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GEOCHEMICAL COMPARISON OF THE 1883 KRAKATAU PUMICE FLOW, INDONESIA, AND THE ATA AND AIRA "SHIRASU" PUMICE FLOWS, JAPAN*

By

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Abstract

Pumice flow of the 1883 Krakatau eruption occurs at Small Rakata, Rakata and Sertung, those which roughly correspond to the wall of Krakatau caldera, Indonesia. It significantly differs in both mineral and chemical compositions against other all kinds of volcanic rocks and ejecta of the Krakatau Group, those of which belong to MIYASHIRO's (1974) tholeiitic series. Meanwhile, lithic fragments of granitic rock, ranging in modal composition from quartz monzonite to quartz mozodiorite, those of which were found from the pumice flow are, in both mineral and chemical compositions, similar to west Malayan granitic rocks represented by biotite quartz monzonite which occurs as the dominant rock type in west Malay Peninsula (HAMILTON, 1979). None of granitic rock occurs thoughout over the Krakatau Group, and lithic fragment of granitic rock has never been reported from the pumice flow, except a one quartz diorite inclusion which was reported from Small Rakata (DE NÉVE, 1981 a, b) and may correspond to the lithic fragment of quartz monzodiorite found from the pumice flow. Therefore, it should be considered that the lithic fragments of granitic rock came from the underlying complex at depths, wher they were captured as foreign materials by magma, and that genetically the pumice flow was closely related with the underlying granitic complex in regard to the production of its source magma.

Geochemical comparison between a suite of the 1883 Krakatau pumice flow, its related lithic fragment of granitic rock and selected Malayan granitic rocks and a suite of the Ata and Aira "Shirasu" pumice flows those which came from Ata and Aira calderas and their related granitic rocks, South Kyushu, Japan, shows that the respective pumice flow is good correlative in chemical character with the respective related granitic rock in the locations of their plots on the AFM and SiO_2-total FeO/MgO diagrams. This fact suggests that the 1883 Krakatau pumice flow was genetically related with some granitic rocks nearby Krakatau caldera.

Thus, it may possibly be considered that sialic crustal materials, such as granitic rocks

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and sediments those which occur in Sumatra, plunged into depths along the peculiar tectonic structure locating at the Sunda Strait waters between Sumatra and Java, and was partially melted and mixed with or assimilated by the ascending basaltic magma, and dacitic magma distinctly dominant in silica, alkalies and volatile components was produced, and, as a result, the 1883 Krakatau eruption characterized by the pumice flow of dacitic composition took place.

Introduction

In 1981 and 1982, field works were done geologically at the Krakatau Group, called for the whole islands of Anak Krakatau, Small Rakata, Rakata and Sertung, those which are located in the Sunda Strait waters between Sumatra and Java, Indonesia. Following to the field work, analyses of mineral and chemical compositions, X-ray diffraction, differential thermal analysis, scanning electron microscopy and infrared absorption spectra have been carried out for the volcanic products of the Krakatau Group. Some of the research products have been reported on the geochemical and lithological natures of collected volcanic rocks, ejecta and pumice flow (ŌBA and others, 1982, 1983).

Major attention will be given in this paper to the genetical relationship between the pumice flow erupted out in 1883 and foreign lithic fragments of granitic rock found from the pumice flow, and some geochemical comparison will be made of a suite of the pumice flow of the Krakatau Group and its related rocks and a suite of the Ata and Aira "Shirasu" (ŌBA and others, 1967 a) pumice flows and its related rocks, South Kyushu, Japan.

Mode of occurrence of the 1883 Krakatau pumice flow

Pumice flow, characterized by abundant pumice and dacitic composition in bothe mineral and chemical compositions in many cases, will be used in a narrow sense in this paper for one of the volcanic products, i.e., pumice flow and pumice fall, of the 1883 Krakatau eruption to be descriminated from pyroclastic flow which is used in a broad sense for the volcanic products formed from the so-called "nuée ardente", "glowing cloud" and others.

