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PETROCHEMICAL REGIONALITY OF THE MIOCENE DOLERITES FROM THE SAN'IN-HOKURIKU GREEN-TUFF REGION, THE INNER BELT OF SOUTHWEST JAPAN

By

Kiyoshi MIURA*

I. Introduction

The San'in-Hokuriku region is situated in inner belt of the Southwest Japan composed of the so-called "green-tuff", an important geologic unit of Japan. In this region, the violent volcanic products of this age are found as lavas, dikes, tuffs, tuff breccias and volcanic conglomerates from basic to acidic volcanic rocks. Their field appearance is generally greenish in color by special diagenesis and hydrothermal alterations. Therefore, they are generally refered to as green-tuff, although they are actually volcanic products composed of rhyolite, andesite, dacite, basalt and their pyroclastic sediments.

Atthis age, it must call a attention to this fact that dolerite intrusions found in there and here in this region. Furthermore, these dolerites are systematic variations in alkali-silica relation of the rocks. There is a fact that these rock type of the dolerites in this region shows the intimate relation to the Pre-Miocene basement rocks.

On the basis of the results of the petrological studies, the writer wants to describe an outline of the dolerites distributed in this region.

II. Geological relations of the dolerite

The Miocene formations are widely distributed in the Japanese Island along the general trend of each island arc. They show various picture of sedimentary facies and lithology at places.

They can be divided into two main types py their geological characters, viz. the Miocene developed inner and outer belts of each arc respectively. Of these the former is characterised by the predominance of various kind of volcanic rocks and their pyroclastic rocks. And the Miocene dolerite intrusions are only found in this inner belt. On the contray, the outer belt is poor in such volcanic products. The inner belt have been called the green-tuff region by their field appearancies that volcanic products is genrally greenish in color, the outer belt having been called the non green-tuff region.

The standard sequence of the Miocene geology of Japan adopts its in the Oga district, Akita prefecture of the Northeast Japan. In there, the following six stages

*Department of Geology, Faculty of Education, Shimane University, Matsue, Japan.

are established in ascending order : Namely, the Nishioga, Daishima, Nishikurosawa, Onnagawa, Funakawa and Kitaura stages.

The Miocene strata of the Southwest Japan arc designated here is clearly defined, in its easternmost part, by the northern extension of the so called Itoigawa-Shizuoka tectonic line. Its western boundary is tentatively placed in the central part of Yamaguchi prefecture, West Chugoku.

Northern boundery of the San'in-Hokuriku subregion under the Japan sea is still unknown, but the writer draw a presumed line off the coast of the Oki island and Higurajima in the Japan sea. The boundary between the green-tuff region (San'in-Hokuriku region) and non green-tuff region is nearly lined by an older tectonic line called the Hida marginal structual belt.

The green-tuff region as the San'in-Hokuriku region covers the ares where older basement rocks of the various ages had been subjected to block movement and erosion over a long times prior to the begining of the Miocene age.

The Miocene strata developed in the Hokuriku subregion directly ride on the Hida metamorphic complex, the Cretaceous acidic effusive rocks and upper Cretaceous Tetori group.

On the contrary, the Miocene formations developed in San'in subregion usually rest on the Cretaceous to the Paleogene granite, granodiorite, Late Mesozoic acidic volcanic products and Sangun metamorphic rocks, except in the case of the Oki island in the Japan sea and west half block of the Shimane peninsula where the Miocene strata cover directly the Hida-Oki metamorphic complex and its related granitic intrusives.

The lower part of the Miocene deposits in the Hokuriku subregion is represented by a formation without any remarkable volcanic materials. For example, the Nirehara formation in Toyama prefecture and the Noto peninsula is composed of arkose sadstone and conglomerate and their thickness are about 300 m. These clastic sediments are deposited of non marine environments.

Since then, such environment partly became the loci of the violent volcanism correlated to those of the Nishioga stage of the Early Miocene in the Northeast Japan.

The volcanic formations in this age are mostly composed of lavas, and pyroclastics of the basic rocks with intercalation of tuffaceous sandstones and mudstones together with volcanic conglomerates. These volasnic products sometimes attains as much as 1000 m in thickness.

On the cotrary, in the San'in subregion, the deposits correlated to the Nishioga stage noexisttent.

In Hokuriku subregion, after the Nishioga stage, the volcanism of the Daishima stage arised locally. They are characterised by the enormous large volume of various pyroclustic rocks of dacite and rhyolite and small amount of their lava.

In the San'in subregion, the Hata formation corresponding to the Daishima stage is much alike in characters of volcanism. This formation is distributed in the five areas of Hamada city, the southern Ooda city, the southern Iumo city, southern Matsue city and southern Yasugi city, which are geotecnically corresponding to the great embayments.

They are usually composed of a small amount of lava and large volume of pyroclastic rocks of dacite and rhyorite. But at the lower horison, the volcanisms of andesite and basaltic andesite are observed in the mentioned above areas. Generally, these volcanic rocks and their pyroclastic rocks are intensely altered by the hydrothermal metamorphism and the diagenesis. These volcanic pyroclastic sediments and lavas are suposed to be the deposits of non-marine environments.

