報　　文

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Geologic Structure of the Permian Formations in the Suzuka Mountains, Central Japan

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Abstract

The Suzuka mountains is characterized by a thrust block which lies on the non-calcareous facies of the middle Permian. The thrust block consists of the calcareous (upper) and the chert (lower) formations of the lower Permian. A part of the former forms three "klippen" which are the remnants of "superficial nappe", while the main part shows "superficial wedge" which is believed to have been resulted from the thrust movement.

This thrust block shows an appearance of "nappe", however it probably was deposited *in situ* simultaneously with the non-calcareous facies and on the barrier-like narrow belt of N–S direction. This block is believed to have been squeezed and thrust upon the non-calcareous facies of the middle Permian by the Oga orogeny of the early Cretaceous age which was proposed by T. KOBAYASHI (1935).

The above-mentioned barrier-like narrow belt, probably, was formed during the latest Sakamotozawan (Early Permian) in the Suzuka mountains (southern part) and the latest Akasakan (Middle Permian) to the earliest Kuman (Late Permian) in the Ibuki mountains (northern part).

1. Introduction

The Suzuka mountains lies between the Kinki and the Chubu districts in the geographic distribution and forms the range which has a height of more than 1,000m above sea level. The Permian formations are distributed in the northern part of the Suzuka mountains and form the high mounts, such as Mt. Ryozensan, Mt. Takamuroyama, Mt. Suzugatake, Mt. Oikedake, Mt. Fujiwaradake and Mt. Ryugatake.

It was discussed by many geologists that the calcareous facies lies on the non-calcareous one in this district: K. TAKIMOTO (1936), who made a geological work in Mt. Ryozensan and its vicinity, concluded that the calcareous formation is thrust on the non-calcareous one. And also K. FUJIWARA (1940), who made a geological work in Mt. Oikedake and its vicinity, too, drew the same inference as K. TAKIMOTO, T. KOBAYASHI (1941, 1951) believed that the calcareous facies (Para-Akiyoshi facies) is a remnants of "nappe" which is thrust upon the non-calcareous facies (Yamaguchi facies) from northward and he inferred that this movement belongs to the Oga orogeny** of the early Cretaceous age. M. MURATA (1960), who made reconnaissance survey in Mt. Fujiwaradake and its vicinity, did not support T. KOBAYASHI's opinion expecting the geologic age of the movement. He also thought that the calcareous facies has been deposited *in situ* simultaneously with the non-calcareous facies and was thrust upon the adjoining formations by folding and thrust movement subsequently, and that the deposition of the calcareous facies was carried probably on the reef resulted from the submarine volcanos.

The present writer surveyed geologically to make clear the geologic structure and the tectonic

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** Oga orogeny, strong in the Inner Zone of the Southwest Japan during the Early Cretaceous Period, which produced the Oga Decke to the northwest of Okayama. The Paleozoic group of the calcareous facies was thrust upon the Triassic group and the Paleozoic group of the non-calcareous facies. The thrust is overlain by the Lower Cretaceous group (T. KOBAYASHI, 1935).

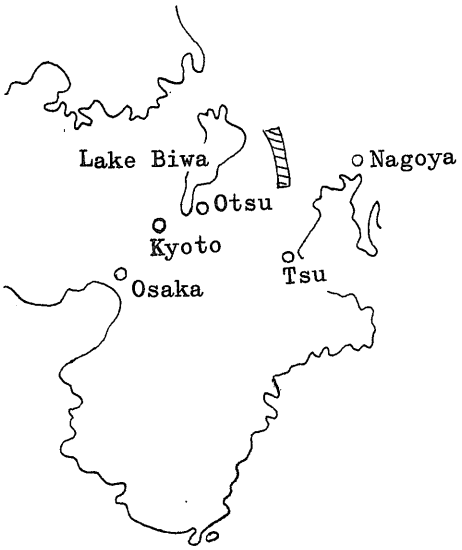
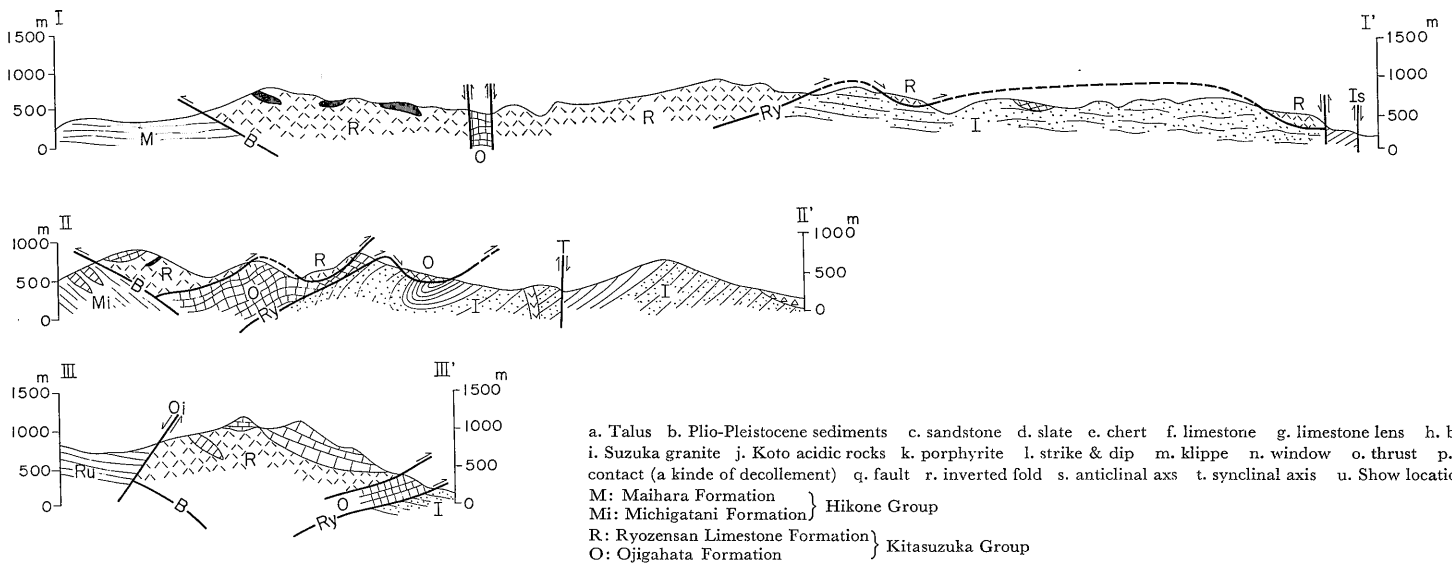


Fig. 1 Index map.

Table 1 Correlation of the Paleozoic formations of the Suzuka mountains.

