SOME CONSIDERATIONS ON THE RELATION BETWEEN THE CHEMICAL CHARACTER AND THE GEOGRAPHICAL POSITION OF THE VOLCANIC ZONES IN JAPAN

By

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Pleistocene and recent volcanoes in Japan and the Kurile Islands have been generally classified geographically into those of the Tisima (Chishima), Daisetu, Nasu, Tyôkai (Chôkai), Huzi (Fuji), Norikura, Daisen and Ryûkyû volcanic zones from the northeast to the southwest. (Figure 1)

Volcanoes which stand on the Kurile arc from Alaid at the northeastern end of Kurile Islands to Daisetu and Tokati at the central part of Hokkaido, were formerly included in the Tisima zone. The western part of that zone or the volcanic range running in NNE direction in central Hokkaido was called the Daisetu volcanic zone also from the petrological view point by the present authors (Ishikawa, T., Katsui, Y. and Suzuki, Y., 1952) since 1950, though it had been already distinguished as the Tokati volcanic chain also geographically by some geologists. The lavas of the Daisetu zone often contain hornblende as well as pyroxene and olivine, and are chemically more alkalic than those of most other volcanoes of the Tisima zone, which are petrographically pyroxene andesite and dacite or basalt of tholeiitic magma origin. Only Alaid and its parasitic volcano, Taketomi are made up of slightly alkaline olivine basalt comparatively rich in K_2O (Kuno, 1935); they stand distinctly at the west or inner side of the Tisima main zone.

The Nasu volcanic zone which starts from western Hokkaido and extends to central Honshu comprises volcanoes mostly made up of pyroxene andesite and dacite, and rarely of basalt of tholeiitic magma origin. But the lavas of several volcanoes in its southern part often contain hornblende and are slightly more alkalic than those from most other volcanoes of this zone. Risiri, a volcanic islet off the most northwestern coast of Hokkaido is built of pyroxene andesite and slightly

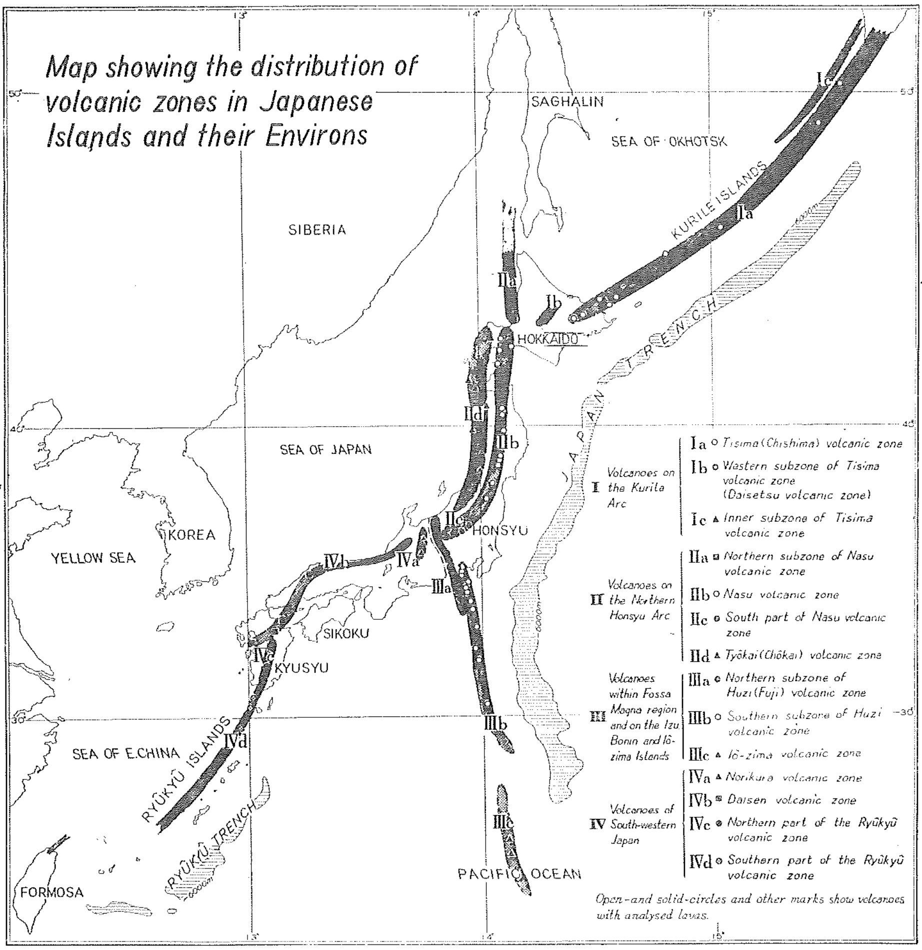


Fig. 1.

alkaline basalt comparatively rich in Na_2O. Shokanbetu, a large dissected stratovolcano on the coast of the Japan Sea, to the south of the just-mentioned volcano, is made up of hornblende pyroxene andesite and olivine basalt comparatively rich in alkalies. The above two volcanoes both lie on the line of an extension of the Nasu zone to the north and then have been considered to be included in the above zone by some students. But they seem not to belong to the Nasu zone proper from the petrological viewpoint. (Katsui, 1953) The authors will term them here as volcanoes of the northern subzone of the Nasu zone.

Volcanoes arranged parallel to the Nasu zone at the west or inner side of the northern Honshu arc are included in the Tyôkai zone. It starts from Oshima-ôshima, a volcanic islet off the most south-western coast of Hokkaido and runs near the coast of Japan Sea to central Honshu. The lavas from volcanoes belonging to the Tyôkai zone are hornblende pyroxene andesite, hornblende and olivine bearing pyroxene andesite, pyroxene andesite and olivene basalt rather rich in K_2O, being far different petrologically from those lavas of the Nasu zone.