The sedimentary formation corresponding to the Nishikurosawa stage have a wide distribution throughout San'in-Hokuriku region. These strata unconformably cover not only on the lower Miocene volcanic formation but also these formation directly ride on the Pre-Miocene basement rocks. These strata are composed of various sediments such as arkose sandstone, conglomerate and shale intercalating acidic to basic lava and their pyroclastic rocks, which show rapid lateral facies changes everywhere.

An open sea environment appeared at the Onnagawa stage caused the thick muddy sediments to be deposited. This stage was the age of maximum transgression. During this stage, an inland sea was formed on the inner side of the Southeast Japan. The formation of this stage, lying conformably upon the correlated formation to the Nishikurosawa stage, consist of thick beds of black shale accompanying andesite, dolerite intrusives, plagioliparite, and basic to acidic volcanic pyroclastic rocks, and includes marine fossils. These black shales indicate the culmination of transgression in this region in accordance with the rapid extension of basin and the rapid growth of Japan sea at this stage.

At later stage of the Onnagawa, volcanism was rather intensed again in the San'in subregion, which are shown by the andesite, dacite and their pyroclastic rocks accompanied with some thin sedimentary beds containing marine molluscs, about 400 m to 600 m in thickness. It relation to the former is different in different localities. But, generally, the writer presume that these relation is unconformable or conformable in places.

The formations belonging to the Funakawa stage, consists of basal conglomerates, coarse to medium sandstones originated to the andesitic rocks intercalating andesitic tuff and the thick siltstone in the upper part. The siltstone contains marine molluscus and foraminiferas.

But, these strata shows local differences in facies, in accordance with the differenciation of the basin owing to the general tendency of the uplift which became prominant in this stage.

During the Late Miocene, the Miocene basin as described above become narrow due to the local uplifting of the Pre-Miocene basement rocks and leave the several enclosed bays or non-marine basins here and there.

As stated above, throughout the Miocene age of the San'in-Hokuriku region, the greatest care must be taken about the fact that the activities of dolerite intrusives convergent at the Onnagawa stage bring with the thick black shale indicated the culumination of marine transgression.

The products of these activities are now found as the forms of sills, sheets, laccoliths and dikes in this region.

Furthermore, this is a still more important fact that the areas of the dolerite intrusion occur in these sedimentary basin of the San'in-Hokuriku region at the Onnagawa stage cause the thick black shale to be deposited.

The writer has confirmed that the dolerite magmas are not only the parental magma of various kinds of the volcanic rocks in green-tuff region, but also are related to the causes of the areal subsidence and tectonic movements.

III. Rock types of the dolerites and their distributions

The Miocene dolerites of the San'in-Hokuriku region, as describe about the details later on, change continuously from less alkali and more siliceous type (tholeiitic) to more alkali and less siliceous type (alkali olivine dolerite).

Alkali olivine dolerites occurs in the western half of the Shimane peninsula district and the Noto peninsula district. High almina dolerites occurs in various places, namely, the eastern half of the Shimane peninsula, the Izumo Miocene embayment district, the Muraoka Miocene embayment district and the Tango peninsula district. Tholeiitic dolerites occurs only in the Ooda Miocene embayment district.

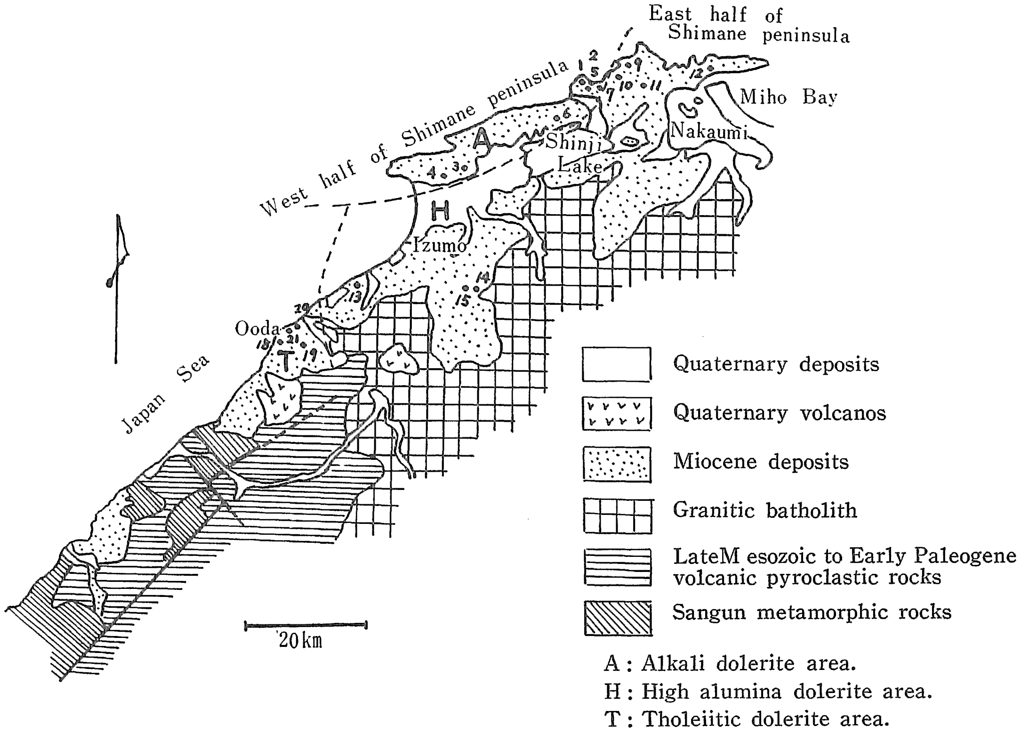

Fig. I : Geological map of the east part of Shimane prefecture and localities of dolerites for analysis.

