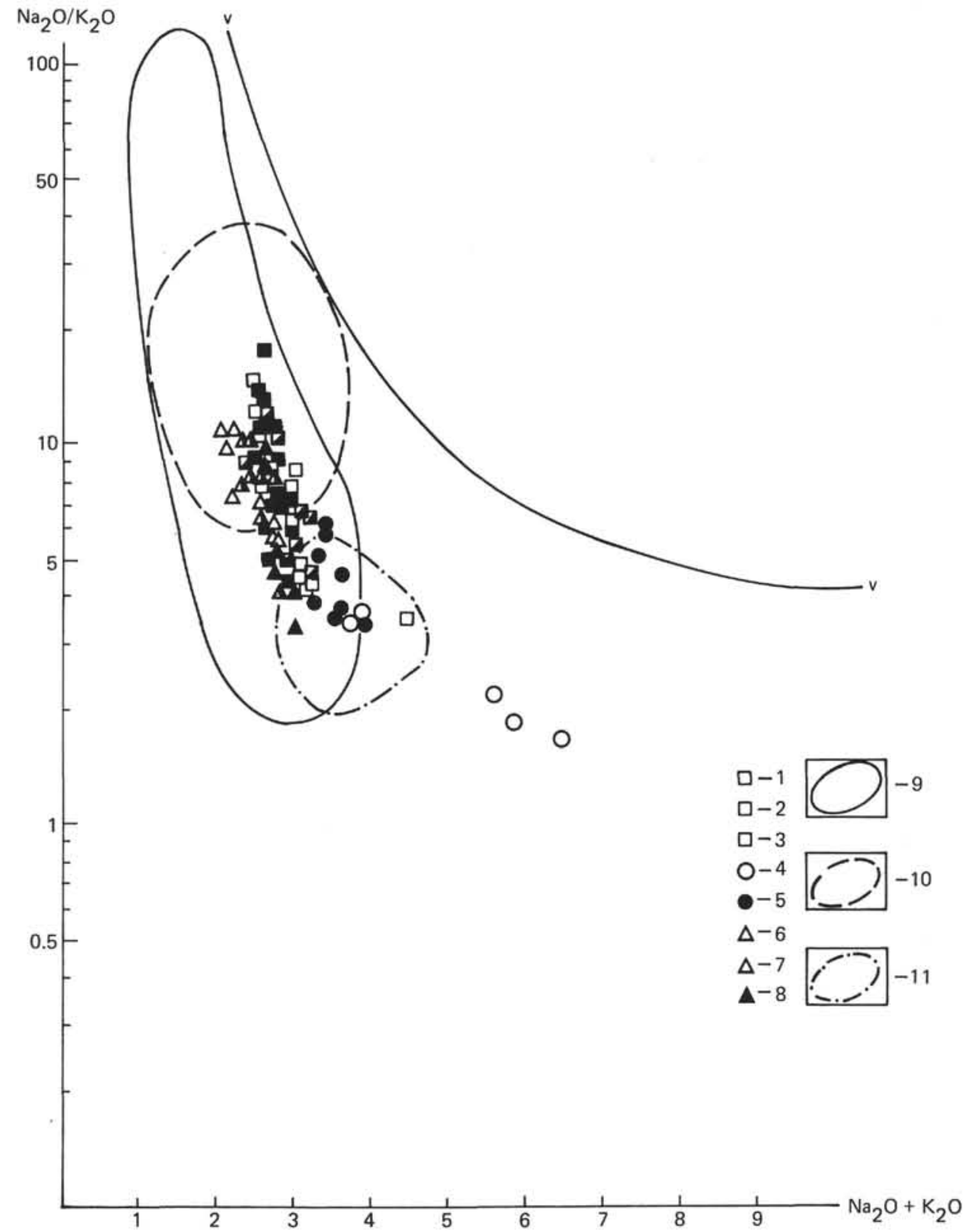

Figure 11. *Miyashiro variation diagram. V-V = the boundary line separating fresh rocks from those altered by epimagmatic processes. 9 = Icelandic tholeiite field, 10 = abyssal tholeiite field, 11 - field of alkaline rocks of the Atlantic islands; other symbols as in Figure 4.*

