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Report on DELP 1987 Cruises in the Ogasawara Area

Part VII: Petrochemistry of Volcanic Rocks of Ogasawara Area

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Abstract

A large number of volcanic rocks were collected from knolls on the western side of Kita Iwo Jima and the Kaikata Seamount. Examinations on the major chemical elements of these rocks show that the volcanic materials of Kita Iwo Jima are of low-alkali tholeiitic andesite and contain about 61-66% of SiO_2. Only one sample belongs to high-alkali tholeiitic andesite containing about 55% SiO_2. If we assume that the high-alkali tholeiitic andesite is autochthonous, the volcanic edifice of Kita Iwo Jima consists mainly of low-alkali tholeiite and partly of high-alkali tholeiite.

In contrast, the volcanic rocks from the Kaikata Seamount are of high-alkali tholeiitic basalt containing about 49-54% SiO_2.

1. Introduction

Many islands and seamounts belonging to the Shichito-Iwo Jima Ridge consist of volcanic rocks. Volcanic rocks on the ridge are mainly composed of tholeiitic rocks. It is known that K_2O and Na_2O contents of volcanic rocks increase not only to the west (perpendicular to the Izu-Ogasawara Arc) but also to the south (along the arc) (SUGIMURA, 1960; ARAMAKI and UI, 1983). This tendency may be correct in general; however, local variations of chemical compositions of volcanic rocks should be studied on the basis of analyses of rocks dredged from each body. For example, AOKI and TOKAI UNIVERSITY RESEARCH GROUP FOR MARINE VOLCANO (1983), OKITSU *et al.* (1987) and AOKI and ISHIKAWA (1988) have recently indicated some differences in rock types between lower and upper parts of the volcanic edifices on the ridge. Alkali content of volcanic rocks from the lower part has higher value than that from the upper part.

During the DELP-87 Tokaidaigaku-maru Nisei Cruise, many volcanic rocks were sampled from knolls on the western side of Kita Iwo Jima and the Kaikata Seamount. Locations of dredge hauls are shown in Fig. 1. The characteristics of chemical compositions of these rocks are discussed

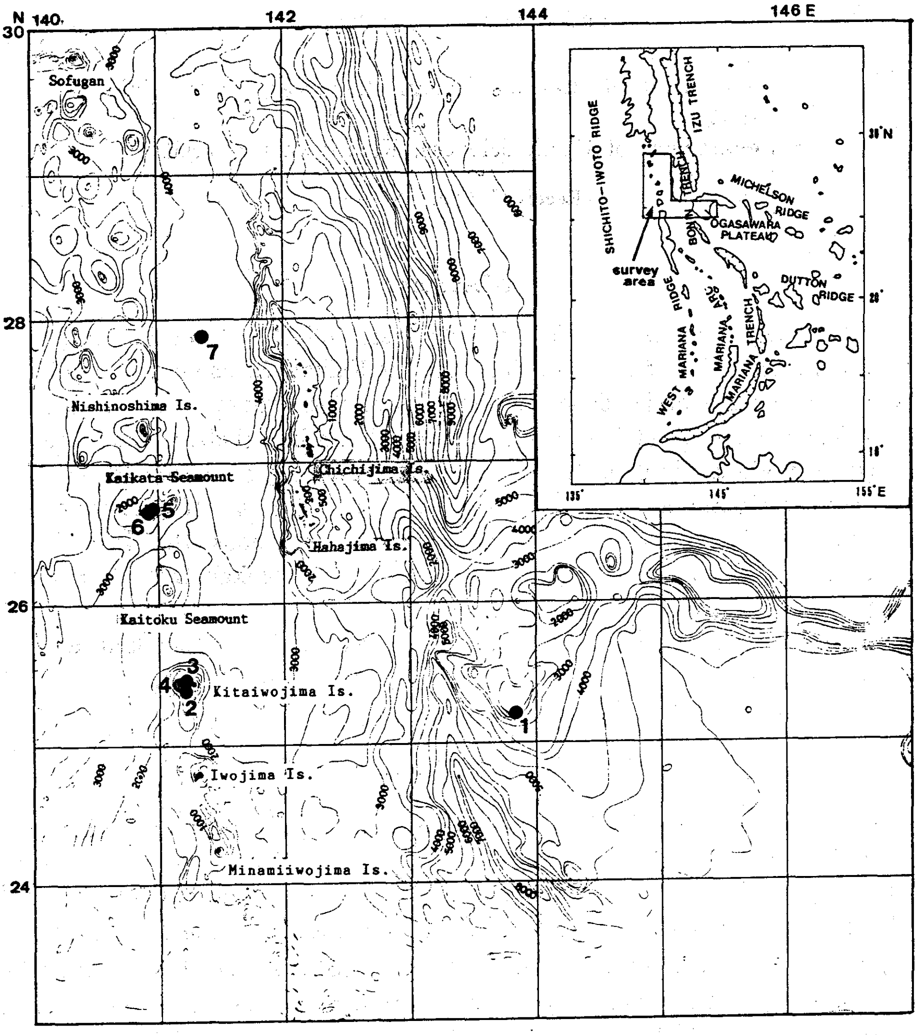

Fig. 1. Location map of the dredge hauls during the DELP-87 Daigakumaru Nisei Cruise in the Ogasawara area. Numbers of solid circles show the dredge site.

in the present paper.

The general topography and geological setting of the Izu-Ogasawara Arc have been described by YUASA and MURAKAMI (1985). In the arc, the major part of the Shichito-Iwo Jima Ridge, the volcanic front at present times, is below sea level. Islands above sea level consist of volcanic rocks of the Quaternary System. Except for islands in the northern part of the ridge system (such as Niijima, Kozushima and Shikineshima), the majority of islands on the Shichito-Iwo Jima Ridge consists of basalt, andesite and dacite, with SiO_2 content less than 65% (e.g. ARAMAKI and UI, 1978 ; UTO, 1983). In contrast, there are few petrographical data of rocks on the ridge below sea level. There are the following reports: Basalts from large and small submarine volcanoes between east shore of the Izu Peninsula and Oshima, and, rhyolites from Omurodashi seamount south of Oshima Island (YUASA and HONZA, 1976 ; AOKI, 1979 ; HAMURO *et al.*, 1980, 1983), andesites and basalts from the Kurose Bank north of Hachijo Jima (AOKI, 1979 ; YUASA, *et al.*, 1981), andesites from a seamount north-west of Hachijo Jima (OKITSU *et al.*, 1987), andesites from the Smith Island, andesites and basalts from insular shelves around the Sofugan (AOKI, 1979), basalts from the submarine slope northwest of the Bayonnaise Rocks (HONDA and KITANO, 1974), basalts from north of the Kaitoku Seamount and Nishinoshima, dacites from south of Sofugan, and andesites around Minami Iwo Jima (YUASA *et al.*, 1981b).

