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GEOLOGICAL SURVEY OF JAPAN

THE CARBONIFEROUS LEXICON OF JAPAN

Edited by

Editorial Committee for

the Carboniferous Lexicon of Japan

GEOLOGICAL SURVEY OF JAPAN

Hisamoto, Takatsu-ku, Kawasaki-shi, Japan

1978

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Shigeru SATŌ, Director

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By the request of the Subcommission for the Stratigraphic Lexicon, the International Union of Geological Sciences, the Carboniferous Lexicon of Japan was completed by the members of the editorial board organized by the National Committees of Geology and Palaeontology, Science Council of Japan at the end of August 1973. The final text, together with maps and diagrams, was sent to the subcommission of IUGS in Paris in July 1974.

To my regret, in May 1977 I was, however, informed by Dr. A. Bouroz, Chairman of the Subcommission that the first part of the Carboniferous Lexicon had not yet been planned for publication owing to exceptional circumstances.

Accordingly, it was earnestly requested that the Carboniferous Lexicon of Japan should be printed as soon as possible, so as to avoid such a situation that the drafts may become outdated.

Apart from planned publication by IUGS, the Carboniferous Lexicon of Japan has been printed as an issue of the Report of Geological Survey of Japan using the final drafts sent to Paris in agreement with the Subcommission.

I am much obliged to the authors for the presentation of valuable articles and Dr. A. Bouroz for his kind arrangements for the agreement granted by the Subcommission.

November, 1977

Shigeru SATO
Director
Geological Survey of Japan

Preface

The National Committees of Geology and Palaeontology, Science Council of Japan, advised the Geological Survey to organize an editorial board for the Japanese part of the "Carboniferous Lexicon". The director of the Survey, I. KOBAYASHI, in consultation with his staff set up an executive committee of three geologists, H. ISOMI, N. KAMBE, and T. YOSHIDA, to assist in the organization of the board.

Since Carboniferous deposits are fairly widely developed in Japan, and considerably different from place to place either in lithofacies or in age, members of this board were chosen to cover various research fields of the Japanese Carboniferous. They are: H. IGO (Tokyo Univ. of Education), K. ISHII (Osaka City Univ.), K. KANMERA (Kyushu Univ.), M. KATO (Hokkaido Univ.), I. KOBAYASHI (Director, Geol. Surv. Japan), M. MINATO (Hokkaido Univ.) and R. TORIYAMA (Kyushu Univ.).