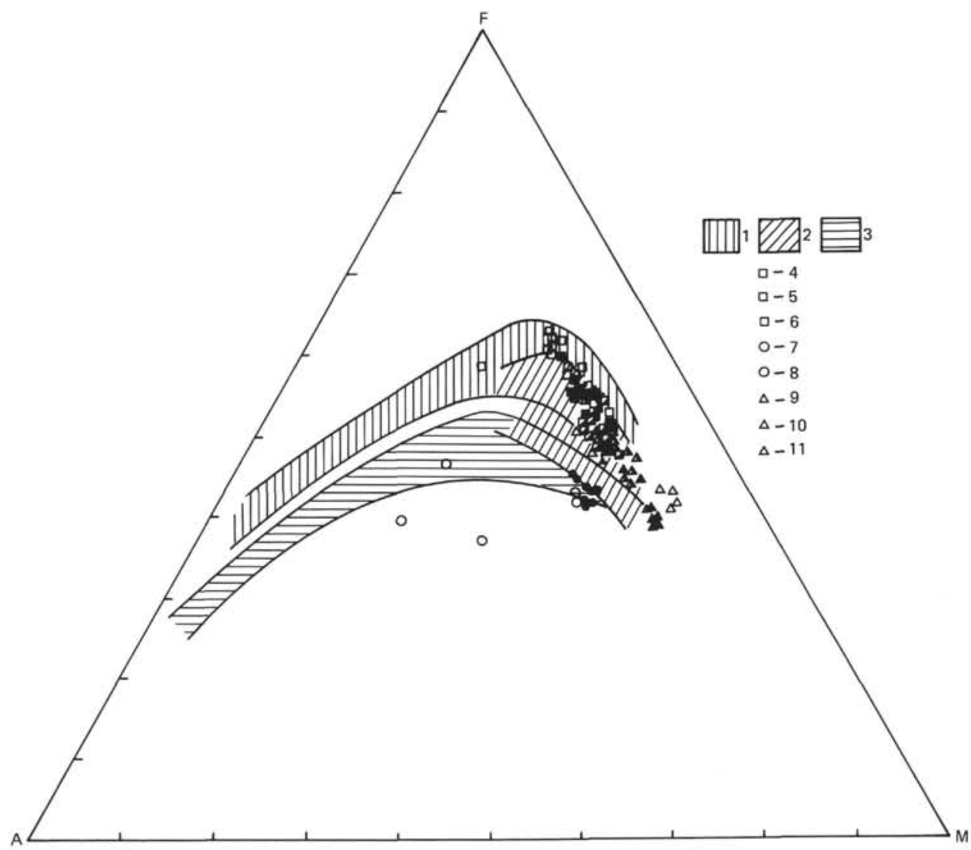

Figure 12. *Three-component AFM diagram. A = (Na_2O + K_2O), F = (Fe_2O_3 + FeO, recalculated to FeO), M = (MgO), 1 = tholeiite field, 2 = high-alumina field, 3 = alkaline olivine-basalt field. Other symbols as in Figure 4.*

TABLE 4
Chemical Composition of Gases in Basalts From Holes 407, 408, 409, 410, 410A, 411, 412A, and 413