Pumice flow erupted out in 1883 occurs at Small Rakata, Rakata and Sertung, those which are isolated each other and roughly correspond to Krakatau caldera wall. Pumice fall preceeding to the successive pumice flow overlays the basement complex composde mainly of lava flows and pyroclastics of these islands. The pumice flow is repeatedly accompanied with air fall, and pyroclastic surge can also be observed (ŌBA and others, 1983).

Petrography and geochemistry of the pumice flow

Modal analysis in grain size 60-115 mesh of the pumice flow, sample no. 811. from Sertung is given in Table 1. The pumice flow is, as seen from the table, characterized by abundant volcanic glasses, which occur in a vesiculated state that bubbles contained in the volcanic glasses were expanding and escaping gases (ŌBA and others, 1982). None of

Table 1. Modal analyses (vol. %) of the 1883 Krakatau pumice flow and the Ata and Aira "Shirasu" pumice flows

No.		1	2	3
Analyzed samples		1883 Krakatau pumice flow	Ata "Shirasu" pumice flow	Aira "Shirasu" pumice flow
Analysts		T. Ishii	T. Ishii	K. Inoue & K. Yokoyama
Grain size (mesh)		60-115	60-115	
Felsic minerals	Volcanic glass	92.2	87.1	86.5
	Plagioclase	5.7	9.5	7.7
	Quartz	n.p.	n.p.	1.8
Mafic minerals	Orthopyroxnene	0.6	1.4	1.1
	Clinopyroxene	0.4	0.9	0.2
	Hornblende	n.p.	0.1	0.1
	Opaque mineral*	1.1	0.9	2.6
	Others	p.	0.1	0.1

1. sample no. 811, Sertung, Krakatau, Indonesia ; 2. sample no. 66122505, Ōnejime, Kagoshima, Japan ; 3. arithmetic mean of 3 modal analyses ; p, present ; n. p., not present. Analytical data 1 and 2 from Ōba and others (1983), and 3 from Ōba and others (1980).

quartz and hornblende is accompanied. For comparison, modal analyses of the Ata and Aira "Shirasu" pumice flows which came from Ata and Aira gigantic calderas, Kagoshima, South Kyushu, are also tabulated in Table 1.

Chemical analyses of the pumice flow, no. 811, and pumice from the same pumice flow, sample no. 811-P, are given in Table 2. As is clear from the chemical analyses, the pumice flow significantly differs in chemical composition against any other volcanic rock or ejecta of the Krakatau Group ; characteristically the pumice flow is rich in SiO_2 and alkalies, but, in contrast, poor in MgO, FeO and CaO. Naturally, a large amount of normative quartz and orthoclase are calculated. Thus, it can be said that in chemical composition the pumice flow is dacitic. For comparison, chemical analyses of the Ata and Aira "Shirasu" pumice flows and pumices are tabulated in Table 2. Comparing with these pumice flows, the 1883 Krakatau pumice flow is similar to the Ata "Shirasu" pumice flow.

Lithic fragments found from the pumice flow

In 1981, a one lithic fragment of granitic rock was found from the pumice flow which occurs on the southeastern sea-coast of Sertung. Later, another one small fragment of the same rock was found from the collected same sample at laboratory. From such a fact, it was suggested that this kind of foreign lithic fragment of granitic rock may be contained much more in the pumice flow (Ōba and others, 1982, and, in contribution). Following to the discovery of the lithic fragments of granitic rock in 1981, several lithic fragments of granitic rock, one of those of which reaches about 30 cm in maximum size, were found from the pumice flow which occurs along the northwestern sea-coast of Sertung in 1982.