ISHIKAWA and EGAWA (1977) have compared the chemical composition of volcanic rocks from the Izu Islands, and of the Northern Mariana Islands, and found that most of the volcanic rocks from the former are low-alkali tholeiite, but in the latter, both low and high-alkali tholeiite are present. They proposed that the boundary of this difference is around Iwo Jima. YUASA and TAMAKI (1982) studied the topography and petrochemistry of the Shichito-Iwo Jima Ridge, and proposed the presence of the Sofugan Tectonic Line which pass as south of Sofugan. They postulated that the region where high-alkali tholeiite and low-alkali tholeiite coexist is restricted to the south of this tectonic line. Against such a horizontal change of volcanic rocks, AOKI and TOKAI UNIVERSITY RESEARCH GROUP FOR MARINE VOLCANO (1983) pointed out the common occurrence of the low-alkali tholeiitic volcanic islands on the high-alkali tholeiitic fundation along the Shichito-Iwo Jima Ridge.

Both the western knolls of Kita Iwo Jima and the Kaikata Seamount belong to the southern part of Shichito-Iwo Jima. Kita Iwo Jima is a volcanic island located on the northeastern edge of a volcanic body 28 km wide and 48 km long, oriented from south to north. This volcanic body has a gentle flat part at depth about 500 m, the knolls are distributed on this flat part. The knoll (the depth of the top is less than 100 m) where volcanic rocks were sampled is several kilometers west of Kita Iwo Jima. This knoll is believed to have been formed by submarine eruption in 1880–1889 (KUNO, 1962),

Kaikata Seamount is a volcanic body located between Nishinoshima and the Kaitoku Seamount. These is no historic record of volcanic activity of Kaikata Seamount. Kaikata Seamount is a composite volcano composed of major four mounts. The top of the eastern mount forms a submarine caldera (YUASA *et al.*, 1987). Dredge positions are near the top (water depth: 159 m) of the central mount among the three mounts which are aligned from north-northeast to the south-southwest on the western side of the seamount, and on the south slope (water depth: 1,205 m) of the southern mount.

2. Description of rocks

2·1. Macroscopic observation of volcanic rocks

Samples of volcanic rock were collected from five positions (site 2 to site 6) in total, namely three positions on the western side submarine slope of Kita Iwo Jima and at the knolls (water depths: 203 to 310 m), and two

Table 1. Dredge statiohs (DELP-87) Daigakumaru Nisei Cruise).

Dredge station	Area	Loaction	Depth(m)
DELP-87-1	Matsubara Seamount on the Ogasawara Plateau	25°12.50'N-143°49.39'E on 25°12.99'N-143°49.22'E off	1,710 1,360
-2	Western slope of the Kitaiwojima Island	25°25.75'N-141°15.40 E on 25°25.95'N-141°15.35'E off	210 290
-3	Western knoll of the Kitaiwojima Island	25°26.08'N-141°14.20'E on 25°26.35'N-141°14.00'E off	203 217
-4	Western knoll of the Kitaiwojima Island	25°26.20'N-141°12.80'E on 25°26.50'N-141°12.50'E off	210 105
-5	Kaikata Seamount	26°39.77'N-140°56.00'E on 26°39.91'N-140°56.16'E off	159 173
-6	Kaikata Seamount	26°37.18'N-140°56.28'E on 26°37.52'N-140°56.80'E off	1,205 1,196
-7	Central part of the Bonin Trough	27°49.76'N-141°23.44'E on 27°49.12'N-141°22.35'E off	4,140 4,143

positions at the Kaikata Seamount (water depth: 159 and 1,205 m), during the DELP-87 Cruise (Fig. 1 and Tables 1 and 2). The dredger was of chain-bag type provided by Ocean Research Institute, University of Tokyo.

Site 2 is on the west submarine slope of Kita Iwo Jima. From here, andesitic tuff breccia (11 cm in largest diameter), several pieces of andesite (8 cm in largest diameter) and small grained pieces of diorite which constitute the tuff breccia were collected. Total weight of the sample was 0.8 kg. All of the collected rocks were fresh and no organisms sticking to the rock surface were observed (Table 2).

Site 3 is a knoll adjacent to the west side of site 2. A large amount of fresh andesite breccia (32 cm in largest diameter, total weight of sample was 45.3 kg) was collected from the western slope of the knoll. Andesite breccia, on the whole, is porous. Organism sticking to rocks were not observed.

Site 4 is a knoll adjacent to the west side of site 3. A large amount of foamed pumice and pumiceous andesite breccia (largest diameter of pumice was 15 cm, largest diameter of pumiceous andesite was 6 cm and total weight of sample was 8.4 kg) was collected. These breccias were fresh, and organism sticking to the rock surface were not observed.

Site 5 is near the top of the central mount of three mounts constituting the western part of the Kaikata Seamount. A large amount of basalt breccia was collected (30 cm in largest diameter, and 45.8 kg in total weight). Organisms several centimeters thick were observed adhering to the rocks. Rocks are fresh and porous on the whole.

Site 6 is on the south side slope of mounts to the south of site 5. Semiconsolidated layered scoriaceous sandstone and tuffaceous siltstone (0.5 to 2.0 cm in thickness and 20 cm in largest diameter) were collected in large amount (0.5 kg in total weight) from this site. Many burrows of bottom fauna are observed on the surface of these samples. Together with their rocks, a small amount of basaltic fragments was collected.

2-2. Petrography of volcanic rocks

(1) Site 2

Micro quartz diorite ⟨*gravel in tuff breccia*⟩ (*samples No. 2-3*)

Rock is holocrystalline and shows intergranular texture. Main constituent minerals are plagioclase, quartz and interstitial mafic minerals chloritized by alteration. A small amount of magnetite (modal ratio: 4%) is observed as an accessory mineral. Plagioclase (modal ratio: 55%) shows hypidiomorphic or idiomorphic form with 1.5 mm in largest length (length of 0.4 mm is predominates). The peripheral parts of some plagioclase are

Table 2. Location of the dredge hauls and principal rock types of the volcanic rocks during the DELP-87 Cruise.

