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The Triassic System in the Maizuru Zone, Southwest Japan

By

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Abstract

In the Maizuru zone nearly whole the Triassic successions are developed. The Scythian to Aniso-Ladinian strata make a continuous sequence, in which are distinguished three faunizones, *Neoschizous-"Bakevellia"*, *Hollandites-"Danubites"* and *Monophyllites*, corresponding to Scythian, lower Anisian and Aniso-Ladinian, respectively. Main portion of the Ladinian series is lacking in this region. The earliest Carnian or Ladino-Carnian Arakuran age is newly proposed founded on the palaeontological and stratigraphical studies on the Arakura formation. In the next Sakawan (≒ Carnian) Nabae group, two and probably one more, faunizones are recognizable, *Palaeopharus-Lima yataensis*, *Tosapecten-Pseudolimea*, and *Pleuromya-Neoschizodus*. The Sakawan age is classified into two subages better than the three formerly proposed by K. ICHIKAWA. The Norian sediments are probably represented by the Nakaiso conglomerate bed, although barren in fossil. The Rhaetic strata are not found at all like other regions in Japan. From the facies-analysis, the Palaeo-Maizuru Bay during the Scythian to Aniso-Ladinian epochs and the Palaeo-Maizuru Inland Sea during the Carnian epoch are assumed. Finally, the orogenic history of the Triassic period in this zone is briefly stated.

Introduction and Acknowledgements

The presence of the Mesozoic sediments of the Yakuno, Maizuru and Shidaka districts in the northern part of Kyoto Prefecture has been well known since over sixty years ago. T. KOCHIBE (1891) was the first to report the occurrence of the Mesozoic pelecypod-fossils from Heki in the Yakuno district. They were referred to *Trigonia*, *Pholadomya*, *Lima* and *Cardinia* by M. YOKOYAMA (1891), who considered their age as Jurassic. The geological investigations around the fossil-locality were carried out by S. SAEKI and C. MIKUMO in 1924 and 1932 respectively, but the results were not published except for the description of the species of *Trigonia* (SAEKI, 1925). S. OISHI (1933) named the *Trigonia* beds as well as the neighbouring strata provided with lenses of limestone the Nukada formation. However, K. MASHIKO (1934) discovered *Lyttonia richthofeni* (KEYSER), an undoubted Permian brachiopod from the limestone next year. A little later, T. KOBAYASHI (1935) reported the other Permian brachiopod- and bryozoan fossils from the same limestone,

and proposed the Heki formation for the Mesozoic strata exclusive of the Permian rocks. He, further, clarified the Triassic age of this formation, correlating it with the Hirabara formation of the Miné series in Yamaguchi Prefecture (1936).

The Mesozoic age of the coal-bearing strata in the Shidaka and Maizuru districts has been maintained by many authors, but the exact age was not in accordence among them. D. YAMASHITA (1895) inferred the Cretaceous age, while the Jurrassic age was expressed by H. YABE (1922), S. OISHI (1932, 1940) and T. KOBAYASHI (1937, 1939) from the examination of the plant-fossils.

The restudy of these Mesozoic beds was started immediately after the Second World War by the surveys of coal-field taken under the Ministry of Commerce and Industry. Since then the knowledges have been much increased. Discoveries of the Anisian ammonite from Yakuno by T. KOGA (1948) and the Triassic pelecypods from Shidaka by N. KAMBE (1950) are valuable. The writer and S. OKADA also proved the Triassic age of the coal-measures in the Maizuru district by discovering the Carnian faunules in them (1949). Summarizing the geology of the Kinki region, S. MATSUSHITA divided the region into several geological provinces in 1950.

The Maizuru zone is one of them named by him. He also distinguishes two other zonal provinces: the Tango-Tajima zone to the north and the Tamba zone to the south (See general map, Fig. 1). The Tango-Tajima zone is characterized by the Neogene sediments and the Caenozoic volcanics upon the basement of granite, while the Tamba zone by the T. KOBAYASHI's (1941) Yamaguchi facies of Permo-Carboniferous Chichibu system which is represented by predominating chert and scarcity of limestone. The intermediary Maizuru zone between them has been distinguished by the Triassic sediments and the so-called Yakuno intrusive rocks. Afterwards the writer discovered the upper Permian *Lepidolina-Yabeina* "zone". Zonal arrangement of these constituents is characteristic. He could confirm the west extension of this zone toward Okayama Prefecture in Chugoku Region (NAKAZAWA, 1954 a). The Triassic rocks are separately exposed in several districts. These were partly worked out and the results were published by the writer jointly with his collaborators (NAKAZAWA and others, 1954–1957). Palaeontological research in the upper Triassic fossils has also been carried out. Some papers on the pelecypods have already been published (NAKAZAWA, 1952–1956; T. KOBAYASHI and K. ICHIKAWA, 1952 a). However, many fossils from the lower and middle Triassic strata still remain undescribed. A few exceptions are the papers given by the same authors (NAKAZAWA, 1953; KOBAYASHI and ICHIKAWA, 1952).

This paper is devoted to the biostratigraphy of the Triassic system. It seems not worthless to publish the results in this occassion, because the knowledge of the Trias is rather meagre in this country. The palaeontology will be reported in other papers.

The writer wishes to express his most sincere thanks to Prof. S. MATSUSHITA of Kyoto University for his guidance and encouragement throughout the present study and to Prof. J. MAKIYAMA for reading the manuscript. Messrs. S. OKADA of Otsu High School, T. SHIKI, D. SHIMIZU and Y. NOGAMI of Kyoto University cooper-

ated witn the writer in field survey and discussed the paper. Prof. T. KOBAYASHI and Mr. A. TOKUYAMA of Tokyo University, Assist. Prof. K. ICHIKAWA of Osaka City University, Assist. Prof. A. HASÉ of Hiroshima University, Messrs. M. KAWAI and N. KAMBE of Geological Survey of Japan gave him many valuable suggestions and criticisms. The writer is also much obliged to these persons. Grateful acknowlege-

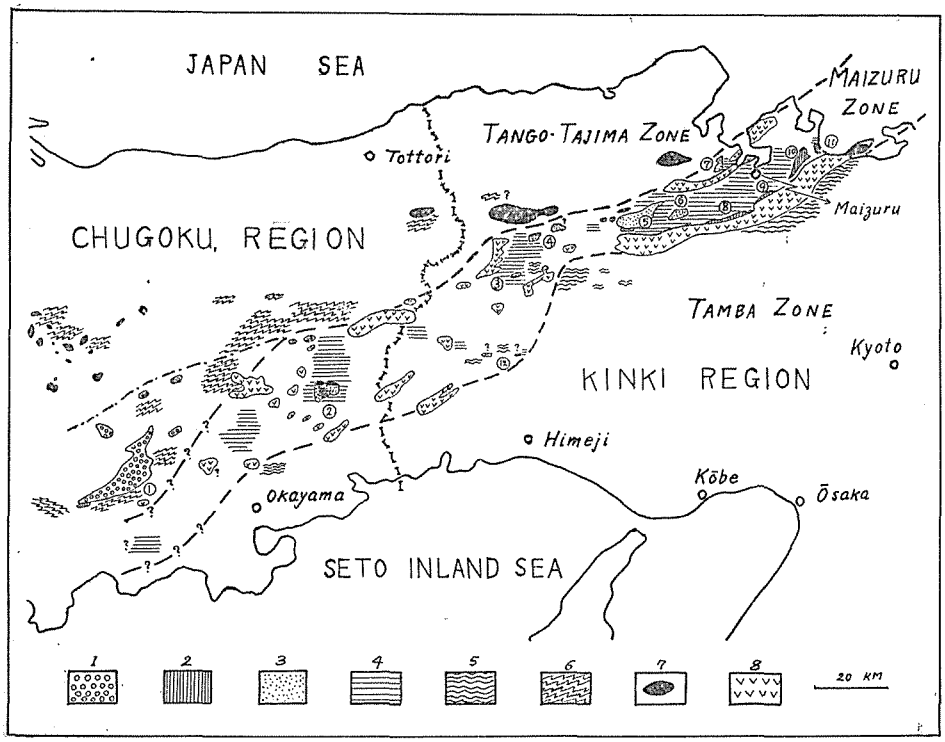

Fig. 1. General map of the Maizuru zone.

Legend: 1. Saragian (≒ Norian) 2. Sakawan (≒ Carnian) 3. Lower to middle Triassic 4. Upper Permian 5. Phyllite–phyllitic rocks 6. Sangun metamorphic rocks (schists and phyllites) 7. Serpentine 8. Yakuno intrusive rocks

Districts: ① Nariwa ② Fukumoto ③ Mikata ④ Miharaiyama ⑤ Yakuno ⑥ Ōe ⑦ Shidaka ⑧ Yata ⑨ Ikenouchi ⑩ Matsunoodera ⑪ Nabae ⑫ Yamasaki

ment is also due to many persons who gave him many facilities in surveying the field, and to Miss. T. IMAI for the typescript. The financial support was made through the Grant in Aid for Fundamental Scientific Research of the Ministry of Education.

LOWER AND MIDDLE TRIASSIC SYSTEM

1. Biostratigraphy

The lower and middle Triassic rocks are distributed in the Fukumoto, Mikata, Miharaiyama, Yakuno, Ōe and Shidaka districts from west to east.

A. Fukumoto district

As stated by the writer jointly with T. SHIKI and D. SHIMIZU (1954), the lower and middle Triassic system in this area as a whole was named the

Table 1. List of fossils of the Fukumoto group.

F1 : Kusano formation, F2 : Kyogakubo formation, F3 : Miyanooku formation,
A : abundant, C : common, R : rare, r : very rare

Species \ Loc. No. F–	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Formation	F1	F1	F2	F1?	F2	F2	F2	F1	F2?	F1	F1	F1	F2	F2	F2	F2	F1	F1?	F2	F2
Neoschizodus cf. *laevigatus* (Zieth.)	A	C	C	A	C	—	—	—	R	C	C	C	C	—	R	R	C	—	A	—
"Bakevellia" kambei Nakazawa MS.	A	R	C	A	—	—	R	—	—	—	C	R	C	R	—	—	C	—	C	R
"B." kambei dannensis Nakazawa MS.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"Pecten" ussuricus Bittner	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	R
"Pecten" sp. indet.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Eumorphotis aff. *maritima* Kiparisova	—	—	—	—	—	—	—	—	—	C	—	r	—	—	—	—	—	—	—	—
Nuculana sp. α aff. *excavata* Goldfuss	?	—	—	R	—	—	—	R	—	—	—	R	—	—	—	—	—	—	C	—
Palaeoneilo sp. α aff. *elliptica* in Kiparisova	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Palaeoneilo sp. β	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	C	C	—	A
"B." miyanokuensis Nakazawa MS.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pinna muikadaniensis Nakazawa MS.	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—
Selenimyalina sp. α	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—
Spiriferina sp. α?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sp. sp. γ	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—
Sp. sp. δ	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhynchonella sp. γ	—	—	—	—	—	—	—	—	—	C	R	—	R	—	—	—	—	—	—	—
Retzia sp.	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
Brachiopod gen. & sp. indet.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sisenna? japonica Kobayashi & Ichikawa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gastropod gen. & sp. indet.	—	—	—	C	—	—	—	—	—	—	—	A	—	—	—	—	—	—	C	—
Hollandites sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anakashmirites? sp.	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—
Pseudasageceras aff. *"intermontanum"*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—
Ammonite gen. & sp. indet. α, β	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Michelinoceras sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Fukumoto group which is subdivided as follows in descending order at the type locality (Fig. 2):

Miyanooku formation (F_3)···composed mainly of shales and sandy shales, rarely with intercalated fine-grained sandstones. More than 300 m thick.

Kyôgakubo formation (F_2)···alternations of shale and sandstone, variable in lithology, bearing thin conglomerate layers. 260–300 m thick.

Kusano formation (F_1)···divisible into the upper member consisting mostly of sandstone and the lower one of alternations of sandstone and conglomerate. Total thickness more than 170 m.

The Kusano formation is in contact with the upper Permian Kosé group by faults at most places, but overlies it para-unconformably near the old mound of Tsukinowa in the northern part of the district (NAKAZAWA, 1954 b). Fossils of the Kusano and the Kyogakubo formations are represented by pelecypods, while other kinds such as ammonites, brachiopods and gastropods, are very rare. On the other hand those of the Miyanooku formation are characterized by cephalopods. As shown in the fossil-list and the range-chart (Table 1 and Fig. 3) fossil contents of the lower two formations are not essentially different from each other. *Neoschizodus* cf. *laevigatus* (ZIETHEN) and *"Bakevellia" kambei* NAKAZAWA MS. are the most abundant species throughout the formations. *Palaeoneilo* sp. β and *Sisenna*? sp. are the next common forms. Not rarely there are the species limited to the Kusano formation like *"Pecten" ussuricus* BITTNER, *Eumorphotis* aff. *maritima* KIPARISOVA, *Pinna muikadanienis* NAKAZAWA MS., *Spiriferina* sp. α aff. *lilangensis* BITTNER, *Rhynchonella* sp. γ, *Retzia* sp. α and others. They are too small in number be used as zone markers. The two formations shall be united into one zonule of *Neoschizodus-"Bakevellia"* characterized by such species as *Neoschizodus* cf. *laevigatus*, *"Bakevellia" kambei* and *Palaeoneilo* sp. β. Cephalopod-fossils are too scarce to make a biozone, but the following species

(continued)

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	F2	F3	F3	F3	F0	F0	F0	F0	F0	F0	F0	F0	F0	F0	F1?	F0
	C	—	—	—	—	—	—	—	—	—	—	—	A	—	A	—
	C	—	—	—	—	R	R	R	—	—	—	—	—	—	A	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
	A	C	—	—	—	—	—	—	—	—	—	—	—	—	—	A
	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	A	A	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	R	R	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	A	A	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	R	?	—	R	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—
	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	—	r	—	—	r	—	—	—	—	—	—	—	—	—	—	—
		(α)			(β)											
	—	r	R	—	—	—	—	—	—	—	—	—	—	—	—	—

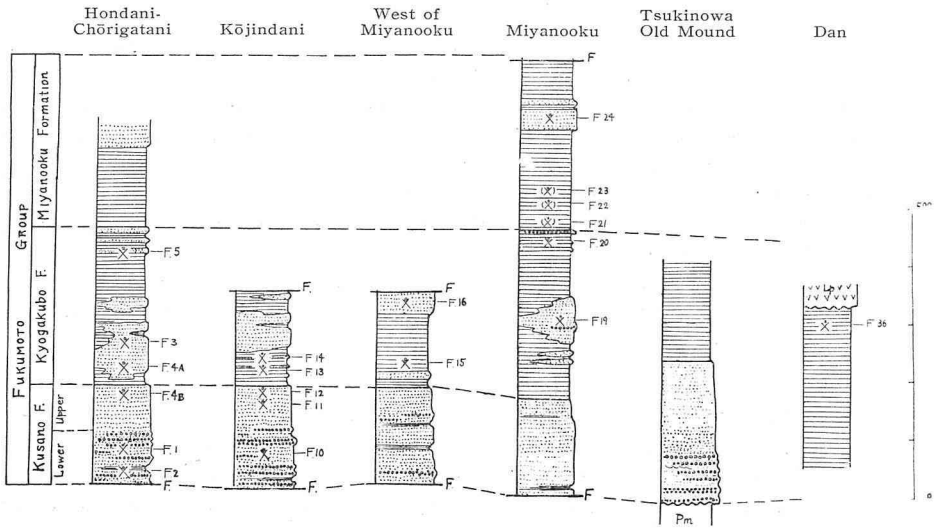

Fig. 2. Columnar sections of the Fukumoto group.

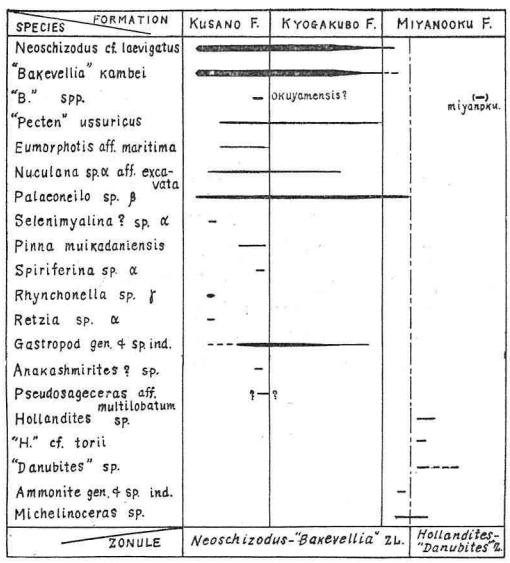

Fig. 3. Range-chart of species of the Fukumoto group.

show the middle Eo-Triassic age.

Anakashmirites? sp. from the top of the Kusano formation.

Pseudosageceras sp. probably from a horizon near the preceeding. *Anakashmirites*? sp. is somewhat similar to *A. nivalis* (DIENER), and the second species resembles especially *Psudosageceras intermontanum* HYATT and SMITH, which was later emended to *multilobatum* NOETAING by SMITH.

As already stated, the Miyanooku formation is characterized by the cephalopods, but a pelecypod faunule like that of the lower formations has been obtained from a boulder considered to be derived from the lowest horizon. Therefore the lowest part of this formation, too, may belong to *Neoschizodus-"Bakevellia"* zonule. The cephalopods, chiefly collected from the horizon about 50 m above the base are of the Anisian type, such as *Hollandites* sp., *"H."* cf. *torii* NAKAZAWA MS., *"Danubites"* sp. and

Michelinoceras sp.. This part of the formation is separated from the other as the *Hollandites-"Danubites"* zonule. The upper part is almost lacking in fossil, except for *"Bakevellia" miyanokuensis* NAKAZAWA MS..

There is a large area of the Fukumoto to the east of the type locality, where the shale and sandy shale accompanied by fine-grained sandstone with a limestone-lens are exposed. Because of the monotonous rock facies and scarcity of animal remains, the group in this area has been left undivided. Fossils obtained from several localities in this area are compared to those of both *Neoschizodus-"Bakevellia"* and *Hollandites-"Danubites"* zonules. There are *"Pecten" ussuricus*, *"Bakevellia" kambei dannensis* NAKAZAWA MS., *"B."* cf. *okuyamensis* NAKAZAWA MS., *Palaeoneilo* sp. β, *Nuculana* sp. α aff. *excavata* (GOLDFUSS) and *"Danubites"* sp.. These fossil contents prove the group be contemporaneous but heterotopic with the type Fukumoto group.