		Geological age		Fusulinid zone	Western part			Central part		Eastern part
Carboniferous	upper	Hikawan		Triticites z.						
Permian	lower	Sakamotozawan		Pseudoschwagerina zone	Hikone Group	Michigatani Formation		Kitasuzuka Group	Ojigahata Formation	
			Nabeyaman	Parafusulina zone			Maihara Formation		Ryozensan Limestone Formation	
	middle	Akasakan		Neoschwagerina–Verbeekina zone						Ikuridani Group
	upper	Kuman		Yabeina–Lepidolina z.			Ryugtake Group			

Fig. 2 a Geological map of the Suzuka mountains.



a. Talus b. Plio-Pleistocene sediments c. sandstone d. slate e. chert f. limestone g. limestone lens h. basic volcanic rocks i. Suzuka granite j. Koto acidic rocks k. porphyrite l. strike & dip m. klippe n. window o. thrust p. abnormal tectonic contact (a kinde of decollement) q. fault r. inverted fold s. anticlinal axs t. synclinal axis u. Show locations of profiles

M: Maihara Formation
Mi: Michigatani Formation } Hikone Group

R: Ryozensan Limestone Formation
O: Ojigahata Formation } Kitasuzuka Group

Ru: Ryugatake Group

I: Ikuridani Group

Oi: Oike fault T: Tokiyama fault Is: Ichishi fault B: Busshoji thrust Ry: Ryozensan thrust E: Eboshidake fault 1. Samegai 2. Shimonyu 3. Kaminyu 4. Maihara 5. Busshoji 6. Shide 7. Kawanai 8. Hida 9. Kanaya 10. Same 11. Ojigahata 12. Hagihara 13. Iwasu 14. Toki 15. Tokiyama 16. Funahara 17. Sakamoto 18. Nishinojiri 19. Mie dolomite mine 20. Minami-Ishigure 21. Ibaragawa 22. Kurakake pass 23. Ikuridani valley 24. Yabutani valley 25. Tashidadani valley 26. Aodani valley 27. Ugake valley 28. Michigatani valley Rz: Mt. Ryozensan Nj: Mt. Nabejiriyama Tm: Mt. Takamuro-yama Kk: Mk. Mikunidake Eb: Mt. Eboshidake Sz: Mt. Suzugatake Ok: Mt. Oikedake Fu: Mt. Fujiwaradake Rg: Mt. Ryugatake

Fig. 2 b Geological profiles of the Suzuka mountains.

movement of the Suzuka mountains, and got some important facts concerning the above-mentioned problems.

2. Stratigraphy

The Permian formations of the Suzuka mountains are divided into four groups, namely, the Hikone, Ikuridani, Ryugatake and Kitasuzuka Groups (Table 1), the last of which forms thrust block.

2.1 The autochthonous terrane

2.1.1 Hikone Group

This group is distributed in the western part of the Suzuka mountains and is divided into the Michigatani (lower) and the Maihara (upper) Formations by lithofacies (Table 1, Fig. 3).

a) Michigatani Formation

This formation is mainly distributed in the basin along the river Michigatani, which is a tributary of the river Echigawa and flows from the northward to the southward on the west side of Mt. Oikedake.

The Michigatani Formation is chiefly composed of black slate with distinct bedding plane, and contains lenticular or thin bedded chert, grayish black, grayish white and red in color.

This formation is overlain with conformity by the Maihara Formation which will be mentioned in the next paragraph and is in contact with the Ryugatake Group by the fault in the southern part. The western part of the Michigatani Formation is intruded by the Koto acidic rocks. Thickness is about 2,500 m.

Slate of this formation occasionally tuffaceous and contains tuffaceous sandstone lens. This lithology is considered to represent the transitional facies between the calcareous and the non-calcareous facies. The Michigatani Formation is probably simultaneous with the upper part of the Ryozensan Limestone Formation (Fig. 6A). At least, a part of the Michigatani Formation may be correlated with the upper part of the Ryozensan Limestone Formation which will be mentioned later (Table 1).

A part of this formation belongs to the Ibaragawa Formation by M. MURATA (1960).

The Michigatani Formation is the lowest part of the autochthonous block in this mountains, which may be correlated with the Nabeyaman-Sakamotozawan (Table 1).

b) Maihara Formation

The Maihara Formation is distributed in the eastern part of Hikone area and forms the low mountains adjoining to the western margin of the Suzuka mountains. Besides, this formation is distributed in Ibaragawa and its vicinity.

This formation is mainly composed of slate and chert, the former is generally dominant compared with the latter and sometimes intercalates sandstone lens or bed. Thickness is some 4,000 m.

In the middle and the lower parts of this formation, considerably the thick chert is developed, it is bedded or massive and grayish white, grayish black, red and sometimes pale green, in color, and sometimes alternates with thin black slate (Fig. 3). The manganese ore deposits in the eastern part of Hikone area are contained in the chert of this formation.

This formation corresponds with "Seibu-Chichibu Kei" (Western Chichibu System) by K. TAKIMOTO (1963) and its southern extension corresponds with the Ibaragawa Formation by M. MURATA (1960).

The Maihara Formation may be correlated with the Nabeyaman (Table 1).

2.1.2 Ikuridani Group

This group is mainly distributed in the eastern part of the Suzuka mountains and occupies the uppermost part of the Permian formations of this mountains.

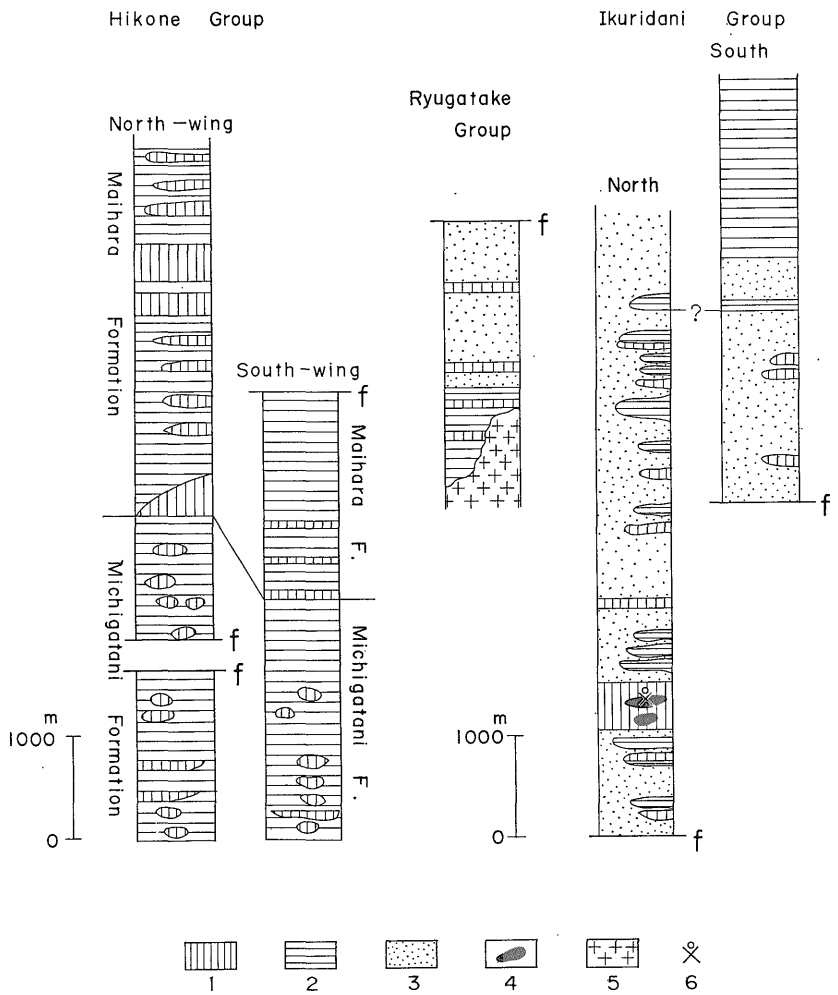
In the lower part of this group the medium sandstone is generally dominant, however the

grain size of sandstone becomes gradually finer upward in the stratigraphic succession, and finally slate is dominant in place of sandstone in the uppermost part of this group. Thickness is about 7,000 m.