Modal compositions of analyzed two lithic fragments of granitic rock, sample no. 811-1 and 2301-a, are given in Table 3. The lithic fragments are composed mainly of quartz,

Table 2. Chemical analyses (wt. %) and CIPW norms of the 1883 Krakatau pumice flow, the Ata and Aira "Shirasu" pumice flows and pumices

No.		1	2	3	4	5	6
Analysts		M.Y.	M.Y.	N.O. & H.E.	J.I.	N.O. & H.E.	M.M.
SiO_2		65.22	64.18	65.37	66.27	70.91	70.92
TiO_2		0.71	0.67	0.64	0.69	0.24	0.23
Al_2O_3		14.18	13.90	15.44	15.83	14.05	13.23
Fe_2O_3		1.39	1.06	3.77	0.63	0.83	0.54
FeO		2.16	2.22	1.65	2.40	0.97	1.47
MnO		0.13	0.12	0.10	0.14	0.09	0.02
MgO		1.10	0.88	0.93	1.13	0.54	0.59
CaO		2.54	2.38	3.51	3.10	2.20	2.13
Na_2O		4.91	5.32	3.34	3.88	3.31	3.73
K_2O		2.15	2.17	1.69	2.50	2.56	2.90
H_2O+		4.76	4.11	3.06	3.04	3.14	2.79
H_2O-		0.58	2.84	0.50	0.31	0.55	0.64
P_2O_5		0.15	0.13	0.15	0.27	0.07	0.29
Total		99.98	99.98	100.15	100.19	99.46	99.48
Q		21.19	18.54	30.99	25.20	36.14	32.63
Or		12.71	12.82	9.99	14.77	15.13	17.14
Ab		41.55	45.02	28.26	32.83	28.01	31.56
An		10.30	7.64	16.43	13.62	10.46	8.67
	Wo	0.55	1.39	-	-	-	-
Di	En	0.31	0.66	-	-	-	-
	Fs	0.22	0.70	-	-	-	-
Hy	En	2.43	1.53	-	2.81	1.35	1.47
	Fs	1.67	1.62	-	3.01	1.20	1.91
Mt		2.02	1.54	3.79	0.91	1.20	0.78
Il		1.35	1.27	1.22	1.31	0.46	0.44
Ap		0.35	0.30	0.35	0.63	0.16	0.67
C		-	-	2.09	1.75	2.17	0.78
Hm		-	-	1.16	-	-	-
En		-	-	2.32	-	-	-

1, 1883 Krakatau pumice flow, Sertung, Krakatau, Indonesia, sample no. 811; 2, pumice from pumice flow, Sertung, Krakatau, Indonesia, sample no. 811-P, new analysis in this paper; 3, arithmetic mean of 2 analyses of Ata "Shirasu" pumice flow, Kagoshima, Japan; 4, arithmetic mean of 2 analyses of pumices from Ata "Shirasu" pumice flow, Kagoshima, Japan; 5, arithmetic mean of 13 analyses of Aira "Shirasu" pumice flow, Kagoshima, Japan; 6, arithmetic mean of 2 analyses of pumices from Aira "Shirasu" pumice flow, Kagoshima, Japan. Analytical data.-1 from ŌBA and others (1982); 3 and 5 from ŌBA and others (1980); 4 from MIYACHI (1964); 6 from TANEDA and IRISA (1966). Analysts.-H.E., H. EBIHARA; T.I., T. IRISA; M.M., M. MIYACHI; N.O., N. ŌBA; M.Y., M. YAMAMOTO. Norm calculations for 3-6 by J. NAKAMURA.

Table 3. Modal analyses (vol. %) of lithic fragments of granitic rock found from the 1883 Krakatau pumice flow and selected west Malayan granitic rocks

No.	1	2	3	4
Sample no.	811-1	2301-a	UM16	UM5306
Quartz	11.5	16.6	24	20
Plagioclase	54.0	47.2	42	44
Potash fledspar	24.9	29.4	28	26
Biotite	6.4	0.8	5	8
Hornblende	-	3.5	-	2
Opaque mineral	3.1*	2.4	0.1	0.1
Others	-	0.1	1.5	1.1

1 and 2: lithic fragments of granitic rock found from the 1883 Krakatau pumice flow, Sertung, Krakatau, Indonesia (analyst: S. KIYOSAKI), 1, quartz monzodiorite; 2 quartz monzonite. 3 and 4: selected west Malayan granitic rocks, 3, porphyritic biotite adamellite, Lone Pine Hotel, Penang Island, Malaysia; 4, pink hornblende adamellite, Bukit Labohan, J. K.R. quarry, Trengganu, Malaysia. Analytical data.-1 from ŌBA and others (1982); 2 from ŌBA and others (1983); 3 and 4 from HUTCHISON in GOBBETT and HUTCHISON (1973), p. 215-252. *Opaque mineral and others.