B. Mikata district

According to D. SHIMIZU, the Okukishida formation named by him is mainly made of sandstone similar to that of the Fukumoto group. He estimated the age as Scythian based on the lithic alliance. The formation is distributed in a narrow belt shut into the upper Permian system by faults. There is no positive palaeontological criterion to prove the assumption, though the lithological correlation may be supported*.

C. Miharaiyama district

The Triassic beds convering Mt. Miharaiyama in the northern part of Hyogo Prefecture were discovered by O. HIROKAWA, H. TOGO and N. KAMBE several years ago. The beds represent a geological unit the Miharaiyama group named by them (1954 a). They report the occurrence of *Myophoria* (=*Neoschizodus*), *Gervillia* (=*"Bakevellia"*) and others, and referred it as the upper Triassic. Since then, the writer and SHIKI carried a detailed survey and came to a conclusion that the Miharaiyama is the lower Triassic sediments correlative to the lower part of the Fukumoto group (NAKAZAWA and SHIKI, 1954). The results are summarized here. (See columnar section, Fig. 4).

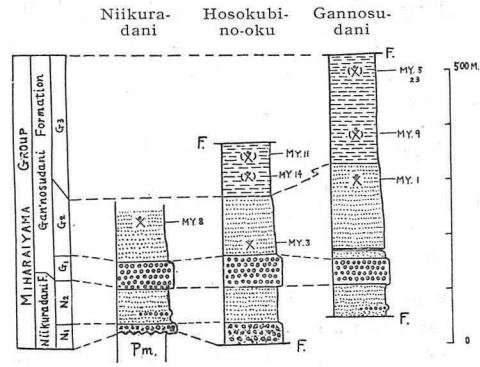

Fig. 4. Columnar sections of the Miharaiyana group.

(2) Gannosudani formation

Bluish grey siltstone member (G_3)···composed mostly of massive, more or less calcareous siltstones. No less than 200 m in thickness.

* Recently, the Eo-Triassic age of this formation was proved by a discovery of *Neoschizodus* cf. *laevigatus* by D. Shimizu.

Bluish grey sandstone member (G_2)···composed mainly of massive, medium- to fine-grained sandstones, partly calcareous, rarely associated with thin conglomerate layers. About 90 m in thickness.

Conglomerate member (G_1)···conglomerate bed comprising well rounded pebbles of chert, sandstone, granulic breccia, granite, quartz-porphyry, acidic and intermediate volcanic rocks and others, most of them less than 6 cm in diameter. About 50 m in thickness.

(1) Niikuradani formation

Bluish grey sandstone member (N_2)···consisting of medium- to fine-grained sandstones similar to those of the G_2 member. 30–60 m thick.

Basal conglomerate member (N_1)···conglomerate bed containing badly sorted, subangular pebbles of chert, limestone, shale, propyrite, serpentine and others of 2 mm–2 cm in size. 15–30 m in thickness.

The Miharaiyama group is generally separated from the upper Permian Minamidani group by faults, but SHIKI confirmed that it covers the Palaeozoic rocks with a well-marked clino-unconformity at several places.

In the Niikuradani formation and the G_1 member, no fossil has been found as yet, but for that limestone pebbles of the N_1 member and a pebble of silicified black shale of the G_1 member contain the Permian fusulinids *Neoschwagerina* cf. *douvillei*, *N.* sp., *Pseudofusulina* cf. *vulgaris* and a Carboniferous coral *Siphonodendron japonicum* MINATO and KATO (1957). From the G_2 member common in fossils the the following species have been obtained:

Table 2. List of fossils of the Miharaiyama group.

Species \ Loc. No. MY–	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	21	28
Formation	G_2	〃	〃	〃	G_3	G_2	〃	〃	G_3	G_2	G_3	G_2	〃	G_3	G_3?	G_2	G_3
Neoschizodus cf. *laevigatus* (Ziethen)	—	A	A	A	C	C	A	C	C	C	—	A	—	R	C	—	R
"Bakevellia" kambei MS.	C	A	A	C	C	C	A	C	C	C	R	A	A	—	—	—	—
Nuculana sp. α aff. *excavata*	R	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—
Palaeoneile sp. α aff. *ellipitica* in Kiparisova	—	—	—	—	—	—	—	R	cf.	—	—	—	—	—	—	—	—
P. sp. β	—	—	—	—	—	—	—	A	?	—	—	—	—	C?	—	—	C
Nuculopsis (*Palaeonucula*) sp. β	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—
Selenimyalina ? sp.	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhynchonella sp. δ aff. *griesbachi*	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—
Terebratula sp. α	—	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—
T. sp. β aff. *margaritowi*	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
Retzia sp. β	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—
Sisenna ? sp. cf. *japonica*	—	—	—	—	—	—	R	R	—	—	—	—	—	—	—	—	—
Ammonite gen. & sp. indet.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—

Neoschizodus cf. *laevigatus*, "*Bakevellia*" *kambei*, *Nuculana* sp. *α*, *Palaeoneilo* sp. *β*, *P.* sp. *α*, *Nuculopsis* sp. *β*, *Selenimyalina*? n. sp., *Rhynchonella* sp. *δ* aff. *griesbachi* BITTNER, *Terebratula* sp. aff. *margaritowi* BITTNER, *Sisenna*? cf. *japonica* KOBAYASHI and ICHIKAWA and others.

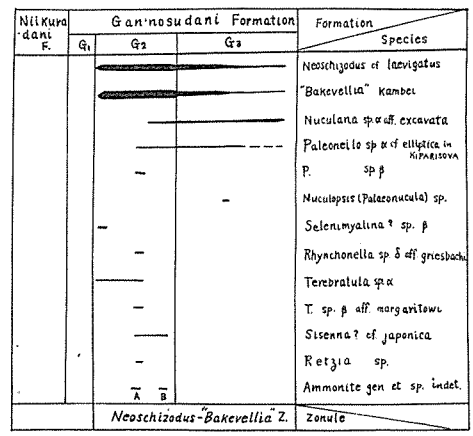

Fig. 5. Range-chart of species of the Miharaiyama group.

The first and second species are most prolific, and the next two species are common, all of which occur in the G_3 member, too, though small in number. The fossil assemblage of the Miharaiyama agrees very well with *Neoschizodus-"Bakevellia"* faunule of the Fukumoto group stated above. It is out of question that the Miharaiyama as a whole belongs to the lower Triassic *Neoschizodus-"Bakevellia"* zonule. (See fossil-list and range-chart, Table 2 and Fig. 5)*.

D. Yakuno district

This is a memorable district, in which the presence of the Anisian stage in Southwest Japan was confirmed by a discovery of "*Danubites*" (T. KOGA, 1948). Afterward an extensive field work by SHIKI, SHIMIZU and the writer has brought a fruitful result (1957).

The lower to middle Triassic Yakuno group is distributed in three belts separated from each other by E-W faults. The strata of the Yakuno dip southward in the northern belt, and northward in the middle and southern belts making a synclinal structure as a whole. The upper Permian Nukada formation is intervening as a narrow stripe between the latter two belts.

The type locality of the Yakuno group is amid the middle belt. It is classified as below in descending order. (See columnar section, Fig. 6).

(2) Waruishi formation···consisting exclusively of shales and sandy shales, divisible into two members.

Upper member (Wu)···composed of dark blue or bluish grey shales and sandy shales, a little calcareous at places, stratified in several tens of centimeters,

* Very recently, the writer confirmed the presence of this group to the south of the known area of distribution. The strata are consisting mainly of shales and sandstones, which indicate the medium-grained facies. Furthermore, "*Hollandites*" sp. has been obtained from a slab of shale. The Miharaiyama group, therefore, contains the Middle Triassic sediments here.

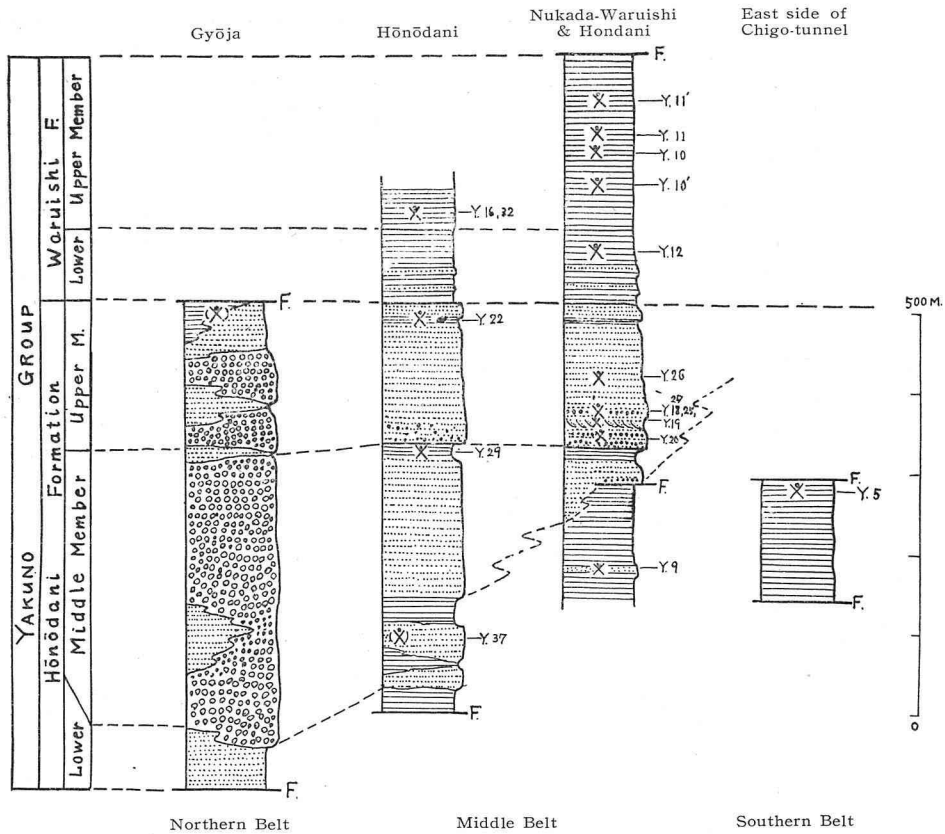

Fig. 6. Columnar sections of the Yakuno group in the Yakuno district.

generally intercalating thin grey silty bands of several centimeters. Thickness more than 220 m.

Lower member (Wl)···constituted by bluish grey, more or less calcareous shales and sandy shales, well laminated in several centimeters. Thickness 70–80 m.

(1) Hônôdani formation···consisting mainly of sandstones associated with shales, subdivided into three members.

Upper member (Hu)···composed of fine- to coarse-grained sandstones, beginning with conglomeratic sandstone and bearing interbedded thin shale layers in the upper part. About 170 m thick.

Middle member (Hm)···composed chiefly of fine- to medium-grained sandstones, ending with a shale bed of about 20 m in thickness. Thickness 200 m or so.

Lower member (Hl)···shale and sandy shale beds of 70–180 m in thickness, changing laterally into sandstone.

The writer (1953) formerly divided the group into three formations, the lower (Y_1), middle (Y_2) and upper (Y_3), respectively corresponding to the Hl member, Hm to Hu members and the Waruishi formation of this paper.

The Hônôdani formation is changeable in rock facies. The sandstone changes eastward into the shale or the sandy shale. Therefore, the Hônôdani in the east can hardly be distinguished from the superjacent Waruishi formation.

A faunule consisting of pelecypods in the main is rather rarely found in the Hônôdani. As shown in the fossil-list and the range-chart (Table 3 and Fig. 7) *Neoschizodus* cf. *laevigatus* and stems of *Isocrinus* are the commonest members. The shell is generally smaller in size than that of the foregoing districts, and "*Bakevellia*" *kambei*, the leading fossil in the other districts is not found at all in this belt, but it is replaced by the intimate species "*Bakevellia*" *okuyamensis* MS.. *Nuculopsis* (*Palaeonucula*) sp. α, *Anodontophora*? sp., "*Pecten*" cf. *ussuricus*, *Lingula* cf. *borealis* BITTNER, "*Dentalium*" sp. are the species confined to the upper member, but they occur as mere accessory species. The Hônôdani formation appears to represent the *Neoschizodus-Lingula* zonule, and it may be correlated to the *Neoschizodus-*"*Bakevellia*" zonule of the Fukumoto and Miharaiyama groups.

The Waruishi formation is marked by cephalopods contrary to the Hônôdani. Although premature in palaeontological study, the following species are able to be mentioned:

Hungarites sp. aff. *proponticus* TOULA, *Hollandites*? sp. *Sisenna*? *japonica* from a horizon about 60 m above the base. *Danubites japonicus* SHIMIZU, "*Hollandites*" cf. *torii* NAKAZAWA MS. from a horizon about 100 m above the base.

"*Danubites*" *kogai* NAKAZAWA MS., *Hollandites yakunoensis* NAKAZAWA MS., "*H.*" *torii* MS., *Beyrichites* sp., *Pseudosageceras*? sp., *Michelinoceras* sp., *Sisenna*? *japonica*, *Spiriferina* sp. cf. α and others from a horizon about 180 m above the base.

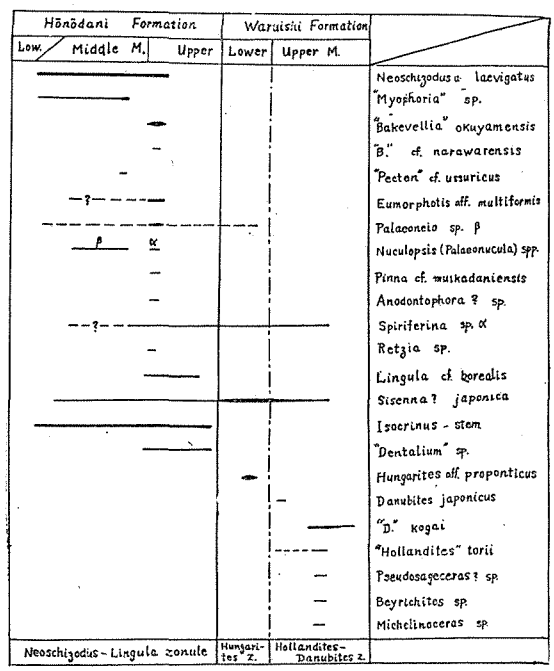

Fig. 7. Range-chart of species of the Yakuno group in the Yakuno district.

Table 3. List of fossils of the Yakuno group in the Yakuno district.

H: Hōnōdani formation, W: Waruishi formation, Y: undivided,
A: abundant, C: common, R: rare, r: very rare,

Species \ Loc. No.	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24
Formation	Y	Y	〃	〃	〃	〃	W	〃	〃	H	〃	W?	W	Y	H	〃	〃	〃	Y	〃
Neoschizodus cf. *laevigatus*	—	—	—	—	—	R	—	—	—	A	—	—	—	—	R	C	C	—	—	—
Myophoria sp. ? indet.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"*Bakevellia*" *kambei* MS. ?	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"*B.*" *okuyamensis* MS.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—
"*B.*" *narawarensis* MS. ?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—
Claraia pulchella	—	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Eumorphotis aff. *multiformis*	—	—	—	—	—	—	—	—	—	—	R	—	—	—	R	—	—	—	—	—
"*Pecten*" cf. *ussuricus*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nuculana nogamii yakunoensis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. sp. α aff. *excavata*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Palaeoneilo sp. α	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
P. sp. β	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	—	—
P. sp. ε	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nuculopsis (*Palaeonucula*) sp. α	—	—	—	—	—	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—
N. (*P.*) sp. β	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	?	?	—	—	—
N. (*P.*) sp. γ	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anodontophora ? sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—
Pinna sp. indet.	—	r	?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pinna muikadaniensis MS.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Spiriferina sp. α	—	—	—	—	—	—	?	—	—	—	A	—	—	—	—	—	—	C	—	—
Retzia sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—
Lingula cf. *borealis* Bittner	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sisenna ? *japonica*	—	—	—	R	r	C	C	—	C	—	—	C	R	R	—	—	R	C	—	R
S. ? cf. *japonica*	—	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"*Dentalium*" sp.	—	—	—	R	—	—	—	—	—	—	—	—	—	—	R	—	—	R	—	—
Isocrinus-stem	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	—	—	A	—	—
Hungarites sp. aff. *proponticus*	—	—	—	—	—	—	—	—	C	—	—	—	—	—	—	—	—	—	—	—
Danubites japonicus	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	—	—	—
"*Hollandites*" *torii* MS.	—	—	—	—	—	—	R	—	—	—	—	—	?	—	—	—	—	—	—	—
"*H.*" *yakunoensis* MS.	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—
"*Danubites*" *kogai* MS.	—	—	—	—	—	—	C	R	—	—	—	—	—	—	—	—	—	—	—	—
Pseudosageceras ? sp.	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—
Beyrichites sp.	—	—	—	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—
Meekoceras sp.	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"*Xenodiscus*" sp.	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ammonite gen. & sp. indet.	—	—	—	—	—	—	—	—	—	—	—	—	—	r	—	—	—	—	r	—
Michelinoceras sp.	—	—	—	—	—	—	C	—	—	—	—	—	—	R	—	—	—	—	—	—
Nautiloid ? sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brachiopod gen. & sp. indet.	—	—	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

(continued)

25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
H	〃	〃	W	H	W	Y	W	Y	〃	W	〃	H	Y	H
—	—	—	—	—	—	—	—	—	—	C	?	—	—	C
—	—	—	—	C	—	—	—	—	—	—	—	C	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	R
C	—	r	—	—	—	—	—	—	R	—	—	—	—	—
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—	—	—	—	R	—	—	—	—	—	—	—	—	—	—
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—	—	—	—	—	—	?	—	—	R	—	—	—	—	—
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R	C	—	—	C	—	—	—	—	—	—	—	—	—	—
—	—	—	R	—	—	—	R	—	—	—	—	—	—	?
—	—	—	—	—	—	—	—	—	—	—	—	—	R	—
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—	—	—	—	—	—	—	r	—	—	—	—	—	r	—
—	—	—	r	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Although materials are poor, two zonules are distinguished, the *Hungarites* and the *Hollandites*-"*Danubites*". The faunal change between the two formations is well in accordance with that seen in the Fukumoto group. It is reasonable to correlate the Waruishi formation to the main part of the Miyanooku formation of the Fukumoto group.