The Fuji zone which comprises volcanoes within the Fossa magna region and those on the Izu Islands, running in NNW direction, was divided into two subzones by Kuno (1952). The southern subzone comprises volcanoes south of Hakone, which are made up of tholeiitic basalt and pyroxene andesite. The northern subzone, which starts from Kôzu-sima among the Izu Islands and extends to the Japan Sea coast running along the west side of the southern subzone, comprises volcanoes built of hornblende or hornblende biotite rhyolite and hornblende pyroxene andesite as well as pyroxene andesite and basalt. The basalt is slightly more alkaline and less siliceous than that from the southern subzone. Iô-zima Islands located near the south end of the Fuji zone are built of trachy-andesite, and are arranged in the direction nearly parallel to it at its west side, constituting Iô-zima zone independent of the Fuji.

The Daisen zone which runs along the Japan Sea coast in south-western Japan and extends to volcano Unzen at the west part of Kyûshû, is petrographically characterized by biotite hornblende andesite and dacite.

The Ryûkyû zone starts from Mt. Aso lying in the middle of Kyûshu and runs to the SSW, including Sakura-zima and volcanoes arranged at the inner or west side of the main arc of Ryûkyû. Volcanoes belonging to this zone are mostly built of pyroxene andesite, but the lavas from those in its northern part contain sometime hornblende. Volcanoes lying at the north end of Formosa, on the extension line of the Ryûkyû zone to the south, are made up of pyroxene andesite and biotite hornblende andesite, and stand rather at the west side of the Ryûkyû zone.

Volcanic rocks from Japan were early subjected to chemical examination by Yamada (1930); the average chemical compositions of rhyolite, rhyolite-andesite, andesite, andesite-basalt and basalt were calculated respectively. Tomita (1935) studied the chemical compositions of the Cenozoic alkaline rocks of the Circum Japan Sea region and clarified the chemical characters of alkalic rocks in Japan. Iwasaki collected 603 analyses of volcanic rocks from Japan and calculated the average chemical

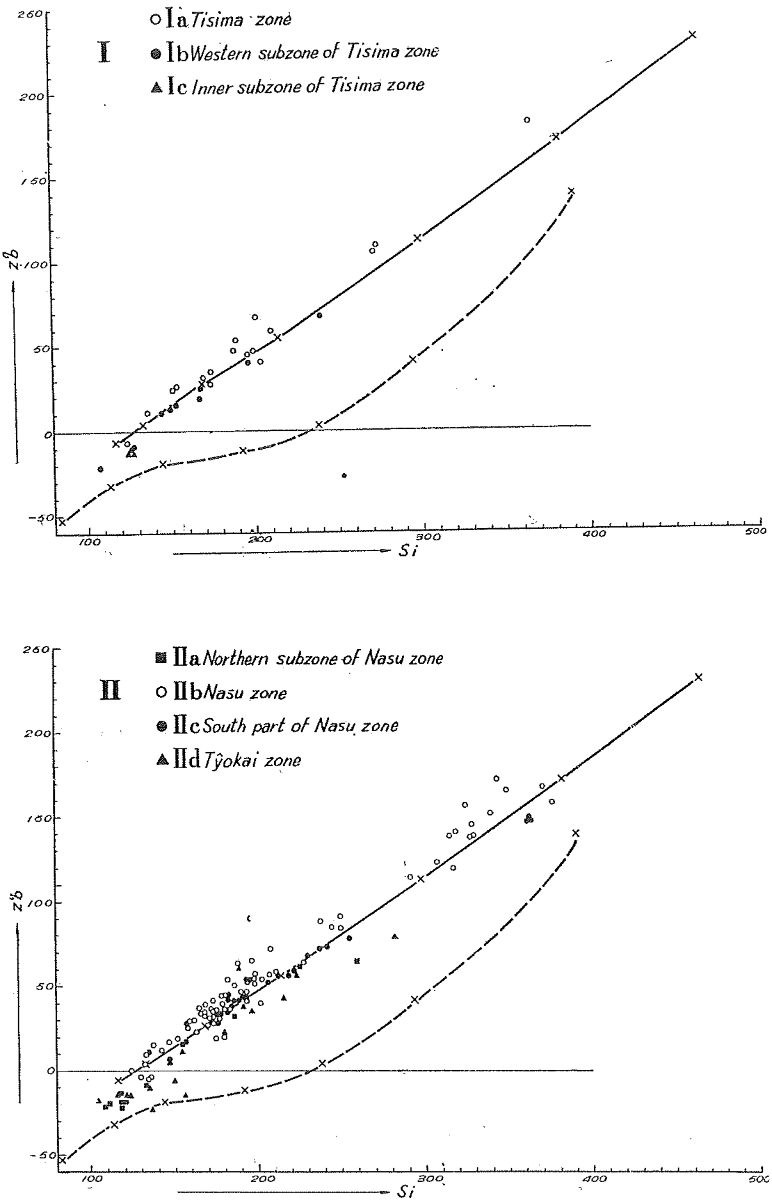
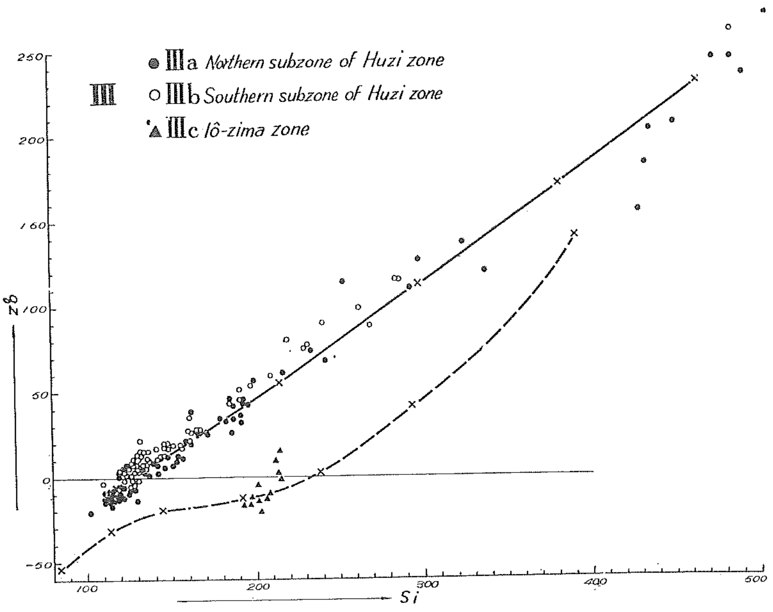
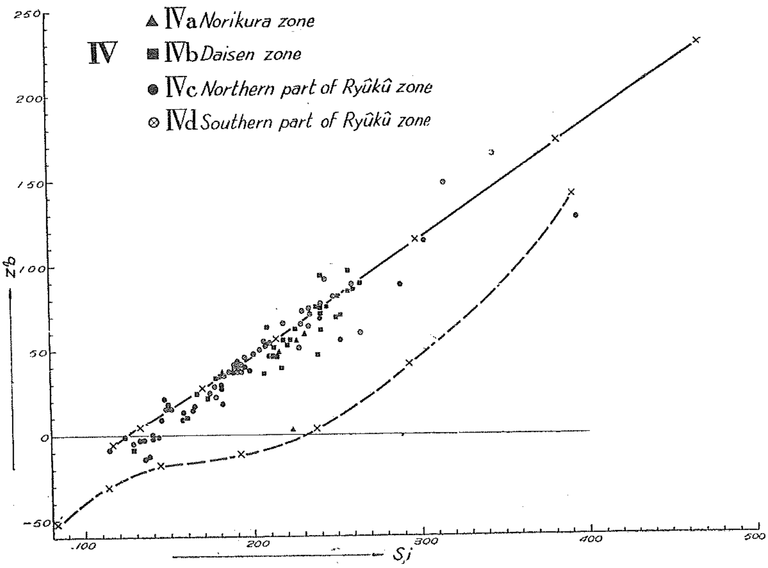