As mentioned above, the Ikuridani Group is dominated by sandstone except for the uppermost part, and intercalates slate some 10 m in thickness and bedded chert.

In the middle part of this group, chert of about 400 m in thickness appears, in which two lenses dolomitic limestone of about 10 m and 5 m in thickness is intercalated (Fig. 3). The former occupies the upper horizon than the latter and contains fusulinids: such as *Pseudofusulina lepida*, *Parafusulina cayeuxi*, *Misellina claudiae* and *Neoschwagerina craticulifera*, of which the last-mentioned is abundant (MIYAMURA, 1969).

The Ikuridani Group of Nishinojiri consists mainly of sandstone and shows the anticlinal structure of which axis plunges to the eastward. Sandstone is medium-grained in the axial part of the anticline and becomes gradually finer toward both wings, and finally changed into siltstone in both ends. That is, the Ikuridani Group in this area is dominated by medium-grained sandstone in the lower part and grain-size becomes finer toward the upper.



1: chert 2: slate 3: sandstone 4: limestone lens 5: granite 6: locality of occurring fusulinids

Fig. 3 The columnar section of the non-calcareous facies of the Suzuka mountains.

The lower and the middle parts of this group corresponds with "Tobu-Chichibu Kei" (Eastern Chichibu System) by K. TAKIMOTO (1936) and the upper part with the Tokiyama Formation by M. MURATA (1960) and with sandstone part of the Kurakaketoge Formation by M. MURATA (1960).

This group is correlated with the Akasakan-Nabeyaman from the above-mentioned fusulinids (Table 1).

2.1.3 Ryugatake Group

This group distributed in the neighborhood of Mt. Ryugatake is mainly composed of sandstone, slate and chert and is in contact with the Kitasuzuka and the Hikone Groups by the fault. This group is dominated by slate and chert in the lower part and by coarse-or medium-grained sandstone in the upper one.

Slate shows generally bedding plane and contains bedded or lenticular chert and lenticular sandstone. Sandstone of the upper part sometimes contains slate and chert lenses (Fig. 3). As this group is intruded by the Suzuka granite, it is changed into hornfels near contact with the granite (Fig. 2).

The lithofacies of the lower and upper parts of this group resembles that of the Maihara Formation and of the lower part of the Ikuridani Group, respectively.

Therefore this group may be correlated with the Akasakan-Nabeyaman (Table 1). This group corresponds with the Ibaragawa Formation by M. MURATA (1960).

2.2 The thrust block

The Kitasuzuka Group which forms a thrust block is distributed in the high area of the Suzuka mountains. This group in the northern part is thrust upon the Hikone Group by the Busshoji thrust on the west side and is upon the Ikuridani Group by the Ryozensan thrust on the east side. On the other hand, in the southern part it is bounded from the Hikone and Ryugatake Groups on the west side by the Oike fault and from the Tara Group (Plio-Pleistocene) on the east side by the Ichishi fault.

The Kitasuzuka Group is divided into the Ojigahata (lower) and the Ryozensan Limestone (upper) Formations by the lithofacies (Table 1), and it is intruded by the Koto acidic rocks in the area between Kawanai and Toki.

2.2.1 Ojigahata Formation

This formation consists mainly of chert, and shows repeatedly the complicated minor folding. Chert changes partially into siliceous slate and is generally grayish black or grayish white and sometimes red or pale green in color, and it sometimes intercalates bedded black slate.

From the above-mentioned lithofacies, this formation corresponds to the upper part of the Kiyotaki Formation which was described by H. ISOMI (1956) in the Ominagahama area adjoining to the north of this surveyed area.

In the district of Ominagahama, the Kiyotaki Formation is overlain conformably by the Samegai Formation which corresponds to the Ryozensan Limestone Formation of the mountains in question (MIYAMURA, 1967). However in this mountains the Ojigahata Formation is separated from the Ryozensan Limestone Formation by the fault or the abnormal tectonic contact line due to the "decollement-like" movement (Fig. 5).

Although the stratigraphic relation between the Ojigahata and the Ryozensan Limestone Formations is not clear, it is essentially deduced that the Ryozensan Limestone Formation originally had a conformable relation to the Ojigahata Formation.

The formation represents on the lowest horizon of the Permian formations of the Suzuka mountains and must be correlated with the Sakamotozawan (Table 1).

The formation corresponds with the alternation of chert and slate in the Kurakaketoge Formation by M. MURATA (1960).

2.2.2 Ryozensan Limestone Formation

This formation is mainly distributed in the central part of the Suzuka mountains. Besides, it

forms "klippen" on the Ikuridani Group mentioned in the preceding chapter.

It is composed chiefly of grayish white or grayish black limestone, basic volcanic rocks and intercalated chert, and shows the gently undulated structure. Basic volcanic rocks of this formation include tuffaceous rock and lava, and are dark green or dark red in color. Sometimes the tuffaceous rock alternates with slate containing chert pebble. Limestone occurs on the form of large mass, bed, lens in the basic volcanic rocks and rarely alternation with chert or basic volcanic rocks as seen in Sakamoto situated at the southwest part of this map. The alternation of strata found in Sakamoto may show the transitional zone to the Ojigahata Formation.

The limestone of this formation yields fusulinid coral and ammonite. Fusulinids in the main limestone block of Mt. Ryozensan include the following species and is suggestive of the early Permian age, *Pseudofusulina vulgaris*, *Psf. vulgaris* var. *globosa*, *Psf. vulgaris* var. *megaspherica*, *Psf. vulgaris* var. *exilis*, *Psf. cushimani*, *Psf. kyowaensis*, *Psf. tenuis*, *Psf. subtenuis*, *Psf. ambigua*, *Psf. isaensis*, *Psf. watanabei*, *Psf. krotowi*, *Psf. bacca*, *Psf. fusiformis*, *Psf. okafujii*, *Psf.* cf. *yobarensis*, *Psf. kraffti*, *Psf. aganoensis*, *Psf. nobilis*, *Psf. gümbeli*, *Psf. paragümbeli*, *Psf.* sp. A, *Schwagerina howkinsi*, *Sch.* sp., *Rugosofusulina alpina*, *Quasifusulina* sp., *Pseudoschwagerina robusta*, *Triticites obai*, *T. simplex*, *T. tuntula*, *T. insaensis*, *T. ellipsoidalis*, *T. noinskyi*, *T. kuroiwaensis*, *T. haydeni*, *Schubertella kingi*, *Schu. giraudi* and *Schu.* cf. *minute*.