Dredge station	Area	Weight (Kg)	Depth (m)	Principal rock types
DELP-87-1	Matsubara Seamount on the Ogasawara Plateau	-	1,710-1,360	Several pieces of crastic limestone blocks with thin ferromanganese coatings, fragments of pumice.
-2	Western slope of the Kitaiwojima Island	0.8	210-290	Blocks of tuffbreccia(28%), andesitic pebbles in tuffbreccias(72%). A.(100%). 18 pieces.
-3	Western knoll of the Kitaiwojima Island	45.4	203-217	Blocks of vesicular andesite(64%) and andesite (30%), fragments of pumice(6%). A.(74%), SA.(23%), SR.(3%). 256 pieces. Small amount of andesitic lapilli(1.3Kg).
-4	Western knoll of the Kitaiwojima Island	8.4	210-105	Fragments of pumice(90%) and andesite(10%). A.(100%). 185 pieces. Small amount of volcanics.
-5	Kaikata Seamount	45.8	159-173	Blocks of tuffbreccia (61%), tuff(23%) and basalt (16%). A.(93%), SA.(6%), SR.(1%). 97 pieces. Small amount of volcanics.
-6	Kaikata Seamount	10.5	1,205-1,196	Basaltic lapilli(35%), fragments of pumice(19%), blocks of thin bedded tuffaceous siltstone(16%) and sandstone(30%). A.(91%), SR.(19%). 212 pieces. Small amount of tuffaceous fragments.
-7	Central part of the Bonin Trough	-	4,140-4,143	Small amount of volcanic sand.

A.: angular shape, SA.: subangular shape, SR.: subround shape, R.: round shape.

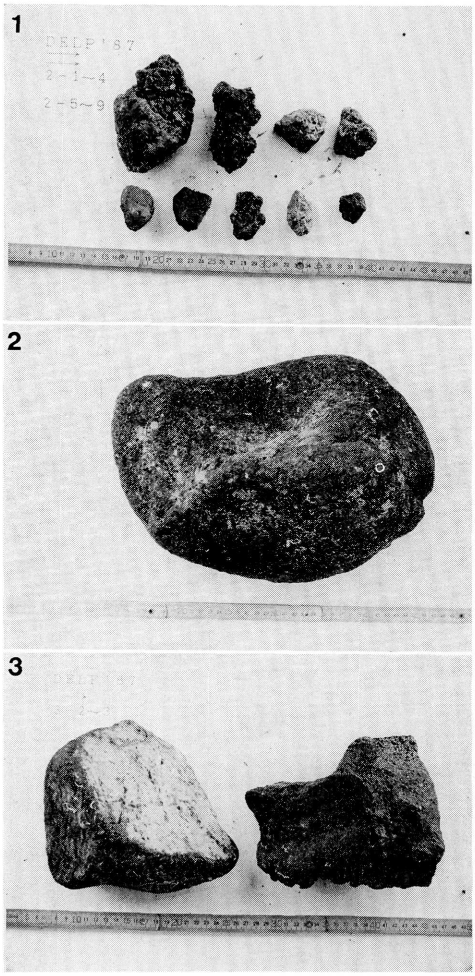

Plate 1. Photographs of the dredged samples of the DELP-87 NISEI Cruise.
1. Dredge site 2 (sample Nos. 2-1 to 2-9). Blocks of andesitic tuff breccia. Pebbles are mostly clinopyroxene andesite. One of those pebbles is micro quartz diorite (2-3).
2. Dredge site 3 (sample No. 3-1). Fresh clinopyroxene andesitic block.
3. Dredge site 3 (sample Nos. 3-2 and 3-3). Fresh clinopyroxene andesitic and two-pyroxene andesitic blocks.

altered. Quartz is present in a modal ratio of 10%.

Clinopyroxene andesite ⟨*almost aphric*⟩ (*samples No. 2-5, 6*)

Rocks are porous and fresh on the whole. Phenocrysts consist of plagioclase and clinopyroxene of modal ratio less than 5%. Plagioclase shows idiomorphic or hypidiomorphic crystal and the majority of crystals

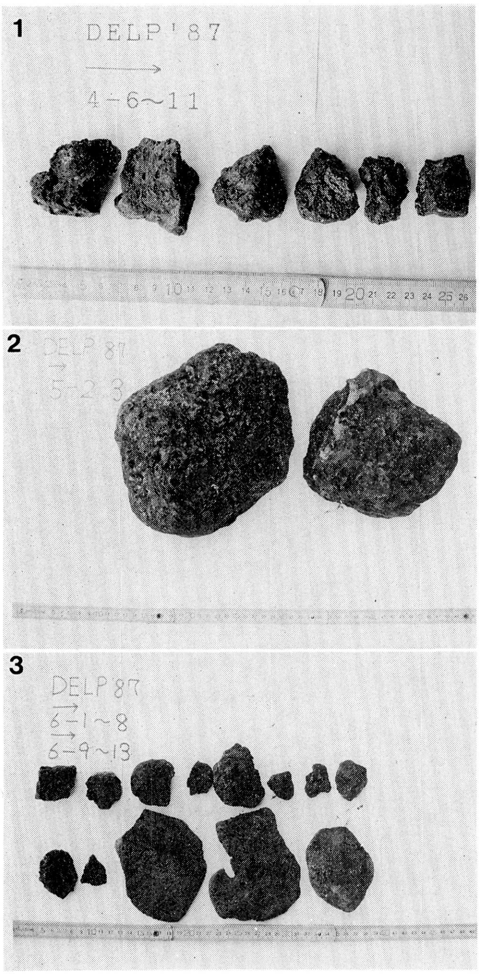

Plate 2. Photographs of the dredged samples of the DELP-87 Cruise.
1. Dredge site 4 (sample Nos. 4-6 to 4-11). Fragments of fresh pumiceous clinophyroxene andesite.
2. Dredge site 5 (sample Nos. 5-2 and 5-3). Two-pyroxene basaltic blocks.
3. Dredge site 6 (sample Nos. 6-1 to 6-13). Olivine basalitc lapilli and blocks of thin layered tuffaceous siltstone.

are short prismatic (1.0 mm in largest length). Zonal structure is not remarkable. Clinopyroxene shows hypidiomorphic and short prismatic crystals, on the whole, and is 0.9 mm in largest length. Groundmass consists of acicular crystals of plagioclase, acicular or granular crystals of clinopyroxene and brown glass of which the modal ratio is about 40%. Crystals of plagioclase and clinopyroxene are aligned parallel to the flow