In the northern belt, the beds of coarse-grained rocks such as conglomerate and sandstone are more prolific than in other belts. The rocks are more or less metamorphosed by granitic intrusion at the north, and almost barren. Most portion of them had been estimated to be Palaeozoic in age (HIROKAWA, TOGO and KAMBE, 1954 b). The writer and his collaborators, however, collected *Neoschizodus* sp., "*Bakevellia*" sp. and small nuculid-pelecypods at several localities, all of which are surely comparable to those of the lower Triassic. From the lithic similarity in addition to the fossil evidences, it is conceived that the beds under consideration represent the deltaic facies of the Yakuno group. In contrast with the northern belt, the southern belt is entirely constituded by calcareous, well laminated shales, from which the writer reported the occurrence of the lower Triassic fossils, *Claraia pulchella* NAKAZAWA, *Meekoceras* sp. and others (NAKAZAWA, 1953). The formation is thought to be an offshore facies of the Yakuno group.

E. Ōe district*

The Triassic rocks in this district crop out in two separate patches on both sides of

* The geology will be reported in Journal of Geological Society of Japan under the following titles:

NAKAZAWA, K. and NOGAMI, Y.: Palaeozoic and Mesozoic Formations in the Vicinity of Kawanishi, Ōe District, Kyoto Prefecture, Japan.

NAKAZAWA, K. and SHIKI, T.: Palaeozoic and Mesozoic Formations in the Vicinity of Kawahigashi, Ōe District, Kyoto Prefecture, Japan.

the Yura river, one in the vicinity of Kawahigashi and the other in the vicinity of Kawanishi. The strata in these areas were tentatively named the Kawahigashi and Kawanishi groups respectively during the reconnaissance survey of the writer and S. OKADA (NAKAZAWA, 1951). At the same time, the "Kawahigashi group" was divided into the Narawara and Hirobatake formations, and the "Kawanishi group" into the Gujô and Ichio. The superfluous nomenclature is now simplified, inasmuch as it has been clarified by later investigations that they are nothing but eastern extensions of the Yakuno group.

(a) The Yakuno group in the vicinity of Kawanishi

The Gujô formation developed at Gujô in the eastern part of this area is alternating conglomerates, sandstones and shales, that are deltaic in nature. Described *Myophoria goldfussi* ALBERTI var. *kobayashii*, KAMBE (1951) referred its age as Ladinian or Carnian. The writer expressed his view independently that the formation was assumed to be contemporaneous but heterotopic with the upper half of the Ichio formation, and referred the middle Triassic age (NAKAZAWA, 1951). At that time he distinguished two facies in the formation, the Ichio and Gujô, regarding the different origins. After the detailed stratigraphical and palaeontological studies continued by him, now the writer comes to a conclusion that the portion belonging to the Gujô facies is late Permian in age, and the one included in the Ichio facies is early Triassic. The reasons are stated in the following lines. The name Gujô formation is emended to be ristricted to the Permian strata which is distributed in the eastern half of the Gujô district.

The Gujô formation proper contains characteristic faunule consisting mainly of pelecypods and brachiopods of both palaeozoic and mesozoic types. They are as follows:

Myophoria kobayashii KAMBE, *Neoschizodus* n. sp., *Bakevellia* (s. s.) *gujoensis* NAKAZAWA MS., *B.* (s. s.) *nipponica* NAKAZAWA MS., *"Pleurophorus" tenuistriatus* NAKAZAWA MS., *Actinodontophora* aff. *katsurensis* ICHIKAWA, *"Volsella"* sp., *"Lopha"* n. sp., *Pinna* sp., *Aviculopecten* n. sp., *Septimyalina* sp., *Edmondina* sp., *Allorisma* sp., *Schellwienella* cf. *ruber* (FRECH), *Spinomarginifera* aff. *kueichowensis* HUANG, *Bellerophon* sp., *Bucanopsis* sp., bryozoans and others.

Though the faunal study is not completed and the accurate consideration is left in future, it is reasonable to regard the age as late Permian rather than Triassic, perhaps not older than *Lepidolina-Yabeina* zone around the formation, judging from these fossil contents as well as the lithological features resembling the Permian Maizuru group. On the other hand *Neoschizodus* cf. *laevigatus*, *"Bakevellia" kambei*, *Sisenna? japonica* and stems of *Isocrinus* have been found from the bed belonging to the Ichio facies, all of which are typical members of the lower Triassic faunule. Furthermore it has been confirmed that the bed is in fault-contact with the Gujô formation proper. Accordingly the strata in problem are undoubtedly of lower Triassic.

The strata of the Yakuno group in the western neighbouring area of Gujô is

classified as follows due to the restudy of the writer and Y. NOGAMI (See columnar section, Fig. 8).

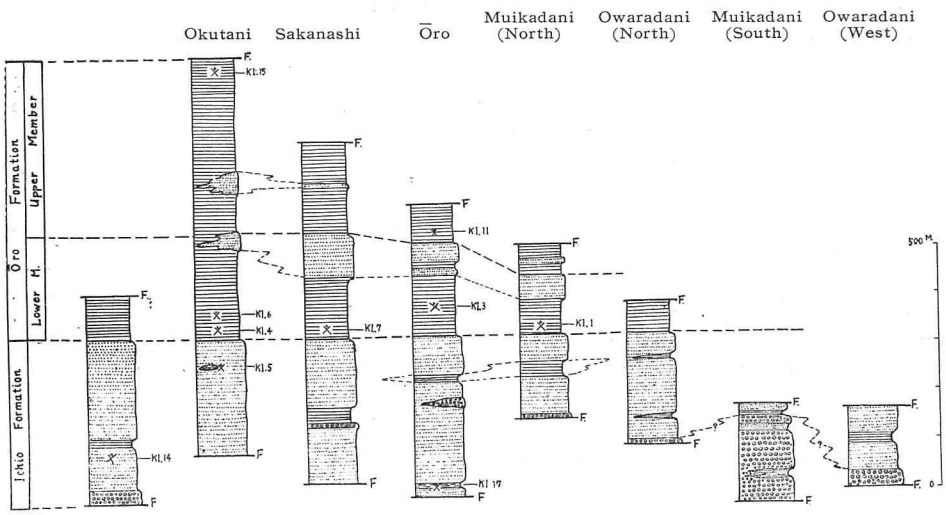


Fig. 8. Columnar sections of the Yakuno group in the vicinity of Kawanishi, Ōe district.

(2) Ōro formation

Upper member (Ou)···composed mostly of shales and sandy shales rarely intervening thin sandstones. More than 400 m thick.

Lower member (Ol)···consisting of upper sandstone bed varying from 0 to 80 m in thickness and lower muddy bed of 80–220 m in thickness.

(1) Ichio formation···composed mainly of fine- to medium- grained, more or less calcareous sandstones with intercalated shale and conglomerate beds of 10–80 m in thickness; containing rarely small lenses of dark grey or black oolitic limestone. Total thickness no less than 350 m.

The Yakuno is in contact with the upper Permian Maizuru group by faults and the base is not exposed.

A faunule seen in the Ichio formation is rather rare in kinds and in quantities. Most species range up into the Ōro formation (Table 4 and Fig. 9). *Neoschizodus* cf. *laevigatus* and *"Bakevellia" kambei* are chief constituents. An occurrence of *Meekoceras*? sp. in a shale block derived from the upper part suggests the middle Eo-Triassic age of this part.

The Ōro formation contains many fossils in its lowest part, for instance, *"Entolium"* cf. *discites* (SCHLOTH.), *"Pecten" ussuricus*, *Eumorphotis* aff. *tenuistriata* BITTNER, *Nuculana nogamii* NAKAZAWA MS., *N. nogamii yakunoensis* NAKAZAWA MS., *Pinna muikadaniensis*, *Palaeoneilo* spp., *Nuculopsis* (*Palaeonucula*)

Table 4. List of fossils of the Yakuno group in Kawanishi, Ōe district.

C: common, R: rare, r: very rare, Ol: lower member of Ōro formation, Ou: upper member of Ōro formation, I: Ichio formation,

Species \ Loc. No. KI-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Formatin	Ol	I?	Ol	〃	I	Ol	〃	〃	〃	I?	Ou	I	〃	〃	Ou	〃	I	〃	〃	〃
Neoschizodus cf. *laevigatus* (Zieth.)							R					C	R	C						
"Bakevellia" kambei Nakazawa MS.	R	R					R					C		C						
"Entolium" cf. *discites* (Schloth.)	R							R												
"Pecten" ussuricus Bittner	C			C			R													
Eumorphotis aff. *tenuistriata* Bittner	R																			
Nuculana nogamii yakunoensis Nak. MS.						R			R	r										
Nuculana sp. α aff. *excavata* Goldfuss							R							R			?		R	
Nuculana nogamii Nakazawa MS.				R											R					
Palaeoneilo sp. α			r				R													
P. sp. β							?													
P. sp. γ	R	R		R				R												
P. sp. δ	R	R		R				R												
P. sp. ε		R						R			R									
Nuculopsis (*Palaeonucula*) sp. α	R			R															R	
N. (*P.*) sp. β	R			C						R										
N. (*P.*) sp. γ				R																
Pinna muikadaniensis Nak. MS.	C			C		C				R										
Daonella ? sp.															R					
Pteria ? sp.												C								
Pelecypod gen. & sp. indet.	C			C		C			R											
Spiriferina spp. α, β	R				C				R											
Rhynchonella sp. α	R			R				R												
Rh. sp. β aff. *procreatrix* Bittner					R															
Sisenna ? *japonica* Kobayashi & Ichik.	R					C														
Sisenna ? sp. cf. *japonica*	C			C																
S. ? sp. α	?																			
Gastropod gen. & sp. indet.															R					
Meekoceras ? sp.																		r		
Pleuronautilus sp.					r															
Paratirolites ? sp.								r												
Monophyllites cf. *sphaerophyllus* (Hauer)															r					
Ammonite gen. & sp. indet.	R																			
Isocrinus-stem				R	R		R		R	R		R				R				C
Echinoid							R													

spp., *Spiriferina* spp., *Rhynchonella* sp. α aff. *procreatrix* BITTNER, *Rh.* sp. β aff. *griesbachi* BITTNER, *Paranautilus*? sp., *Michelinoceras* sp., *Paratilorites*? sp., *Sisenna*? sp. and others. Seemingly this part may be distinguished as a different zonule from the underlying Ichio formation by the occurrences of *"Pecten" ussuricus, Pinna muikadaniensis, Nuculana nogamii yakunoensis, Palaeoneilo* spp., *Rhynchonella* aff. *procreatrix* and others, but cannot be separated as a distinct zone, because these fossils are also found at the lower horizons in other districts. Founded on the chief constituents of faunules, both the Ichio and lowest part of the Ōro formations are summarized in a single zone of *Neoschizodus-"Bakevellia"*. Besides the lowest part, the Ōro formation is very scarce in fossil, and bears only scattering remains of *Sisenna*? *japonica* and *Palaeoneilo* sp. γ. However, very recently some important fossils were discovered from the uppermost part of the Ōro. They are *Monophyllites* cf. *sphaerophyllus* (HAUER), *Daonella*? sp., *Nuculana nogamii* and a gastropod species. The first species is most probably conspecific with *M.* cf. *wengensis* (KLIPSTEIN) of YABE and SHIMIZU (1927) from the Matsushiman (≒ latest Anisian or Ansio-Ladinian) Rifu formation near Sendai, Northeast Japan. Moreover, the other two species of the Ōro are also identical with those collected from the Rifu formation. *Daonella*? sp. is represented by fragmental specimens. These fossils strongly suggest that this part of the Ōro is correlative to the Rifu. This is the first discovery of the Rifu equivalent in Japan. The main part of the Ōro about 500 m in thickness is, therefore, estimated to be Anisian in age.

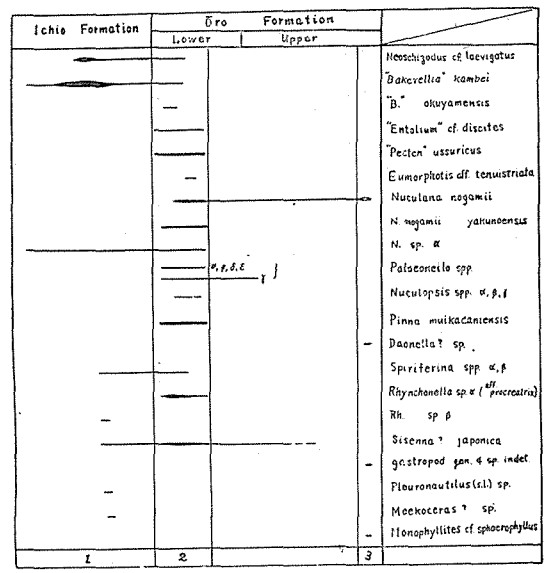


Fig. 9. Range-chart of species of the Yakuno group in the vicinity of Kawanishi, Ōe district. 1: *Neoschizodus-"Bakevellia"* z., 2: *"Pecten"-Pinna* z., 3: *Monophyllites* "zonule"

(b) The Yakuno group in the vicinity of Kawahigashi (See geological map, Fig. 10).

The Yakuno group in this area together with the upper Permian Maizuru group makes a complicated zonal structure clarified after careful investigations by the writer and SHIKI. At first the Yakuno group was subdivided into the Narawara and Hirobatake formations in descending order (NAKAZAWA, 1951). Now, it is known that the two formations are equivalent to each other in spite of their con-

spicuous difference in lithology. (See columnar sections, Fig. 11)

Hirobatake formation

This formation represents a facies rich in sandstone, and is divisible into two members.

Upper member (HBu)···composed mainly of shales and sandy shales intercalating fine-grained sandstone layers variable in lithofacies. More than 100 m thick.

Lower member (HBl)···consisting chiefly of fine- to medium-grained sandstones with a few interbedded shales of 5–15 m in thickness. More than 320 m thick.

The Hirobatake formation is rather poor in fossil, especially in the upper member. *Neoschizoidus* cf. *laevigatus*, *"Bakevellia" okuyamensis* MS., *"Pecten" ussuricus*, *Lingula* cf. *borealis*, *Spiriferina* sp. α and *Sisenna*? cf. *japonica* are the species obtained from the lower member and only two species, *Nuculana nogamii* MS. and *Sisenna*? *japonica* have been found from the upper. Inasmuch as all the species are common to the Hônôdani formation in the Yakuno district, the lower member is surely included in *Neosehizodus-"Bakevellia"* zonule. The fossils from the upper member are also common to the Ōro formation of the preceeding area. This member of the Hirobatake is probably referrable to the lowest part of the Ōro judging from the stratigraphical succession. Due to the scarcity of fossils, it is almost impossible

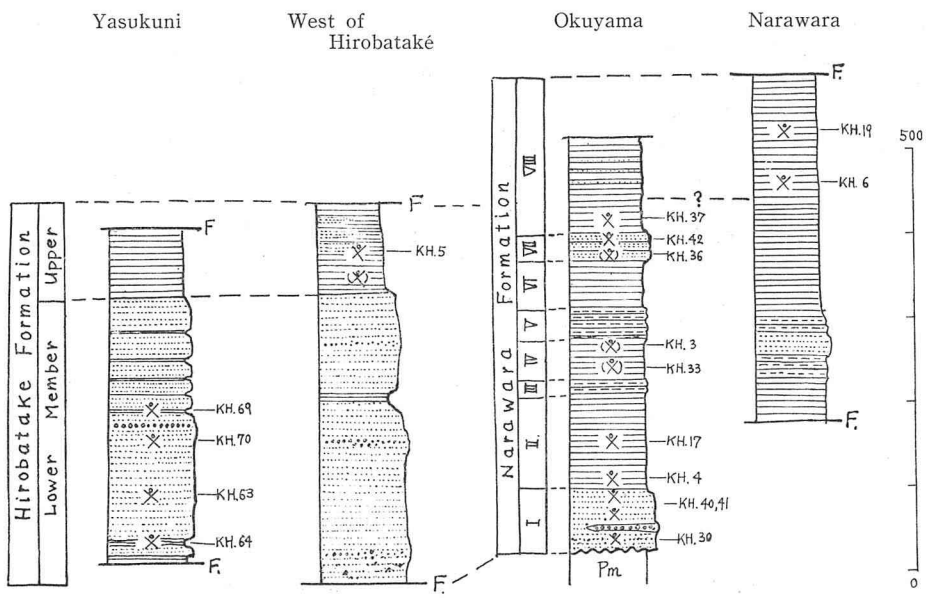
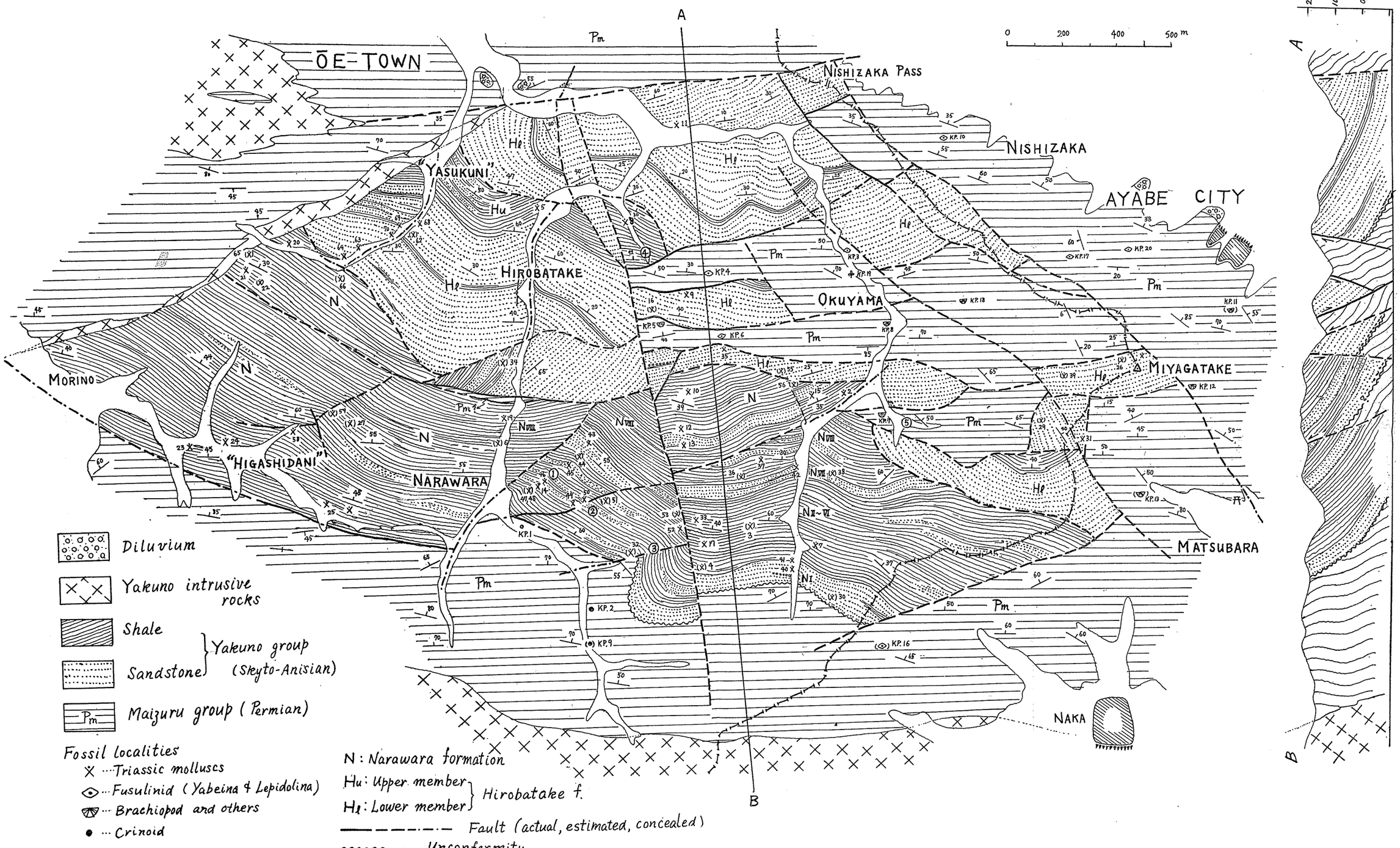


Fig. 11. Columnar sections of the Yakuno group in the vicinity of Kwahigashi, Ōe district.