The "klippen" lain on the Ikuridani Group are named A, B and C in the order from west to east (Fig. 2, Fig. 5). Limestone of each "klippe" contains the following fusulinids:

"Klippe" A; *Pseudofusulina vulgaris* var. *megaspherica*, *Psf. gümbeli*, *Psf.* cf. *yobarensis*, *Paraschwagerina* (*Acervoschwagerina*) sp. and *Quasifusulina* sp.

"Klippe" B; *Pseudofusulina krotowi*, *Psf. aganoensis*, *Psf. cushimani* and *Psf. gümbeli*.

"Klippe" C; *Misellina* sp., *Nagatoella* sp. A, *Pseudofusulina ambigua* and *Schubertella kingi*.

From the fusulinid assemblage of each "klippe", it is easily concluded that "klippe" C occupies the higher horizon than the other two and is correlated with the uppermost Sakamotozawan.

The Ryozensan Limestone Formation in the neighborhood of Ishigure and on the high part of Mt. Ryugatake consists mainly of predominant basic volcanic rocks and limestone lens and is contact-metamorphosed by the Suzuka granite. Basic volcanic rocks are changed into hornfels by this contact metamorphism and limestone is changed, as is encountered in the Mie dolomite mine, into the rocks consisting of dolomite and wollastonite or showing the saccharoidal texture by recrystallization.

Fusulinid zonation over the whole region of the Ryozensan Limestone Formation is not yet established, as the detailed paleontological study of fusulinids covers only Mt. Ryozensan and its vicinity. However, the fusulinid which indicates the age of the middle or the late Permian is not found in the field.

Therefore, the fusulinid zone of this limestone formation may be the *Triticites* & *Pseudofusulina* (lower) and the *Pseudofusulina* (upper) zones in Mt. Ryozensan and its vicinity.

From the above-mentioned fusulinid, the Ryozensan Limestone Formation is correlated with the Sakamotozawan (Table 1).

This formation corresponds with the following formations; the Ryozensan Formation by K. Takimoto (1936), the Inugami Series by K. Fujiwara (1940) and the Fujiwaradake Limestone Formation by M. Murata (1960).

2.2.3 Kitasuzuka Group in the neighborhood of Nishinojiri

The stratigraphy of the Kitasuzuka Group of the southwest valley of Nishinojiri is as follows in discending order:

Ryozensan ls. F.	limestone	.....450 m
	basic volcanic rocks	.....150 m

—abnormal tectonic contact (a kind of decollement)—

Ojigahata Formation	slate	..... 45 m
	chert	.....200 m

The limestone contains *Pseudofusulina*, *Schwagerina* and *Paraschwagerina* (*Acervoschwagerina*) and

overlies basic volcanic rocks with a conformity, the latter is lain on slate of the Ojigahata Formation with the relation of abnormal tectonic contact of a kind of "decollement".

Slate is black or grayish black and rests on chert with a conformity, the latter is generally grayish black or grayish white and is thrust upon sandstone of the Ikuridani Group.

2.2.4 On the so-called Kurakaketoge Formation

M. MURATA (1960) gave the name of Kurakaketoge Formation for the formation which is composed of sandstone and alternation of chert and slate in the Kurakake pass, Mt. Mikunidake and Nishifujiwara. He inferred that the formation named by him overlies the Fujiwaradake Limestone Formation with a conformity.

He described *Neoschwagerina craticulifera* from the matrix of the brecciated limestone in Nishinojiri and thought that the brecciated limestone is lain between the Kurakaketoge and the Fujiwarada -ke Limestone Formations. From the above things, he correlated the Kurakaketoge Formation with the *Neoschwagerina* zone.

The present writer has a doubt about the above-mentioned MURATA's opinion from the following facts: As mentioned in the paragraph of the Ojigahata Formation, in the Samegai area the Kiyotaki Formation which is all the same as the Ojigahata Formation, underlies conformably the Samegai Formation which is correlated with the Ryozensan Limestone Formation, and in the neighborhood of Ojigahata the Ryozensan Limestone Formation is detached from the underlying Ojigahata Formation by an abnormal tectonic contact due to "decollement".

The Ojigahata and the Ryozensan Limestone Formations are all the same as the alternation of chert and slate in the Kurakaketoge Formation and the Fujiwaradake Limestone Formation by M. MURATA (1960), respectively.

M. MURATA (1960) mentioned that the Kurakaketoge Formation in the southwest valley of Nishinojiri is dominated by sandstone in the upper part and by the alternation of chert and slate in the lower. But the present writer, in the same valley, confirmed that the alternation of chert and slate by M. MURATA (1960) is discordantly separated from the sandstone, that is, the former shows the N–S trend and the latter has the E–W trend (See Fig. 2).

From the stratigraphic point and the lithofacies, therefore, the Kurakaketoge Formation by M. MURATA (1960) should be divided into two formations, namely the lower part of the Kurakaketoge Formation named by him may be included in the Ojigahata Formation and the upper part of that formation may be included in the Ikuridani Group.

Limestone breccia which was described by M. MURATA (1960) is nothing but a limestone talus which overlies the basic volcanic rocks with disconformity. The limestone talus consists of the limestone breccia of the Ryozensan Limestone Formation, 3 to 5 cm in diameter, and their breccias are secondly cemented with the calcareous material which was dissolved from the breccia.

The present writer has not found *Neoschwagerina craticulifera* from the limestone breccia.

3. Geologic Structure

3.1 The authochthonous terrane

3.1.1 Hikone Group

Deformation of the Hikone Group is intense. The lower Michigatani Formation of this group gives the monoclinal structure in appearance, with the inclination of 70 to 60° northward. The upper Maihara Formation of this group shows the more complicated folding with frequently minor fault.

But as a whole, the structure of the Hikone Group is probably the isoclinal folding by the following reasons: (1) The Maihara Formation is repeatedly found on the north and the south sides of the Michigatani Formation. (2) Fault is hardly found between both formations (Figs. 2, 4a).

3.1.2 Ikuridani Group

The Ikuridani Group is divided into four blocks by the Tokiyama and the Eboshidake faults.