Fig. 2. Variation diagrams of *qz* values corresponding to *si*. The full line shows the average value of young volcanic rocks in Japan, and the dashed line that of alkalic volcanic rocks in Circum Japan Sea region.


III
● IIIa Northern subzone of Huzi zone
○ IIIb Southern subzone of Huzi zone
▲ IIIc Iô-zima zone
zδ
Si
250
200
150
100
50
0
-50
100
200
300
400
500


IV
▲ IVa Norikura zone
■ IVb Daisen zone
● IVc Northern part of Ryûkû zone
⊗ IVd Southern part of Ryûkû zone
zδ
Si
250
200
150
100
50
0
-50
100
200
300
400
500

compositions of rock groups classified according to SiO_2 contents respectively (Iwasaki, 1937a). Furthermore he made detailed studies of the chemical constitution of the lavas of each volcanic zone in Japan (Iwasaki, 1937b). Taneda (1951) examined particularly the chemical compositions of the lavas from volcanoes in Japan and discussed the chemical characteristics of every volcanic zone. Ishikawa (1952), the present senior author, compared the chemical compositions of the lavas from volcanoes in Japan in terms of Niggli values calculated from them, especially in *al—alk,qz*, *al/al—alk* and *c*—(*al—alk*) values corresponding to *si* and *k-mg* relation.

According to him, the lavas from the volcanoes of Tisima, Nasu and Fuji zones are mostly higher in *al—alk* and *qz* values than the average of the young volcanic rocks of the Pelée Lassen-Peak type which is the highest in both the above values among all types of the North America Cordillera (Burri, 1926). As the more alkalic rocks are lower in (*al—alk*) and *qz* values, the above three zones in Japan are considered to be of the most calcic type in the world. It is interesting also that large crystals of anorthite have been often found in the lavas from the above zones and never reported from any other volcanic zones. Ishikawa (1951) suggested from the above fact that the formation of the large anorthite crystals may be due to magmatic assimilation of sedimentary rocks rich in Al_2O_3. The lavas from the Daisen and Ryûkyû zones are generally lower in *al—alk* and *qz* values than the average of volcanic rocks of the Pelée Lassen-Peak type, proving to be more alkalic. Katsui (1953, 1954), the junior author, made chemical analyses of some lavas from Tyôkai and Daisetsu zones and from Rishiri and Shokanbetu volcanoes; he reported on the chemical characteristics of the above zones or volcanoes.

Comparing the chemical compositions of the lavas from every volcanic zone in Japan in terms of Niggli values, the authors (Ishikawa and Katsui, 1955) have previously noticed that the lavas of the more inner zone or subzone are the more alkalic. Accordingly it is now proposed to classify volcanoes in Japan and Kuriles petrochemically into the following zones and subzones (see Fig. 1);

I. Volcanoes on the Kurile arc
   - Ia. Tisima volcanic zone
   - Ib. Western subzone of the Tisima volcanic zone or Daisetu volcanic zone
   - Ic. Inner subzone of the Tisima volcanic zone

II. Volcanoes on the northern Honshu arc
   - IIa. Northern subzone of the Nasu volcanic zone
   - IIb. Nasu volcanic zone

IIc. South part of the Nasu volcanic zone
IId. Tyôkai volcanic zone
III. Volcanoes within the Fossa magna region and on the Izu and Iô-zima islands.
IIIa. Northern subzone of Fuzi volcanic zone
IIIb. Southern subzone of Fuzi volcanic zone
IIIc. Iô-zima volcanic zone
IV. Volcanoes of south-western Japan
IVa. Norikura volcanic zone
IVb. Daisen volcanic zone
IVc. Northern part of Ryûkyû volcanic zone
IVd. Southern part of Ryûkyû volcanic zone

The above zones and subzones are distributed geographically as shown in Figure 1. The available chemical analyses of the lavas from volcanoes in Japan, selected by the authors for the present study totalled 416; the numbers of analyses from every volcano and zone respectively are shown in Table I.

The chemical compositions represented in oxide form were calculated into Niggli values and compared with one another in *qz*, *al*−*alk* and *c*−(*al*−*alk*) corresponding to *si* and *mg*-*k* relation as shown in Figures 2 to 5. For the comparison, also average values of young volcanic rocks in Japan (Taneda, 1951) and alkalic volcanic rocks in Circum Japan Sea region (Tomita, 1936) were shown respectively in each of the above Figures.

In Figures 2 and 3, the numbers of the samples of lava plotted above and on the line showing the average of volcanic rocks in Japan in *qz* and *al*−*alk* values were counted in every zone or subzone, as shown in Table II.