Fig. 10. GEOLOGICAL MAP OF THE VICIMITY OF KAWAHIGASHI, ŌE DISTRICT by K. Nakazawa and T. Shiki, 1957



to distinguish zonules in the Hirobatake formation, though at least the distinction of *Nuculana nogamii* zonule from the lower *Neoschizouds-"Bakevellia"* zonule is permissible. (See fossil-list, Table 5)

To the east of Katsuradani fault of N–S trend the sandstone bed is repeatedly exposed together with the upper Permian shale bed, and yields many individuals of *Claraia okuyamensis* NAKAZAWA MS. and *Lingula* cf. *borealis* accompanied by *"Pecten"* cf. *ussuricus*, *"Neoschizodus" shikii* NAKAZAWA MS., *Spiriferina* sp. α and stems of *Isocrinus*. The bed is thought to represent the lower part of the lower member with the common occurrence of *Claraia*.

Narawara formation

The Narawara formation is better examined along the valley of Okuyama than in the type locality at Narawara. It is divisible into eight members. (Fig. 11).

The member VIII···composed mainly of sandy shales with alternating thin fine-grained sandstones, more than 100 m thick.

The member VII···fine- to very fine-grained sandstones with an interbedded shale layer of several meters in thickness, 26 m thick.

The members II–VI···composed chiefly of shales and sandy shales, each member identified by differences in minute lithologic characters such as bedding, lamination, colour and joints. Total thickness about 260 m.

The member I (basal sandstone)···fine- to medium-grained sandstone bed with a lenticular conglomerate of several meters in thickness, 75 m thick.

The basal sandstone of the Narawara overlies the Permian Maizuru group in clino-unconformity. The column along the valley of Okuyama is not applicable to any other section, because lateral changes of the lithic characters are large. In the western part of this area, the Narawara is represented exclusively by the shaly facies.

The basal member is rare in fossils, which consist of small *Neoschizodus* cf. *laevigatus*, *Claraia okuyamensis* MS., *"Pecten"* cf. *ussuricus*, *Lingula* cf. *borealis* and *Sisenna*? spp.. The Member II contains the following species in addition.

"Bakevellia" narawarensis NAKAZAWA MS., *"Pecten"* cf. *minimus* KIPARISOVA, *Claraia* aff. *decidens* BITTNER, *Nuculana* sp. α, *Palaeoneilo* sp. α cf. *elliptica* in KIPARISOVA, *P.* sp. β.

Most of these fossils occur also in the fossiliferous member IV, while the member III is barren. *"Bakevellia" tsuzuradaniensis* NAKAZAWA MS., *"Ophiceras"* sp. and *Michelinoceras* sp. join them in the IV. Beyond the member V fossils become very poor, and decrease the number of species. *Neoschizodus* cf. *laevigatus*, *"Bakevellia" okuyamensis*, *Lingula* cf. *borealis* and *Sisenna*? *japonica* are the elements of this member. The main portin of the member VIII is barren, with an exception of *Sisenna*? *japonica*, but the lithic aspect observed at the type locality is similar to the

Hollandites-"Danubites" zonule of the Waruishi formation in the Yakuno district. Based on such fossil-occurrences, *Claraia* zonule and *"Bakevellia" okuyamensis* zonule are identified. The two zonules together are correlated to *Neoschizodus-"Bakevellia"* zonule of the other districts. (See range-chart, Fig. 12, and fossil-list,

Table 5. List of fossils of the Yakuno group in the vicinity of Kawahigashi, Ōe district.

N: Narawara formation, I~VIII: Member of Narawara formation,
H: Hirobatake formation, (Hu: upper member, HL: lower member),
A: abundant, C: common, R: rare, r: very rare.

Species \ Loc. No. KH-	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	23
Formatin	N	IV	II	HU	VIII	II	HU	HL	N	HL	N	N	IV	N	HL	II	VIII	N	N	NL
Neoschizodus cf. *laevigatus* (Ziethen)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"Neoschizodus" shikii MS.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A	—	—	—	—	—
"Pecten" cf. *ussuricus* Bittner	—	—	—	—	—	—	—	R	—	—	—	—	—	—	R	—	—	—	—	—
"Pecten" cf. *sojalis* Wittenburg	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Claraia aff. *decidens* Bittner	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
C. okuyamensis MS.	?	C	R	—	—	—	—	C	—	—	—	—	R	—	R	—	—	—	—	—
"Bakevellia" okuyamensis MS.	A	—	?	—	—	—	—	?	—	—	—	—	R	?	—	—	—	—	—	—
"B." kambei MS.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"B." narawarensis MS.	—	A	C	—	—	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—
"B." tsuzuradaniensis MS.	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nuculana nogamii MS.	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. sp. α aff. *excavata* Goldf.	—	R	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Palaeoneilo sp. α cf. *elliptica* in Kipar.	—	A	—	—	C	—	—	—	—	C	—	—	C	—	—	C	—	—	—	—
P. sp. β	—	A	C	—	—	—	—	—	?	—	—	C	—	—	—	—	—	—	—	—
Selenimyalina ? sp. β	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—
"Pecten" cf. *minimus* Kiparisova	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anodontophora ? sp.	C	—	—	—	—	C	—	—	—	—	—	—	—	—	—	—	—	—	?	—
Spiriferina sp.	—	—	—	—	—	—	—	C	—	—	—	—	—	—	—	—	—	—	R	—
Lingula af. *borealis* Bittner	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	—	—
"Dentalium" sp.	—	—	—	—	—	R	—	—	—	—	—	C	—	—	—	R	—	—	—	—
Sisenna ? *japonica* Kobayashi & Ichikawa	—	—	—	C	C	—	R	—	—	—	R	—	—	—	—	—	R	R	?	—
Sisenna ? sp. cf. *japonica* K. & I.	—	C	C	—	—	C	—	—	—	C	—	C	C	—	C	—	—	—	—	R
"Ophiceras" sp.	C	?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ammonite gen. & sp. indet.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Paranautilus ? sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Michelinoceras sp.	—	r	—	r	—	r	—	—	—	—	—	R	—	—	—	—	—	—	—	—
Lima ? sp.	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Retzia sp.	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—
Gastropod gen. & sp. indet.	R	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Isacrinus-stem	—	C	—	—	—	—	—	—	A	—	—	—	—	R	—	—	—	—	—	—

Table 5) The formation is confirmed to be in contact with the Hirobatake formation by a fault, contrary to the former supposition of a conformable relationship. The two formations are now understood correlative to each other in spite of the lithological contrast.

(continued)

26	27	28	30	31	32	33	34	35	36	37	38	39	40	41	43	44	45	46	47	48	49	50	51	52	53	55	56	57	58	62	63	64–7	68	69	70
NU	HL	HL	I	HL	N	III	HL?	HL	VII	VIII	VII	HL	I	I	VII	N	VII?	V?	IV?	IV?	IV	IV	IV?	IV	IV	HL	N	N	NL	HL	HL	N	HL	HL	HL
—	—	—	R	—	A	C	—	—	R	R	C	—	—	—	R	—	—	—	—	—	—	—	—	R	—	—	A	R	—	—	R	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	R	—	—	—	—	—	—	—	—	—	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
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C	—	A	C	A	—	—	—	—	—	—	—	A	A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
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—	—	C	—	C	—	—	—	—	—	—	R	C	C	R	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	R	C	—	—	—	R
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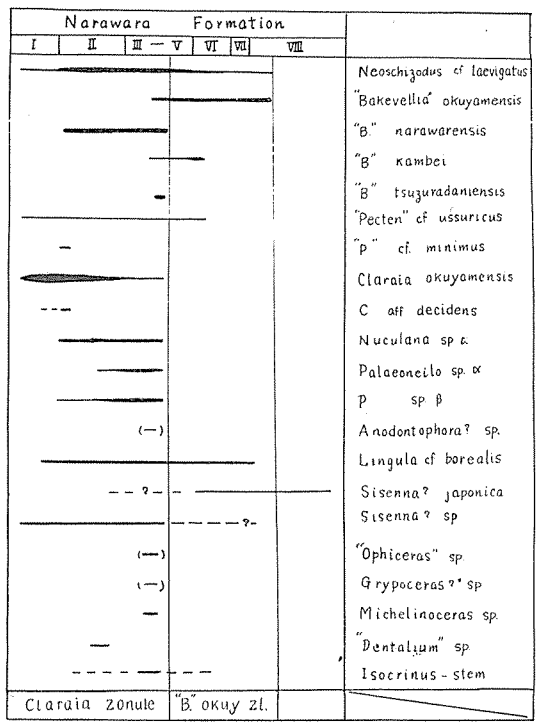


Fig. 12. Range-chart of species of the Yakuno group in the vicinity of Kawahigashi, Oe district.

F. Shidaka district

The presence of the coal-bearing Mesozoic strata in this area has been known since many yearns ago. S. OISHI (1932) describing 17 species of the fossil plants considered the middle Jurassic age. The floral list revised later by himself is quoted here (OISHI, 1940):

Cladophlebis nebbensis (BRONGN.), *Cl. denticulata* (BRONGN.), *Cl. haiburnensis* (L. & H.), *Cl. raciborskii* forma *integra* (OISHI), Cfr. *Zamites megaphyllus* (PHILLIPS), *Taeniopteris stenophylla* KRYSHT., *T. shitakensis* OISHI, *Czekanowskia* sp., *Podozamites griesbachi* SEWARD, *P. lanceolatus* (L. & H.).

T. KOBAYASHI (1939) expressed an opinion that the Shidaka flora is more closely related to the Liassic Kuruma and Carnian Miné floras than to the middle or upper Jurrasic Toyora flora; and that the age shall not be younger than Lias. Recently KAMBE compiled the following succession of the Shidaka group (1950).

(5) Shidaka formation···composed of conglomerates, sandstones and shales, bearing coal-seams, more than 260 m thick.

(4) Okadashimo formation···alternations of shale and sandstone with conglomerate at the base, 180–250 m thick.

(3) Okadayuri formation···alternations of sandstone and conglomerate, beginning with a thick conglomerate bed and ending with a shale bed, about 430 m thick.

(2) Fumuro formation···alternations of sandstone and conglomerate with intercalated reddish shales, about 600 m thick.

(1) Hannyaji formation···alternations of reddish shale, sandstone and fine-grained conglomerate about 180 m thick.

The Shidaka group of molasse-type deposit lies unconformably over the contorted Palaeozoic formation perhaps older than the upper Permian *Lepidoline-Yabeina* zone.

He discovered from the basal part of the Shidaka formation some marine fossils, such as *Myophoria* (=*Neoschizodus*), *Gervillia* (="*Bakevellia*") and *Nucula*?, and proved the Triassic age. Furthermore, he estimated it younger than the Carnian Nabac group in the Maizuru zone from the structural point of view.

Investigating the same area, the present writer arrived at a different conclusion. He could realize that the upper part of the Fumuro formation (KAMBE's MII_{3-4}) is nothing but the upper part of the Hannyaji formation (KAMBE's MI_{2-3}), and the Okadayuri is the Fumuro formation, both of which are exposed repeatedly by a fault. Accordingly the total thickness of the Shidaka group measures 1100 m, less than the KAMBE's estimation 1650–1720 m. (See columnar sections, Fig. 13). KAMBE

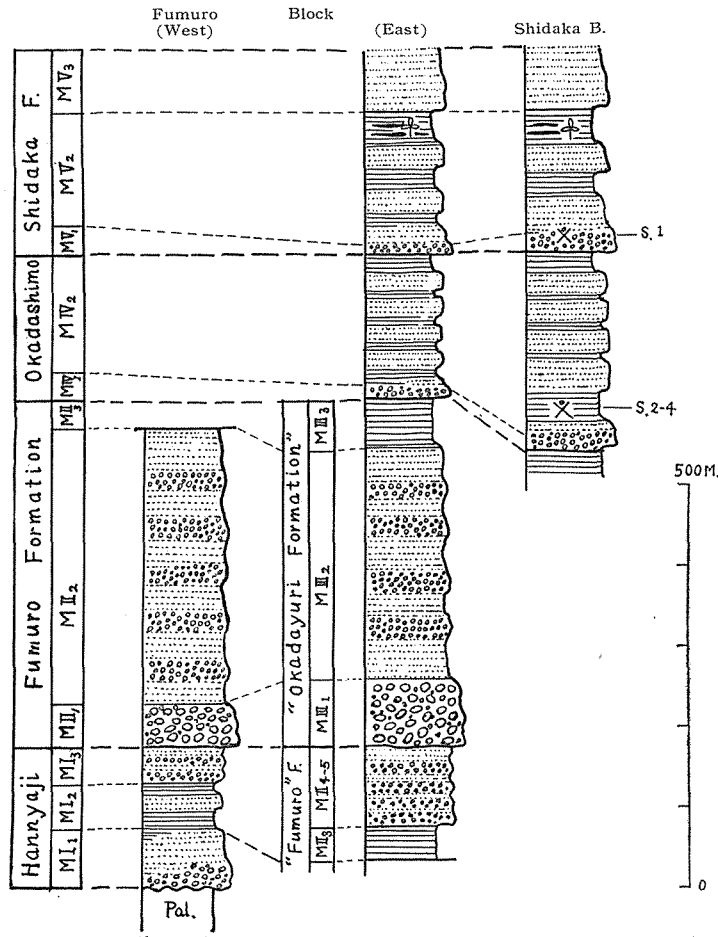


Fig. 13. Columnar sections of the Shidaka group.
After N. KAMBE emend. by K. NAKAZAWA

distinguished six species of "*Myophoria*" including two new species in his collection, namely, *Myophoria tangoensis* KAMBE, *M. shidakensis* KAMBE, *M.* α sp. nov. indet., *M.* β sp. nov. indet., Cfr. *M. laevigata* (ZIETHEN) var. *elongata* PHILIPPI and Cfr. *M. laevigata* (ZIETHEN) var. *rotunda* PHILIPPI, all of which belong to the *laevigata* group of RUBENSTRUNCK (=*Neoschizodus* GIEBEL). It is adequate to infer that these species and varieties fall into one or two species, because the specimens, suffered the crustal movement, have been deformed in various ways. With such fossils, it is almost impossible to determine the exact chronology but for a vague statement that the fossils are Triassic origin. However, "*Bakevellia*" sp. found in association with them is intimately related to "*B.*" *okuyamaensis* NAKAZAWA MS. from the lower Trias in the other districts. Furthermore, the writer collected *Palaeoneilo* sp. from the same locality and "*Bakevellia*" cf. *kambei* MS., *Palaeoneilo* sp., *Nuculana*? sp., "*Entolium*" sp., Michelinoceratoid? and a gastropod species from the shale of the Okadashimo formation subjacent the preceeding fossil bed. Most of these are allied, if not conspecific, to the fossils from the lower Trias in the Maizuzu zone. It is not unreasonable to regard the age of the main part of the Shidaka group be Eo-Triassic, approximate to that *Neoschizodus* horizon. Being slightly higher than the marine fossil bed in horizon, the plant bed is considered not younger than Anisian. How far the age of plant fossils goes back is an important question. The Rhaeto-Liassic type of flora appeared in Japan so early as in the Carnian epoch as pointed out by T. KOBAYASHI (1939).

G. Other districts in question.

The writer jointly with D. SHIMIZU (1955) described *Glyptophiceras japonicum* from a black shale obtained in the Yamasaki district, Hyogo Prefecture. Inasmuch as, in spite of their efforts, no Triassic strata could be found, they supposed that the *Glyptophiceras*-bearing block was derived from a small mass shut into the upper Permian rocks around the locality by faulting.

Another problem is news of an occurrence of *Daonella* from the tunnel of the Kishin railway line about ten kilometers west of Himeji, but unfortunately the specimen was missing. The locality under consideration is composed exclusively of tuff-breccia containing fragments of black shale, from which the fossil is thought to have been collected.