That is to say, alkali olivine dolerites occurs in a zone near the Japan sea coast of the San'in-Hokuriku region, extending eastward to the Noto penisula from the Western half of the Shimane peninsula.

To the south of this zone, high alumina dolerite zone runs to the Tango peninsula from the Izumo Miocene embayment district parrallel to the alkali dolerite zone.

Over against these arrangement of the both types of the dolerites above mentioned, tholeiitic dolerite zone expose rather in wedge-shaped distribution into above mentioned both zones.

The distributions of the tholeiitic dolerites, the high alumina dolerites and the alkali dolerites in the San'in-Hokuriku region are shown in Fig. I, Fig. II, Fig. III and Fig. IV.

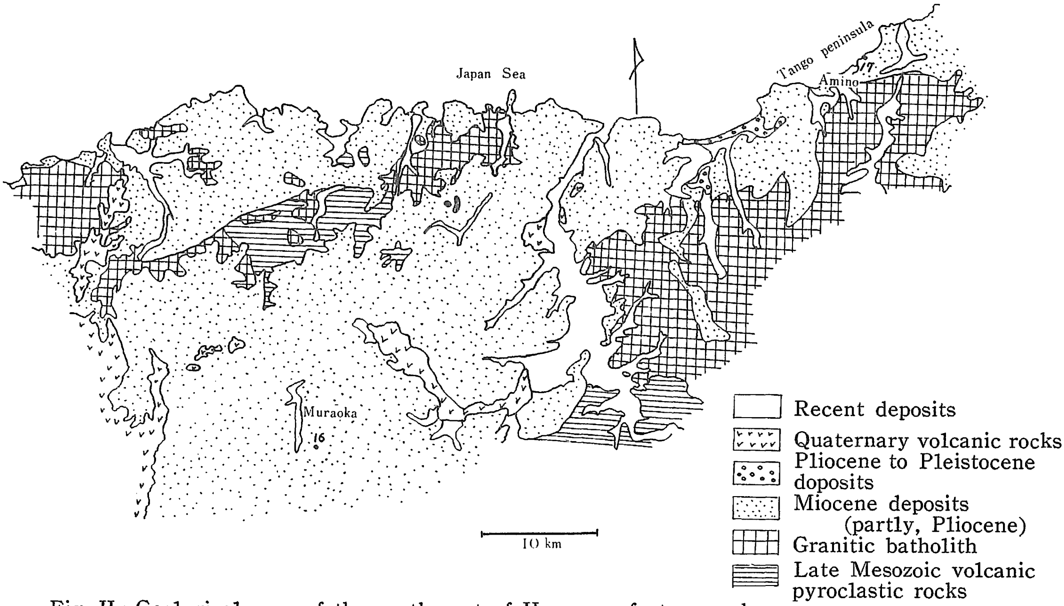

Fig. II : Geological map of the north part of Hyogo prefecture and Tango paninsula district of Kyoto prefecture and localities of dolerites for analysis.