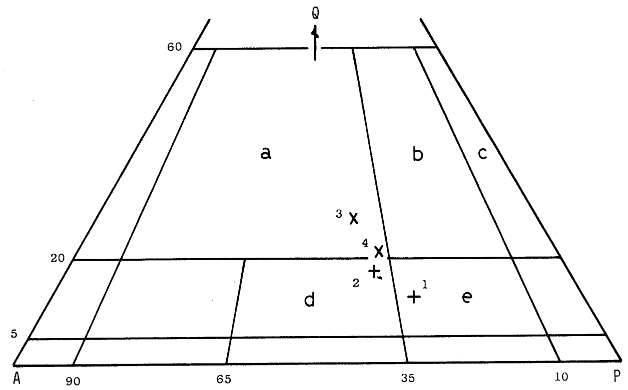

Fig. 1. Plots of lithic fragments of granitic rock found from the 1883 Krakatau pumice flow and selected west Malayan granitic rocks on the modal quartz (Q)-alkali feldspar (A)-plagioclase (P) diagram. Numbers agree to those in Table 3. a, granite; b, granodiorite; c, tonalite; d, quartz monzonite; e, quartz monzodiorite.

Table 4. Chemical analysis (wt. %) and CIPW norms of lithic fragment of granitic rock found from the 1883 Krakatau pumice flow and chemical analyses of selected Malayan granitic rocks

No	1			2	3
Sample no.	2301-a			GS15072	GS27423
SiO_2	69.18	Q	20.77	70.61	67.60
TiO_2	0.62	Or	16.25	0.40	0.45
Al_2O_3	14.01	Ab	46.12	14.01	15.00
Fe_2O_3	1.25	Di Wo	2.96	0.45	1.04
FeO	2.38	Di En	1.29	2.75	3.07
MnO	0.05	Di Fs	1.67	0.07	0.09
MgO	0.75	Hy En	0.57	0.90	0.88
CaO	2.70	Hy Fs	0.74	1.85	3.02
Na_2O	5.45	Mt	1.81	2.75	3.48
K_2O	2.75	Il	1.18	4.93	3.95
H_2O+	0.48	Ap	0.23	0.98	1.12
H_2O-	0.22			0.12	0.10
P_2O_5	0.10			0.17	0.12
CO_2	-			0.09	0.07
Total	99.94			100.15	99.99

1, lithic fragment of granitic rock found from the 1883 Krakatau pumice flow, Sertung, Krakatau, Indonesia (analyst: M. YAMAMOTO); 2 and 3: selected Malayan granitic rocks, 2, porphyritic granite, near milestone 52.5 Tranum-Gap road, Bentong area, Pahang, Malaysia; 3, biotite adamellite, Ulu Sungei Kemaman, near Kampong Ayer Puteh, Trengganu, Malaysia. Analytical data.-1 from ŌBA and others (1983); 2 and 3 from HUTCHISON in GOBBETT and HUTCHISON (1973), p. 215-252.

plagioclase, potash feldspar, biotite with or without hornblende, and opaque mineral. They are, in texture, characterized by the presence of well-developed myrmekite which is common in adamellite and granodiorite. On the quartz (Q)-alkali feldspar (A)-plagioclase (P) diagram (Fig. 1), the lithic fragments of granitic rock range in modal composition from quartz monzonite to quartz monzodiorite.