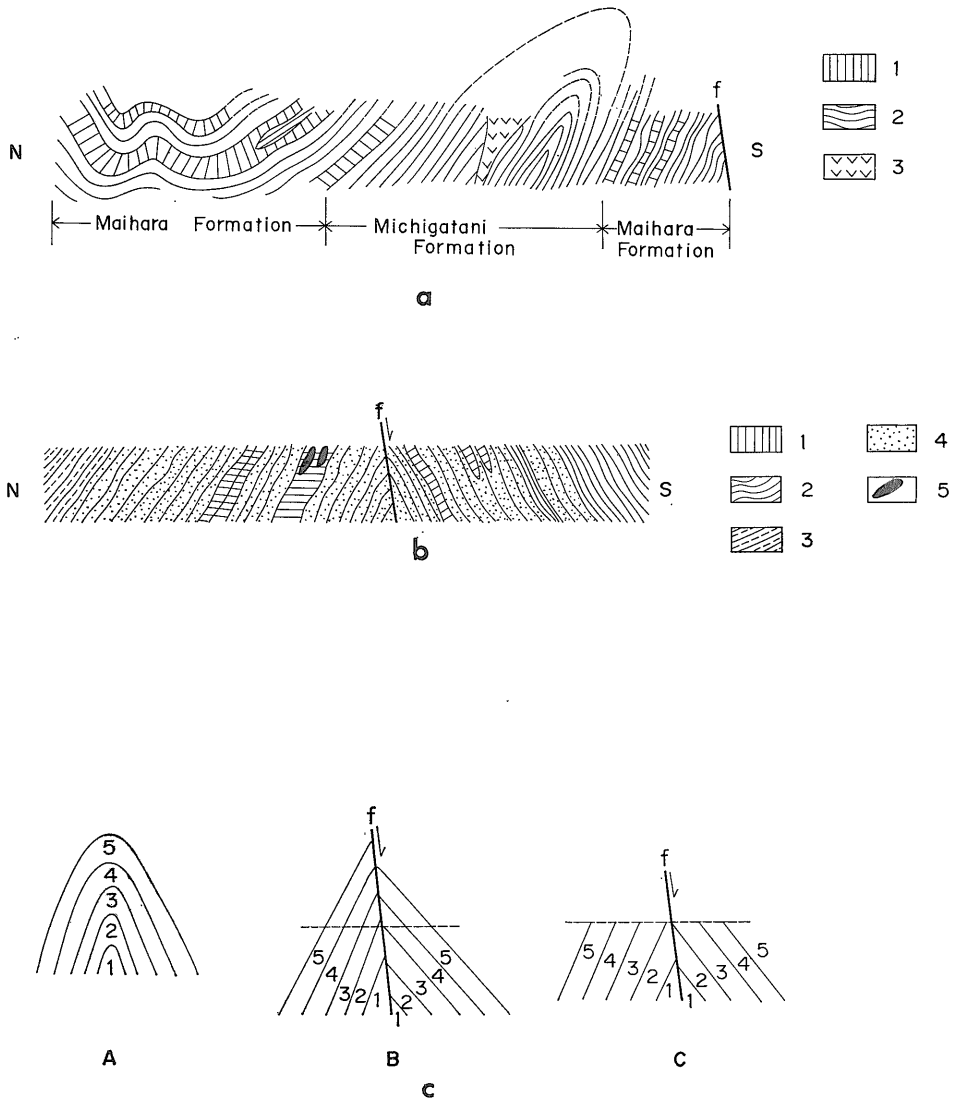


Fig. 4 a Schematic profile of the Hikone Group.
1: chert 2: slate 3: acidic rock

Fig. 4 b Schematic profile of the Ikuridani Group.
1: chert 2: slate 3: siltstone 4: sandstone 5: limestone lens

Fig. 4 c Schematic diagram showing the development of the geologic structure of the Ikuridani Group (Arabic numerals show the layers).
Note : In fig. c, arabic numerals in the right side of the fault line are corrected as follows : I is changed into 2, equally, 2→3, 3→4, and 4→5,

On the east side of the Tokiyama fault, this group is cut by the fault running E–W in the neighborhood of Iwasu and gives the anticlinal structure having an axis plunged to east in the neighborhood of Nishinojiri (Figs. 2, 4b).

The group in the neighborhood of the Kurakaketoge pass gives the folding structure having an axis of E–W in direction.

3.1.3 Tokiyama fault

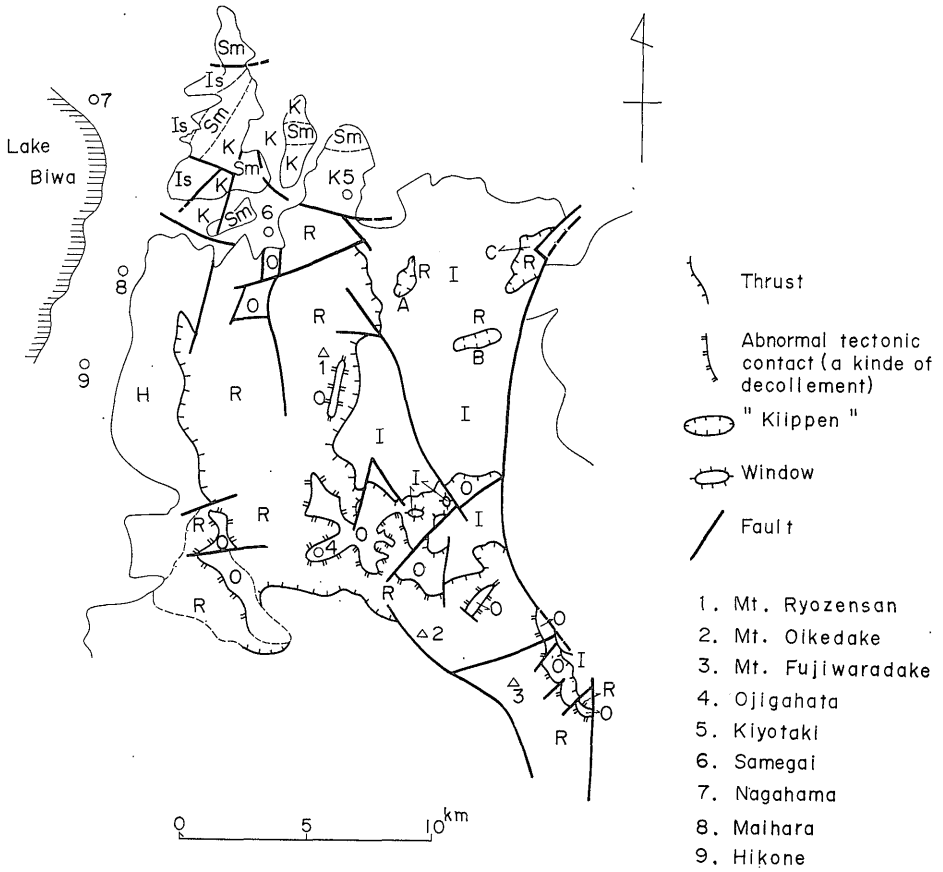
The Tokiyama fault runs from the neighborhood of Mt. Ryozensan to Mt. Eboshidake, and cuts the Ryozensan Limestone Formation and the Ikuridani Group. The formation on the east side of this fault is displaced to the southward compared with that on the west side. So that, this fault is said to be the right lateral (Fig. 2).

3.2 The thrust block (Kitasuzuka Group)

Tectonic deformation of the thrust block in the Suzuka mountains may be interpreted as a result of the Oga orogeny, which took place during early Cretaceous time in the Inner Zone of Southwest Japan. Although the age of deformation can not be dated directly, because of lack of the Mesozoic formations, it can be indirectly inferred by the fact that thrusting took place prior to the activity of the Koto acidic rocks in the late Cretaceous age.