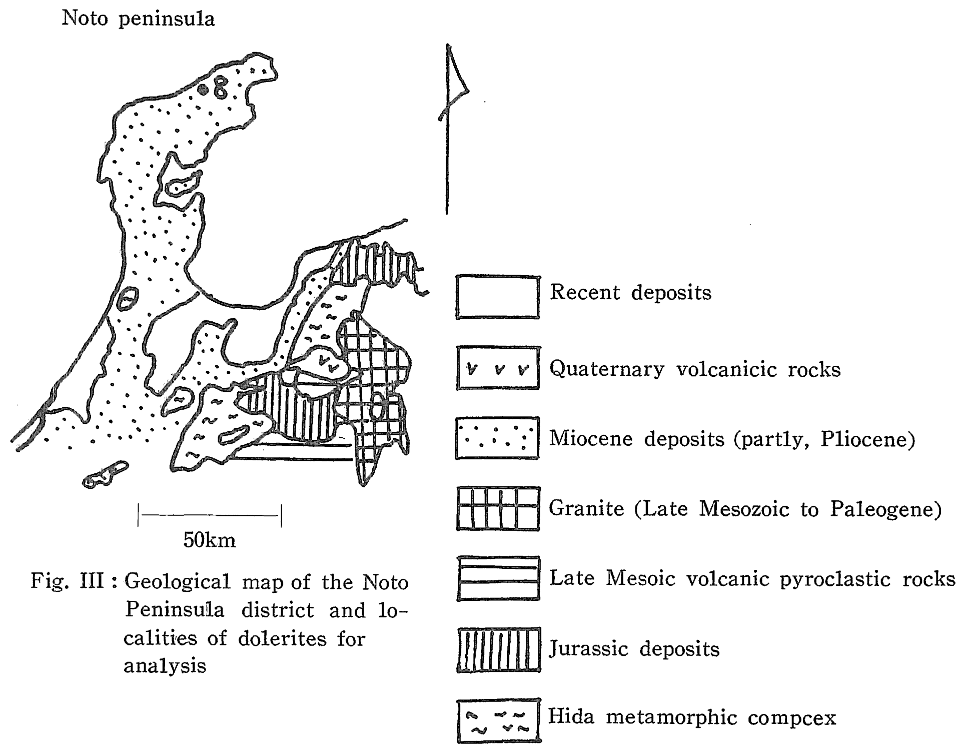

Fig. III : Geological map of the Noto Peninsula district and localities of dolerites for analysis

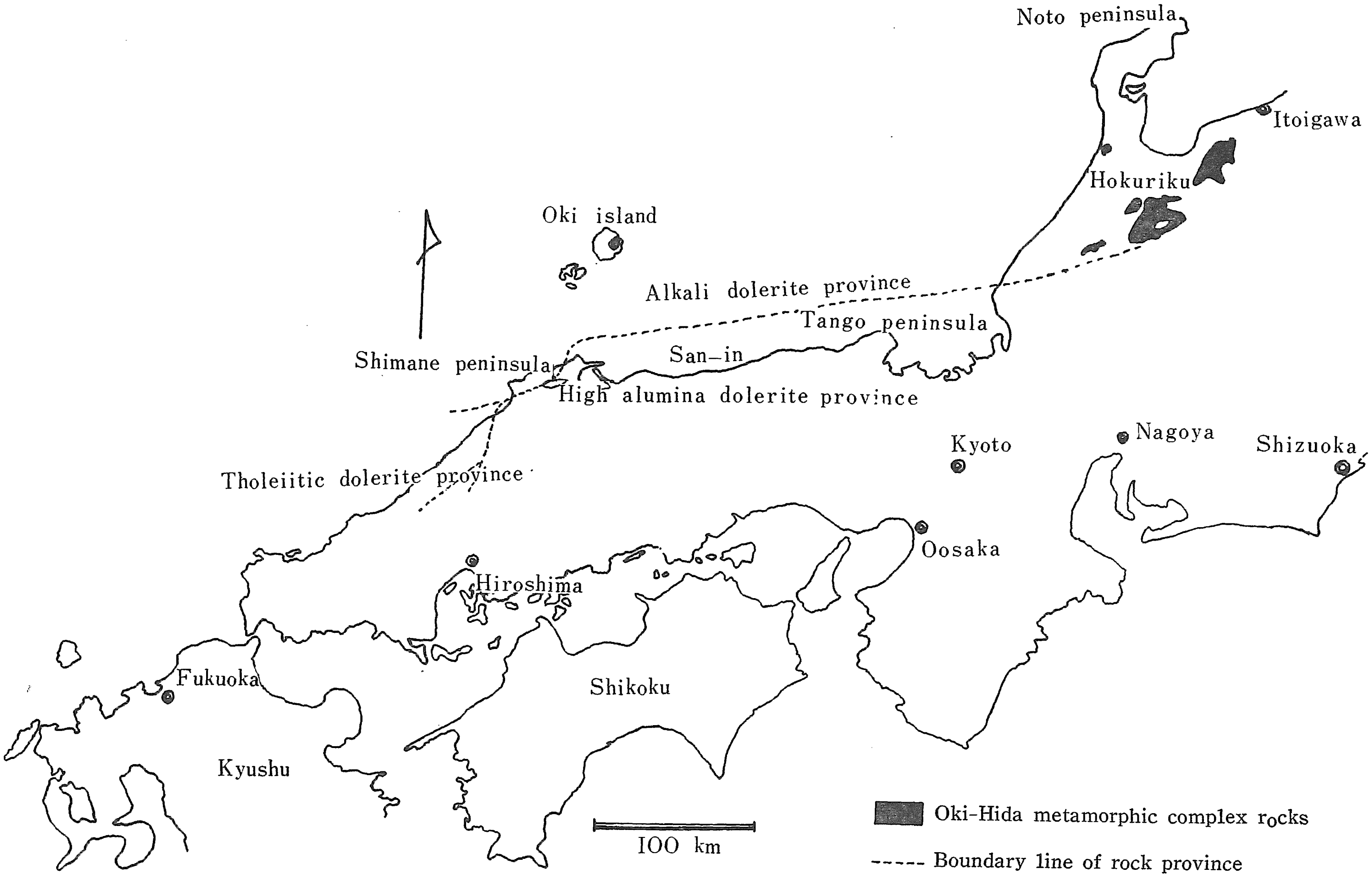

Fig. IV. Rock province of the Miocene dolerites in San'in-Hokuriku green tuff region.

The basement rocks of the alkali dolerite zone are the gneissoze metamorphic complex rocks belonging to the Hida-Oki metamorphic belt.

On the other hand, the basement rocks of the high alumina dolerite zone are composed of the Late Mesozoic to Paleogene granitic rocks.