For comparison, selected west Malayan granitic rocks in which biotite quartz monzonite occurs as the dominant rock type in west Malay Peninsula (HAMILTON, 1979) are tabulated in Table 3 and plotted in Fig. 1. As seen from Fig. 1, the lithic fragments of granitic rock are lithologically very much similar to the selected west Malayan granitic rocks.

Chemical analysis of one of the collected lithic fragments of granitic rock, sample no. 2301-a, is given in Table 4. The analyzed lithic fragment is characterized by the high-contents of silica and alkalies and the low-contents of magnesia, ferrous iron oxide and lime. For comparison, chemical analyses of selected Malayan granitic rocks are also tabulated in Table 4. As seen from the table, the analyzed lithic fragment is very much similar to the selected Malayan granitic rocks.

Besides, a one lithic fragment of metabasic igneous rock, fragments of tuff and lithic fragments of glassy andesitic rock were found at the same exposure of the pumice flow where the lithic fragments of granitic rock were collected. No lithic fragment of metamorphic rock has been reported from the Krakatau Group. Therefore, it should be considered that the lithic fragment of metabasic igneous rock came from the underlying complex at depths, where it was captured as a foreign material by magma. Fragments of tuff are grey-colored ones, with or without stratification, and, rarely, with a glassy fused thin skin, for which much interest is concerned. Some of fragments of black-colored glassy andesitic rock are extremely vitreous, and some are very much porous. Thus, some of them look obsidian, and some are gradationally changed into pumice. Such a fact appears to suggest that this kind of lithic fragment may not be foreign material, but cogenetic material which was derived from the same source magma of the 1883 Krakatau pumice flow.

Petrogenic significance of lithic fragments of granitic rock found from the pumice flow

None of granitic rokc occurs throughout over the whole islands of the Krakatau Group, and lithic fragment of granitic rock has never been reported from the 1883 Krakatau pumice flow, except a one quartz diorite inclusion which was reported from Small Rakata (DE NÉVE, 1981 a,b). Quartz diorite inclusion may correspond to lithic fragments of quartz monzodiorite in this paper. Lithic fragments of quartz monzonite and quartz monzodiorite found from the pumice flow, therefore, should be considered that they came from the underlying complex at depths, where they were captured as foreign materials by magma.

Meanwhile, the pumice flow significantly differs in both mineral and chemical composi-

compositions against any other volcanic rock or ejecta of the Krakatau Group. That is, the pumice flow is characterized, in mineral composition, by abundant volcanic glass which occurs in a vesiculated state, and, in chemical composition, by the high-contents of silica and alkalies and the low-contents of magnesia, ferrous iron oxide and lime ; it is dacitic. Thus, it may possibly be considered that the pumice flow was genetically related with the underlying granitic complex in regard to the production of its source magma.

Geochemical comparison and genetical consideration of the 1883 Krakatau pumice flow and the Ata and Aira "Shirasu" pumice flows

Some of calderas of Japan, such as Ata and Aira, are believed to have had such a great eruption as called "Krakatau-type". Therefore, geochemical comparison between volcanic products of a suite of the Krakatau caldera and its related volcano and those of a suite of the Ata and Aira calderas and its related volcano will be worthful to obtain the informations concerning the mechanism of eruption and magma genesis.

The composition of any melt would depend on that of the source rock, phase chemistry and the degree of melting (CARMICHAEL and others, 1974). On the basis of the experimental framework for the complex synthetic system gabbro-tonalite-granite-H_2O, WYLLIE and others (1976) suggested that the batholiths may be generated in different ways from different sources, and argued that batholiths composed of granite are readily generated in the continental crust. The experimental work by WYLLIE and TUTTLE (1961 a) also showed that shales begin to liquefy at temperatures ranging from 700° to 800℃ under water activities produced by about 2 kb H_2O pressure ; liquid of granodioritic composition is produced. If alkalies and volatile components such as HF and NaF are present in addition to water, shales begin to melt at lower temperatures (KOSTER VAN CROOS and WYLKLIE, 1968 ; WYLLIE and TUTTLE, 1961 b). WINKLER and v. PLATEN (1961 a, b) established that granitic, granodioritic and tonalitic melts can be formed by the partial melting of sedimets such as shale and greywacke as a result of their experimental studies.