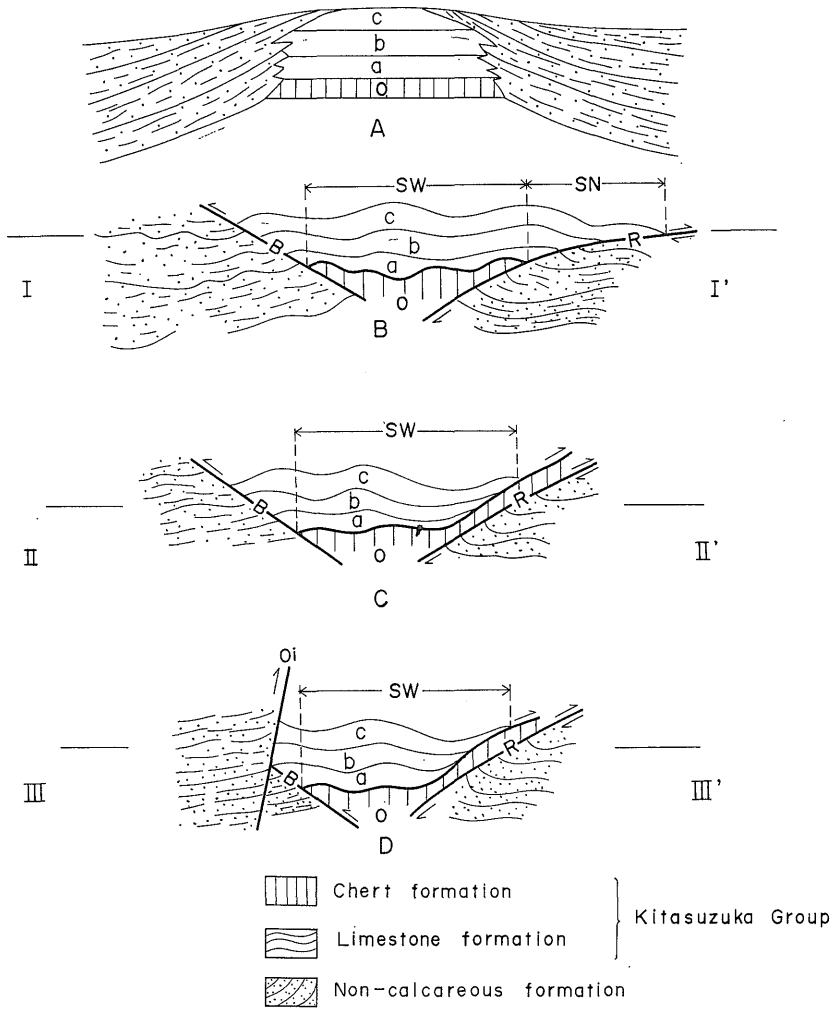
The Kitasuzuka Group is a large thrust block and it is divided into small wedges or slices. Deformation degree within the Ryozensan Limestone Formation varies from moderate to intense. The Ojigahata Formation shows repeatedly the complicated minor folding and is divided into blocks by the fault.

In the northern part the Ryozensan Limestone Formation is directly thrust upon the Hikone and the Ikuridani Groups, and the Ojigata Formation is exposed as "in lier" by the steep faults



K: Kiyotaki F. O: Ojigahata F. Sm: Samegai F. R: Ryozensan Limestone F.
H: Hikone G. I: Ikuridani G. Is: Ishida F.

Fig. 5 Tectonic sketch map of the Suzuka mountains.



a: Tr and Psf zone b: Psf zone c: Psf² zone SW: Superficial wedge O: Ojigahata Formation
B: Busshoji thrust R: Ryozensan thrust Oi: Oike fault SN: Superficial nappe
Roman neumeras correspond to each proffile of the Suzuka mountains (Fig. 2b)
A: deposited stage B: north part C:middle part D: south part

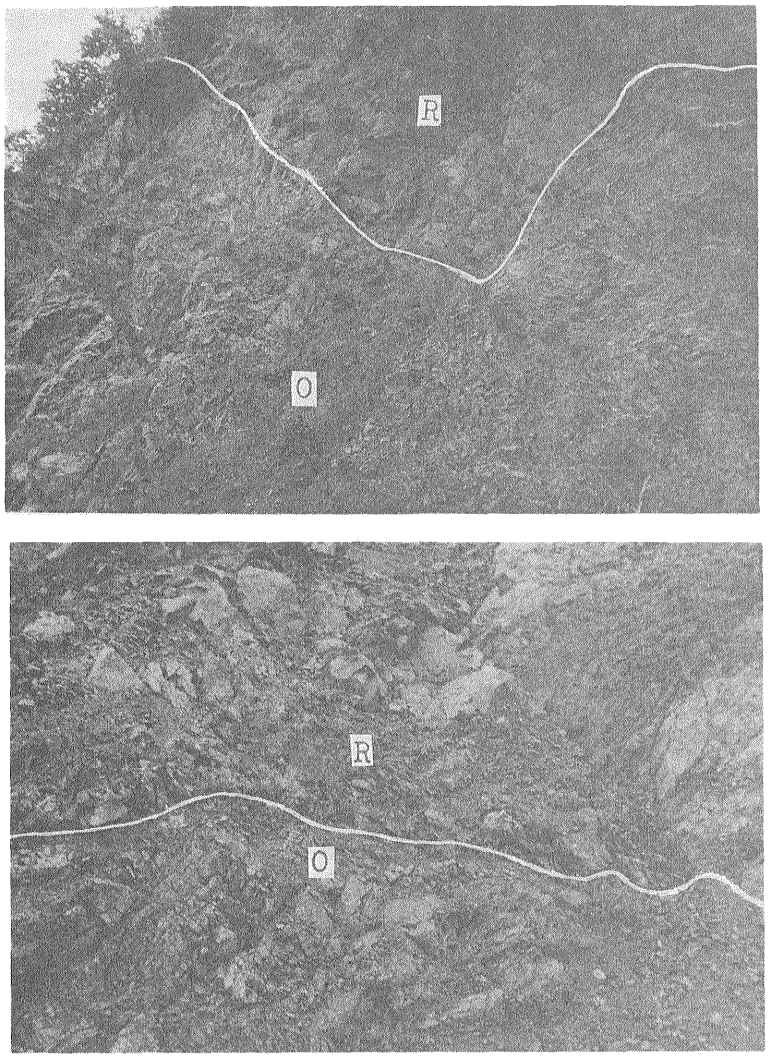
Fig. 6 Schematic diagram showing the thrust structure of the Kitasuzuka Group deposited on the Suzuka—Ibuki barrier-like narrow belt.

within the Ryozensan Limestone Formation at Shimonyu and Kaminyu (Fig. 2).

In the neighborhood of Ojigahata the Ryozensan Limestone Formation is thin "decollement-like" thrust sheet which is glided upon the Ojigahata Formation(Fig.7).The latter is directly thrust upon the Ikuridani Group and forms the thin slice near the thrust contact, and the Ikuridani Group appears as "window" into the Ojigahata Formation in Mt. Mikunidake and Mt. Eboshidake (Figs. 2,5, 6C).

From the above facts it is implied that the thrust sheet of the Ryozensan Limestone Formation is a "superficial wedge".