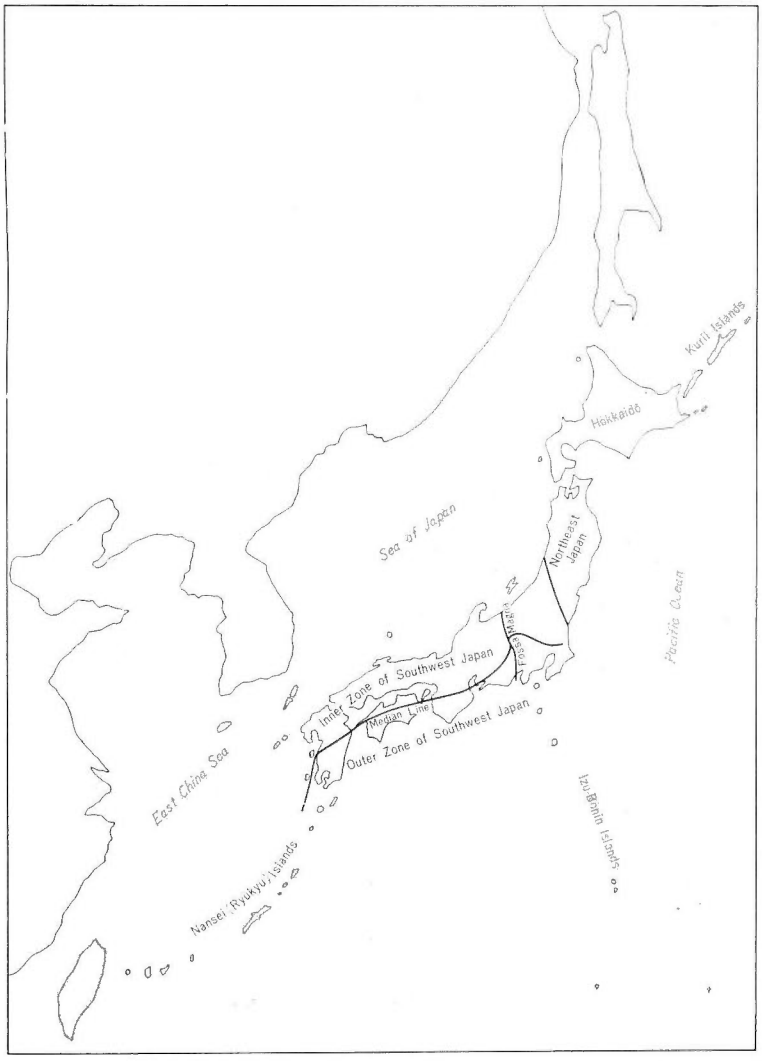

Fig. 1 Geologic division of the Japanese Islands

Fig. 2 Distribution of the Carboniferous in Japan

The first manuscript for each region was sent by these members to the executive committee in early 1972. M. MINATO and M. KATO deal with Northeast Japan and Hokkaido, H. IGO the Kwanto and Chubu districts, K. ISHII the Shikoku and Kii districts, R. TORIYAMA the Chugoku district, and K. KANMERA Kyushu.

The geologic division of the Japanese Islands is shown in Fig. 1 and the distribution of the Carboniferous in Japan is in Fig. 2.

A correlation table for the Lower Carboniferous was prepared by M. MINATO and M. KATO, and one for the Upper Carboniferous (s.l.) by R. TORIYAMA.

The boundaries between the Devonian and Carboniferous, and the lower and upper

Carboniferous deposits are described by M. MINATO and M. KATO in detail. Likewise R. TORIYAMA discussed ways to settle the boundary problems at the top of the Carboniferous in Japan.

The executive committee members read and checked in cooperation these manuscripts including the many tables and figures and tried to amend terms and sentences without changing the original content. The bibliography was also rearranged and additions were made when necessary. Final drafts were prepared by the efforts of members of the editorial board and the executive committee by the end of August 1973.

In sending this manuscript to the IUGS Commission on Stratigraphy, Paris, the director of the Geological Survey of Japan should like to express his thanks to all the members of the editorial board and the executive committee for their kind co-operation. Last but not least he should like to mention that there were a number of geologists who contributed much to the accomplishment of the present task by bringing new data to the attention of the members of the editorial board. Their names are listed below and their assistance is greatfully acknowledged: D. R. CHOI (Hokkaido Univ.), Y. HASEGAWA (Niigata Univ.), S. KUMANO (Hokkaido Univ.), M. MURATA (Tohoku Univ.), Y. OKIMURA (Hiroshima Univ.), M. OTA (Akiyoshidai Science Museum), T. OZAWA (Kyushu Univ.), J. TAZAWA (Hokkaido Univ.), and J. YANAGIDA (Kyushu Univ.).

July 1974

Isamu KOBAYASHI
Director
Geological Survey of Japan

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1. The Carboniferous of Northeast Japan

1.1 The Carboniferous of Hokkaido

Masao MINATO *and Makoto* KATO

So-called Paleozoic complexes have long been known as scattered inliers within the realm of extensively developed Neogene volcanics and pyroclastics in the southwestern part of Hokkaido. Carboniferous fossils have been reported from a number of localities (MINATO and ROWETT, 1967 etc.).

In the Kaminokuni region ONUKI, MORIAI and SATO (1969) named the Katsuraoka Formation which was divided into 5 members based on lithology (Fig. 3 and 4). Fossils such as *Fusulinella* and *Chaetetes* occur in the lowest chert member. Therefore the Katsuraoka Formation is correlative with the Upper Carboniferous Moscovian, though the upper part of the formation may be much younger. Cherts and slates are dominant in the Katsuraoka Formation with lenses of limestones and some intercalations of tuffs. The thickness of the Katsuraoka Formation is more than 700 m.

As a whole it may be said that the Carboniferous in Southwestern Hokkaido is represented by a thick sequence of geosynclinal sediments.

Incidentally these Carboniferous strata are the oldest fossil bearing sediments in this part of Japan.