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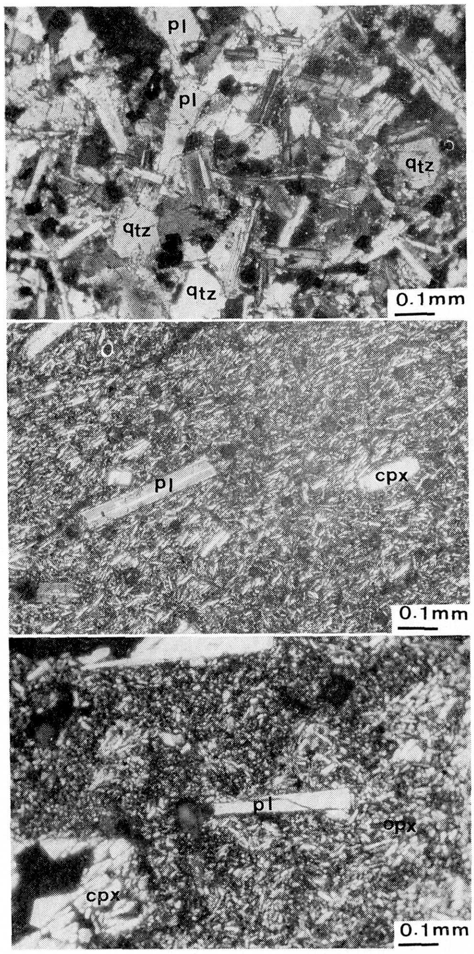
2
3


Plate 3. Photomicrographs of the dredged samples, taken under crossed polarizers.
1. Sample No. 2–3. Micro quartz diorite.
2. Sample No. 2–5. Clinopyroxene andesite.
3. Sample No. 3–2. Two-pyroxene andesite.
pl : plagioclase, cpx : clinopyroxene, opx : orthopyroxene, qtz : quartz.

structure. Magnetite is present in small amount.

(2) Site 3

Clinopyroxene andesite ⟨*almost aphyric*⟩ (*samples No. 3–1, 3, 8*)

Fresh and porous samples occupy the majority, on the whole. Phenocrysts are composed of plagioclase and clinopyroxene, and their modal ratios are less than 4%. Plagioclase crystals are hypidiomorphic or idiomorphic, and the largest length is 2.0 mm. Zonal structure is not remarkable. The majority of clinopyroxene crystals are in hypidiomorphic and short prismatic form; their largest length is 0.8 mm. Groundmass shows a hyalo-ophitic texture, and is composed of acicular crystals of plagioclase, acicular or granular crystals of clinopyroxene and interstitial light brownish glass of which the modal ratio is about 20%. Magnetite is present in small amount.

Two-pyroxene andesite <*almost aphyric*> (*samples No. 3-2, 6, 7, 10*)

Rocks are fresh on the whole. Some samples are porous (3-10). Phenocrysts are composed of plagioclase, clinopyroxene and orthopyroxene. The modal ratio of phenocrysts is less than 8%. Plagioclase is present as hypidiomorphic crystal and the largest length is 1.4 mm. Zonal structure is remarkable in some crystals (3-6) and less remarkable in others (3-2, 7, 10). Clinopyroxene crystals show hypidiomorphic form; their largest length is 0.5 mm. Orthopyroxene crystals are hypidiomorphic; its largest length is 1.2 mm. Reaction rims of clinopyroxene are found in the peripheral part of the orthopyroxene crystals. Groundmass is composed of acicular or granular crystals of clinopyroxene. Magnetite content is very small. Beside their crystals, the samples No. 3-6 contain 20% of brown glass in a modal ratio.

(3) Site 4

Andesitic pumice (*samples No. 4-1*)

Phenocrysts of plagioclase (1.2 mm in largest length) and clinopyroxene (0.8 mm in largest length) appear in small amount in remarkably foamed light brownish glass.

Pumiceous clinopyroxene andesite (*samples No. 4-1, 4-6-1, 4-6-2*)

Vesiculation of rock specimen is remarkable. Plagioclase and clinopyroxene are found as phenocrysts in modal ratio 15%. Plagioclase appears in hypidiomorphic crystals having largest length of 1.6 mm. Zonal structure is not remarkable. Clinopyroxene shows hypidiomorphic or idiomorphic form, its largest length is 0.8 mm. Most of the groundmass is light brownish glass, and the acicular crystals of plagioclase are aligned parallel to the flow structure. Clinopyroxene crystals are in small grains, and the amount is small. Magnetite was not found.

(4) Site 5

Two-pyroxene basalt (*sample Nos. 5-1, 2, 3, 4, 9, 10*)

Rocks are porphyritic. Phenocrysts are composed of plagioclase, clinopyroxene and orthopyroxene, and are contained in rocks with modal ratio of 35%. Plagioclase crystals are idiomorphic or hypidiomorphic, and exhibit a prismatic or short prismatic form, the largest length of which

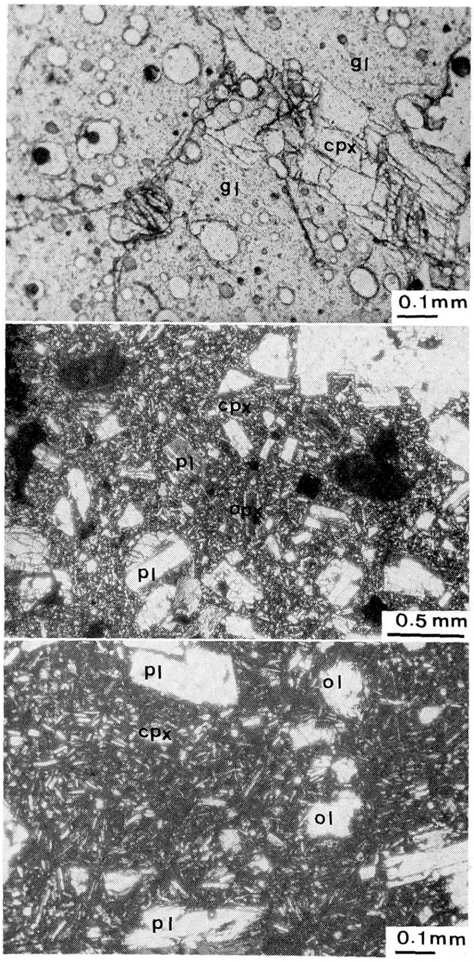


Plate 4. Photomicrographs of the dredged samples, taken under crossed polarizers except for the upper photograph (No. 1).
1. Sample No. 4-6. Pumiceous clinopyroxene andesite.
2. Sample No. 5-1. Two-pyroxene basalt.
3. Sample No. 6-8. Olivine basalt.
pl : plagioclase, cpx : clinopyroxene, opx : orthopyroxene, ol : olivine, gl : glass.

is 2.0 mm. Two kinds of groundmass are observed, one of which shows hyaloophitic texture with much glass (5-1), and the other shows intersertal texture with less glass (5-2, 3, 4, 10). Groundmass minerals are short prismatic plagioclase, clinopyroxene and magnetite (about 1% in modal ratio). Reaction rims of clinopyroxene are found in the peripheral part of the orthopyroxene crystals.