2. Zoning and Correlation

A. Zoning

The writer is of the opinion that a zone is a biostratigraphic unit limited to a sedimentary basin. It is desirable to set a zone after thorough stratigraphical and palaeontological examination. Correlation of local zonules must be established first. Zone-fossils should be preferred among the common forms over the whole basin. The Maizuru "belt"* deposits an entire sedimentary basin. As already stated, the

* To avoid the confusion between regional "zone" and biostratigraphic "zone", the Maizuru "belt" is used in this section instead of the Maizuru "zone".

lower half of the Triassic groups in this belt is prolific in pelecypods associated with brachiopods and gastropods, among which *Neoschizouds* cf. *laevigatus*, "*Bakevellia*" *kambei*, "*B.*" *okuyamaensis*, *Nuculana* spp., *Palaeoneilo* spp. and "*Pecton*" *ussuricus* occur everywhere in the belt. *Neoschizodus-*"*Bakevellia*" zonule distinguished in each district is now established as a distinct zone applicable to the entire basin. There can be recognized no remarkable difference among fossil contents. Therefore, the faunizone of the Maizuru belt is apparently unique. However, in the Ōe and Yakuno districts, *Claraia okuyamensis*, *C. pulchella* and *C.* aff. *decidens* are most probably restricted to the lower half, and *Nuculana nogamii* and its subspecies *yakunoensis* are confined to the upper. *N. nogamii* survived untill the later times. In this connection *Neoschizodus-*"*Bakevellia*" zone may be divisible into two subzones, namely, *Claraia* and *Nuculana nogamii yakunoensis* subzones at least in this area**. Most species of this zone common to or intimately related to species of other regions are of the lower Triassic as shown in the annexed table (Table 6). Although the species of ammonites are very rare and their situations among the

Table 6. All species are confined to Eo-Triassic in age except remarked ones.
T_1, T_2, T_3=E_0-, Meo-, Late-Trias, respectively.
○: Common species, △: intimate species

	Kitakami	Ussuri	Himalaya	Alps	Remarks
Neoshizodus cf. *laevigatus*	○	○	○	○*	*T_1-T_2
"*Bakevellia*" *kambei* MS.	cf. *exporrecta*	*exporrecta*	*exporrecta*	*exporrecta*	
"*Pecten*" *ussuricus*	○	○	—	—	
"*P.*" aff. *tenuistriata*	—	—	△	—	
"*P.*" cf. *minimus*	○	○	—	—	
"*P.*" aff. *sojalis*	—	—	—	△	
"*Entolium*" cf. *discites*	○	○	○	○*	*T_1-T_3
Eumorphotis aff. *multiformis*	△	△	△	△	
E. aff. *maritima*	△	△	—	—	
Claraia aff. *decidens*	—	—	△	—	
Palaeoneilo sp. α	—	*elliptica* in Kipar.	—	—	
P. sp. β	○	△	—	—	
Nuculana sp. α	—	—	—	*excavata**	*T_2-T_3
Lingula cf. *borealis*	—	○	—	—	
Spiriferina sp. α	—	—	*lilangensis**	—	*T_2
Rhynhonella sp. β	—	—	*procreatrix*	—	
R. sp. γ	—	—	*griesbachi**	—	*T_2
Terebratula sp.	—	*margaritowi*	—	—	

** Absence of these species makes it impossible to apply in the other districts, although subzone is desirable to have the same extension as zone.

fauna are only accessories, they are exclusively of Eo-Triassic, namely, "*Ophiceras*" sp., *Meekoceras* sp., *Pseudosagoceras* aff. "*intermontanum*" HYATT and SMITH, *Anakashmirites*? sp. from the lower part and *Paratirolites*? sp. from the upper. It is out of question that this zone belongs to the Eo-Triassic epoch.

Succeeding the *Neoschizodus-"Bakevellia"* zone comes the unbroken succession of thick bluish black shales all over the belt. The shales yield the prosperous cephalopods contrasting with the preceeding zone. There can be recognized two zones, one *Hollandites-"Danubites"* zone which is further subdivided into two zonules in the Yakuno district, and the other *Monophyllites* zone distributed only in the vicinity of Kawanishi, Ōe district. The former zone containing *Hungarites* aff. *proponticus, Danubites japonicum*, "*Danubites*" *kogai* MS., "*Hollandites*" *yakunoensis* MS., "*H.*" *torii* MS., *H.* sp., *Beyrichites* sp., *Pseudosageceras*? sp. and *Michelinoceras* sp. is presumed to be of an early Anisian origin. The latter one bearing *Monophyllites* cf. *sphaerophyllus, Nuculana nogamii* MS, *Daonella*? sp. and a gastropod, is of a latest Anisian or Aniso-Ladinian origin. Between the two zones there are shale beds of several hundred of meters almost lacking fossil, that are referred to the late Anisian in age, judging from the stratigraphic succession.

B. Correlation

The lower and middle Triassic section in each district within the

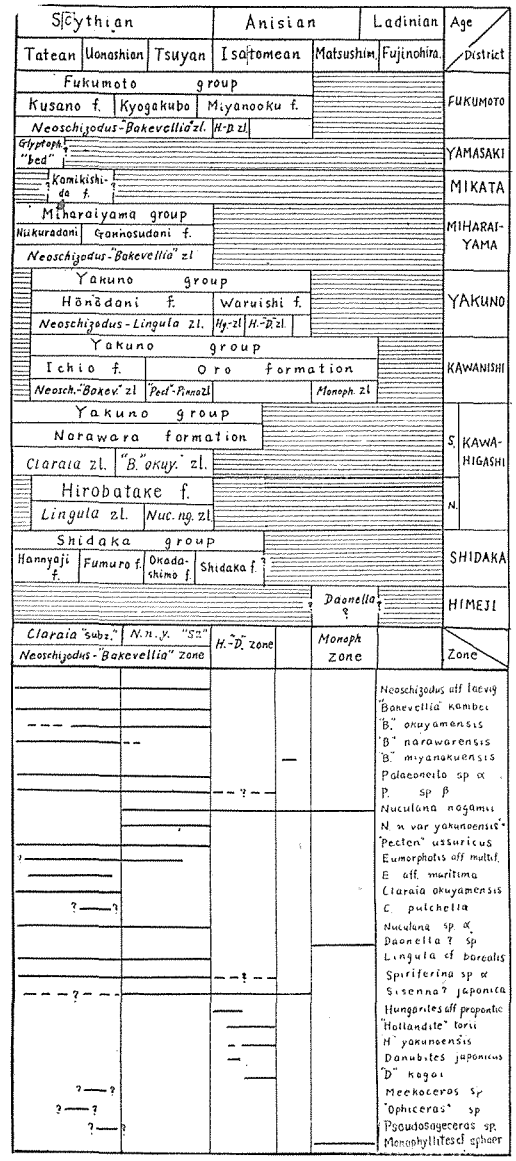


Table 7. Correlation of the lower to middle Triassic strata within the Maizuru zone, and range-chart of representative species.

N. n. y. "SZ"=*Nuculana nogamii yakunoensis* "subzone"
H.-"D". zone=*Hollandites-"Danubites"* zone.

Maizuru belt is correlated to each other as shown in the Table 7 using the zones, zonules and rock-stratigraphic sequences. The facies is fairly variable especially in the lower Triassic. The system as a whole resembles very much the Inai group of the southern Kitakami massif, Northeast Japan, both in fossil and in rock facies. It is a remarkable fact that their faunules in both areas are intimately related to those of the Himalaya and, especially, of the Ussuri region. In Japan the Anisian sediments are not exposed besides the above two areas, and the Scythian, too, is very limited in distrihution and only a part is seen. The Shionosawa limestone (H. OZAKI and T. SHIKAMA, 1954; Y. YABE, 1955) in the Kwanto massif is a limestone block 2 m thick presumably shut in the Permian by faults. It is crowded with shells of *Eumorphotis multiformis shionosawensis*, "*Bakevellia*" *ussurica* var. *rostrata* YABE, *Andontophora canalensis* etc.. The Iwai formation near Tokyo is about 85 m thick, composed of lower sandstone beds and upper shale. S. SAKAGAMI (1955) distinguished two fossil beds in the upper shale, i. e., *Ophiceras* bed with *Ophiceras iwaiensis* SAKAGAMI, *Vishnuites* sp., *Proptychites* aff. *rosenkrantzi* SPATH, *Kingites shimizui* SAKAGAMI, in its small limestone-lens and *Aspenites* bed containing *Aspenites* sp. in the marly nodule. He considers the formation ranging from Otoceratan to Owenitan of Eo-Triassic epoch. The Kurotaki limestone reported by S. MATSUSHITA (1926) from Kochi Prefecture in Shikoku is rich in pelecypod fossils such as *Eumorphotis multiformis* var., "*Pecten*" cf. *ussuricus*, "*Entolium*" *discites*, *Myalina* aff. *schmarae*, *Anodontophora canalensis* etc. The Tao formation* consisting of black shales with intercalated sandstones and limestone-lens is several tens of meters thick, and flourished by *Meekoceras-Anasibirites* faunule of middle Eo-Triassic age (S. YEHARA, 1925 and 1929; S. SHIMIZU and M. JIMBO, 1933).

It is obvious from the above statement, that these Lower Triassic beds are relatively thin, bearing no coarse-grained clastic rocks, and the fossils are generally concentrated in the limestone. This fact shows a marked contrast in depositional condintions between the Mairuzu-Kitakami regions and the others.

When ICHIKAWA (1950) proposed the chronological classification of Triassic period in Japan, he divided the Eo-Triassic period into three ages, Tatean, Uonashian and Tsuyan in ascending order. The Tatean is characterized by pelecypod fossils like *Eumorphotis nipponicus* ICHIKAWA MS. (aff. *maritima* KIPARISOVA), "*Pecten*" *ussuricus*, "*Entolium*" *discites*, *Neoschizodus* aff. *laevigatus* and *Anodontophora fassaensis*. He designated the lower to middle part of the Hiraiso formation of the Inai group as the type. The Uonashian is represented by *Meekoceras-Anasibirites* faunule of the Tao formation, and the Tsuyan by species of "*Xenodiscus*", *Ophiceras* s. l., Prohangaritoid, Pseudharpoceratoid, Keyserlingitoid and *Eumorphotis* aff. *telleri* BITTNER of the upper part of the Osawa formation lying conformably on the Hiraiso formation. At the same time, he included the Iwai formation and Kurotaki limestone in the Tatean. *Neoschizodus*-"*Bakevella*" faunule of the Maizuru belt is almost identical with that of the Hiraiso, the type of Tatean, but occurs commonly through the entire lower Triassic epoch in this belt. An accurate correlation by

* The Taho formation of many authors should be written more correctly the Tao formation.

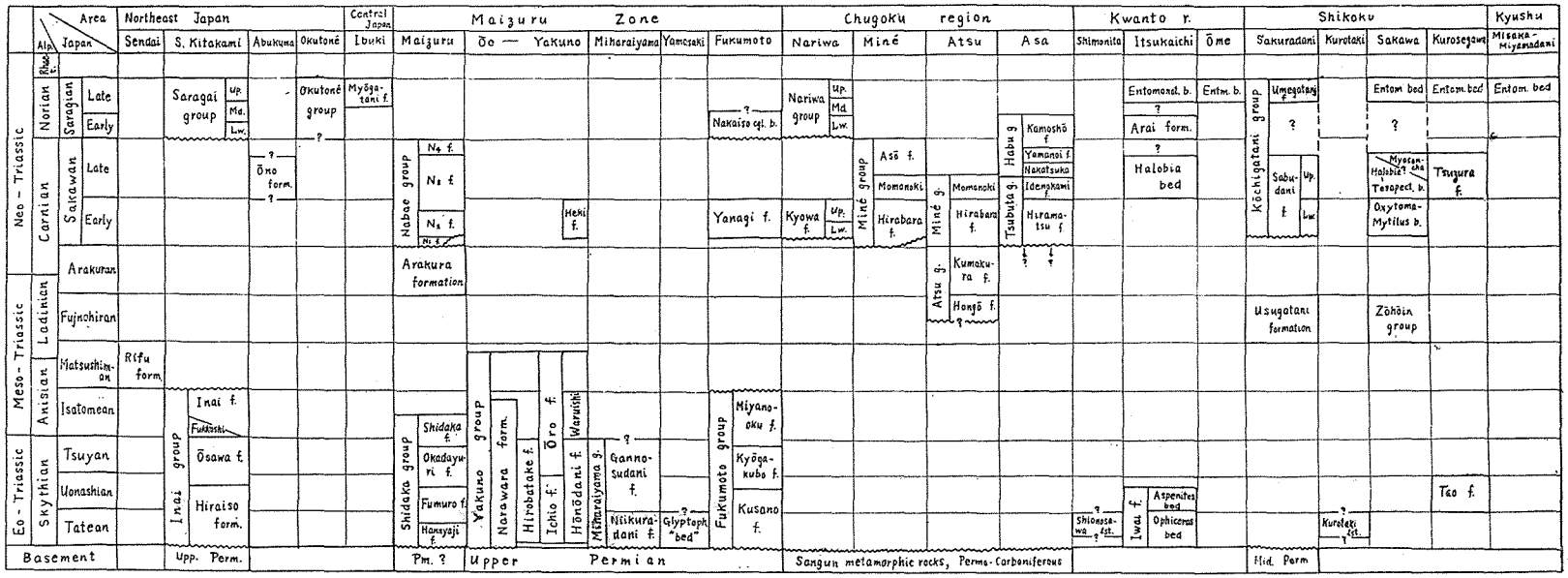


Table 8. Correlation of the Triassic Strata in Japan.

means of pelecypods appears to be very difficult in Japan. Accordingly the age of the Kurotaki and the Shionosawa limestones provided with no cephalopod cannot be determined exactly any more than it be undoubted Eo-Triassic.

Sufficient correlation will be accomplished after careful biostratigraphical investigation of other areas. A tentative correlation is shown herewith in Table 8.

3. Palaeogeography

A. Change of lithofacies (Fig. 14).

The lower Triassic system in the Maizuru zone is fairly changeable in rock facies. This phenomenon is clearely examined going along the strike-direction in the Yakuno and Ōe districts. In the northern belt of the Yakuno district, the conglomerate of the lower Triassic Hônôdani formation changes abruptly into the alternations of sandstone and shale. In the middle belt, the Hônôdani formation

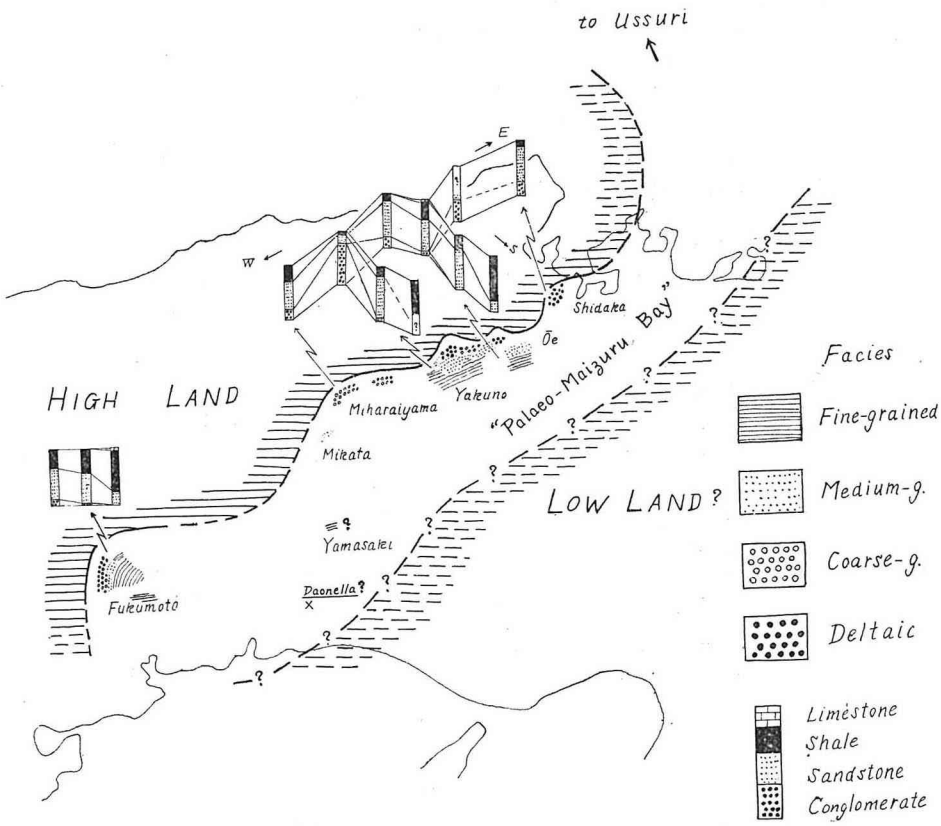


Fig. 14. Palaeogeographical map of the Maizuru zone during Eo-Triassic epoch.

consisting chiefly of sandstones varies laterally into the shale facies. At Gujô, the similar lithic change is also observed. The sudden change of rock facies and predominance of coarse clastic sediment indicate deltaic depositions at those places. In other districts, the changes are not so conspicuous showing the coastal deposition. Besides the change of strike-direction parallel to the axis of the Maizuru zone, a general tendency that the sediment becomes coarser toward the north (toward the west in the Fukumoto district) and finer toward the south border of this zone is schematized in Figure 14. The coarse-grained facies in the figure is composed mainly of the sandstone accompanied by the conglomerate several tens of meters thick or the alternations of conglomerate and sandstone; the portion especially rich in conglomerate, but variable in rock facies is distinguished as deltaic. The medium grained facies is consisting mainly of the fine- to medium-grained sandstones, intercalating shales, but almost without a conglomerate, while the fine-grained facies is mostly represented by the shale. The total thickness decreases in accordence with the grain-sizes. The Kusano and Kyogakubo formations in the type locality, the Miharaiyama group and a part of the Ōro formation are of coarse-grained facies. The Hônôdani formation in the northern belt of Yakuno, the Ichio formation at Gujô and the Shidaka group exhibit the deltaic facies. The Hônôdani formation in the middle belt, a part of the Ichio formation and the Hirobatake formation of Kawahigashi are of the medium-grained facies. On the other hand, the undivided Fukumoto group in the Fukumoto, the *Meekoceras*-bearing shales in the southern belt of Yakuno and the Narawara formation at Kawahigashi are the representatives of the fine-grained facies. The pattern of these facies arrangement indicates the presence of an uplifting land at the north side of the Maizuru zone. The *Glyptophiceras* "bed" at Yamasaki may be the offshore deposits far from the north land.

B. Change of biofacies

Parallel to the change of the sedimentary facies, the biofacies also varied from place to place. The deltaic facies is almost lacking in fossil. Fossils of the coarse-grained facies are represented by *Neoschizodus* cf. *laevigatus* and *"Bakevellia" kambei* generally crowded in fossil banks, associated with a few other forms. In the fine- or medium-grained facies *"Bakevellia" kambei* is replaced by *"B." okuyamensis* or *narawarensis* and *Neoschizodus* cf. *laevigatus* is substituted for small type, furthermore *Lingula* cf. *borealis* is apparently confined to these facies. *Claraia* and smooth brachiopods are mostly found in the fine-grained facies. *"Pecten" ussuricus* occurs in all facies, but it has a tendency to become smaller in the upper horizons. *Nuculana* and *Palaeoneilo* are also common in all facies. They are found generally massed in the shales, forming thin fossil-layers or scattered in the sandstones. Cephalopods are found chiefly in the fine-grained facies or in the shales of the other facies.

The relation between litho- and biofacies is shown diagrammatically in Fig. 15.

C. Palaeogeography (Fig. 14)

As discussed above, there was the unquestionable uplifting high land during the

Eo-Triassic epoch, bordering the north side of the Maizuru zone, which extends west-southwest from Maizuru to Okayama for about 130 km. But the southern margin is not always clear. Yamasaki is the southernmost locality of the lower Triassic. Going farther south there is no reliable Triassic rocks not to speak for the medium or coarse-grained facies. Judging from these facts, a southern low land faced the "Palaeo-Maizuru Bay" is inferred.