And, the basement rocks of the tholeiitic dolerite zone are the Paleozoic crystalline schists belonging to the Sangun metamorphic belt.

As mentioned above, it is a very important matter that a close correspondence of the distributions of the different magma types of the dolerites to the distributions of their basement rocks is storongly in evidence.

IV. Chemistry of the dolerites

In Tables I, II, and III, analyses of the Miocene dolerites from the San'in-Hokuriku region are listed.

Table I. Petrochemical notes as to the alkali dolerites in the San'in-Hokuriku region.

sample	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SiO_2	46.92	47.68	48.01	48.51	48.97	49.13	49.37	49.92
TiO_2	0.86	0.88	0.93	0.30	0.87	1.51	2.14	1.92
Al_2O_3	17.99	19.06	16.95	17.34	18.67	17.73	15.15	20.46
Fe_2O_3	3.41	3.41	4.04	4.60	3.35	1.55	2.45	4.01
FeO	5.65	5.56	5.33	9.47	5.65	5.41	9.22	4.05
MnO	0.16	0.17	0.15	0.17	0.30	0.13	0.26	0.24
MgO	6.76	5.74	7.95	5.53	5.98	6.70	4.51	3.51
CaO	9.50	9.65	8.25	7.17	8.33	9.44	7.59	9.85
Na_2O	3.16	3.42	2.76	3.25	3.19	3.08	3.78	3.66
K_2O	0.55	0.48	1.30	0.53	0.58	0.96	0.58	0.47
$H_2O(+)$	3.17	3.49	1.43	2.63	2.60	3.53	4.93	0.72
$H_2O(-)$	1.01	0.94	3.04	1.00	1.20	0.51	0.46	0.22
P_2O_5	0.31	0.31	0.54	0.24	0.63	0.41	0.24	0.20
total	99.46	100.79	100.68	100.72	100.32	99.82	100.68	99.23
CIPW Norm								
q					0.66		0.48	2.40
or	3.34	2.72	7.78	3.34	3.34	5.56	3.34	2.78
ab	26.72	28.82	23.58	27.25	26.72	26.20	31.96	30.92
an	33.08	35.31	29.75	31.14	35.03	33.08	22.80	38.09
wo	5.22	4.52	3.25	1.16	1.23	5.45	5.57	4.18
en	7.40	7.00	14.30	12.40	15.00	12.90	11.30	8.70
fs	2.90	3.04	3.60	12.01	6.60	4.89	11.88	1.32
fo	6.70	5.18	3.92	0.98		2.73		
fa	2.65	2.45	1.02	1.02		1.12		
mt	4.87	4.87	5.80	6.73	4.87	2.32	3.48	5.80
il	1.67	1.67	1.82	0.61	1.67	2.89	4.10	3.65
ap	0.67	0.67	1.34	0.67	1.34	0.43	0.67	0.34

Localities: (1) Tayui, Kashima-cho, Yatsuka-gun. (2) Tayui, Kashima-cho, Yatsuka-gun. (3) Higashihayashigi-cho, Izumo-city. (4) Yokan, Taisha-cho. (5) Tayui, Kashima-cho, Yatsuka-gun. (6) aika-cho, Matsue city. (7) Mitsu, Kashima-cho, Yatsuka-gun. (8) Shinobu, a tip of the Noto-peninsula, Ishikawa-prefecture.

Table II. Petrochmical notes as to the high alumina dolerites in the San'in-Hokuriku region.

Sample	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
SiO_2	49.47	49.65	50.56	48.11	50.24	52.09	52.34	55.09	49.32
TiO_2	1.01	0.99	1.39	0.88	1.05	0.73	0.73	0.37	0.95
Al_2O_3	22.31	20.73	18.73	18.41	16.56	13.18	18.99	18.30	19.36
Fe_2O_3	3.78	2.50	1.70	4.03	6.37	8.85	3.90	2.37	2.49
FeO	3.59	5.03	9.00	5.43	5.00	5.42	4.94	5.46	7.26
MnO	0.14	0.14	0.16	0.19	0.18	0.14	0.14	0.15	0.20
MgO	3.11	4.49	3.82	6.09	3.79	4.23	3.49	4.16	5.22
CaO	10.98	11.79	10.17	10.13	8.37	8.57	8.42	7.20	11.30
Na_2O	2.69	2.70	2.93	2.42	3.13	3.02	2.75	3.02	2.18
K_2O	0.39	0.50	0.28	0.50	0.38	0.29	0.48	0.79	0.49
$H_2O(+)$	1.11	1.71	1.41	2.21	1.57	3.19	2.28	1.51	0.24
$H_2O(-)$	1.83	0.42	0.19	1.13	3.41	0.47	0.81	0.87	1.12
P_2O_5	0.26	0.29	0.25	0.15	0.63	0.30	0.18	0.19	0.17
total	100.67	100.94	100.53	99.68	100.70	100.48	99.46	99.49	100.39
CIPW Norm									
q	5.28	1.44	2.28	1.80	9.12	12.78	10.14	9.90	1.56
or	2.22	2.78	1.67	2.78	2.22	1.67	2.78	4.45	2.78
ab	22.53	22.53	24.63	20.44	26.20	25.68	23.06	25.68	18.34
an	47.82	43.09	37.25	37.81	30.02	21.41	38.09	34.19	41.70
wo	2.09	5.80	4.87	4.87	3.48	8.12	1.16	0.35	5.68
en	7.80	11.20	9.60	15.20	9.50	10.60	8.70	10.40	13.10
fs	1.98	5.80	13.07	5.54	2.63	1.72	5.02	7.66	10.03
fo									
fa									
mt	5.57	3.71	2.55	5.80	9.28	12.76	5.57	3.48	3.71
il	1.98	1.82	2.58	1.67	1.19	1.37	1.37	0.76	1.82
ap	0.67	0.67	0.67	0.34	1.34	0.67	0.34	0.34	0.34