(5) Site 6

Olivine basalt (sample Nos. 6-1, 2, 3, 5, 8, 9)

All rock samples are nearly holocrystalline and fresh. Phenocrysts are composed of plagioclase and clinopyroxene, 20% in modal ratio. Plagioclase crystals are square or short prismatic and show a hypidiomorphic or idiomorphic form. Most of them show remarkable zonal structure. Clinopyroxene appears in short prismatic crystals in a hypidiomorphic or idiomorphic form. Some of the samples (6-9) accompany large crystals (largest length: 5.5 mm) of clinopyroxene. Groundmass is composed of plagioclase, clinopyroxene, olivine and a small amount of brownish glass, and shows an intersertal texture. Plagioclase and clinopyroxene are short prismatic crystals and are contained in groundmass by 25 and 38% respectively in modal ratio. Olivine shows idiomorphic form, and contains about 4% in modal ratio.

From the results of macroscopic and microscopic observations of collected volcanic rocks, fresh volcanic rocks of site 3 and site 4 which do not have organism adhering to their surfaces are supposed to be the products of recent volcanic activities in the region west of Kita Iwo Jima. Tuff breccias at site 2 are fresh, and organism are not observed adhering to their surfaces. The rocks, which constitute the flank of Kita Iwo Jima, were probably transported to the present sea bottom by collapsing. There is also a possibility that the rocks were broken down at the present bottom because of their fragile nature. Organisms up to the thickness of several centimeters are found on the surface of the volcanic rocks at site 5, but the volcanic rocks are relatively fresh and alteration minerals are not recognized. Hence, these volcanic rocks are considered to be of relatively recent age (Quaternary).

3. Chemical composition of volcanic rocks

The bulk chemical compositions of the fresh volcanic rocks (25 in total) from knolls west of Kita Iwo Jima and from the Kaikata Seamount, and of one quartz diorite in tuff breccia from site 2, were analyzed by EPMA. For EPMA analysis, JEOL LTD's EPMA type JXA-733 of the Ocean Research Institute, University of Tokyo, was used, and the Fused Glass Method (glass specimen prepared by fusing pulverized rock sample on Ir foil) was applied. Beam diameter was 10 μm and beam current was kept at 12 nA. BENCE and ALBEE's (1968) method was applied for correction.

The analytical results are presented in Tables 3 and 4. H_2O and P_2O_5 were excluded from major elements, and total Fe was converted to FeO,

Table 3. Chemical compositions of the volcanic rocks at site 2 to site 4.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
DELP87	2-3	2-5	2-6	3-1	3-2	3-3	3-6	3-7	3-8	3-10	4-2	4-6-1	4-6-2	4-7
SiO_2	60.76	61.02	55.22	64.63	65.69	64.59	65.96	65.01	64.96	63.47	65.26	65.07	64.65	65.83
TiO_2	1.10	0.93	1.20	0.73	0.78	0.78	0.76	0.76	0.78	0.91	0.78	0.79	0.76	0.79
Al_2O_3	14.53	14.45	15.29	14.11	13.89	14.16	14.25	14.23	14.09	14.23	14.13	14.13	13.89	14.51
FeO*	9.86	10.07	11.20	7.55	6.89	7.73	6.90	7.22	7.05	7.93	6.93	7.02	8.51	6.66
MnO	0.07	0.15	0.13	0.18	0.13	0.20	0.13	0.13	0.25	0.18	0.16	0.11	0.13	0.14
MgO	2.80	1.57	3.47	1.22	1.13	1.23	1.23	1.15	1.21	1.30	1.28	1.15	1.07	1.38
CaO	3.55	4.90	7.33	3.97	3.64	4.05	3.89	3.90	3.93	4.01	3.74	3.68	3.79	3.89
Na_2O	3.59	3.47	3.62	3.91	3.34	3.63	3.74	3.62	3.89	3.77	3.35	3.99	3.52	3.40
K_2O	1.17	1.09	0.67	1.15	1.20	1.12	1.15	1.14	1.16	1.13	1.20	1.20	1.15	1.16
Cr_2O_3	-	-	0.01	0.01	-	-	-	-	-	-	0.01	-	-	-
NiO	-	0.01	-	-	-	-	-	0.01	0.03	0.01	-	0.01	-	-
Total	97.42	97.67	98.13	97.45	96.70	97.49	98.01	97.16	97.33	96.94	96.83	97.15	97.49	97.75
Qz	19.7	20.4	8.6	24.7	30.0	25.9	27.1	27.0	25.4	24.0	29.0	25.4	26.7	28.8
Or	7.1	6.6	4.0	7.0	7.3	6.8	6.9	6.9	7.0	6.9	7.3	7.3	7.0	7.0
Ab	31.1	30.0	31.1	33.9	29.2	31.4	32.3	31.4	33.7	32.8	29.2	34.7	30.5	29.4
An	18.0	21.1	23.9	18.0	18.6	19.5	19.0	19.7	18.0	19.1	19.1	17.6	19.1	19.7
Ne	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DiWo	-	1.6	5.5	0.9	-	0.4	0.3	0.1	0.8	0.6	-	0.5	-	-
DiEn	-	0.4	2.4	0.3	-	0.1	0.1	-	0.3	0.2	-	0.1	-	-
DiFs	-	1.2	3.1	0.7	-	0.3	0.2	-	0.6	0.4	-	0.4	-	-
HyEn	7.1	3.5	6.4	2.8	2.9	3.0	3.0	2.9	2.8	3.2	3.3	2.8	2.7	3.5
HyFs	9.9	9.4	8.2	7.3	7.1	7.8	6.9	7.4	6.9	7.8	7.2	6.8	8.9	6.8
OlFo	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OlFa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Il	2.1	4.1	2.3	1.4	1.5	1.5	1.5	1.5	1.5	1.8	1.5	1.5	1.5	1.5
Mt	4.1	4.1	4.6	3.1	2.9	3.2	2.8	3.0	2.9	3.3	2.9	2.9	3.5	2.7
C	0.9	-	-	-	0.5	-	-	-	-	-	0.5	-	-	0.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mg#	33.73	21.74	35.57	22.35	22.61	22.09	24.11	22.11	23.42	22.61	24.76	22.59	18.30	26.96
SI	16.13	9.69	18.30	8.82	9.00	8.97	9.45	8.76	9.09	9.20	10.03	8.61	7.51	10.95
Rock type	LT	LT	HT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT	LT

Table 4. Chemical compositions of the volcanic rocks at site 5 and site 6.