Sample (Interval in cm)	Chemical Composition of Gases; Numerator %, Denominator cm^3/kg										
	H_2	O_2		CO_2	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	n C_4H_{10}	n C_4H_{10}
2	3	4	5	6	7	8	9	10	11	12	13
Hole 407											
40735-1, 30-33	-	-	-	-	77.77 / 0.03	11.11 / 0.0043	-	11.11 / 0.0043	-	-	-
40736-1, 20-25	2.436 / 0.937	-	97.43 / 35.50	-	0.114 / 0.044	0.011 / 0.004	-	0.006 / 0.0016	-	-	-
40736-3, 95-97	98.54 / 1.098	-	-	-	1.36 / 0.015	0.102 / 0.001	-	-	-	-	-
40737-1, 112-117	2.199 / 1.125	-	97.77 / 46.77	-	0.048 / 0.011	0.006 / 0.003	-	0.003 / 0.0015	-	-	-
40737-2, 109-111	-	-	94.99 / 88.89	-	5.01 / 0.009	-	-	-	-	-	-
40738-2, 15-17	0.148 / 0.139	-	99.22 / 21.29	-	0.103 / 0.022	0.0013 / 0.0028	-	0.0013 / 0.0028	-	-	-
40739-2, 100-105	0.53 / 1.438	-	99.41 / 277.25	-	0.009 / 0.023	0.001 / 0.0025	-	-	-	-	-
40740-1, 70-75	3.38 / 0.641	-	96.44 / 14.74	-	0.12 / 0.025	0.014 / 0.0039	-	-	-	-	-
407-42-2, 35-40	1.011 / 1.212	-	98.90 / 119.0	-	0.0234 / 0.028	0.0039 / 0.0047	0.0026 / 0.003	0.0039 / 0.0047	-	0.0013 / 0.0015	0.0039 / 0.0047
407-44-1, 60-65	0.689 / 0.895	-	99.85 / 129.0	-	0.0173 / 0.022	0.0017 / 0.0021	-	-	-	-	-
407-45-1, 55-60	1.025 / 2.16	-	98.95 / 208.3	-	0.0165 / 0.0348	0.0016 / 0.0075	-	-	-	-	-
407-45-2, 0-5	97.90 / 0.99	-		-	0.855 / 0.0188	0.145 / 0.00145	-	0.144 / 0.00144	-	-	-
407-47-3, 77-80	0.576 / 0.395	-	99.40 / 68.50	-	0.05 / 0.0342	0.0057 / 0.0039	-	0.0025 / 0.0017	-	0.0036 / 0.0026	0.0029 / 0.002
Hole 408											
40836-2, 83-85	2.24 / 3.14	-	97.60 / 137.0	-	0.033 / 0.0646	0.018 / 0.0025	-	-	-	-	-
40836-3, 7-10	2.2 / 0.785	-	97.40 / 35.70	-	0.129 / 0.472	0.0312 / 0.114	0.156 / 0.057	0.156 / 0.057	0.0195 / 0.0715	0.0078 / 0.028	0.0156 / 0.057
40836-5, 34-37		-	99.99 / 264.0	-	0.0058 / 0.0154	0.0108 / 0.0029	-	-	-	-	-
40837-1, 74-77	0.481 / 2.188	-	99.51 / 452.08	-	0.011 / 0.050	0.0014 / 0.0063	-	-	-	-	-
40837-2, 89-91	0.967 / 2.232	-	99.01 / 228.57	-	0.020 / 0.0464	0.0015 / 0.0036	-	-	-	-	-
40837-3, 33-35	5.92 / 2.417	-	93.96 / 38.33	-	0.098 / 0.040	0.0123 / 0.005	-	0.0053 / 0.0022	-	-	-
40838-1, 66-68	1.695 / 0.375	-	97.95 / 21.67	-	0.354 / 0.078	0.0049 / 0.0011	-	-	-	-	-
40838-2, 38-40	0.988 / 0.298	-	98.845 / 29.762	-	0.1304 / 0.0393	0.0158 / 0.0048	0.0079 / 0.0024	0.0118 / 0.0086	-	-	-
40838-3, 95-97	3.740 / 1.544	-	96.174 / 39.706	-	0.0784 / 0.0324	0.0071 / 0.0029	-	-	-	-	-
Hole 409											
4097-6, 135-140	3.996 / 1.157	-	95.913 / 27.78	-	0.0799 / 0.023	0.0064 / 0.0019	-	0.0042 / 0.0012	-	-	-
4099-2, 95-100	0.369 / 0.658	-	99.61 / 177.63	-	0.0192 / 0.0342	0.0015 / 0.0026	-	-	-	-	-
409-10-1-50-55	10.592 / 2.375	-	89.196 / 20.00	-	0.1895 / 0.0425	0.0167 / 0.0038	-	0.0056 / 0.0013	-	-	-
40910-4, 95-100	1.419 / 2.813	-	98.556 / 195.31	-	0.0228 / 0.0453	0.0016 / 0.0031	-	-	-	-	-
40911-3, 70-75	1.848 / 0.833	-	98.102 / 44.23	-	0.0426 / 0.0192	0.0057 / 0.0026	-	0.0018 / 0.0008	-	-	-