With respect to the locations occupied by plots representing the Ata and Aira "Shirasu" pumice flows, prevailing over South Kyushu, Japan, and their related granitic rocks on the AFM diagram (Fig. 2), ŌBA and others (1967 b) recognized that the plots represesting the Ata "Shirasu" pumice flow erupted out from Ata caldera fall close to or nearby the area occupied by the plots representing Ōsumi granodiorite which occurs as batholith adjacent to Ata caldera, and that the Aira "Shirasu" pumice flow which came from Aira caldera is plotted in the area close to or nearby the plots representing Takakumayama aplogranite which occurs as dome-like stock adjacent to Aira caldera ; the respective pumice flow is good correlative in chemical character with the respective adjacent granitic rock. From such a fact and other evidences, they concluded that genetically the "Shirasu" pumice flows are closely related with granitic materials in a broad sense, such as granitic rocks and sediments, e.g., pelitic and psammitic rocks, and suggested that the "Shirasu" pumice flows came one source magma, which was produced through assimilation of granitic materials in

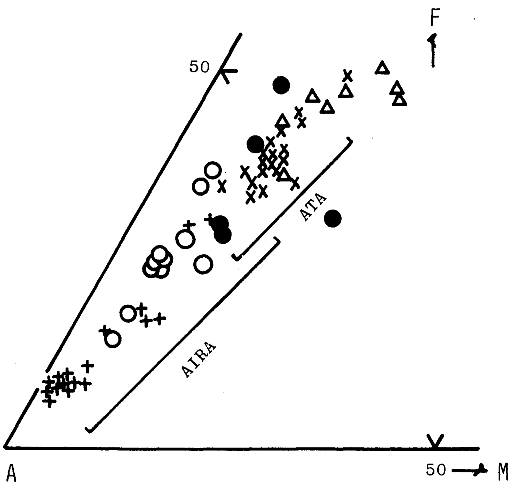

Fig. 2. Plots of the Ata and Aira "Shirasu" pumice flows and its related granitic and volcanic rocks on the A (Na_2O+K_2O)-F(total FeO)-M (MgO) diagram. Symbols.-solid circles, Ata "Shirasu" pumice flow and pumices; open circles, Aira "Shirasu" pumice flow and pumices; cross, ŌSUMI granodiorite; plus, Takakumayama aplogranite; open triangles, lava flows of Sakurajima Volcano. Analytical data used for construction of the diagram from ŌBA and others (1967a, 1980, 1982) and FUKUYAMA and ONO (1981). Calculations for AFM ratios by J. NAKAMURA and T. INOME.