As the Kitasuzuka Group in the Kawani-Hida district is intruded and covered by the Koto acidic rocks, the original nature of thrust block is not revealed. But the following phenomena may be inferable from the above-mentioned tectonic features of this group: the blocks of the Ojigahata

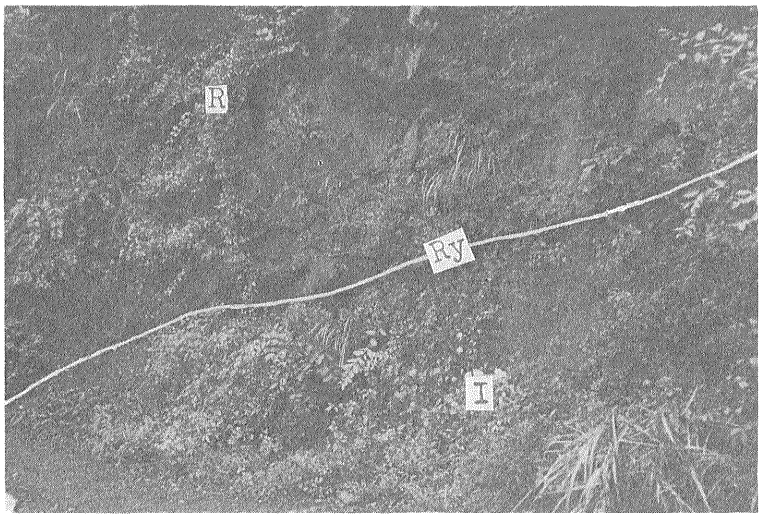


R: Ryozensan Limestone Formation O: Ojigahata Formation

Fig. 7 An outcrop of the abnormal tectonic contact (a kind of decollement) exposed at the west of the Kurakaketoge Pass.

Formation which is sporadically exposed from WNW to ESE in the Koto acidic rocks may be subordinate wedges or slices (Figs. 2, 5). And also the Kitasuzuka Group is isolatedly exposed near Shide and Kanaya within the distribution area of the Plio-Pleistocene Kobiwako Group, and this fact implies that the area in question covered by the Plio-Pleistocene sediments belongs to the thrust block of the Kitasuzuka Group. As the Ryozensan Limestone Formation in the west of Same shows the thrust sheet which is glided upon the Ojigahata Formation, it can be said to be "superficial wedge" (Fig. 2).

In the neighborhood of Nishinojiri the Ojigahata Formation is directly thrust upon the Ikuridani Group, and the Ryozensan Limestone Formation forms "decollement-like" thrust sheet which is glided upon the Ojigahata Formation. That is, the Ryozensan Limestone Formation shows the same "superficial wedge" as this limestone formation in the neighborhood of Ojigahata (Figs. 2, 5, 6D).



R: Ryozensan Limestone Formation (early Permian) I: Ikuridani Group (middle Permian)

Fig. 8 An outcrop of the Ryozensan thrust (Ry) exposed at the east of Mt. Ryozensan. The Ojigahata Formation is tectonically eliminated from the thrust sheet.

And also the Ryozensan Limestone Formation in Sakamoto and Funahara shows "decollement-like" thrust sheet which is glided upon the Ojigahata Formation, on the other hand, inasmuch as the Ojigahata Formation is directly bounded by the Tara Group (Plio-Pleistocene) and by the Ichishi fault, the tectonic relation between the Ojigahata Formation and the Ikuridani Group is not clear. But judging from the tectonic character of the Kitasuzuka Group near these places, it is inferred that the Ojigahata Formation is directly thrust upon the Ikuridani Group and both groups are cut together by the Ichishi fault. Therefore the thrust sheet of the Ryozensan Limestone Formation in Sakamoto and Funahara can be said to be "superficial wedge" too.

To the east of the Kurakaketoge pass, the Ryozensan Limestone Formation is directly thrust upon the Ikuridani Group, and the Ojigahata Formation is tectonically eliminated from the thrust sheet (Fig.8).

Judging from the tectonic character and the stratigraphic sequence of the Kitasuzuka Group, the Ryozensan Limestone Formation, which forms "klippen" on the Ikuridani Group of the eastern slope of the Suzuka mountains, may be the remnants of "superficial nappe" (Figs. 2, 5, 6B).

Of their "klippen", as mentioned in the paragraph of stratigraphy, "klippe" C situated most far from the main block of the Ryozensan Limestone Formation represents the uppermost horizon of this limestone formation. "Klippe" A and B occupy the lower horizon than "klippe" C, and are assigned to the Pseudofusulina zone which occupies the upper part of the main block of the Ryozensan Limestone Formation in Mt. Ryozensan.

It is noteworthy that the upper part of this limestone formation of the main block was thrust to the farther point than the lower part.

As the detailed paleontological study of fusulinid do not wholly cover the Ryozensan Limestone Formation, it is not clear whether the uppermost horizon of this formation remains in the main block or not. However the uppermost part of this formation is not found, so far as Mt. Ryozensan and its vicinity are concerned. It is probable that the uppermost part of this limestone formation of the main block was thrust as "superficial nappe" on the Ikuridani Group and disappeared in the main block. The "superficial nappe" may be thought to be resulted from thrusting, which was thrust

eastward on the Ikuridani Group from the main block of the Ryozensan Limestone Formation.

In the neighborhood of Ishigure, the Ryozensan Limestone Formation is in contact with the Ryugatake Group on the west side by the fault and with the Tara Group (Plio-Pleistocene) by the Ichishi fault or is covered with the talus on the east side. This limestone formation is in contact with the Suzuka granite on the south side. On the other hand, the Ojigahata Formation is not found near Ishigure.

By the above-mentioned reason, the structure of the Kitasuzuka Group in the neighborhood of Ishigure cannot be directly known. But on the high part of Mt. Ryugatake, the Ryozensan Limestone Formation lies as "klippe". This "klippe" may be interpreted to be the remnant of "superficial nappe" which was thrust westward on the Ryugatake Group from the main block of the Ryozensan Limestone Formation (Fig. 2).

If this interpretation is possible, it may be easily deduced that the main block of this limestone formation in the neighborhood of Ishigure is thrust upon the Ryugatake Group and afterwards was cut by the fault.

The Kitasuzuka Group of the early Permian age forms the thrust block which lies tectonically upon the non-calcareous formation of the middle Permian age. In the stratigraphic sequence of this thrust block, the Ojigahata Formation occupies the lower part and the Ryozensan Limestone Formation the upper part, the latter can be said to give the "superficial wedge" due to "decollement-like" glide or the "superficial nappe" which tectonically covers the heteropic zone (Figs. 2, 5, 6B and 6D).

4. Suzuka-Ibuki Barrier-like Narrow Belt

It is inferable from the following facts that the calcareous facies in the Suzuka and the Ibuki mountains is essentially autochthonous and was deposited *in situ* simultaneous with the non-calcareous facies (Fig. 6A).

1) The calcareous facies in the Suzuka and the Ibuki mountains is distributed in a narrow and continuous belt with the trend of N–S (Fig. 9).