As shown in Figue 2 and Table II, the lavas from zones Ia, IIb and IIIb are mostly higher in *qz* than the average value of volcanic rocks in Japan. Zones IIc, IIIa and IVd are next to the above three in *qz* value. The lavas from IIIc, IId, IIa, IVa, Ic, Ib, IVb and IVc zones are generally lower in *qz* value than the average. Especially IIIc or Iô-zima zone is exceptionally low in *qz* and very near to the average of alkalic volcanic rocks in Circum Japan Sea region. Also in *al*−*alk* value, Ia, IIb and IIIb zones are higher than the average of volcanic rocks in Japan. The third zone is not much higher than the average, but it is distinctly higher than the Pelée Lassen-Peak type (Ishikawa, 1952). Zones IIc, IIIa, IVc, IVd and IVb are next to the above three and near to the average, while zones IIIc, IId, IIa, IVa, Ib and Ic are lower in *al*−*alk*

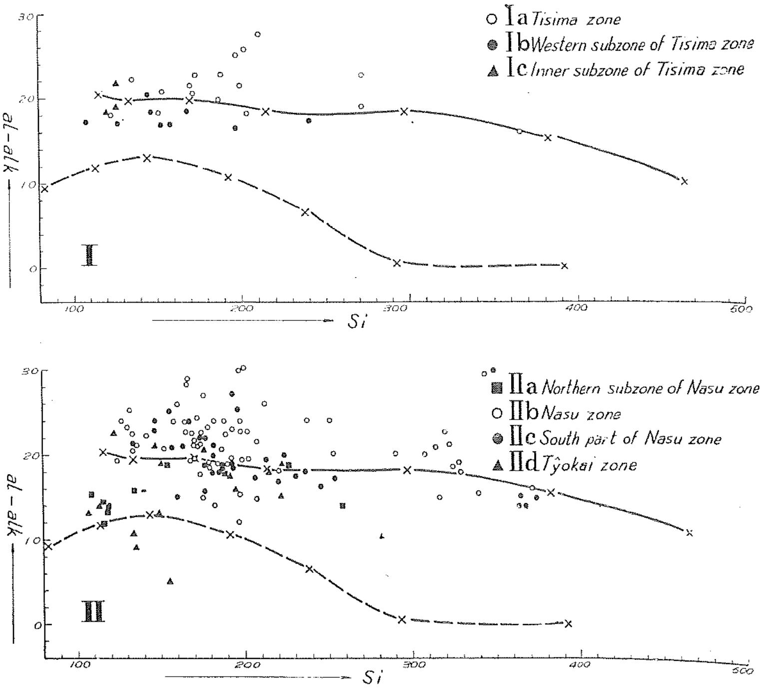
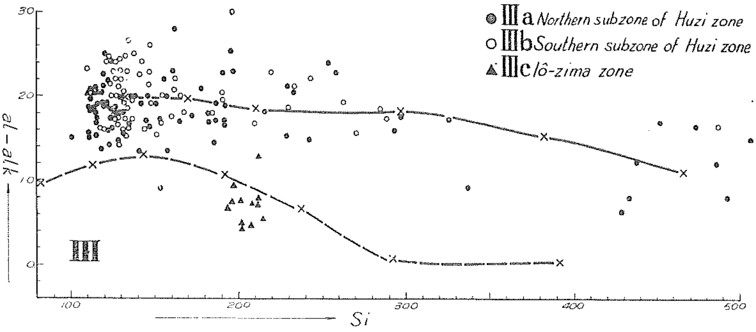
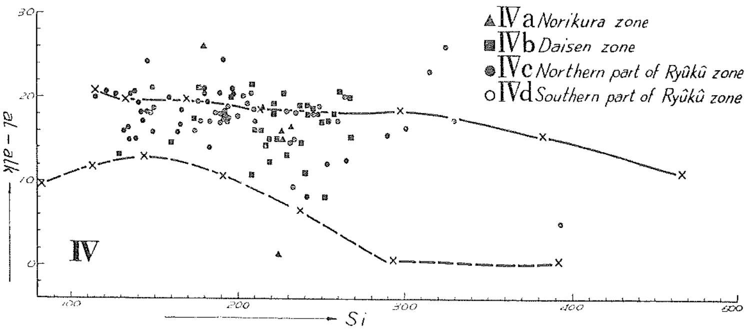


Fig. 3. Variation diagrams of *al-alk* values corresponding to *si*. The full line shows the average value of young volcanic rocks in Japan, and the dashed line that of alkalic volcanic rocks in Circum Japan Sea region.

value than the average. Especially IIIc is remarkably low in *al*−*alk* as such in *qz*.

As the more alkalic rock group is the lower either in *qz* or in *al*−*alk* values, as already stated by Ishikawa (1952), the descending order of zones in respect to the above values may represent gradual change from calcic to alkalic characters. Among volcanoes on the Kurile arc, the Tisima zone is the most calcic, whilst the inner and western subzones are more alkalic. On the northern Honshu arc, the Nasu zone is the most calcic and its inner zone or the Tyôkai zone and the northern subzone of the Nasu are distinctly more alkalic. Volcanoes at the south part of the Nasu zone which stand slightly to the inner side of the Nasu zone proper are more alkalic than the latter and show character similar to the northern subzone of the Fuji, with which the south part of the Nasu joins geographically at its southern end. Of volcanoes within the Fossa magna region and on the Izu and Iô-zima Islands, the





southern subzone is the most calcic, whilst the northern subzone running at its inner side is more alkalic. The lavas from the Iô-zima Islands are remarkably alkalic.

Viewing generally the above three geographical units, one may say that volcanoes on the outer side are more calcic than those on the inner side in chemical character, and thus the zonal arrangement of the volcanoes with calcic to alkalic lavas from the south-east to the north-west is well shown. Surrounding the outside of the most calcic zone, the Japan trench, more than 8,000 m in depth, stretches as shown in Figure 1, and this fact suggests that the magmatic character of volcano is closely related to the tectonic position.