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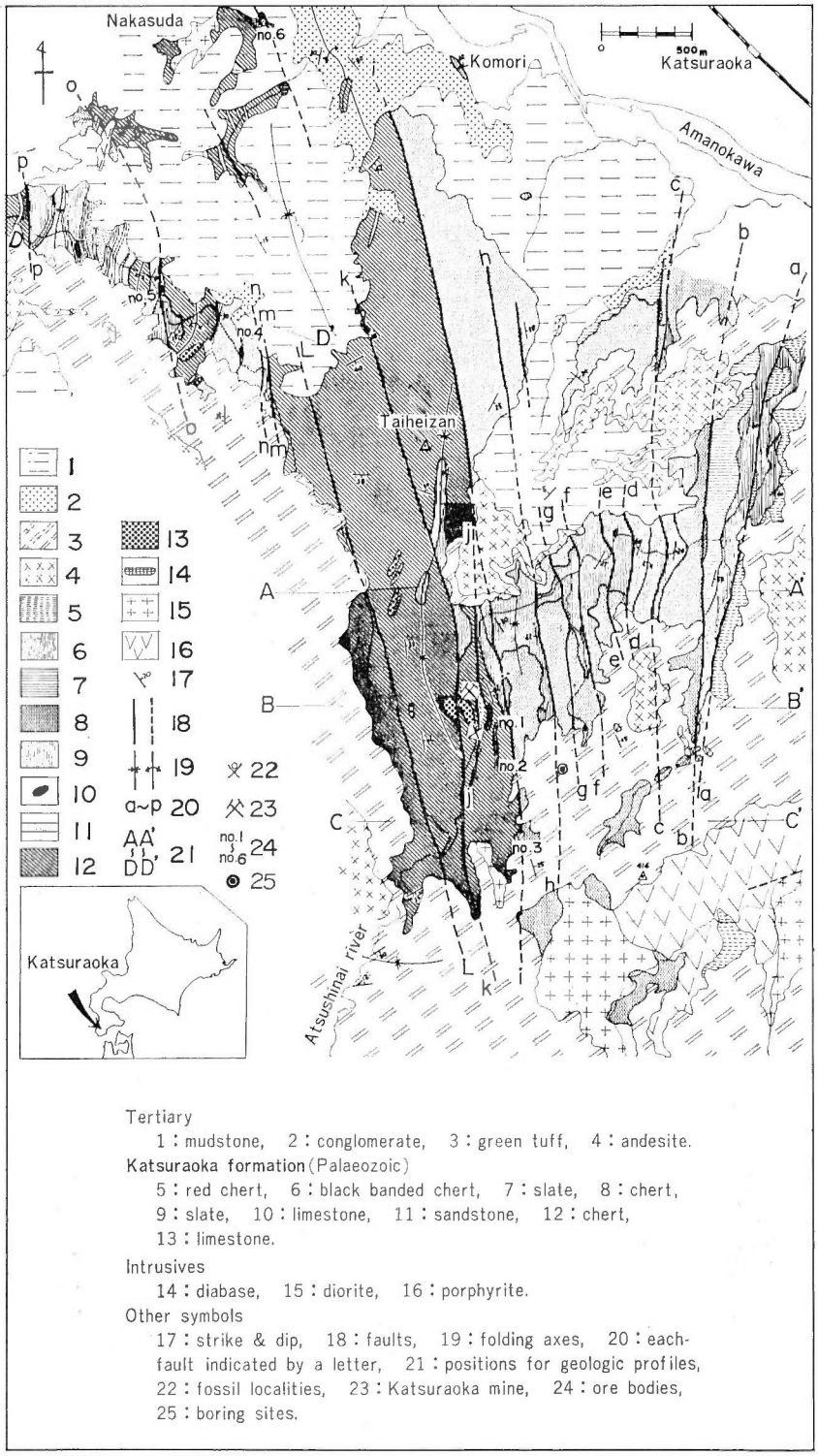


Tertiary
1 : mudstone, 2 : conglomerate, 3 : green tuff, 4 : andesite.
Katsuraoka formation (Palaeozoic)
5 : red chert, 6 : black banded chert, 7 : slate, 8 : chert,
9 : slate, 10 : limestone, 11 : sandstone, 12 : chert,
13 : limestone.
Intrusives
14 : diabase, 15 : diorite, 16 : porphyrite.
Other symbols
17 : strike & dip, 18 : faults, 19 : folding axes, 20 : each-fault indicated by a letter, 21 : positions for geologic profiles, 22 : fossil localities, 23 : Katsuraoka mine, 24 : ore bodies, 25 : boring sites.