Localities : (9) Kaga, Shimane-cho, Yatsuka-gun. (10) Kaga, Shimane-cho, Yatsuka-gun. (11) Kaga, Shimane-cho, Yatsuka-gun. (12) Shichirui, Mihonoseki-cho, Yatsuka-gun. (13) Asayama-cho, Ooda city. (14) Asahara, Sada-cho, Hikawa-gun. (15) Asahara, sada-cho, Hikawa-gun. (16) Muraoka-cho, Hyogo prefecture. (17) Amino, Tango peninsula, kyoto prefecture.

From the chemical composition showned in above Tables, these dolerites can be distinctly classified into three types from one another by plotting their analyses in a series of diagrams showened by Fig. V and VI, showing the relations between Al_2O_3, Na_2O+K_2O, and SiO_2 represented by Kuno (1960).

Table III. Petrochmical otes as to the tholeiitic dolerites in the San'in-Hokuriku region.

Sample	(18)	(19)	(20)	(21)
SiO_2	49.68	50.10	50.73	53.58
TiO_2	1.21	0.95	0.46	1.12
Al_2O_3	17.64	17.08	20.39	16.53
Fe_2O_3	4.98	4.36	2.61	6.03
FeO	6.24	6.64	6.07	4.27
MnO	0.15	0.18	0.12	0.16
MgO	4.04	6.01	5.38	3.80
CaO	10.01	8.98	11.29	9.14
Na_2O	1.93	1.64	1.67	2.06
K_2O	0.50	0.25	0.38	0.37
$H_2O(+)$	1.13	1.69	0.86	1.78
$H_2O(-)$	2.91	2.51	0.57	0.89
P_2O_5	0.24	0.66	0.36	0.49
total	100.66	101.05	100.89	100.22
CIPW Norm				
q	9.48	10.56	5.94	17.29
or	2.78	1.67	2.22	2.22
ab	16.24	13.62	14.15	17.29
an	38.09	38.36	46.98	34.75
wo	4.18	0.81	2.78	3.36
en	10.10	15.00	13.50	9.50
fs	9.98	6.86	8.45	1.19
fo				
fa				
mt	7.19	6.26	3.71	8.82
il	2.28	2.43	0.91	2.13
ap	0.68	1.68	1.01	1.01

Localities : (18) Isotake-cho, Ooda city. (19) Kuri-cho, Oodacity. (20) Isotake-cho, Ooda city. (21) Isotake-cho, Ooda city.

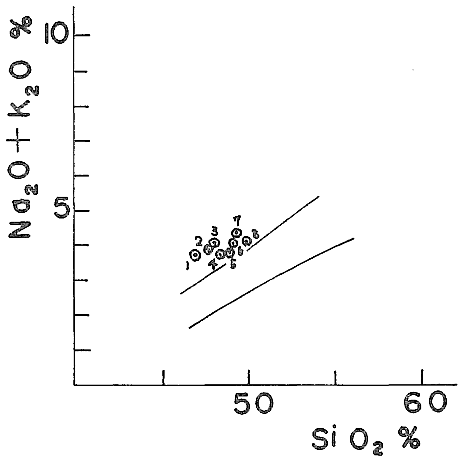

Fig. V-a : Total alkali-SiO_2 relation in the alkali dolerite.

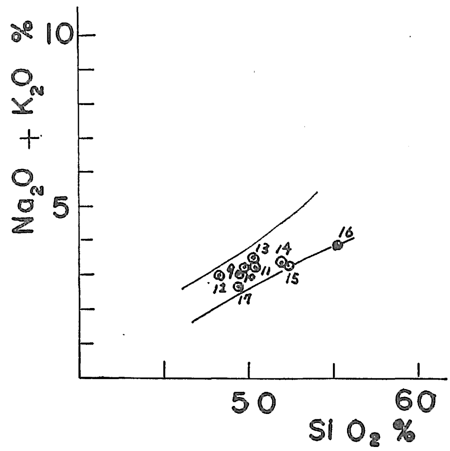

Fig. V-b : Total alkali-SiO_2 relatio nin the high alumina dolerite.