High *qz* value corresponding to *si* suggests the existence of free silica as quartz, tridymite and cristobalite in mode. In andesite and basalt of calc-alkalic type in Japan, richness in *qz* and Norm Q is generally represented in the form of silica minerals in the groundmass or as glass containing excess silica.

The *al*−*alk* value is related to anorthite content of plagioclase in

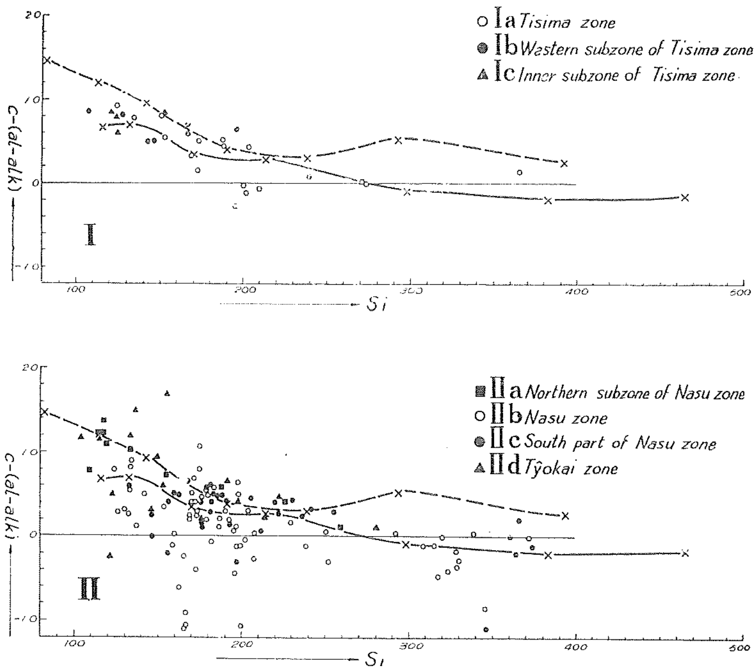
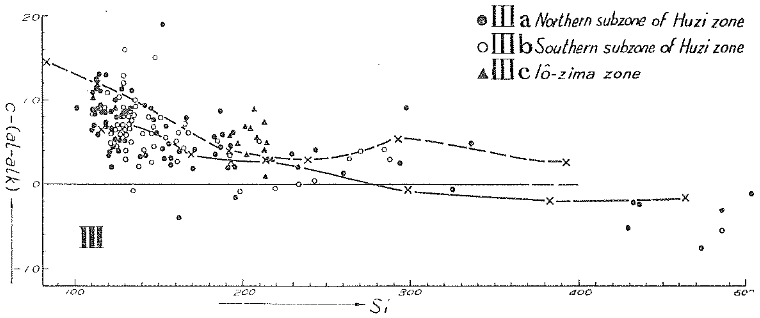


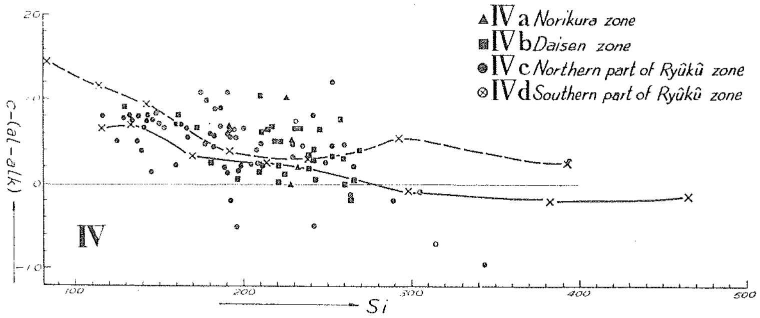
Fig. 4. Variation diagrams of *c*-(*al*-*alk*) values corresponding to *si*. The full line shows the average value of young volcanic rocks in Japan, and the dashed line that of alkalic volcanic rocks in Circum Japan Sea region.

mode. Plagioclases contained as phenocrysts in the lavas from Tisima, Nasu and Fuji zones are generally calcic. Large anorthite crystals which have been often found from volcanoes of the above three zones, whose lavas are mostly rich in *al*−*alk*, are genetically related to the magmatic character.

The *c*−(*al*−*alk*) value is related to the lime content in pyroxene. Accordingly the low value of *c*−(*al*−*alk*) may suggest richness in rhombic pyroxene. Pyroxene andesite and basalt rich in rhombic pyroxene are generally very low in *c*−(*al*−*alk*) value.

Numbers of the lavas plotted below and on the lines showing the average values of volcanic rocks in Japan and alkalic volcanic rocks in Circum Japan Sea region in *c*−(*al*−*alk*) value are shown for every zone in Table III. The lavas from zones Ia and IIb of the most calcic type are mostly plotted below the average line of volcanic rocks in Japan. Next to them, IIIb, IIIa, IIc and IVc zones are low in *c*−(*al*−*alk*) value. The lavas of IIIc, IIa and IVa are mostly higher than the average line,

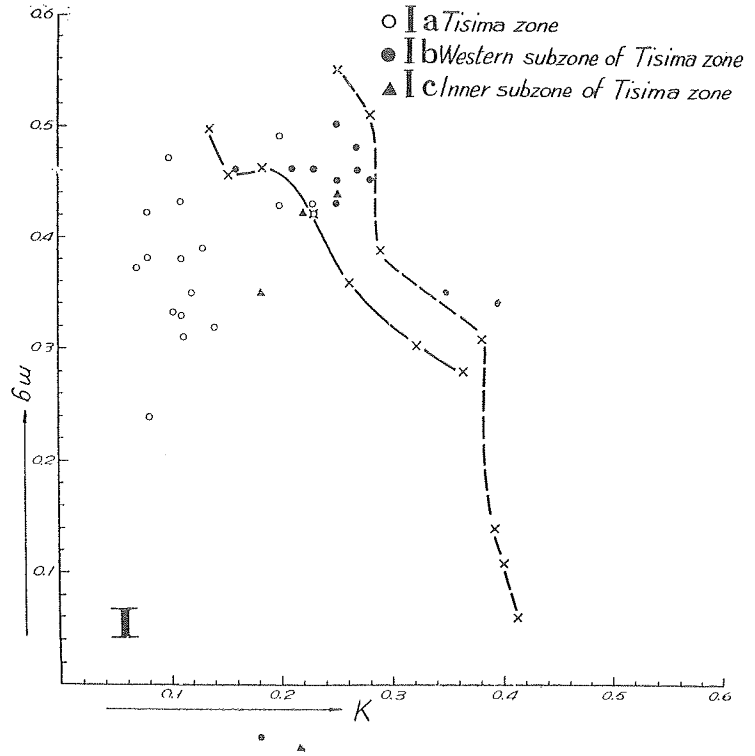




or more alkalic in magmatic character. Zones IId, Ic, IVb, Ib and IVd are comparatively high in $c-(al-alk)$ value next to the above three.