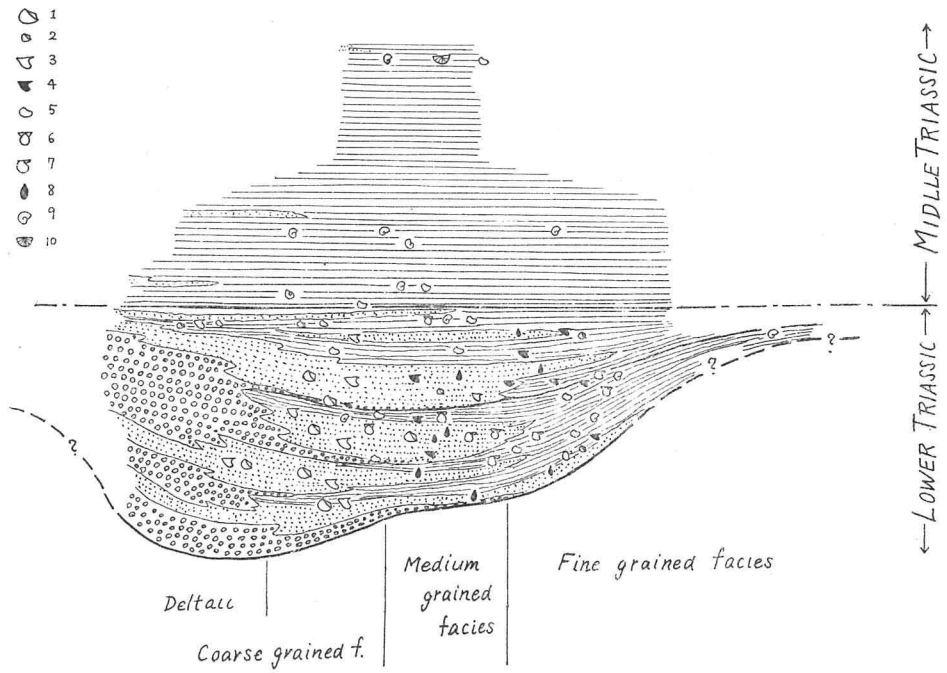


Fig. 15. Schematic profile of the Maizuru zone showing the relation between bio- and lithofacies.

1. *Neoschizodus* cf. *laevigatus* (large form), 2. *N.* cf. *laevigatus* (small form), 3. *"Bakevellia" kambei*, 4. *"B." okuyamensis*, 5. *Nuculana* and *Palaeoneilo*, 6. *"Pecten" ussuricus*, 7. *Claraia*, 8. *Lingula* cf. *borealis*, 9. Cephalopods, 10. *Daonella*? sp.

The middle Triassic formation at all places in this zone consists mostly of the homogeneous, laminated shales and sandy shales and is characterized by cephalopod fossils. If taking into the consideration of the uncertain occurrence of *Daonella* near Himeji in addittion to the above facts, the Maizuru Bay seems to have extended widely more than the above statement. The crustal movement became weaker during the early Meso-Triassic epoch.

It is reasonable to suppose that the Maizuru Bay invaded into the Ussuri region,

where the Triassic system is closely related to that of the Maizuru zone both in faunule and lithofacies. But the direct communication to the Pacific Ocean through Shikoku considered by KOBAYASHI (1956) seems to be negative to the writer by the following reasons:

(a) A distribution of the lower to middle Triassic group is intimately connected with the upper Permian series in the Maizuru and southern Kitakami massif. In the Maizuru zone the latter series extends westward nearlly parallel to Seto Inland Sea beyond the Fukumoto district, the western extremity of the former group, but does not go toward Shikoku.

(b) The Triassic system has a trend of N–S direction at Fukumoto suggesting a tendency to close the Maizuru Bay.

(c) The faunule and rock facies are less similar to those of Shikoku than to those of the Ussuri region, although the latter region is situated far apart from the Maizuru zone.

However, the writer must confess that he has not a sufficient idea substituting KOBAYASHI's opinion, although the Maizuru Bay is considered to have been connected with the Pacific Ocean somewhere through the Japan Sea.

UPPER TRIASSIC SYSTEM

The Fujinohiran (≒ Ladinian) stage is not discovered in the Maizuru zone. Distribution of the Arakuran (≒ Ladino-Carnian or earliest Carnian, newly proposed in this paper) is comparatively small, while the Sakawan (≒ Carnian) Nabae group occupies wide places in the zone, and the Saragian (≒ Norian) Nakaiso conglomerate bed is only seen in a small area of the Fukumoto district.

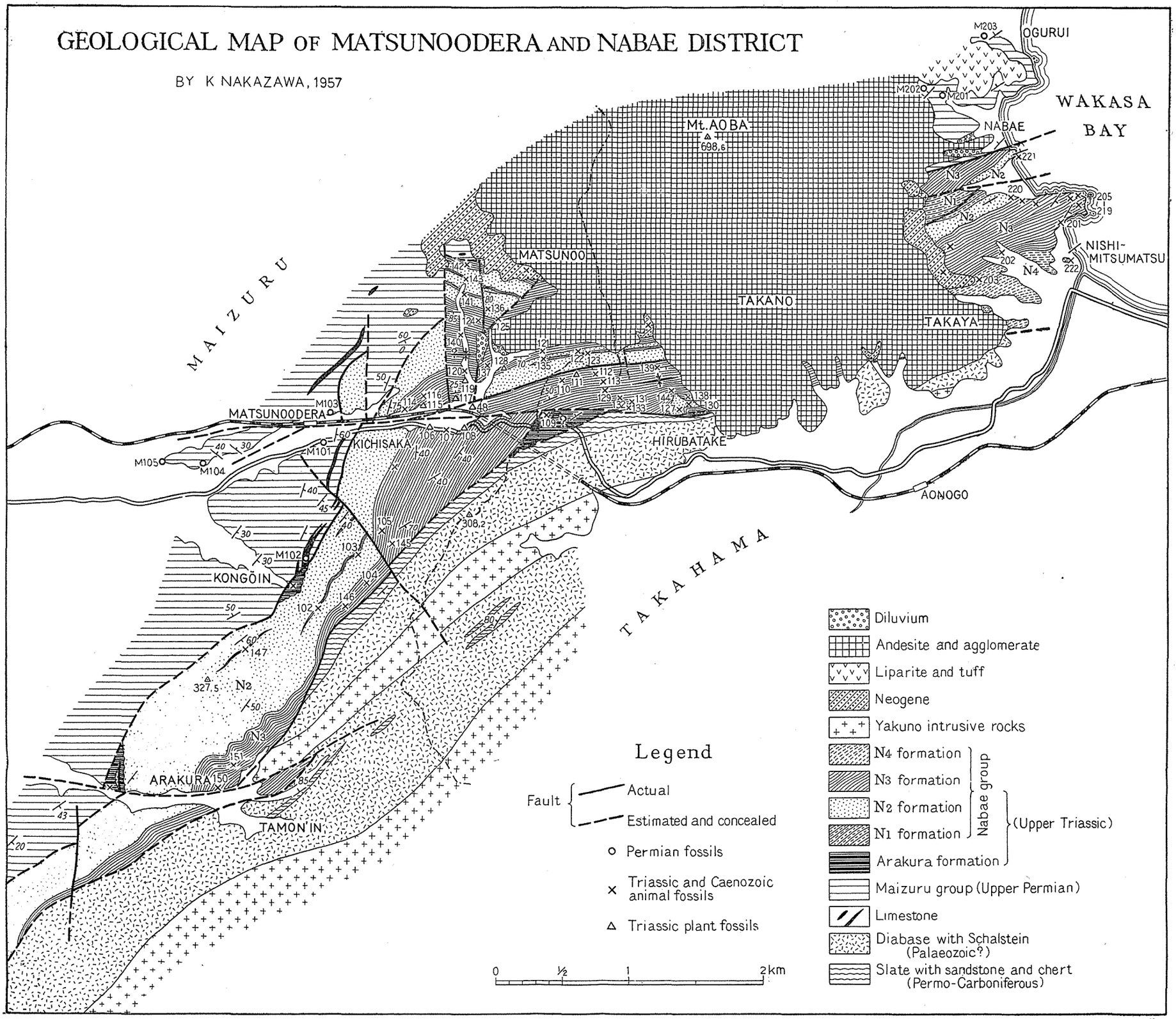
1. Arakura formation (See geological map, Fig. 16)

The writer has given a statement that the N_1 formation of the Nabae group is present at Arakura, Maizuru City (NAKAZAWA and OKADA, 1949). It is better to separate the "N_1" at this place with a new name, Arakura formation from the Nabae proper. The reasons are:

(1) The strata in question are confirmed to be overlain by the N_2 formation with a slight clino-unconformity at Arakura, while the N_1 passes conformably into the N_2 at the type locality Nabae.

(2) They are composed mostly of black shales and sandy shales which are more or less slaty and hardly distinguishable from those of the Permian Maizuru group. The sediments are considered to be open sea deposits, judging from its fossil content. On the other hand, the N_1 is alternations of sandstone, conglomerate and shale with a few, thin, poor coal-seams, and only the uppermost horizon yields marine shells. The N_1 seems to be deposited under fresh or brackish water at the beginning of transgression.

Fig. 16. GEOLOGICAL MAP OF MATSUNOODERA AND NABAE DISTRICTS by K. NAKAZAWA, 1957



(3) Fossils of the Arakura entirely differ from those of the N_2, while the N_1 is essentially similar to the N_2 in this connection.

The absence of the N_1 at Arakura is explained by overlapping of the N_2 which seems to be the oulcome of the most transgressive reach during the Sakawan age. The lower boundary of the Arakura is not seen, but, it is assumed to be in a fault-contact with the Maizuru group. The formation consisting mostly of shales and sandy shales with interbedded thin sandstone layers is no less than 70 m in thickness; and it has some marine animal fossils at several horizons, such as: "*Monophyllites*" *arakurensis* NAKAZAWA MS., *Monophyllites* sp., *Holobia*? sp., *Palaeoneilo* sp., *Lima* sp., *Nuculopsis* (*Palaeonucula*) sp., *Psioidea* spp. α, β, *Spiriferina* sp., gastropods and bryozoans. (See columnar sections, Fig. 17) Inasmuch as all of them have been severely deformed by force of the secondary influences

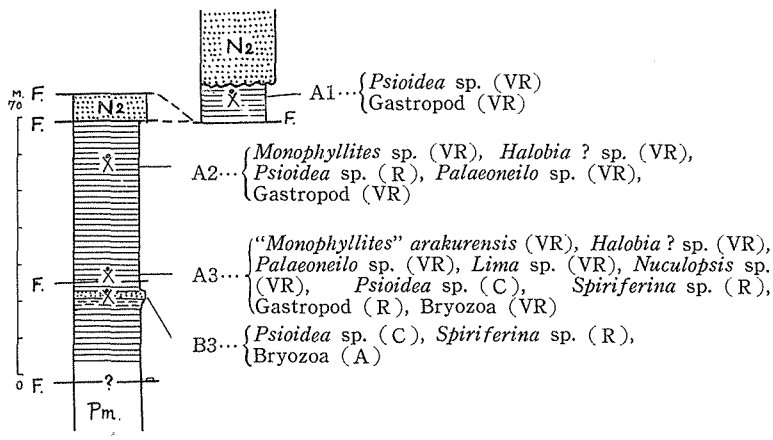


Fig. 17. Columnar sections of the Arakura formation.

Pm.: Maizuru group (upper Permian), N_2: N_2 formation of the Nabae group, (A): Abundant, (C): Common, (R): rare, (VR): very rare

and scarce in individual number except *Psioidea*, their specific determination is difficult in general. Among them, "*Mhnophyllites*", *Psioidea*, and *Halobia*? are the important species for the determination of age. "*Monophyllites*" *arakurensis* will represent a new genus in Monophyllitidae. The suture line is similar to that of *Mojsvarites*, smooth Monophyllitid ranging from Carnian to Norian, but the sculpture resembles that of *Monophyllites* s. s., though stronger near and on the ventral side. The species is certainly derived from *Monophyllites* stock like *Mojsvarites*. *Psioidea* sp. α has a striking resemblance to *P. conjuncta* HECTOR from the Oretian ($\fallingdotseq$ lower Carnian) of New Zealand. *Halobia*? sp. is better referrable to the genus than to *Daonella*, although the specimens are fragmentary. These fossils suggest the Carnian age rather than Ladinian. But, on the other hand, the formation is

overlain unconformably by the Sakawan Nabae group which is safely correlated to the Carnian of the Alps. So the age should be regarded as earliest Carnian or Ladino-Carnian.

ICHIKAWA (1950) classified Meso- and Neo-Triassic epochs in Japan into five ages, Isatomean, Matsushiman, Fujinohiran, Sakawan and Saragian corresponding approximately to Anisian, Aniso-Ladinian, late Ladinian, Carnian and Norian respectively. The Zôhôin group in Shikoku selected by him as the representative of the Fujinohiran is characterized by typical Ladinian fossils such as *Protrachyceras*, *Trachyceras*, *Danella* and others. The Miné group in Yamaguchi Prefecture designated as the type of the Sakawan is underlain conformably by the Atsu group which is referred by him to the Fujinohiran. But a stratigraphical relation between the Zohoin and Atsu groups cannot be ascertained, because they are distributed far apart from each other. KOBAYASHI (1950) is sceptical of the correlation without any common fossil between them, and he has pointed out a possibility to set up another unit of age between the two. Unfortunately the Atsu group is too poor in fossil to deal with this problem. As will be stated later, the Nabae group being the undoubted equivalent of the Miné, the Sakawan stage, the Arakura formation is conceived to be older than the Sakawan viewing from the stratigraphical stand point and youger than the Fujinohiran with the palaeontological evidences. This fact demands a new unit of age as suggested by KOBAYASHI. Here the writer proposes the Arakuran age as a chronological unit filling the gap between the Fujinohiran and the Sakawan. Whether the entire Atsu group can be included in the Arakuran stage or not is a question left in future, for the Atsu group is much thicker than the Arakura.

2. Nabae group (Fig. 16)

The Nabae group is distributed from east to west extending over 130 km in the following districts: Nabae, Matsunoodera, Ikenouchi (including Terada), Yata (including Oyogi), Monobe, Yakuno and Fukumoto. (See Fig. 1) The subdivisions (N_1–N_4 formations) established at Nabae are applicable to Monobe west of the type locality for about 30 km.. The detailed biostratigraphical examination has already been reported (NAKAZAWA, 1957).

1. Brief note of biostratigraphy

A. Nabae district (See Fig. 18)

A complete sequence of the group is obtained on the sea shore of the Wakasa Bay in this area, where the group is divisible into four formations as follows:

N_1 formation···Alternations of shale, sandstone and conglomerate, containing several, discontinuous, thin coal-seams. Lower limit not exposed, presumably lying on the upper Permian Maizuru group with a well-marked clino-unconformity. More than 70 m thick.

N_2 formation···composed entirely of fine- to medium-grained, light coloured

sandstones with a lenticular conglomerate in the type section, but intercalating a few shale layers in the northern wing. Thickness about 130 m.

N_3 formation···consisting exclusively of well-bedded black shales and sandy shales, rarely with intervened thin, very fine-grained sandstones. Some 380 m thick.

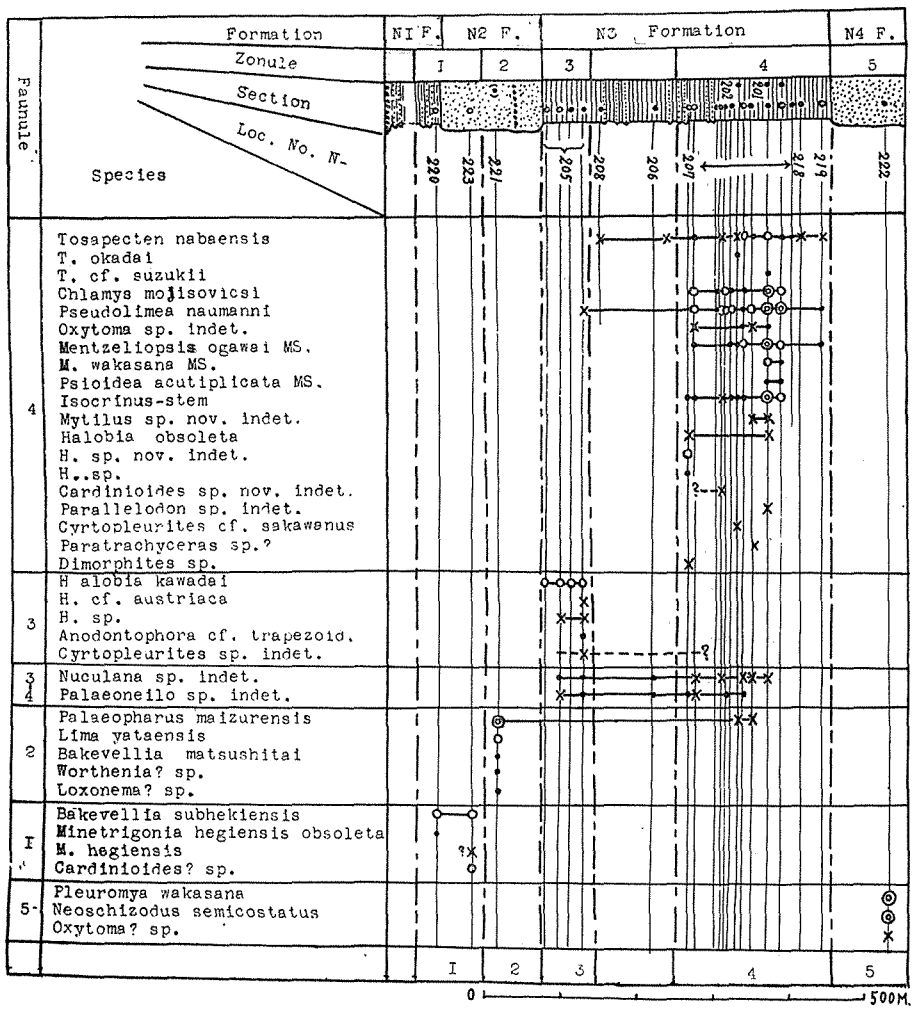


Fig. 18. Range-chart of species of the Nabae group in the Nabae district.