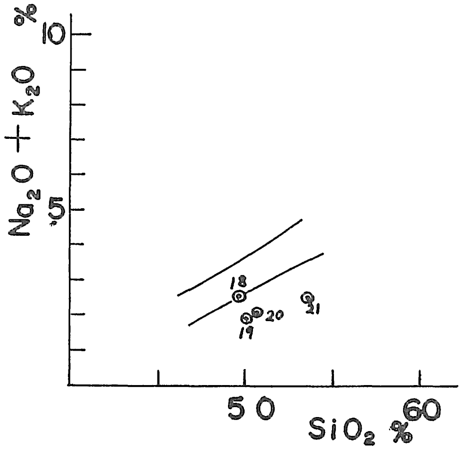

Fig. V-c : Total alkali-SiO_2 relation in the tholeiitic dolerite in the Ooda embayment district.

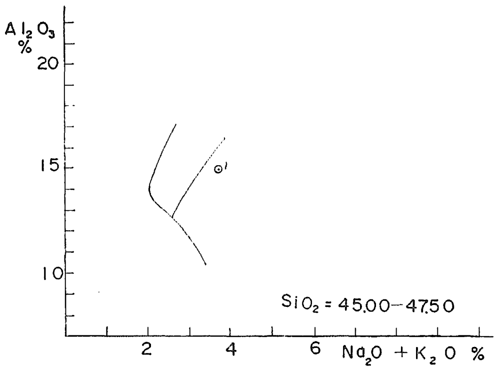

Fig. VI-a : Al_2O_3-total alkali-SiO_2 relation of the three types of dolerite from the San'in-Hokuriku green-tuff region.

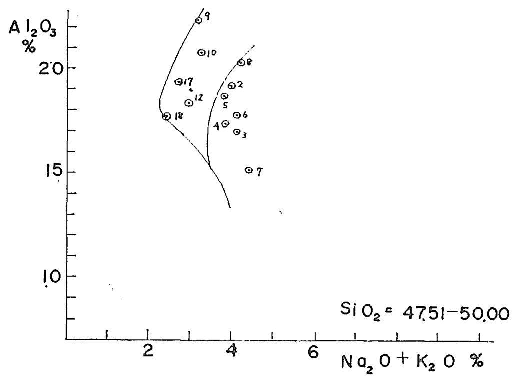

Fig. VI-b : Al_2O_3-total alkali-SiO_2 relation of the three types of dolerite from the San'in-Hokuriku green-tuff region.

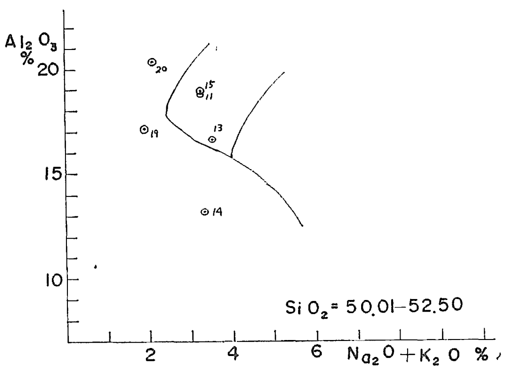

Fig. VI-c : Al_2O_3-total alkali-SiO_2 relation of the three types of dolerite from the San'in-Hokurikugreen-tuff region.

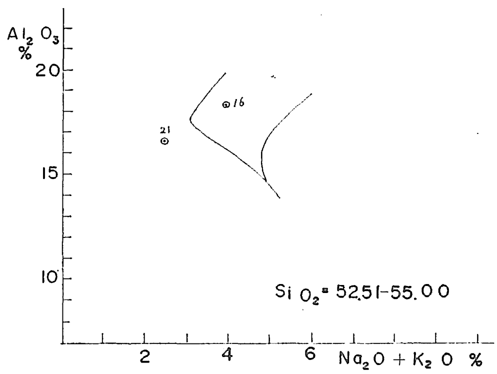

Fig. VI-d : Al_2O_3-total alkali-SiO_2 relation of the three types of dolerite from the San'in-Hokuriku green-tuff region.

That means, in short, these dolerites in San'in-Hokuriku rogion are classified into three types according to these diagrams, the tholeiitic dolerite with the low Al_2O_3 and alkali, alkali dolerite with variable Al_2O_3 and higher alkalis, and high alumina dolerite with higher Al_2O_3 and inter mediate alkalis. The tholeiitic dolerites invariably yields normative quartz. The high alumina dolerites occured in the eastern half of Shimane peninsula yields small amount of normative quartz in comparison with the former, but the high alumina dolerites occured in the Miocene Izumo embayment district yields normative quartz as same as tholeiitic dolerites of the Ooda district in quantity.

That is to say, there is every indication that the nearer it get to the alkali dolerite zone, the less normative quartz of high alumina dolerites yields in quantity. And, this relation to the normative quartz of high alumina dolerites occured in the Tango penisula and the Muraoka district is just the same as above mentioned fact.

The alkali dolerite is undersaturated with SiO_2, except in the case of the alteration.

The high alumina dolerites explained by the writer in this paper are characterized by a high content Al_2O_3 than that of the tholeiitic dolerites with the corresponding SiO_2 and total alkalis, and lower alkali content than that of the alkali dolerites.

For these reasons, the writer belives that the Miocene high alumina dolerites in San'in-Hokuriku region correspond to Kuno's high alumina dolerite.

V. Mineralogy of the dolerites

In hand specimens, these dolerite in San'in-Hokuriku region are generally dark green or black in color, and are either coarse or some extent compact in appearance in spite of the rock types.