TABLE 4 – *Continued*

Sample (Interval in cm)	Chemical Composition of Gases; Numerator %, Denominator cm^3/kg										
	H_2	O_2	5	CO_2	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	n C_4H_{10}	n C_4H_{10}
2	3	4	5	6	7	8	9	10	11	12	13
40912-1, 120-125		–	99.936/80.00	–	0.0499/0.040	0.0014/0.0011	–	–	–	–	–
40915-1, 80-85	2.191/1.204	–	97.758/53.70	–	0.0472/0.0259	0.0034/0.0018	–	–	–	–	–
40917-1, 130-135	96.154/0.408	–	–	–	3.846/0.016	–	–	–	–	–	–
40918-1, 90-91	0.803/0.075	–	98.898/93.33	–	0.0196/0.0183	0.0017/0.0017	0.0079/0.0024	–	–	–	–
40920-1, 10-15	0.0395/0.0492	–	99.765/124.24	–	0.0146/0.0181	0.0012/0.0015	–	–	–	–	–
40921-3, 120-125	0.394/1.513	–	99.596/382.89	–	0.0096/0.0368	0.0004/0.0017	–	–	–	–	–
40924-2, 130-135	1.104/1.05	–	98.845/94.00	–	0.0452/0.043	0.0042/0.0004	–	0.0019/0.0018	–	–	–
40924-3, 145-150	2.055/1.313	–	97.847/62.50	–	0.088/0.0563	0.0079/0.0050	–	0.0036/0.0016	–	–	–
40925-2, 60-65	–	–	99.867/3.503	–	0.0133/0.056	–	–	–	–	–	–
40928-1, 120-125	99.97/1.600	–	–	–	0.0199/0.032	0.0049/0.008	–	0.0037/0.006	–	–	–
40931-2, 45-48	–	–	99.976/77.38	–	0.019/0.0155	0.0034/0.0024	–	–	–	–	–
40922-1, 85-98	1.937/1.70	–	98.004/86.00	–	0.046/0.041	0.0076/0.0067	0.0022/0.0020	0.0044/0.0040	0.0011/0.0010	0.0014/0.0013	0.0018/0.0012
Hole 410											
41037-1, 85-90	10.419/0.35	–	89.312/3.0	–	0.238/0.008	0.029/0.001	–	–	–	–	–
41038-1, 86-91	1.019/0.365	–	98.97/85.42	–	0.0034/0.0013	0.0058/0.002	–	–	–	–	–
41039-3, 119-124	38.09/1.042	–	66.080/2.089	–	0.858/0.0271	0.066/0.0021	–	–	–	–	–
41039-6, 28-38	3.48/1.25	–	96.367/34.62	–	0.128/0.0462	0.0107/0.0038	0.0064/0.0023	0.0069/0.0025	–	–	–
41041-2, 54-59	–	–	99.989/81.13	–	0.011/0.0086	–	–	–	–	–	–
Hole 410		–		–							
410A2-1, 39-44	1.328/1.666	–	98.648/123.8	–	0.0227/0.00286	0.0013/0.0017		–	–	–	–
410A2-4, 25-30	0.338/0.337	–	99.62/99.66	–	0.0354/0.0355	0.0080/0.0051		–	–	–	–
410A3-3, 25-30	12.065/1.65	–	87.745/12.00	–	0.175/0.024	0.0146/0.002		–	–	–	–
410A4-2, 75-80		–	99.97/27.14	–	0.03/0.0093	–		–	–	–	–
410A4-4, 55-60		–	82.80/52.50	171.5/10.87	0.0414/0.0262	0.0059/0.0037		–	–	–	–
410A5-3, 85-90	1.254/0.945	–	98.72/74.39	–	0.0226/0.017	0.0032/0.0024		–	–	–	–
410A5-4, 25-30	2.178/0.833	–	97.776/37.50	–	0.0434/0.0167	0.0072/0.0028	–	–	–	–	–
410A6-2, 115-120	5.49/0.313	–	94.119/5.35	–	0.313/0.0178	0.047/0.0027	–	–	–	–	–
Hole 411											
4111-1, 7-10	1.107/1.666	–	98.873/148.80	–	0.0197/0.0298	–	–	–	–	–	–