1: *Bakevellia subhekiensis* zonule, 2: *Palaeopharus-Lima yataensis* zonule, 3: *Halobia* zonule, 4: *Tosapecten-Pseudolimea* zonule, 5: *Neoschizodus-Pleuromya* zonule, ◎: abundant, ○: common, ●: rare, ×: very rare

N_4 formation···composed generally of fine- to medium-grained, sometimes, muddy sandstones similar to the N_2. Upper limit considered to be intruded by the so-called Yakuno intrusive rocks. More than 360 m thick.

Main portion of the N_1 is entirely lacking in animal remain and is thought to have been deposited under fresh or brackish waters. From its uppermost horizon some marine pelecypods are found such as *Minetrigonia hegiensis obsoleta* NAKAZAWA and *Bakevellia subhekiensis* NAKAZAWA.

The N_2 contains the shallow sea forms such as *Bakevellia subhekiensis* and *Cardinioides*? sp. in the lower part, and *Palaeopharus maizurensis* KOBAYASHI and ICHIKAWA, *Lima yataensis* NAKAZAWA, *Bakevellia matsushitai* NAKAZAWA and gastropods in the upper part on the northern wing at Kosaki.

The N_3 is everywhere abundant in pelecypods and brachiopods. It is divisible into two zonules founded on the marked contrast of fossil-assemblages. The lower part is characterized by *Halobia* faunule including *H. kawadai* YEHARA, *H.* cf. *austriaca* MOJSISOVICS, *H.* sp. β, *Anodontophora*? cf. *trapezoidalis* MANSUY and *Cyrtopleurites* sp., while the upper part is represented by *Tosapecten-Pseudolimea* faunule constituted mainly by *Tosapecten nabaensis* NAKAZAWA., *Chlamys mojsisovicsi* KOBAYASHI and ICHIKAWA, *Pseudolimea naumanni* (KOBAYASHI and ICHIKAWA), *Holobia obsoleta* KOBAYASHI and AOTI, *Mentzeliopsis ogawai* NAKAZAWA MS., *M. wakasana* NAKAZAWA MS..

The N_4 yields fossils at only one locality, where *Neoschizodus semicostatus* NAKAZAWA and *Pleuromya wakasana* NAKAZAWA are crowded in a thin layer.

The Nabae group may be divided into five zonules as shown in Fig. 18, of which *Bakevella subhekiensis* and *Pleuromya-Neoschizodus* zonules are put forward for the time being, as the criteria seem to be insufficient.

B. Matsunoodera district (See Table 9).

A shale bed assumed to be the N_1 crops out at a place in the northern area of this district, covered conformably by the N_2. *Ostrea*? sp. and *Anodontophora* sp. are the only fossils in hand.

The N_2 attaining more than 520 m in the maximum thickness overlies disconformably the Arakura formation at Arakura as already stated. Fossils are rather rare in the lower part but rich in the upper. Inasmuch as the most species from the lower also occur in the upper, all the N_2 is included in one and the same zonule, though the number of species in the upper is far greater than that of the lower. *Minetrigonia hegiensis*, *M. hegiensis obsoleta*, *Homomya matsuoensis* NAKAZAWA, *Cardinia triadica* KOBAYASHI and ICHIKAWA, *Bakevellia matsushitai*, *Lima yataensis*, *L. yatensis* var. *kuredaniensis* NAKAZAWA are the representative elements.

The N_3 is composed mainly of shales and sandy shales like in the Nabae, but is associated with several coal-seams suggesting a different depositional environment from the Nabae. Marine animal fossils are almost limited to the lower 100 m, while plant fossils occur throughout. The animal fossils are grouped into two faunules; one is *Anodontophora* faunule represented by thin shelled *A.* (?) aff. *manmuensis*

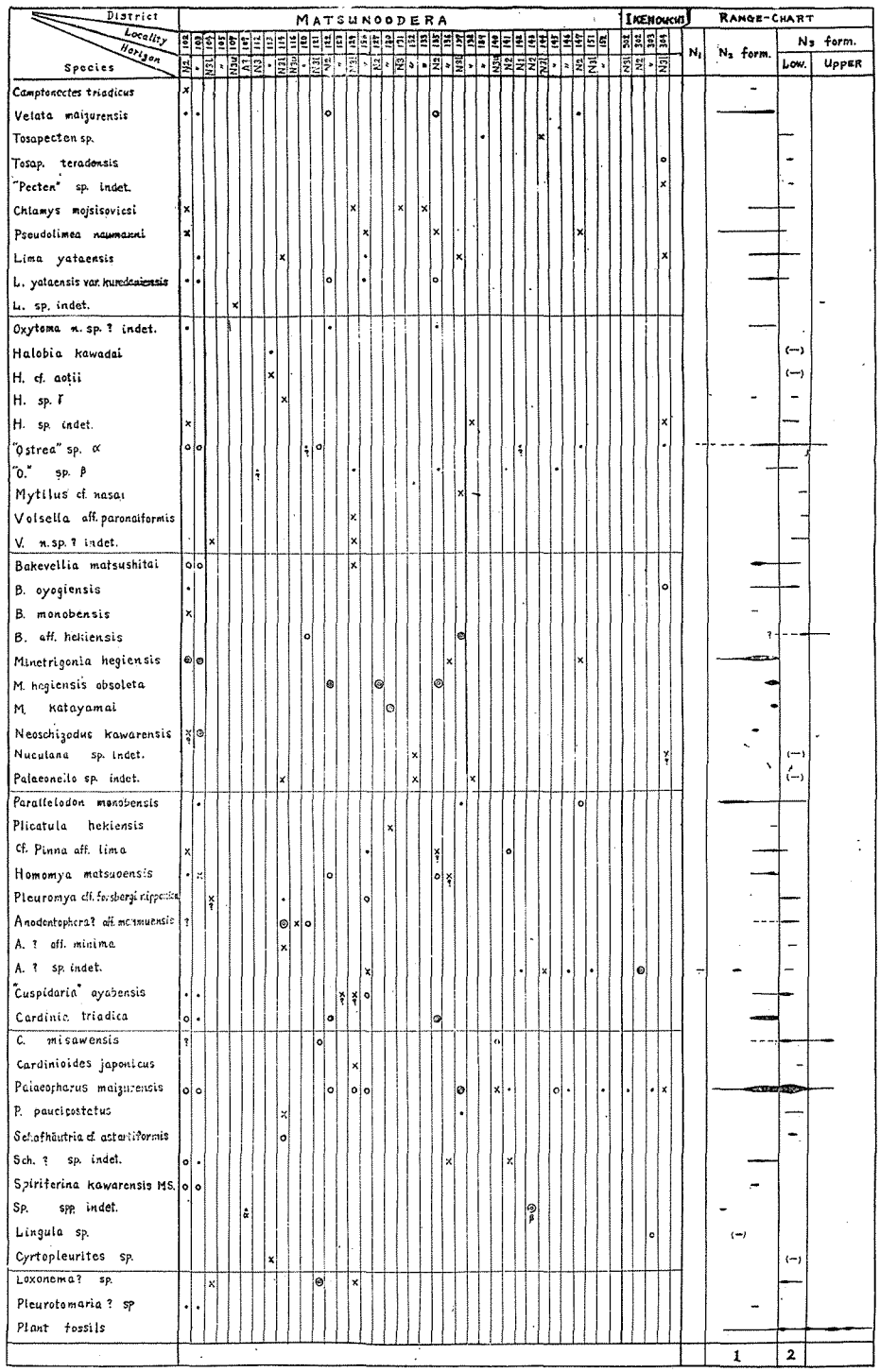


Table 9. List of fossils of the Nabae group and the range-chart in the Matsunoodera and Ikenouchi districts.
Symbols are same as in Fig. 18.
1: *Minetrigonia-Homomya* zonule, 2: *Anodontophora-Palaeophalus* zonule

REED, *A.* (?) aff. *minima* MANSUY, *A.* sp., *Schafhäutlia* cf. *astartiformis* (MÜNSTER) accompanied by a small number of *Halobia*, *Palaeopharus* and *Pleuromya*?. They seem to indicate a calm brackish water environment. The other one comprises *Bakevellia matsushitai*, *Lima yataensis*, *Parallelodon monobensis* NAKAZAWA, "*Cuspidaria*" *ayabensis* NAKAZAWA, *Palaeopharus maizurensis*, *Volsella* spp. etc. common to the underlying zonule, except for the last species. However, *Minetrigonia hegiensis*, *Homomya matsuoensis* and *Cardinia triadica* of the N_2 dissapeared; so *Andontophora-Palaeopharus* zonule occupying the lowest part of the N_3 is separable from the lower zonule. Presumably owing to the unfavourable evironment, the main part is so poor in animal fossil as it can hardly be zoned. *Cardinia misawensis* KOBAYASHI and ICHIKAWA, *Palaeopharus maizurensis*, *Lima* sp. and *Bakevellia* aff. *hekiensis* are found sporadically in the middle part, but none in the upper besides fragmental plant impressions.

Above-mentioned fossil assemblages of the N_3 are quite different from those in the Nabae, but a similar faunule to the latter is found in a narrow belt in the central area hemmed in by faults, for example, the occurrence of *Halobia* cf. *kawadai*, *Nuculana* sp., *Cyrtopleurites* sp. and *Isocrinus*-stem at Hôdaiyama (loc. no. N. 113), and *Tosapecten* sp., *Palaeoneilo* sp., *Nuculana* sp. and *Anodontophora*? sp. at Kurodani (N. 138, 144).

The N_4 is not exposed.

C. Ikenouchi district (See Table 9)

Only the N_2 and N_3 formations are developed. The N_2 is scanty in fossil. A small number of *Palaeopharus* and *Lingula* sp. were obtained from the lowest part and small *Anodontophora* from a middle horizon. It is noticeable that the elements of *Bakevellia*-"*Cuspidaria*" faunule flourished in the neighbouring Yata district, such as *Bakevellia oyogiensis*, "*Cuspidaria*" *ayabensis*, *Lima yataensis* and *Palaeopharus maizurensis* are found associated with the Nabae elements like *Tosapecten teradensis* NAKAZAWA and *Halobia* sp..

D. Yata district (See Table 10)

The N_1 and N_4 formations are also absent.

A faunule of the N_2 agrees very well with *Minetrigonia-Homomya* faunule in the Matsunoodera. Most species are also found in the lowest part of the N_3, but *Minetrigonia* and *Homomya* were diminished here as well. *Bakevellia hekiensis*, *B. oyogiensis* NAKAZAWA, *Cardinioides japonicus* KOBAYASHI and ICHIKAWA, *Lima yataensis*, *Volsella* sp. are the species restricted in the N_3. *Velata maizurensis*, and "*Cuspidaria*" *ayabensis* are predominent here. The lowest part of the N_3 is distinguished as *Bakevellia*-"*Cuspidaria*" zonule from the underlying *Minetrigonia-Homomya*. The succeeding strata have no animal fossil.

E. Monobe district (See Table 10)

The N_2 formation is small in exposures, comprising *Minetrigonia hegiensis* and "*Ostrea*" sp.. The fossils of the lowest part of the N_3 is rich, those similar to the

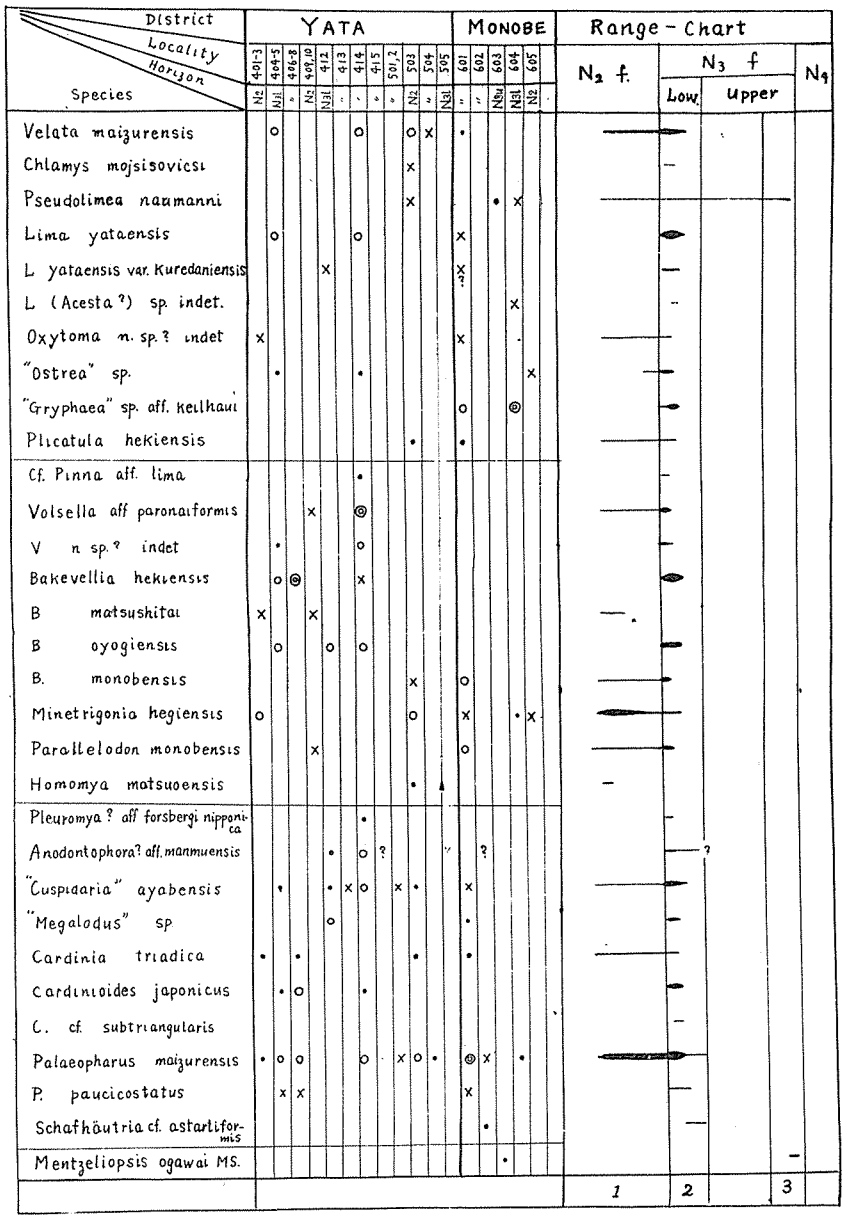


Table 10. List of fossils of the Nabae group and range-chart in the Yata and Monobe districts.

1: *Minetrigonia-Homomya* zonule, 2: *Bakevellia*--"*Cuspidaria*" zonule
3: *Pseudolimea-Mentzeliopsis* "zonule"
(For *Plicatula* in the table, read *Plicatura*.)

Bakevellia-"Cuspidaria" assemblage, *Plicatula hekiensis* NAKAZAWA, *Bakevellia monobensis* and *Parallelodon monobensis* are more common than in the Yata, and *"Gryphaea"* aff. *keilhaui* KIPARISOVA is a new face. It is a remarkable fact that *Minetrigonia hegiensis* is not rare in this part. The rest of the N_3 is barren except the uppermost horizon, from which the representative elements of *Tosapecten-Pseudolimea* zonule such as *Pseudolimea naumanni* and *Mentzeliopsis ogawai* were collected.

The N_4 distributed in a small area bears no fossil.

In conclusion, the Nabae group in this district are zoned into three zonules, *Minetrigonia*, *Bakevellia-"Cuspidaria"* and *Pseudolimea-Mentzeliopsis.*

F. Yakuno district

The Nabae group in this area is composed mainly of sandstones and is similar to the N_2 formation in lithological aspects. The facies is changeable laterally, so as it is hardly be subdivided, therefore the collective name Heki formation (KOBAYASHI, 1936) is adopted. The faunules were discussed in detail by KOBAYASHI and ICHIKAWA (1952a). They distinguished three fossil assemblages of *Cardinioides, Minetrigonia-Palaeopharus* and *Lima* (=*Pseudolimea*)-*Chlamys.* The faunal differences do not mean time-differences but environmental differences. After that time, the increased materials tabulated in the list of fossils (Table 11), showed the faunal

Locality / Species	Heki Formation									Yanagi	
	701 (5)	702	703 (4)	704 (2)	705 (1)	706	707	708	709	710	701, 702
Velata maizurensis	○			•						×	•
Chlamys mojsisovicsi	×										
Pseudolimea nanmanni	•										
Lima yataensis	•							•			•
L. yataensis var. kuredaniensis	•										
"Ostrea" sp.	?										
"Gryphaea" aff. keilhaui	•					○					
Mytilus cf. tenuiformis				×							
M. tenuiformis var. punctatus				○							
Aff. M. t var. punctatus				×							
Bakevellia hekiensis	○	○		•	○	•					
B. saekii				×							
B. cf. monobensis	×										
Plicatula hekiensis	○										
Minetrigonia hegiensis	○	○		○	○			•		○	•
Parallelodon monobensis	•										•
Cf. Pinna aff. lima	•			•		×					
Homomya matsuoensis				×							
"Cuspidaria" ayabensis	×										
Pleuromya sp. indet.						×					
Cardinia triadica	•			○	○						
Cardinioides japonicus					○						
C. spp.					•						
Palaeopharus maizurensis	○	•		○		×				○	•
Spiriferina cf. kawarensis MS.	×										
Lingula sp.									×		
Isocrinus (stem)				•							

Table 11. List of fossils of the Heki and Yanagi formations.

○: common ●: rare ×: very rare

differences be smaller than ever considered. The Heki formation may be well summarized in a single zonule *Minetrigonia-Palaeopharus.*

G. Fukumoto district (See Table 11)

The Yanagi formation consists mostly of black, sometimes carbonaceous shales and sandy shales of more than 70 m in thickness. It resembles the N_3 in rock facies, but its faunule is well in accordence with those of *Minetrigonia-Homomya* or *Minetrigonia-Palaeopharus* faunules.

2. Zoning and Correlation

Because of the discontinuous distribution without any noticeable key bed, it is not easy to correlate the zonules accurately. However, the N_2 is fairly continuous and the boundary between the N_2 and N_3 is possibly assumed to be a definite horizon, expressing a time plane. Accordingly *Palaeopharus-Lima yataensis* zonule is comparable to *Minetrigonia-Homomya*, and their fossil assemblages, too, agree very well with each other. But whether the N_1 formation is really earlier than the N_2 or contemporaneous with its lower part elsewhere in the Maizuru belt is not certain, because the N_2 in the Matsunoodera district is much thicker than in the Nabae district. It is justifiable, however, to consider that the N_1 is the deposits at the beginning of the transgression while the N_2 is the product at its maximum stage and is overlapping the N_1. By the way *Bakevellia subhekiensis* zonule extending over two formations at Nabae is not recognized in the other districts. Moreover, *Minetrigonia hegiensis obsoleta* in this zonule is a representative species of the *Minetrigonia-Homomya* zonule. Both the zonules are combined together for the time being. Zonules of *Halobia*, *Anodontophora-Palaeopharus* and *Bakevellia-"Cuspidaria"* are equivalent to each other. Their faunal difference is undoubtedly due to differential environments. *Palaeopharus* faunule of *Anodontophora-Palaeopharus* zonule is similar to *Bakevellia-"Cuspidaria"*, while *Anodontophora* faunule resembles rather *Halobia* faunule. The latter two are quite different from the lower faunule. This difference is also due to the change of sedimentary conditions, as the other equivalents are intimately related to the underlying faunule with the common species such as *Palaeopharus maizurensis*, *Velata maizurensis*, *Parallelodon monobensis*, *Plicatula hekiensis*, *"Cuspidaria" ayabensis*, *Lima yataensis*, and others.