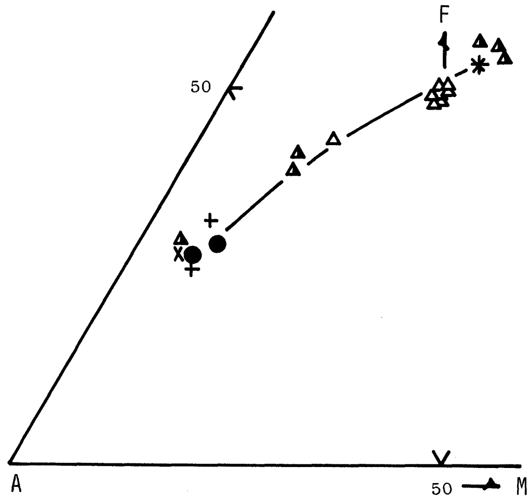

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Fig. 3. Plots of the 1883 Krakatau pumice flow and its related granitic and volcanic rocks on the A(Na_2O+K_2O)−F(total FeO)-M(MgO) diagram and the evolution-trend for the volcanic products of the Krakatau Group. Symbols.-solid circles, the 1883 Krakatau pumice flow and pumice; cross, lithic fragment of quartz monzodiorite found from the pumice flow; plus, selected Malayan granitic rocks (biotite adamellite and porphyritic granite); open triangles, lava flows and ejecta of Anak Krakatau; half solid triangles, lava flows and dike those which make the basement complex of the Krakatau Group except Anak Krakatau; asterisk, average composition of basaltic andesites of typical volcanoes of island arcs of western and northern Pacific and Carribean regions. Analytical data used for construction of the diagram from ŌBA and others (1982, 1983), this paper and EWART (1976). Calculations for AFM ratios by J. NAKAMURA and T. INOME.

through assimilation of granitic materials in a broad sense by the essential magma which was being in the process of differentiation.

A good correlation can also be seen in the 1883 Krakatau pumice flow and its related rocks on the AFM diagram (Fig. 3), which shows, at the same time, an evolution-trend for the volcanic products of the Krakatau Group.

Plotting of the 1883 Krakatau pumice flow and pumice, lithic fragment of quartz monzodiorite found found from the pumice flow, selected Malayan granitic rocks (biotite adamellite and porphyritic granite), volcanic rocks and ejecta of Anak Krakatau and other volcanic rocks which make the basement complex of the Krakatau Group on the AFM

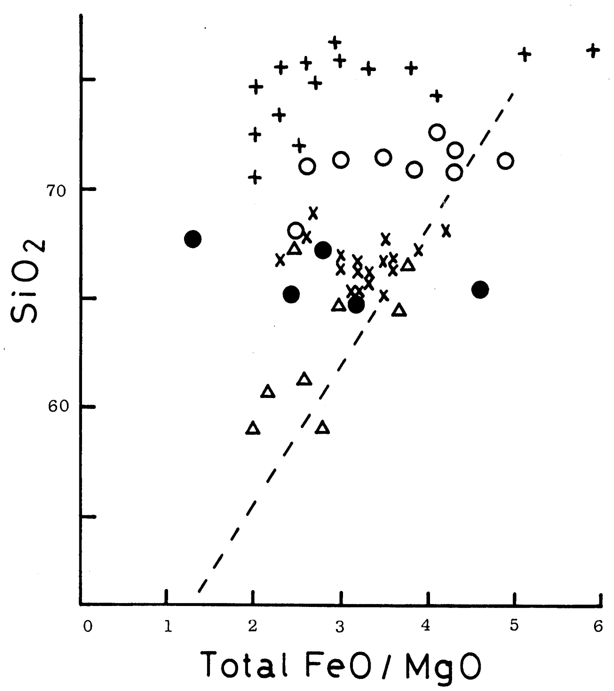

Fig. 4. Plots of the Ata and Aira "Shirasu" pumice flows and its related granitic and volcanic rocks on MIYASHIRO's (1974) SiO_2-total FeO/MgO diagram. Symbols are the same as those in Fig. 2. The dashed line represents the general boundary between the calc-alkalic rock series and the tholeiitic series for non-alkalic volcanic rocks of western Pacific island arcs.