2) The Michigatani Formation, the lowest part of the non-calcareous complex, shows the

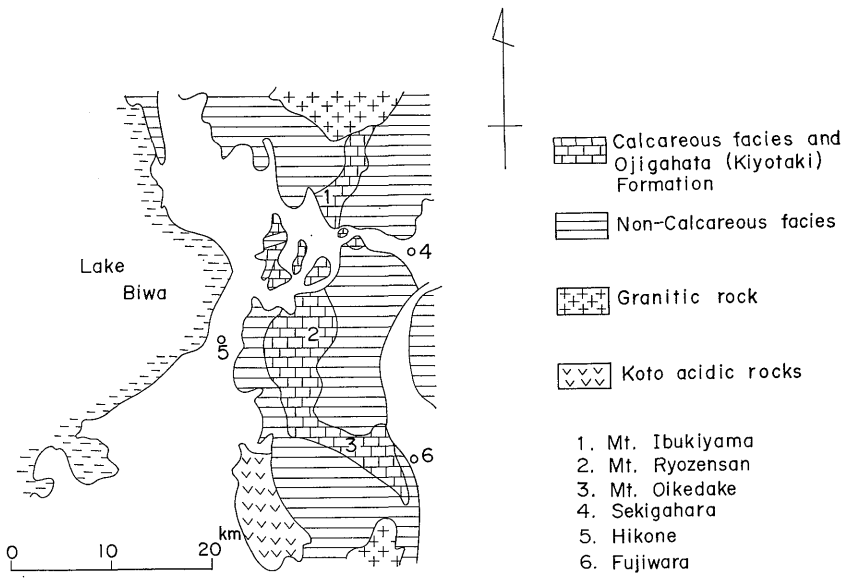


Fig. 9 Diagram showing the distribution of the calcareous and non-calcareous facies of the Ibuki and Suzuka mountains (Suzuka-Ibuki barrier-like narrow belt).

Table 2 Correlation of the Paleozoic limestone formations of the Ibuki and Suzuka mountains.

	Geological Age		Fusulinid zone	Ibuki mountains	Samegai district	Suzuka mountains	
Permian	upper	Kuman	Yabeina-Lepidolina z.	Ibukiyama Limestone Formation			
	middle	Akasakan	Neoschwagerina-Verbeekina zone				
		Nabeyaman	Parafusulina zone				
	lower	Sakamotozawan	Pseudoschwagerina zone		Samegai Formation	Kitasuzuka Group	Ryozensan Limestone Formation
					Kiyotaki Formation		Ojigahata Formation
Carboniferous	upper	Hikawan	Triticites z.				

transitional facies between the calcareous and the non-calcareous facies (See 2.1.1.a).

3) In the northern part of the Ibuki mountains, the Itanamiyama Limestone Formation is formed of the alternation of limestone, basic volcanic rocks and slate or sandstone. It shows the transitional facies between the calcareous and the non-calcareous facies (MIYAMURA, 1967).

4) In the Suzuka mountains, the upper part of the Ryozensan Limestone Formation may be correlated to the lower part of the non-calcareous facies (Table 1).

From the above-mentioned phenomena, it is deduced that the calcareous facies was deposited in a narrow and elongated belt of barrier-like in nature, and changes gradually into the surrounding non-calcareous facies through the transitional facies (Figs. 6A and 9).

The Fusulinid zone of the Ibukiyama Limestone Formation ranges from the *Pseudoschwagerina* zone to the *Yabeina* zone, while the Ryozensan Limestone Formation is mostly belongs to the *Pseudoschwagerina* zone (Table 2).

It means that the southern part of the Suzuka-Ibuki barrier-like narrow belt was formed during the early Permian and the northern part in the middle or late Permian.

The small block resting in a "klippen-like" form on the non-calcareous facies is not a true "klippen" removed far from the lost area, but a remnant of the terminal part of the thrust (Fig. 6). The limestone block of this barrier-like narrow belt is inferred to have been squeezed and to be

thrust upon the surrounding non-calcareous formations of the middle Permian by the Oga orogeny of the early Cretaceous age.

In short, the Suzuka-Ibuki barrier-like belt was formed during the Sakamotozawan and the Akasakan on the submarine volcanic mounts within the late Paleozoic geosyncline.

Summary

1. The Kitasuzuka Group was deposited in a barrier-like narrow belt extending N–S in direction and changed into the heteropic groups of clastic rocks deposited on both sides of the belt through the transitional zone in lithofacies.

2. The Kitasuzuka Group laid in a "klippen-like" form on the non-calcareous facies is not the true "klippen", but merely the remnant of thrust sheet which was squeezed from the barrier-like narrow belt toward the both sides. It is essentially autochthonous rather than the allochthonous.

3. The Ojigahata Formation occupies the lower part in the stratigraphic sequence of the thrust block (Kitasuzuka Group) and the Ryozensan Limestone Formation the upper part. The latter forms the "superficial wedge" which is initiated by "decollement-like" glide or the "superficial nappe" which tectonically covers the heteropic zone.

4. The "klippen-like" form on the Ikuridani Group to the east of the Suzuka mountains is concluded to be the remnant of "superficial nappe". Of the "klippen", "Klippe" C is thought to reserve the uppermost horizon of the Ryozensan Limestone Formation and to be correlated with the uppermost Sakamotozawan. This facts implies that the upper part of the main block of the Ryozensan Limestone Formation was removed farther than the lower. In so far as is known in Mt. Ryozensan and its vicinity, the uppermost part of this limestone formation is not found in the main block.

5. Suzuka-Ibuki barrier-like narrow belt was formed during the Sakamotozawan and the Akasakan on the submarine volcanic range within the late Paleozoic geosyncline.

6. The barrier-like narrow belt continued during the early Permian age in the southern part and during the middle or late Permian age in the northern part.

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Appendix

List of place, mountain, valley and river names used in this article showing the comparison between the names written in Roman letters and those written in Chinese characters.

1) Place names

Busshoji	仏生寺	Maihara	米 原
Funahara	船 原	Minami-Ishigure	南石褌
Hagihara	萩 原	Nishinojiri	西野尻
Hida	肥 田	Ojigahata	大君ケ畑
Hikone	彦 根	Same	佐目
Ibaragawa	茨 川	Samegai	醒ケ井
Ichishi	一 志	Sakamoto	坂 本
Iwasu	岩 須	Shide	四 手
Kaminyu	上丹生	Shimonyu	下丹生
Kanaya	金 谷	Tara	多 良
Kawanai	川 相	Toki	時
		Tokiyama	時 山

2) Mountain and Pass names

Eboshidake	烏帽子嶽	Oikedake	御池嶽
Fujiwaradake	藤原嶽	Ryozensan	霊仙山
Kurakaketoge P.	鞍掛峠	Ryugatake	竜ケ嶽
Mikunidake	三国嶽	Suzugatake	鈴ケ嶽
Nabejiriyama	鍋尻山	Takamuroyama	高室山

3) Valley and River names

Aodani V.	青　谷	Tashidadani V.	多志田谷
Echi R.	愛知川	Yabutani V.	藪　谷
Ikuridani V.	幾里谷	Ugake V.	宇賀渓谷
Michigatani V.	道ケ谷		

鈴鹿山地の二畳系の地質構造

宮村　学

要　旨

鈴鹿山地は中部二畳系の上に横たわる衝上地塊によって特徴づけられる．衝上地塊は下部二畳系の石灰岩層（上部）とチャート層（下部）からなり，前者の一部は“superficial nappe”の残留物であるクリッペを，またその大部分は衝上運動に起因する“superficial wedge”を示す．

衝上地塊は非石灰岩相と同時に同じ場所にそして南北方向の barrier-like narrow belt の上に堆積し，大賀造山運動により絞り出され中部二畳系の非石灰岩相上に衝上したものと思われる．

この belt はおそらく鈴鹿山地では二畳紀前期，伊吹山地では二畳紀中期または後期を通じて生成されたものと考えられる．