Under the microscope, some of these samples are subjected to the alterations.

In the tholeiitic dolerites, the phenocrysts composed of anorthite to bytownite, olivine, augite and small amount of orthopyroxene. The groundmass composed of bytownite to labradorite, pigionite, olivine, quartz, magnetite, ilmenite, zircon and chlorite. The olivine in the groundmass are surrounded by the reaction rim of pyroxene.

The groundmass varies in texture from a coarse-grained ophitic or subophitic to even medium-grained intergranular types.

In most case, olivine are altered to serpentine.

On the other hand, in the high alumina dolerites, the phenocrysts of bytownite, olivine, augite and orthopyroxene are present. But, in large intrusion of the laccolith form, the phenocrysts of hornblende and augite with reaction rim by hornblende are present in large amount.

The groundmass composed of labradorite, augite, olivine, quartz, magnetite, ilmenite, zircon and chlorite. In most case, olivine are altered to serpentine.

The groundmass of these high alumina dolerite varies in texture from a coarse-grained ophitic or subophitic types.

In the alkali dolerites, the phenocrysts of labradorite to andesine, olivine and titanaugite are always present. In rare case, biotite phenocryst are present.

The groundmass composed of andesine, augite, olivine, anorthoclase, magnetite, ilmenite, zircon and chlorite. In altered sample, talc are rarely present. Olivine with reaction rim by pyroxene are not existed. And, anorthoclase exist as the mesostasis or outermost marginal part of plagioclase. In this rock type, olivine are altered to serpentine in most case.

VI. Discussions on the rock types of the dolerites

As mentioned in the foregoing chapter, difference of parental magma of the three types is reflected especially in the silica-saturation rate, and this rate is represented by excess or deficiency of normative quartz.

On the basis of physico-chemical studies, Kushiro and Kuno (1963) suggested, on the assumption that upper mantle is homogeneous regarding major elements, that different types of primary basalt magmas originate in dependently from partial melting of the mantle peridotite including garnet peridotite under different pressure : tholeiite, high alumina basalt, and alkali olivine basalt under, low, intermediate, and high pressure repectively. From his experimental studies of system $NaAlSiO_4$-Mg_2SiO_4-SiO_2 under different pressure up to 30 Kb, system of $CaMgSi_2O_6$-Mg_2SiO_4-SiO_2 and system of $CaAl_2SiO_6$-Mg_2SiO_4-SiO_2, Kushiro (1964, 1965, 1966) found the important results that the isobaric invariant point representing the initial point from experiment of the first system, changes from SiO_2-oversaturated, alkali-poor composition to SiO_2-undersaturate, alkali rich composition of the system with increase pressure and the isobaric invariant point products, from the experiments of the last two system, moves from SiO_2-oversaturated to SiO_2-undersaturated composition with increase of pressure.

Kushiro's experiments therefore support to a certain extent Kuno's hypothesis shown on the origin of the Quaternary basalt that the tholeiite magma is produced by partial melting of the mantle peridotite at the earthquake foci shallower than 200 km, alkali olivine basalt magma by partial melting at the foci deeper than this level, and high alumina basalt magma by partial melting of the mantle at the intermediate depths between above two types, say at about 200 km.

The Late Mesozoic to the Late Paleogene, especially, the Chugoku and Mino-Tanba belt of the Southwest Japan was the age in which igneous activities composed of numerous acidic intrusives and their related extrusive mass was most violent. This acidic volcanism was succeded by the intrusion of several batholithic plutons above mentioned regions. This plutonic intrusions and the consolidation of this magma must have occurred in the shallower part of the earth crust.

This pluton is the complex rock composed of medium or coarsegrained biotite granite and granodiorite mainly.

In conclusion, each succesive granite-forming event was farther out from Oki-Hida metamorphic belt as the oldest continental nuclei, and this fact support the continental accretion hypothsis.

The pluton may have grown by *in situ* remelting processes of the earth crust, it may have risen passively into a previous existing zone of relative low pressure. Forceful injection means the active upward risen of an intrusion magma together with outward expansion of the magma and pushing a side of a country rocks. As the result, the many thrusts and structural lines may develop in outer parts of the pluton as continued upward rise of the pluton and outward expansion.

One of these structural lines show a nearly E-W trend in the boundary between above mentioned granitic pluton and the oldest continent of Oki-Hida metamorphic belt, for another, show a nearly NNE-SSW trend in the boundary of the granitic pluton and the district composed of Sangun metamorphic rocks.

Toward the Early Miocene, the denudation as its continued, this is a important fact that the three types of the dolerite magmas as mentioned previous chapter, were formed in upper mantle under these different three crusts.

Settig aside Kuno 'hypothesis shown on the origin of the Quarternary basalt, if it take the Kushiro's experimental results into consideration, different basaltic magma are produced at different pressure in upper mantle under the crust are quite different from another : tholeiitic dolerite at Sangun metamorphic district, high alumina dolerite at granitic batholith, alkali dolerite at Oki-Hida metamophic belt.

At present, the writer is considering of the relation of the thickness of the crust resulting from their character and the pressure where the magma are produced at upper mantle.

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