TABLE 4 – *Continued*

Sample (Interval in cm)	Chemical Composition of Gases; Numerator %, Denominator cm^3/kg										
	H_2	O_2		CO_2	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	n C_4H_{10}	n C_4H_{10}
2	3	4	5	6	7	8	9	10	11	12	13
4111-1, 70-75	2.065/1.250	–	97.907/59.25	–	0.0260/0.0157	0.0021/0.0013	–	–	–	–	–
4112-1, 60-65	0.887/0.151	–	99.099/168.75	–	0.0135/0.0229	0.009/0.0015	–	–	–	–	–
4113-1, 37-41	3.053/0.58	–	96.866/46.00	–	0.0505/0.024	0.0029/0.0014	–	–	–	–	–
4113-1, 143-145	0.38/0.859	–	99.605/225.0	–	0.0131/0.0297	0.0009/0.0022	–	–	–	–	–
4114-1, 84-88	1.73/0.807	–	98.22/45.83	–	0.037/0.0171	0.0044/0.0021	0.0013/0.006	0.0028/0.0013	0.0015/0.0007	–	–
Hole 412A											
412A1-1, 16-20	91.32/0.208	–	–	–	7.305/0.0017	1.369/0.0031	–	–	–	–	–
412A2-1, 71-75	0.858/1.285	–	99,133/149.30	–	0.0115/0.024	0.0013/0.0021	–	–	–	–	–
412A3-1, 47-50	2.952/1.521	–	96.983/50.00	–	0.0611/0.0315	0.0042/0.0022	–	–	–	–	–
412A3-2, 45-50	97.50/1.547	–	–	–	2.175/0.0345	0.225/0.0086	0.0775/0.0015	0.0775/0.0015	–	–	–
412A3-3, 42-45	0.949/0.921	–	99.031/96.05	–	0.0189/0.0184	0.0027/0.0026	–	–	–	–	–
412A-51, 35-40	0.96/0.955	–	99.01/98.52	–	0.0026/0.0257	0.0022/0.0022	–	0.0002/0.0024	–	–	–
412A6-1, 85-90	2.001/0.363	–	97.862/17.74	–	0.116/0.0209	0.0151/0.0027	–	0.0058/0.00102	–	–	–
412A7-2, 130-135	1.797/1.16	–	98.166/63.39	–	0.0345/0.0228	0.0017/0.0012	–	–	–	–	–
412A8-1, 90-95	98.159/1.176	–	–	–	1.718/0.0205	0.122/0.0015	–	–	–	–	–
412A9-1, 130-135	11.847/1.688	–	87.758/12.50	–	0.307/0.0438	0.0351/0.005	–	0.263/0.0037	0.0087/0.00125	0.0174/0.0025	–
412A11-2, 140-145	1.706/0.801	–	98.264/46.15	–	0.030/0.0141	–	–	–	–	–	–
412A11-3, 5	6.426/1.031	–	93.469/15.00	–	0.0973/0.0156	0.0077/0.0013	–	–	–	–	–
412A13-1, 9-7100	2.095/0.662	–	97.79/29.66	–	0.093/0.0294	0.0093/0.0029	0.0046/0.0015	0.0093/0.0029	–	–	–
412A13-2, 30-35	5.53/2.656	–	94.36/45.31	–	0.976/0.0469	0.0098/0.0047	–	–	–	–	–
412A14-2, 107-112		–	99.996/444.19	–	0.004/0.016	–	–	–	–	–	–
412A-145, 3-7	0.748/0.724	–	99.217/101.71	–	0.0299/0.0289	0.0040/0.0039	–	0.0013/0.0013	–	–	–
Hole 413											
4131-2, 75-80	4.106/1.50	–	95.809/35.00	–	0.0718/0.0263	0.0047/0.0018	0.0034/0.0013	0.0047/0.0016	–	–	–
4131-2, 113-118	0.826/0.156	–	99.119/18.75	–	0.055/0.0104	–	–	–	–	–	–
4132-1, 25-28	0.144/0.135	–	99.816/93.75	–	0.0354/0.033	0.0044/0.0042	–	–	–	–	–
4122-1, 72-75	1.738/1.513	–	98.218/85.52	–	0.0423/0.0368	0.0021/0.0018	–	–	–	–	–
4133-1, 70-75	4.756/0.641	–	95.129/12.82	–	0.105/0.0141	0.0095/0.0013	–	–	–	–	–
4134-1, 56-60	1.768/0.804	–	98.197/44.64	–	0.035/0.0161	–	–	–	–	–	–