From *mg-k* relation diagrams (Figue 5), numbers of the lava samples plotted below (or at the left side of) and on the lines representing respectively the average values of volcanic rocks in Japan and in Circum Japan Sea region are shown in Table IV. Most lavas of Ia, IIb and IIIb zones are below (or at the left side of) the average line of volcanic rocks in Japan. Especially zone IIIb shows the lowest value ranging from 0.02 to 0.17 in k, though mg is variable between 0.77 and 0.60. The above three zones are of the most calcic type, judging from qz and *al-alk* values. The lavas from IIIc and Ic are often plotted below the average line, but the former zone comprises volcanoes made up of alkalic rocks rich in Na_2O and the latter consists of weak alkalic basalt. Zones IIIa, IVd and IIc include more lavas above (or at the right side of) the average line than those below (or at the left side of) it respectively.

The lavas from zones IId, IVb, IVc, IVa and Ib are mostly above (or at the right side of) the average line of volcanic rocks in Japan, and not a few lavas from the former three are even above the average



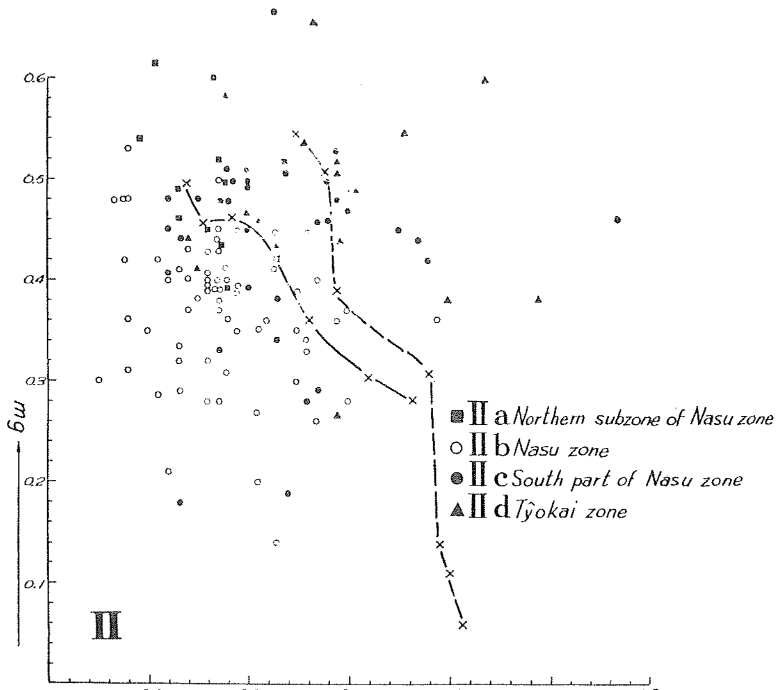
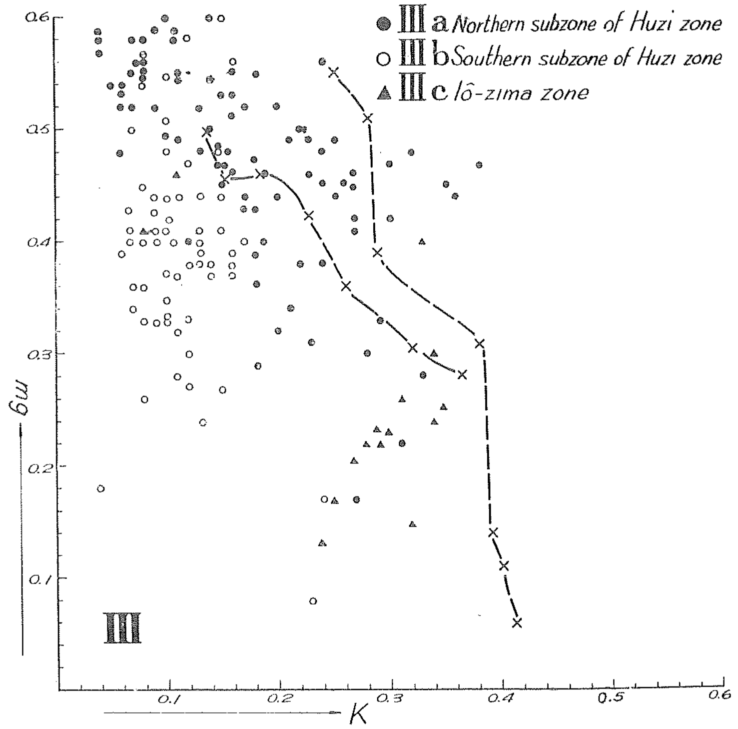
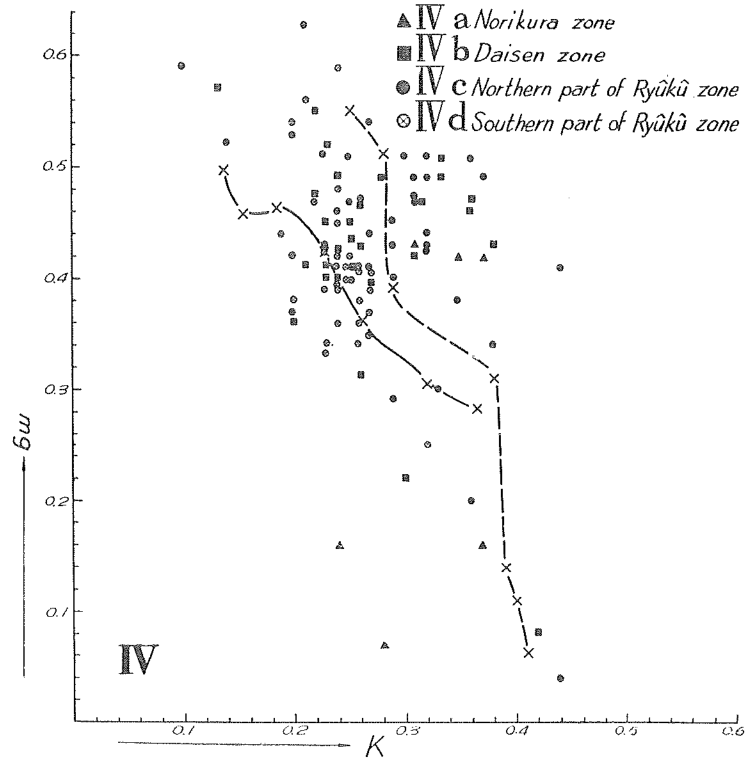