On the other hand, *Tosapecten-Pseudolimea* zonule strikingly differs from the lower zonule in the fossil assemblage in spite of the close alliance of lithological features. This fact suggets that the faunal change indicates the time difference. Unfortunately, the correspondent formation of this zonule in the other areas is scarce in animal remains. However, the discovery of *Pseudolimea naumanni* associated with *Mentzeliopsis ogawai* from the Monobe district proves the wide application of this zonule over the Maizuru belt.

In conclusion the most conspicuous faunal change in the entire belt is sought for between *Tosapecten-Pseudolimea* zonule and its lower ones not in accordence with the boundary of rock units. It is reasonable to divide the Nabae group into

two zones *Palaeopharus-Lima yataensis* and *Tosapecten-Pseudolimea naumanni*. In the eastern half of the basin *Palaeopharus-Lima yataensis* zone is further divisible into upper *Halobia-Bakevellia* and lower *Minetrigonia-Homomya* subzones. *Palaeopharus-Minetrigonia* zonule recognized in the Heki and Yanagi formations is referred to the lower zone by all means. It contains both the elements of the two subzones.

The uppermost zonule of *Neoschizodus-Pleuromya* is provisionally treated as a zone, as the distribution is confined to the Nabae district. These relations were already tabulated in the preceeding papers (NAKAZAWA, 1956 & 1957).

3. Reexamination of Sakawan age

When ICHIKAWA proposed the Sakawan age, he classified it into three subages, founded on the faunal assemblages of the *Oxytoma-Mytilus*, the *Tosapecten-Halobia* and the *Myoconcha* beds of the lower Kochigatani subgroup in the Sakawa basin in Shikoku. Unfortunately the geological structure of that area is too complicated to clarify their stratigraphical relationships, so that the sequence was determined by comparison with the correlative Miné group in Yamaguchi Prefecture, where the geological structure is simple and the reliable succession had been established. Faunules of the Kochigatani group were thoroughly examined by KOBAYASHI and ICHIKAWA (1950–1951), but the faunal study of the Miné is in a delay in spite of the designation for the type Sakawan. As fully discussed in another paper (NAKAZAWA, 1957), the Nabae group is surely correlated to the Miné and lower Kochigatani groups. As shown in the figure (Fig. 19) the correlation of each subdivision of the Nabae and Miné appears to be indisputable. The most remarkable faunal change happened between the stage represented by the Hirabara and that by the Asô formation in the Miné. This case agrees entirely with that occurred between the two zones of the Nabae group. Furthermore, the faunal difference between the uppermost part (H_{IV}) and the main (H_{II-III}) of the Hirabara resembles that of the two subzones in the Maizuru belt. The main coal measure, Momonoki formation barren in animal fossils is compared to the main part of the N_3 also scarce in fossils besides plant impressions.

The faunal change between the *Oxytoma-Mytilus* and the *Halobia-Tosapecten* in Shikoku is also parallel to the change between the two zones mentioned above. The correlation between *Palaeophalus-Lima yataensis* zone, the Hirabara formation and the *Oxytoma-Mytilus* bed can hardly be doubted, while the comparison of *Halobia-Tosapecten* and *Myoconcha* beds with the Momonoki and Asô formations made by KOBAYASHI and ICHIKAWA seems to be questionable, for the theory is only based upon a single species *Eumorphotis* aff. *spitzbergensis* common to the *Myconcha* bed and the Asô formation. The occurrence of *Tosapecten suzukii*, *Pseudolimea naumanni* and *Chlamys mojsisovicsi*, representative species of the *Halobia-Tosapectan* bed from the Asô indicates the intimate relationship between the *Halobia-Tosapecten* bed and the Asô formation. Still more, the most species of the *Myoconcha* bed except for *Eumorphotis* and endemic *Myoconcha trapezoidalis* KOBAYASHI and ICHIKAWA are also found in the *Halobia-Tosapecten*, and the faunal difference between the two

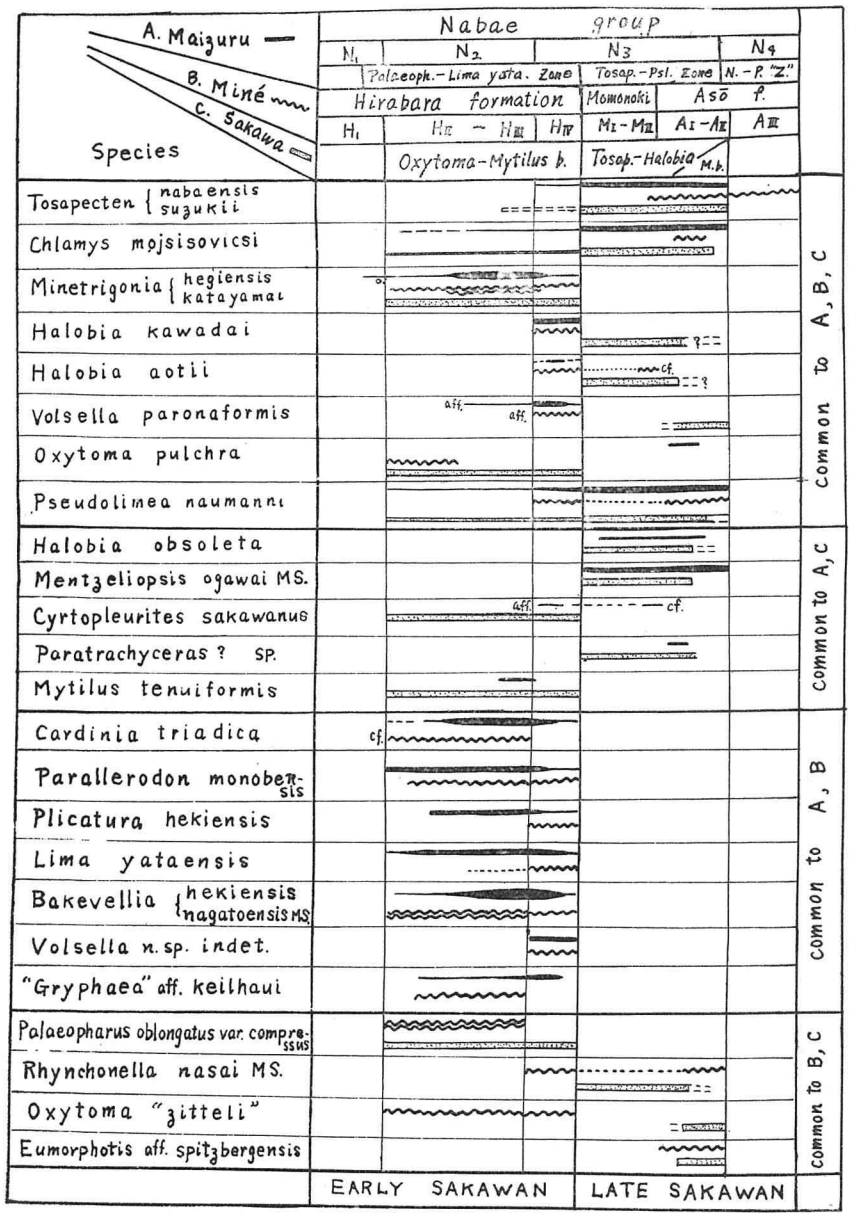


Fig. 19. Correlation of the representative Sakawan strata by comparing the ranges of the common species.

M.b.: *Myoconcha* bed.

beds is much smaller than that between the *Halobia-Tosapecten* and the *Oxytoma-Mytilus*. In addition, taken into account the fact that localities of the *Myoconcha* are known only at neighbouring two places, the *Halobia-Tosapecten* bed and the *Myoconcha* referred to the middle and late subages respectively are now included in one subage. Thus the Sakawan age shall be divided into two subages early and later. The writer infers the *Myoconcha* bed to be correlated to the upper half of the *Halobia-Tosapecten*. The N_4 formation containing characteristic faunule and the upper division of the Asô are comprised tentatively in the late Sakawan.

Minetrigonia hegiensis, M. katayamai, Cardinia triadica, Parallelodon monobensis, Plicatura hekiensis, Lima yataensis, Mytilus tenuiformis, species of *Palaeopharus, Oxytoma* and *Bakevellia* are the leading forms of the early Sakawan, while *Tosapecten-Pseudolimea* fanule and *Eumorphotis* aff. *spitzbergensis* were predominant in the late Sakawan. *Halobia* is common in the upper part of the lower Sakawan in the Maizuru and Miné, but is prolific in the lower? part of the upper Sakawan in Shikoku. It is interesting that the early Sakawan fossils in the Maizuru are more closely connected with those in the Miné than those in Shikoku, but on the contrary the late Sakawan faunule is more related to the faunules in Shikuku.

KOBAYASHI and ICHIKAWA (1950) pointed out the alliance of the early Sakawan and *Tosapecten* faunules with the northern faunules in eastern Siberia and the Bear Island. Close affinity of the late Sakawan faunules with the late Carnian of the Ussuri region is also emphasized by the occurrence of *Tosapecten suzukii, Chlamys simils* and *Oxytoma mojsisovicsi* in that region (KIPARISOVA 1954). The latter two species are intimately related to, if not conspecific, *Chlamys mojsisovicsi* and *Oxytoma yeharai* from Japan. In addition, "*Gryphaea*" sp. recently collected from the Nabae and the Hirabara has much alliance with *G. keilhaui* from Ussuri. On the other side, it is noticeable that brachiopods such as Sakawan *Mentzeliopsis* and Arakuran *Psioidea* are connected with those of Zew Zealand reported by MARWICK (1954).

3. Nakaiso conglomerate bed

In the Fukumoto district a thick conglomerate bed with a name of the Nakaiso conglomerate bed (NAKAZAWA, SHIKI and SHIMIZU, 1954) of no less than 200 m is seen. It contains rounded pebbles of pebble to cobble sizes, which materials are chert, sandstone, shale, various semischists, quartz-porphyry, sheared granite, serpentine and limestone. It is noteworthy that pebbles of semischists are rather common, while they have never found from the preceeding strata. The bed lies on the lower to middle Triassic Fukumoto and the upper Permian Kosé group with a remarkable clino-unconformity. The definite age cannot be determined because of the absence of a fossil, but is assumed to be older than the Cretaceous "Inkstone" group near by. The Nakaiso is severely folded while the "Inkstone" group shows a simple, tilted structure. It was tentatively correlated to the lower division of the Saragian (=Norian) Nariwa group from a lithological alliance.

GEOLOGICAL STRUCTURE AND CRUSTAL MOVEMENTS

The geological structure of the Triassic strata and the crustal movements during that period are closely connected with the Permian. The subject will be discussed in detail in the near future, but it is briefly summarized in the following lines:

A notable feature of the geological structure is the complicated zonal arrangement of the Triassic and Permian strata and the so-called Yakuno intrusive rocks.

(1) There are two main fault-directions, one running parallel to the axis of the zone (i. e. generally E–W), and the other crossing the former nearly at a right angle. They are all high angled—more than 50°—and the most of E–W faults dip northward.

(2) The Permian rocks are more complicated in geological structure than the Triassic.

(3) The Triassic beds show a simple monoclinal structure in each tectonic belt, but the whole basin makes a syncline.

(4) Lower Triassic formations are separated by faults from the Permian at most places, but the clino-unconformity has been confirmed at several places.

(5) The Fujinohiran and Rhaetian stages are entirely lacking.

(6) The relation between the Arakuran and the Sakawan is disconformable.

(7) The Saragian? stage lies on the older formations with remarkable clino-unconformity, and seems to be excluded from the zonal structure.

(8) A general distribution of the upper Triassic is slightly dislocated from that of the older Triassic.

(9) The so-called Yakuno intrusive rocks consisting of various rocks such as gabbro, diorite, diabase, quartz-diorite, and leucocratic granite, show more or less sheared texture which is considered to be protoclastic. They are thought to be intruded along tectonic zone under pressure. The intrusion seems to be related with the latest faults of E–W direction.

From these facts the following inferences are drawn.

(1) The geological structure reminds one the so-called sandwitch structure prevailing in the outer zone of Southwest Japan (MATSUMOTO, T. and KANMERA, K., 1949) which shows the similar zonal arrangement of the palaeozoic and mesozoic strata. The sandwitch structure is considered to have been formed by squeezing in of the younger strata and squeezing out of the older. However, the structure of the Maizuru zone is simpler. In the outer zone the mesozoic formations are generally strongly folded showing a nearly closed anticlinal or synclinal structures in each tectonic belt, while in this zone they seem to be simply monoclinic.

(2) There can be distinguished five phases of crustal movements, that is, of the latest Permian to the earliest Triassic, post-Matsushiman, pre-Sakawan, pre-Saragian and of the end of the Triassic. The first and latest phases are more conspicuous.

(3) The construction of the zonal structure had been fairly advanced at the stage of the Nakaiso conglomerate, and completed with the injection of the Yakuno intrusive rocks.

These geological events should be examined in relation to the history of the Honshu geosyncline called by N. YAMASHITA (1957) (=Chichibu geosyncline of KOBAYASHI), in which the tremendous palaeozoic sediments were deposited. In view of this point, the writer exhibits his schems on the geological history of the Maizuru zone.

The Honshu geosyncline was differentiated into several relic-seas and the marginal mountains as a result of the late Permian orogenic movement. The upper Permian in the Maizuru zone consisting chiefly of black shales associated with sandstones and conglomerates is charactarized by fusulinid *Lepidolina-Yabeina* and brachiopod *Lyttonia* faunules and, in addition, plant fragments. It is considered to be deposited in an inland sea. Judging from the limestone pebbles in the conglomerate, the sediments were transported mainly from the northern folded mountains. This assumption is also supported by the fact that the Sangun metamorphic zone composed of the Palaeozoic crystalline schists and semischists delimits the northern border of the Maizuru zone, and the low grade metamorphic rocks like phyllites and phyllitic rocks are distributed along the south margin (See Fig. 1).

At the end of the Permian the geosynclinal depression completely vanished by the succeeding folding. A Skyto-Anisic invasion of the Palaeo-Maizuru Bay was caused by the similar crustal movement, as it is suggested by the intimate relationship with the late Permian in distribution and the presence of the northern high land.

After that the continental stage intercalating the Arakuran ingression presumably came. The next early Sakawan transgression was the widest throughout the Triassic period. It is traceable to Kyôwa-mura at the western end of Okayama Prefecture, and the basin may be called the Palaeo-Maizuru Inland Sea. Whether the sea was connected with the Miné basin in Yamuguchi Prefecture is not certain, although the writer considers it most probable. The late Sakawan regression is clearly known in this zone as well as in the Miné basin. The post-Sakawan orogeny is represented by faults that are forming the zonal structure. It was completed by the "Yakuno intrusion" at the end of Triassic or the beginning of Jurassic, and the whole Maizuru zone changed into a rigid mass similar to *Cratogen*.

The writer agrees with KOBAYASHI in considering that the crustal movements ranging from the Permian to the end of the Triassic are unified in his Akiyoshi orogenic cycle (1941), aside his conception of his orogenic zones. The writer is of the opinion that the most important event of this cycle was the orogency of the latest Permian to the earliest Triassic, in which the geosynclinal sea dissapeared completely and the Sangun metamorphism came to an end deep undeneath the surface. But KOBAYASHI stresses the middle Triassic folding, regarding his euorogenic phase.

Summary and Conclusion

(1) The Triassic system in the Maizuru zone is classified into the following

groups lithologically in ascending order: the lower to middle Triassic group (including the Fukumoto, Miharaiyama, Yakuno, Shidaka groups), the Arakura formation, the Nabae group (including the Heki and Yanagi formations), and the Nakaiso conglomerate bed.

(2) The lower part of the first group is characterized by fossil pelecypods. *Neoschizodus*-"*Bakevellia*" zone is distinguished in this belt, and further *Claraia* subzone may be fixed in its lower half. This faunizone is surely referred to Scythian in age. The upper part is represented by cephalopods and is zoned into *Hollandites*-"*Danubites*" and *Monophyllites* zones. The former zone corresponds to the lower Anisian and the latter to the uppermost Anisian or Aniso-Ladinian.

The lower to middle Triassic of this belt is similar to the Inai group in the southern Kitakami massif, Northeast Japan and the Skyto-Anisic formations in the Ussuri region in both bio- and lithofacies. The Palaeo-Maizuru Bay in that age is estimated by a facies analysis; it was connected with the Ussuri region, and was bordered by the uplifting high land to the north.

(3) The second group named the Arakura formation is ascertained to represent the intermediate stage between the Fujinohiran and the Sakawan. The Arakuran age which correspnds with Ladino-Carnian or earliest Carnian is proposed here.

(4) The third Sakawan group is divided into three zones founded on pelecypods and brachiopods. The detailed biostratigraphical study offered the revision that the Sakawan age is better classified into two than into three subages.

(5) Crustal movements during the Triassic period are intimately related to the preceeding one, and are unified all together into the KOBAYASHI's Akiyoshi orogenic cycle, but his euorogeny shall be referred to the orogeny ranging from the latest Permian to the earliest Triassic, not to the middle Triassic as considered by him.

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Postscript

ICHIKAWA presented a somewhat different classification on the Eo-Triassic epoch of Japan from his first proposition in his recent paper, which I could not refer until the completion of this paper. In his rivision the Tatean age is settled above the Uonashian formerly considered younger than the Tatean, and the unnamed age is newly proposed under the Uonashian based on the *Ophiceras* faunule of the Iwai formation in Kwanto. However, there is no reliable fossil evidence whether the Tatean is younger than the Uonashian or not, as suggested in this paper (see p. 291). I think it desirable to defer the Tatean age for the time being. (ICHIKAWA, K., 1956, Triassic Biochronology of Japan. Proceedings of the Eighth Pacific Science Congress, **2**, p. 437)