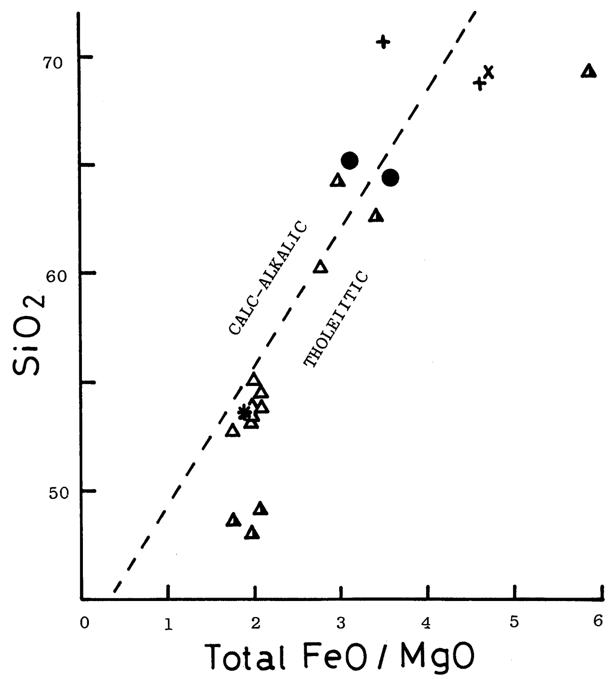

Fig. 5. Plots of the 1883 Krakatau pumice flow and its related granitic and volcanic rocks on the SiO_2-total FeO/MgO diagram. Symbols are the same as those in Fig. 3.

diagram, it can be seen that the plots of the pumice flow and pumice fall in almost the same location as the plots of the lithic fragment of quartz monzodiorite and the selected Malayan granitic rocks. This fact suggests that the 1883 Krakatau pumice flow was genetically related with some kind of granitic rocks, such as biotite quartz monzonite of the dominant rock type in west Malay Peninsula, nearby Krakatau caldera. Meanwhile, the plots of volcanic rocks and ejecta of the Krakatau Group make a smooth curve showing a trend of magma evolution.

The same relations can also be seen in the location of the plots of pumice flows and related rocks on the SiO_2-total FeO/MgO diagrams (Fig. 4 and 5). That is, on Fig. 4, the Ata "Shirasu" pumice flow and pumices are plotted over the area occupied by the plots representing Ōsumi granodiorite, while the Aira "Shirasu" pumice flow and pumices are plotted close to or nearby the area occupied by the plots representing Takakumayama aplogranite; and, on Fig. 5, the plots of the 1883 Krakatau pumice flow and pumice fall in the location biased to the area occupied by the plots representing the lithic fragment of quartz monzodiorite and the selected Malayan granitic rocks.

Besides, the plots of most volcanic rocks and ejecta of the Krakatau Group fall within a field of MIYASHIRO's (1974) tholeiitic series (Fig. 5), and, in contrast, the plots of most volcanic rocks of Sakurajima Volcano, which is located on the southern rim of Aira caldera, fall within a field of the calc-alkalic rock series (Fig. 4). It is noted that the plots of volcanic rocks and ejecta of Anak Krakatau concentrate in just the plot representing an average composition of typical island arc basaltic andesites, and that the plots of volcanic rocks representing basic rock type of the basement complex of the Krakatau Group (see half solid triangles at lower left on Fig. 5) are contrasted in location with those of volcanic rocks representing acidic rock type (see half solid triangles at upper right and center on Fig. 5).

Ignimbrites and tuffs those which are characterized by rhyolitic, rhyodacitic and dacitic compositions at Lake Toba, Sumatra, Indonesia, appear to be related to the peculiar tectonic setting of Sumatra, and plate movement appears to be taken up in part at least (WHITFORD, 1975), along the transcurrent Semangko Fault which extends along the length of Sumatra and possibly into West Java (FITCH, 1972). WHITFORD (1975) showed that rhyolitic ignimbrite and tuff from Lake Toba have an $^{87}Sr/^{86}Sr$ ratio, 0.7139, very much higher than that for any other analyzed lava from the Sunda arc, and such a ratio argues for crustal derivation rather than a mantle origin for these rocks. Such a consideration will be useful to account the mechanism of formation of the 1883 Krakatau pumice flow.

Thus, an suggestion to account for the genesis of the 1883 Krakatau pumice flow is that sialic crustal materials, such as silicic and alkalic granitic rocks and sediments those which occur in Sumatra, plunged into the depths along the peculiar tectonic structure locating at the Sunda Strait waters between Sumatra and Java, and were partially melted, and mixed with or assimilated by the ascending basaltic magma, and dacitic magma distinctly dominant in silica, alkalies and volatile components was produced, and, in such a way, the

1883 Krakatau eruption characterized by the pumice flow of dacitic composition took place.

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