Fig. 5. Variation diagrams of *mg-k* relation. The full line shows the average value of young volcanic rocks in Japan, and the dashed line that of alkalic volcanic rocks in Circum Japan Sea region.


III a Northern subzone of Huzi zone
III b Southern subzone of Huzi zone
III c Iô-zima zone
III
mg
K
0.1
0.2
0.3
0.4
0.5
0.6


IV a Norikura zone
IV b Daisen zone
IV c Northern part of Ryûkû zone
IV d Southern part of Ryûkû zone
IV
mg
K
0.1
0.2
0.3
0.4
0.5
0.6

line of alkalic volcanic rocks in Circum Japan Sea region. Accordingly each zone is chemically characterized also by *k-mg* relation, and concentration area and arrangement of points of each zone are significant to consider the trend of magmatic differentiation in respective areas.

Tectonically, the geological units are distributed zonally either in the Kurile arc or in the northern Honshu arc from the west or the inner to the east or the outer sides as follows (Minato, M., Yagi, K. and Hunahashi, M., 1956);

(1) Japan Sea basin or Okhotsk Sea basin.
(2) Inner zone with volcanic belt.
(3) Outer zone.
(4) Pacific ocean basin surrounded by the Japan trough.

Quarternary volcanoes are arranged only in the inner zones of the above arcs where the so-called green tuffs of Miocene age are distributed widely. Minato and his collaborators stated that Quaternary volcanoes have been formed upon upheaved green tuff regions.

From the results obtained by the present authors, it is concluded that among Quaternary volcanoes formed in the Inner zone as tectonically classified, those made up of the more calcic lavas are arranged at the outer side. Rittmann (1953) has studied already on the magmatic character and tectonic position of the Indonesian volcanoes, and stated that the calc alkaline character of the magmas of the volcanoes decreases regularly in the direction from the foredeep to the hinterland. It is interesting that the similar zonal arrangement of volcanoes is shown also in the Japanese Islands and their environs.

TABLE 1. Numbers of available chemical analyses from each volcano and zone with their sources or analysts.

I *Volcanoes on the Kurile Arc*	
Ia, Tisima (Chishima) volcanic zone; 16	
Pramusiru	2: J. SUZUKI & Y. SASA (1932)
Harimukotan	1: T. NENOTO (1934)
Uruppu	4: T. NEMOTO (1935)
Etorohu	1: Y. KATSUI (unpublished)
Kunasiri	1: S. KOZU (1909)
Siretoko-Iô-zan	1: S. KOZU (1909)
Masyû	5: Y. KATSUI (1955)
Me-akan	1: Y. KATSUI (unpublished)
Ib, Western subzone of Tisima valcanic zone (Daisetu volcanic zone); 9	
Daisetu	5: Y. KATSUI (unpublished)
Takanegahara	1: Y. KATSUI (unpublished)

Tokati	2: F. TADA & H. TSUYA (1927)
Furanodake	1: Y. Katsui & T. TAKAHASHI (unpublished)

Ic, Inner subzone of Tisima volcanic zone; 3

Alaid	1: J. SUZUKI & Y. SASA (1932)
Taketomi	2: H. KUNO (1935)

II *Volcanoes on the Northern Honshu Arc*

IIa, Northern subzone of Nasu volcanic zone; 10

Risiri	9: Y. KATSUI (1953)
Shokanbetu	1: Y. KATSUI (unpublished)

IIb, Nasu volcanic zone; 68

Yôtei (Ezo-huzi)	4: KATSUI (1956)
Tarumai	18: T. ISHIKAWA (1952)
Usu	5: K. YAGI (1953)
Komaga-take	14: S. KOZU (1909), H. TSUYA (1930), K. SETO & T. YAGI (1931) and K. SETO (1931)
Hakkoda	1: Y. KAWANO (1939)
Towada	6: Y. KAWANO (1939)
Iwate	2: S. YAMANE (1915)
Kurikoma	1: Y. KATSUI (unpublished)
Onikobe	1: Y. KATSUI (1955)
Naruko	6: Y. SHIGA (1929)
Zaô-san	2: S. NISHIYAMA (1887) and T. KOCHIBE (1896)
Azuma-san	2: S. NISHIYAMA (1887)
Adatara	1: S. NISHIYAMA (1887)
Bandai	5: S. NISHIYAMA (1887) and S. SEKIYA & Y. KIKUCHI (1890)

IIc, South part of Nasu volcanic zone; 33

Nyohô-Akanagi	8: M. YAMASAKI (1954)
Akagi	5: R. ÔTA (1953)
Kusatu-sirane	5: H. TSUYA (1934a)
Asama	15: S. KOZU (1932), H. TSUYA (1933), K. KANI (1935) and I. IWASAKI (1936)

IId, Tyokai (Chokai) volcanic zone; 16

Iwaonupuri	2: O. HIROKAWA & M. MURAYAMA (1955) and S. KOZU (1909)
Osima-ôsima	4: Y. KATSUI (1954)
Osima-kozima	1: Y. KATSUI (unpublished)
Iwaki-san	1: Y. KATSUI (1954)
Kanpû	5: Y. KATSUI (1954)
Ichinomegata	1: H. HAYASHI (1955)
Tyokai-san	1: Y. KATSUI (1954)
Sumon	1: F. HONMA (1922)