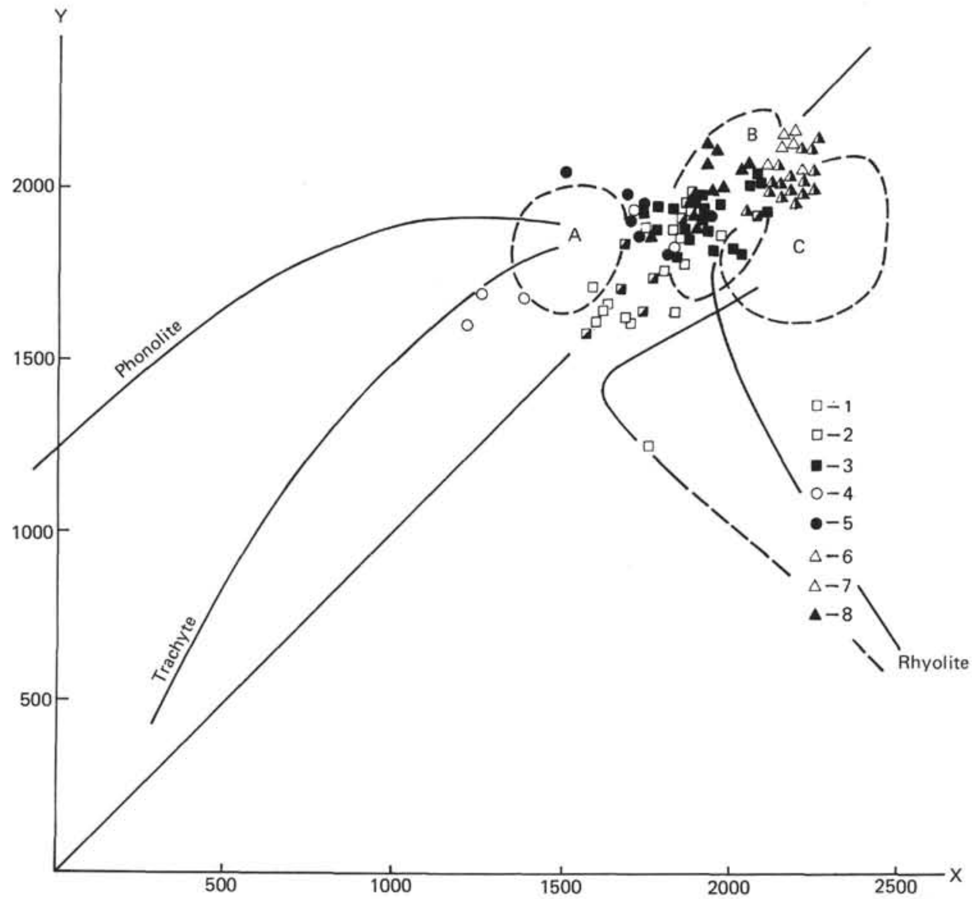

Figure 13. *H. de La Roche and J. Letterier variation diagram. X = 4Si - II(Na+K) - 2 (Fe+Ti), y = 6Ca+2Mg+A1. Elements are presented in atomic proportions. A = alkaline olivine-basalt field, B = high-alumina field, C = tholeiite field. Other symbols as in Figure 4.*

TABLE 5
Average Chemical Composition of Gases in Basalts From Holes 407, 408, 409, 410 410A, 411, 412A, and 413

Holes	Number of Samples	Chemical Composition of Gases, Numerator %, Denominator cm^3/kg									
		H_2		CO_2	CH_4	C_2H_6	C_2H_4	C_3H_8	C_3H_6	C_4H_{10}	C_4H_{10}
407,408,409	39	1.222 (95.62) / 0.994	98.84 / 87.56	- / -	0.045 (3.84) / 0.040	0.0061 (0.53) / 0.0055	- / 0.0161 (4)	- / 0.0074 (17)	- / 0.0363 (2)	- / 0.0363 (2)	- / 0.0162 (4)
410,410A	13	1.31 (95.84) / 0.812	98.38 / 48.49	- / 10.87 (1)	0.045 (3.81) / 0.022	0.005 (0.35) / 0.0025	- / 0.0023 (1)	- / 0.0019 (3)	- / -	- / -	- / -
411,412A,413	28	0.498 (93.96) / 0.422	99.47 / 84.26	- / -	0.027 (5.09) / 0.023	0.005 (0.35) / 0.0014	- / 0.0011 (3)	- / 0.0014 (8)	- / 0.0004 (2)	- / 0.0019 (2)	- / 0.0012 (1)

Note: In the numerator, in brackets: chemical composition of gases without nitrogen, %. In the denominator, in brackets: number of samples, the average content of a component was calculated from.