	15	16	17	18	19	20	21	22	23	24	25	26
DELP87	5-1	5-2	5-3	5-4	5-9	5-10	6-1	6-2	6-3	6-5	6-8	6-9
SiO2	54.40	53.66	51.08	53.77	50.54	54.28	53.00	52.52	51.76	53.01	53.16	49.39
TiO2	0.79	0.93	0.95	0.92	0.92	0.92	0.81	0.78	0.83	0.82	0.80	0.87
Al2O3	18.13	17.79	19.80	18.81	19.55	17.34	18.43	18.80	19.88	18.54	18.71	17.72
FeO*	9.21	9.46	9.08	8.40	9.32	10.15	9.18	9.25	8.87	9.37	9.20	11.29
MnO	0.09	0.15	0.20	0.12	0.31	0.12	0.15	0.18	0.11	0.13	0.13	0.15
MgO	2.93	3.23	3.03	3.03	2.82	3.38	3.60	3.50	3.05	3.08	3.28	5.74
CaO	8.40	8.68	10.00	9.09	11.22	8.12	9.20	9.42	10.37	9.05	9.53	10.56
Na2O	3.65	3.38	3.62	3.55	2.73	3.31	3.31	3.22	2.89	3.53	3.22	2.38
K2O	0.57	0.53	0.32	0.57	0.42	0.57	0.45	0.46	0.37	0.48	0.44	0.31
Cr2O3	0.01	0.01	0.01	-	-	-	0.02	0.01	-	-	-	-
NiO	0.01	-	-	-	-	0.01	-	-	-	-	-	-
Total	98.19	97.82	98.09	98.25	97.83	98.22	98.16	98.15	98.13	98.01	98.46	98.42
Qz	6.7	6.8	1.4	5.7	3.9	7.9	5.2	4.7	5.2	4.9	5.8	1.2
Or	3.4	3.2	1.9	3.4	2.5	3.4	2.7	2.8	2.2	2.9	2.6	1.9
Ab	31.4	29.1	31.1	30.5	23.5	28.4	28.4	27.7	24.8	30.4	27.6	20.4
An	31.9	32.4	37.5	34.2	40.6	31.2	34.7	36.1	40.8	33.9	35.8	37.2
Ne	-	-	-	-	-	-	-	-	-	-	-	-
DiWo	4.3	4.8	5.4	4.8	6.7	4.0	4.9	4.8	4.8	4.9	5.1	6.6
DiEn	1.9	2.2	2.4	2.3	2.8	1.8	2.3	2.2	2.2	2.2	2.3	3.5
DiFs	2.5	2.6	3.0	2.5	3.9	2.2	2.5	2.5	2.6	2.7	2.7	2.9
HyEn	5.5	6.0	5.2	5.4	4.3	6.7	6.8	6.6	5.6	5.6	6.0	11.0
HyFs	7.2	7.2	6.4	6.0	6.0	8.3	7.2	7.4	6.6	7.1	6.9	9.1
OlFo	-	-	-	-	-	-	-	-	-	-	-	-
OlFa	-	-	-	-	-	-	-	-	-	-	-	-
Il	1.5	1.8	1.8	1.8	1.8	1.8	1.6	1.5	1.6	1.6	1.5	1.7
Mt	3.8	3.9	3.7	3.4	3.8	4.1	3.7	3.8	3.6	3.8	3.7	4.6
C	-	-	-	-	-	-	-	-	-	-	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mg#	36.18	37.82	37.29	39.12	35.03	37.24	41.13	40.27	37.99	36.94	38.85	47.53
SI	17.91	19.46	18.88	19.49	18.44	19.41	21.77	21.30	20.09	16.71	20.32	29.11
Rock type	HT	HT	HT	HT	HT	HT	HT	HT	HT	HT	HT	HT

Mg# indicates 100 Mg/(Mg+Fe) (mol ratio). SI indicates the Solidification Index. LT and HT of rock type indicate low-alkali tholeiite and high-alkali tholeiite, respectively. In norm calculation, Fe_2O_3/FeO ratio is assumed to be 0.37 (weight ratio) which is determined from the average ratio obtained from previous analysis of relatively fresh sample taken from the Northern Mariana Islands (wet analysis datas: ISHIKAWA and EGAWA, 1977). Measured value of analysis is recalculalated in order to obtain 100% total value.

Volcanic rocks from the knolls located at the west side of Kita Iwo Jima are andesites which shows SiO_2 content of 61 to 66%. Sample 2-6 show SiO_2 content of 55% and show rather basaltic composition. Chemical composition and normative feldspar of micro quartz diorite gravel (2-3) in the tuff breccia are similar to those of the clinopyroxene andesite (2-5).

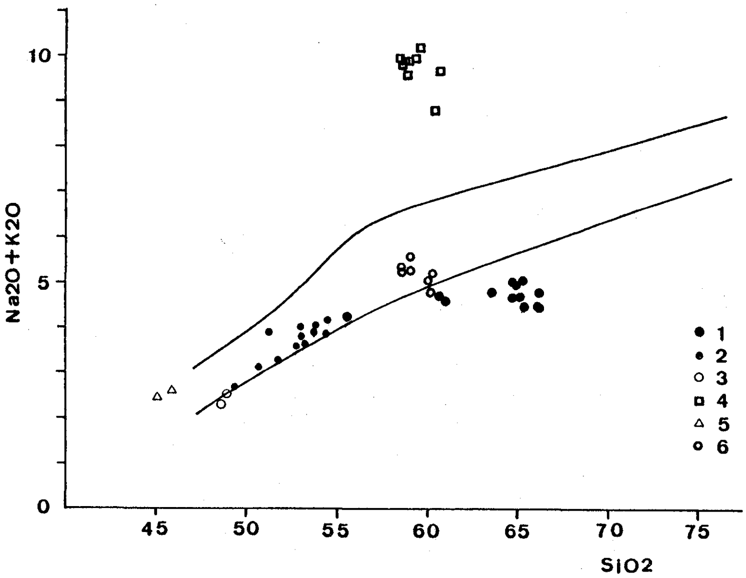


Fig. 2 $(Na_2O+K_2O)-SiO_2$ diagram of the volcanic rocks. General boundaries between the fields of three types of basalt (so- called low-alkali tholeiite, high-alkali tholeiite and alkalic basalt) are shown by curves (after KUNO, 1968).