III *Volcanoes within Fossa magna region and on the Izu and Io-zima Islands*

IIIa, Northern subzone of Huzi (Fuji) volcanic zone; 82

Kurohime	3: H. TSUYA (1937)
Iizuna	3: H. TSUYA (1937)
Kayaga-take	2: M. ICHIKI (1929)
Kurohuzi	1: H. TSUYA (1937)

	Huzi (Fuji) & Asitaka	14: H. TSUYA (1954), (1937)
	Amagi & Ômuro-yama	51: D. SATO (1925), H. TSUYA (1937), (1954), H. KUNO (1954) and H. KURASAWA (1956)
	Nii-zima	3: T. TSUYA (1929), K. KANI (1935) and S. NAGAI (1936)
	Kôzu-sima	5: H. TSUYA (1929)
IIIb,	Southern subzone of Huzi volcanic zone; 61	
	Hakone	8: R. INOUE (1913) and H. KUNO (1950)
	Taga	12: H. KUNO (1950)
	Usami	8: H. TSUYA (1937)
	Ô-sima	12: S. TSUBOI (1920), S. KÔZU (1927), K. KANI (1934), H. KUNO (1950) and R. MORIMOTO *et al* (1953)
	To-sima	1: S. KÔZU (1927)
	Utone-zima	1: S. KÔZU (1927)
	Miyake-zima	6: H. TSUYA (1927), (1937) and S. KÔZU (1928)
	Mikura-zima	1: H. TSUYA (1937)
	Hatizyôzima	1: H. TSUYA (1937)
	Aoga-sima	4: H. TSUYA (1937) and N. ISSHIKI (1955)
	Myôzin-syô	6: H. TSUYA *et al* (1953), H. HAMAGUCHI & M. TATSUMOTO (1953) and R. MORIMOTO (1954)
	Tori-sima	1: H. TSUYA (1937)
IIIc,	Iô-zima volcanic zone; 14	
	Iô-zima Islands	14: H. TSUYA (1936) and I. IWASAKI (1937)
IV	*Volcanoes of South-western Japan*	
IVa,	Norikura volcanic zone; 8	
	Iô-dake	1: T. KATÔ (1913)
	Yakeyama	2: D. SATÔ (1925)
	Norikura	4: S. KÔZU (1911), H. S. WASHINGTON (1917) and D. SATÔ (1925)
	Ontake	1: J. P. IDDINGS (1913)
IVb,	Daisen volcanic zone; 31	
	Sanbe	4: S. KÔZU & B. YOSHIKI (1929)
	Kuzyû	1: D. SATÔ (1925)
	Kasayama	1: K. SUGI (1942)
	Ône-zima	1: E. SAKAI (1939)
	Hutago	13: K. KOMADA (1916) and Y. KAWANO (1937)
	Unzen	11: Volc. Soc Japan (1936), K. KANI (1935), T. OGAWA (1924) and D. SATÔ (1925)
IVc,	Northern part of Ryûkyû volcanic zone; 32	
	Aso	16: F. HONMA & M. MUKAE (1938), K. YAMAGUCHI (1938) and I. SUGANO & G. ARIMURA (1957)
	Kirisima	16: D. SATÔ (1925) and K. TAKAHASHI and K. SAWAMURA (1957)
IVd,	Southern part of Ryûkyû volcanic zone; 33	
	Sakurazima	16: Volc. Soc. Japan (1936)
	Iô-zima	2: H. TANAKADATE (1935)

Kuchinoerabu	2: F. HONMA (1944)
Suwanose-zima	13: S. MURAUCHI (1954) and H. MATSUMOTO (1956)

TABLE 2. Numbers of the lavas plotted above and on the line showing the average volcanic rocks in Japan respectively in Figures 2 and 3 (*qz* and *al*−*alk* values).

Zone	Total number	*qz* value		*al*−*alk* value	
		above	on	above	on
Ia	16	14	0	13	1
Ib	9	0	2	1	0
Ic	3	0	0	1	0
IIa	10	0	1	1	0
IIb	68	55	5	50	4
IIc	33	19	4	16	2
IId	16	1	0	3	0
IIIa	82	24	8	28	5
IIIb	61	53	3	34	2
IIIc	14	0	0	0	2
IVa	8	1	0	2	0
IVb	31	5	6	10	3
IVc	32	2	5	13	1
IVd	33	18	6	8	5

TABLE 3. Numbers of the lavas below and on the lines showing the average values of volcanic rocks in Japan (Average J.) and in Circum Japan Sea region (Average J. S.) in Figure 4 (*c*−(*al*−*alk*) value).

Zones	Total numbers	Average J. S.		Average J.	
		below	on	below	on
Ia	16	14	1	5	4
Ib	9	6	0	3	0
Ic	3	3	0	1	0
IIa	10	4	1	0	0
IIb	68	59	1	44	2
IIc	33	23	1	11	2
IId	16	8	1	5	0
IIIa	82	64	2	25	7
IIIb	61	52	2	27	1
IIIc	14	4	1	1	0
IVa	8	2	0	1	1
IVb	31	13	3	9	2
IVc	32	27	3	12	2
IVd	33	11	0	7	0

TABLE 4. Numbers of the lavas below (or at the left side of) and on the lines showing the averages of volcanic rocks in Japan (Average J.) and in Circum Japan Sea region (Average J. S.) in Figure 5 (*k-mg* relation).

Zones	Total numbers	Average J.		Average J. S.	
		below	on	below	on
Ia	16	13	2	16	0
Ib	9	0	1	9	0
Ic	3	2	0	3	0
IIa	10	4	0	10	0
IIb	68	61	1	67	1
IIc	33	12	0	24	1
IId	16	3	0	7	1
IIIa	82	39	3	75	1
IIIb	61	57	0	61	0
IIIc	14	12	0	13	0
IVa	8	3	0	5	0
IVb	31	6	1	22	0
IVc	32	5	1	15	0
IVd	33	10	2	31	0

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