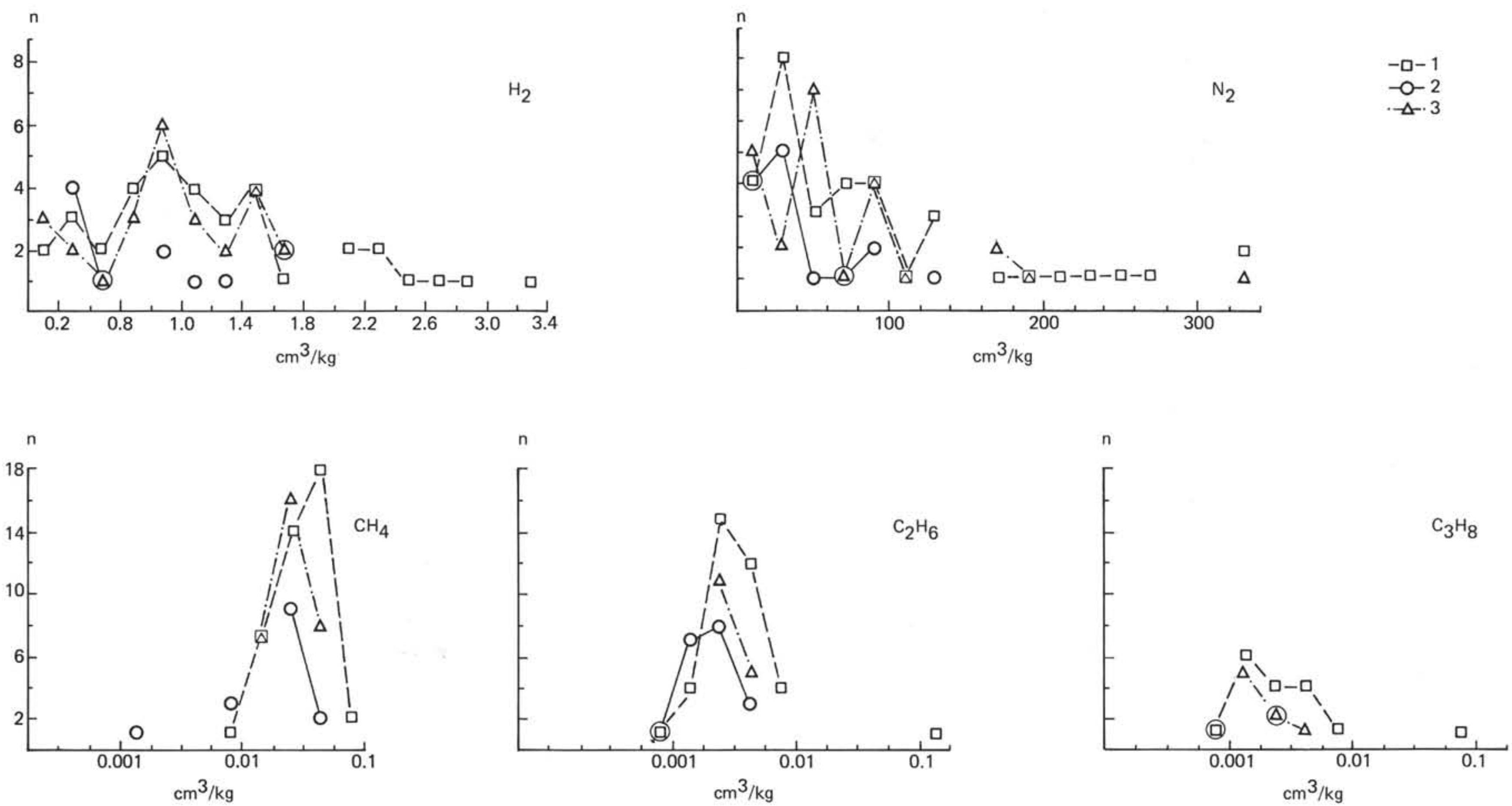

Figure 14. *Histogram of gas distribution. Symbols as in Figure 3.*