1. Site 2 to site 4, western slope of Kita Iwo Jima and western knolls of Kita Iwo Jima.
2. Site 5 and site 6, Kaikata Seamount.
3. Kita Iwo Jima (datas from TSUYA, 1936; IWASAKI, 1937).
4. Iwo Jima (datas from HOMMA, 1925; TSUYA, 1936; IWASAKI, 1937).
5. Minami Iwo Jima (data from YUASA and TAMAKI, 1982).
6. Nishinoshima Island and Nishinoshima-shinto Island (datas by AOKI and OSSAKA, 1974).

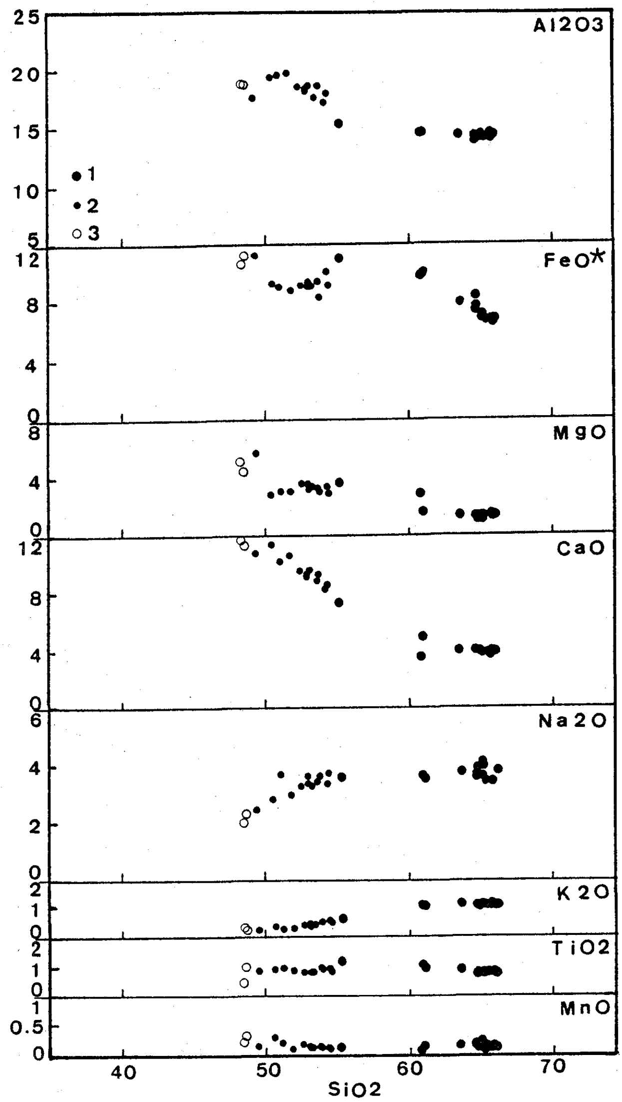


Fig. 3. SiO_2-Oxides diagram of the volcanic rocks. Symbols are same as those in Fig. 2.

Mg# ranges from 18.3 to 33.7 and Al_2O_3 content is 13.9 to 14.5 with small variation.

In contrast, the volcanic rocks from the Kaikata Seamount show SiO_2 content of 49 to 54%. Except samples 6–9, Mg# ranges from 35.0 to 41.1. Al_2O_3 content varies from 17.4% to 19.9%.

Normative quartz is calculated for both volcanic rocks of the Kita Iwo Jima Island area and the Kaikata Seamount. The values of norma-

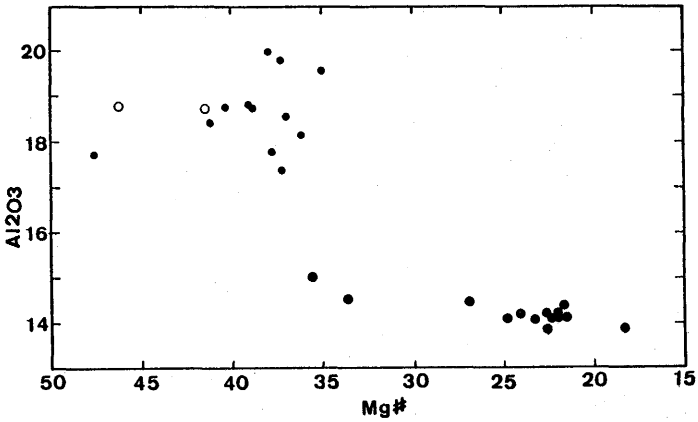


Fig. 4. Mg#-Al_2O_3 diagram of the volcanic rocks. Symbols are same as those in Fig. 2.

tive quartz of the former area are 19.7 to 29.0% except samples 2–6; the values of the latter area are 1.2 to 7.9%. Similarly, feldspar composition in the former area is $An_{39-37}Ab_{58-52}Or_{12-11}$, and the composition of feldspar latter area is $An_{48-63}Ab_{47-34}Or_{5-3}$. Normative olivine was not calculated.

4. Discussion

The SiO_2 content of the andesitic rocks from the western knolls of the Kita Iwo Jima is high with values around 66%. However, the volcanic rocks with such high SiO_2 content are not found on Kita Iwo Jima or on the southern part of the Shichito-Iwo Jima Ridge. These values are comparable to the SiO_2 content of trachyte and trachyandesitic pumice (Fukutokuoka-no-ba Seamount; KATO, 1988; OSSAKA *et al.*, 1986). The andesitic rocks fall in the field of low-alkali tholeiite series of SiO_2-(Na_2O+K_2O) diagram by KUNO (1968). Samples 2–6 are plotted on the high-alkali tholeiite side of the boundary of low-alkali tholeiite and high-alkali tholeiite (Fig. 2), The compositions of the volcanic rocks of Kita Iwo Jima (TSUYA, 1936; IWASAKI, 1937); Iwojima Island (HOMMA, 1925; TSUYA, 1936; IWASAKI, 1937), Minami Iwo Jima (YUASA and TAMAKI, 1982), Nishinoshima and Nishinoshima-shinto (AOKI and OSSAKA, 1974) reported from the southern part of the Shichito-Iwo Jima Ridge are shown in this diagram for comparison.

On Kita Iwo Jima, olivine basalt with SiO_2 content of about 48.5% is known (TSUYA, 1936; IWASAKI, 1937). These rocks are plotted around the boundary line between high-alkali and low-alkali tholeiite. Their alkaline content is high compared to that of volcanic rocks of the Shichito-Iwo Jima Ridge (YUASA and TAMAKI, 1982). All andesitic rocks which were collected by the present cruise fall in the region of low-alkali tholeiite except for one sample. It is possible that the upper part of the volcanic body, including Kita Iwo Jima, consists of low-alkali tholeiitic rocks. It is also possible, as exemplified by samples 2–6, that both low-alkali tholeiite and high-alkali tholeiite can occur in a single volcanic body which might be the case on Kita Iwo Jima.

Samples 2–3 were collected as gravel of clinopyroxene andesitic tuff breccia. The resemblance to clinopyroxene andesite in chemical composition and normative mineral composition could imply that it originated from the same magmatic source.

Oxides constituting the volcanic rocks of the Kita Iwo Jima area and Kaikata Seamount exhibit linear trend in SiO_2-oxide diagram (Fig. 3). The texture of the volcanic rocks from site 3 and site 4 of the Kita Iwo Jima area is quite aphyric under microscopic observation. Chemical compositions of aphyric rock appear to reflect the liquid composition of magma. These are some similarities between the chemical compositions of volcanic rocks which seem to represent the liquid composition of magma. If we assume that the variations of the chemical compositions are a result of crystallization differentiation, then these volcanic rocks of the Kita Iwo Jima Island area are supposed to be from the same magma. If the values of sample composition from the land part of Kita Iwo Jima are plotted on this diagram, they appear on the extension of the trend obtained by the present analyses. But it is difficult to discuss the identity of the magma further because the gap of composition between seafloor materials and island samples is large.

In Fig. 3, the variation of Al_2O_3, Na_2O, K_2O and TiO_2 contents is not found but distributions around fixed values are shown. In contrast values of FeO* and MgO show tendencies of monotonous decrease with the increase in SiO_2. This suggests that in the mineral segregation during magmatic differentiation, mafic minerals such as orthopyroxene, clinopyroxene, etc., and plagioclase played the leading part. The Mg#–Al_2O_3 diagram in Fig. 4 exhibits this phenomenon more clearly in which Al_2O_3 value show almost no change during the fractionation of mafic minerals.

Volcanic rocks from Kaikata Seamount are basalt with SiO_2 content of 49 to 54%, and fall in the region of high-alkali tholeiite in Fig. 2. In the southern part of the Shichito-Iwo Jima Ridge, high-alkali tholeiite is known on the Nishinoshima and Nishinoshima-shinto (AOKI and OSSAKA,

1974) and Minami Iwo Jima Island (YUASA and TAMAKI, 1982). The variation of chemical composition accompanying the change of SiO_2 is clearly shown in Fig. 3. This fact suggests that the changes in composition of the basaltic rocks of the Kaikata Seamount are caused by one series of magmatic differentiation. The values of FeO*, MgO and TiO_2 show almost no change against SiO_2 composition compared to those of andesitic rocks from the western knolls of Kita Iwo Jima. The values of Al_2O_3 and CaO decrease, and, in contrast, the values of Na_2O and K_2O increase monotonically with increase of SiO_2 content. Basaltic rocks of Kaikata Seamount show changes in Al_2O_3 from 17 to 20% (Fig. 4) within a short range of Mg# content. If we assume that the variations of chemical compositions are thought to be a result of crystallization differentiation, then this suggests that in the mineral segregation during magmatic differentiation, plagioclase and small amount of mafic minerals played the leading part.

5. Summary

(1) Volcanic rocks of the western knolls and submarine flank of Kita Iwo Jima are low alkali tholeiitic andesite, the SiO_2 content of which is 61 to 66%. One sample (2-1) among the collected volcanic rocks is of high-alkali tholeiitic andesite with SiO_2 content of 55%. On the contrary, volcanic rocks of the Kaikata Seamount are high-alkali tholeiitic basalt, the SiO_2 content of which is 45 to 54%.

(2) If we assume that on Kita Iwo Jima Island and Kaikata Seamount the variations of the chemical compositions are a result of crystallization differentiation, then the volcanic rocks of the knolls and submarine flank adjacent to Kita Iwo Jima resulted from a series of magmatic differentiation, mostly consisting of segregation of mafic minerals and a small amount of plagioclase.

(3) On Kaikata Seamount, the influence of crystllization of plagioclase phenocrysts predominates compared to the segregation of mafic minerals.

(4) At least the upper part of volcanic body, including the Kita Iwo Jima, may be described as it is composed of low-alkali tholeiitic rocks. There is a possibility that both low-alkali tholeiite and high-alkali tholeiite magmas coexist in the volcanic sources of Kita Iwo Jima.

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DELP 1987年度　小笠原海域航海報告

VII.　小笠原地域の火山岩類の岩石化学

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東海大学丸二世号 DELP-87 航海では，小笠原海台の南西部に位置する松原海山で1地点，北硫黄島西側海底斜面および西方の小海丘で3地点，海形（かいかた）海山で2地点，小笠原舟状盆地の中央部で1地点の合計7地点でドレッジが行われた．この内，火山岩類が採取されたのは北硫黄島西方の3地点（Site 2, Site 3 及び Site 4）と海形海山での2地点（Site 5 及び Site 6）である．

北硫黄島西側の小海丘の火山岩類は SiO_2 含有量が 61～66％を示す低アルカリソレアイト質の安山岩である．得られた火山岩類のうち1資料（2-6）は SiO_2 含有量が55％を示す高アルカリソレアイト質の安山岩である．これに対して，海形海山火山岩類の SiO_2 含有量は 49～54％を示す高アルカリソレアイト質の玄武岩である．北硫黄島を含む火山体の少なくても上部は低アルカリソレアイト質の玄武岩から成ると言えるが，高アルカリソレアイトを示す2-6試料を重視するとあるいは北硫黄島を形成する火山体には低アルカリソレアイトと高アルカリソレアイトの両方が存在している可能性がある．