Fig. 3 Geological map in the vicinity of the Katsuraoka mine, Hokkaidō (after Onuki *et al.*, 1969)

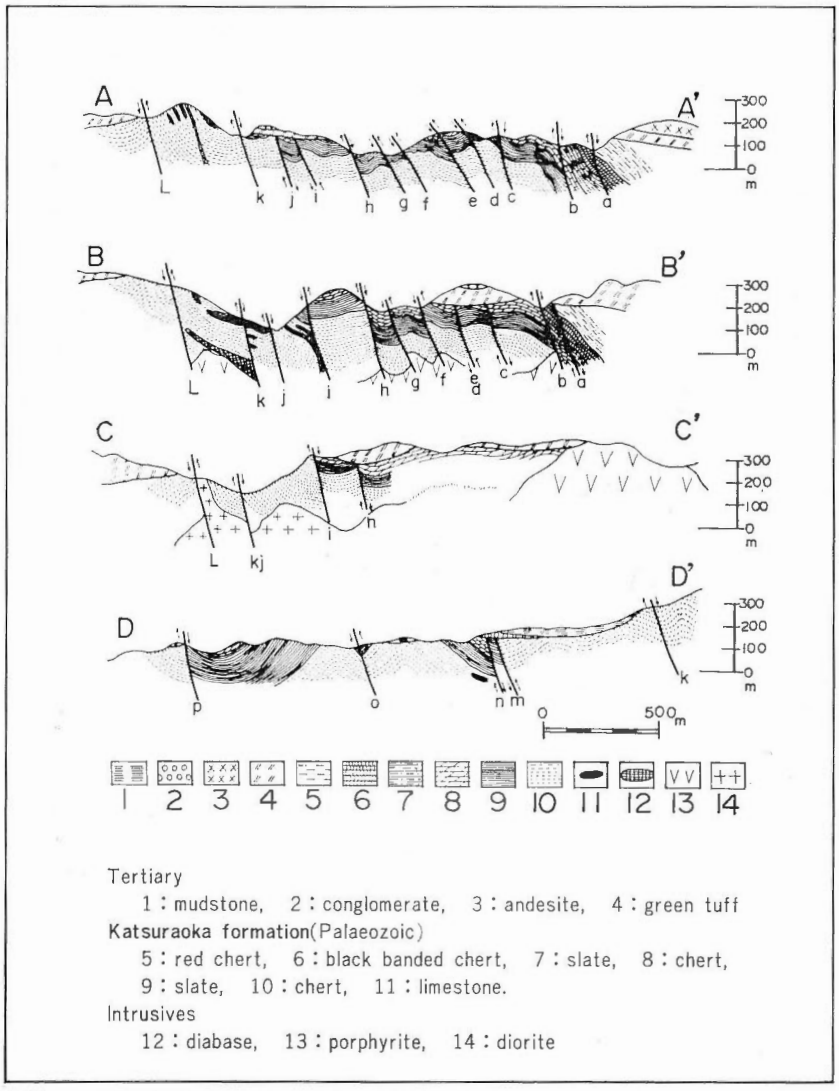


Fig. 4 Geologic profiles in the vicinity of the Katsuraoka mine, Hokkaidō (after ONUKI *et al.*, 1969)

1. 2 The Carboniferous in the Kitakami Mountains

Masao MINATO *and Makoto* KATO

1. 2. 1 General remarks

Carboniferous deposits are best exposed and have been investigated in the Setamai-Hikoroichi region in the southern Kitakami Mountains as shown in Fig. 5 (MINATO *et al.*, 1953, 1959; MINATO, 1966). They have been divided into the following series and stages, which have been generally considered as the standard Carboniferous succession in Japan (Fig. 6).

The Nagaiwa Series is lower Upper Carboniferous and the others are all Lower

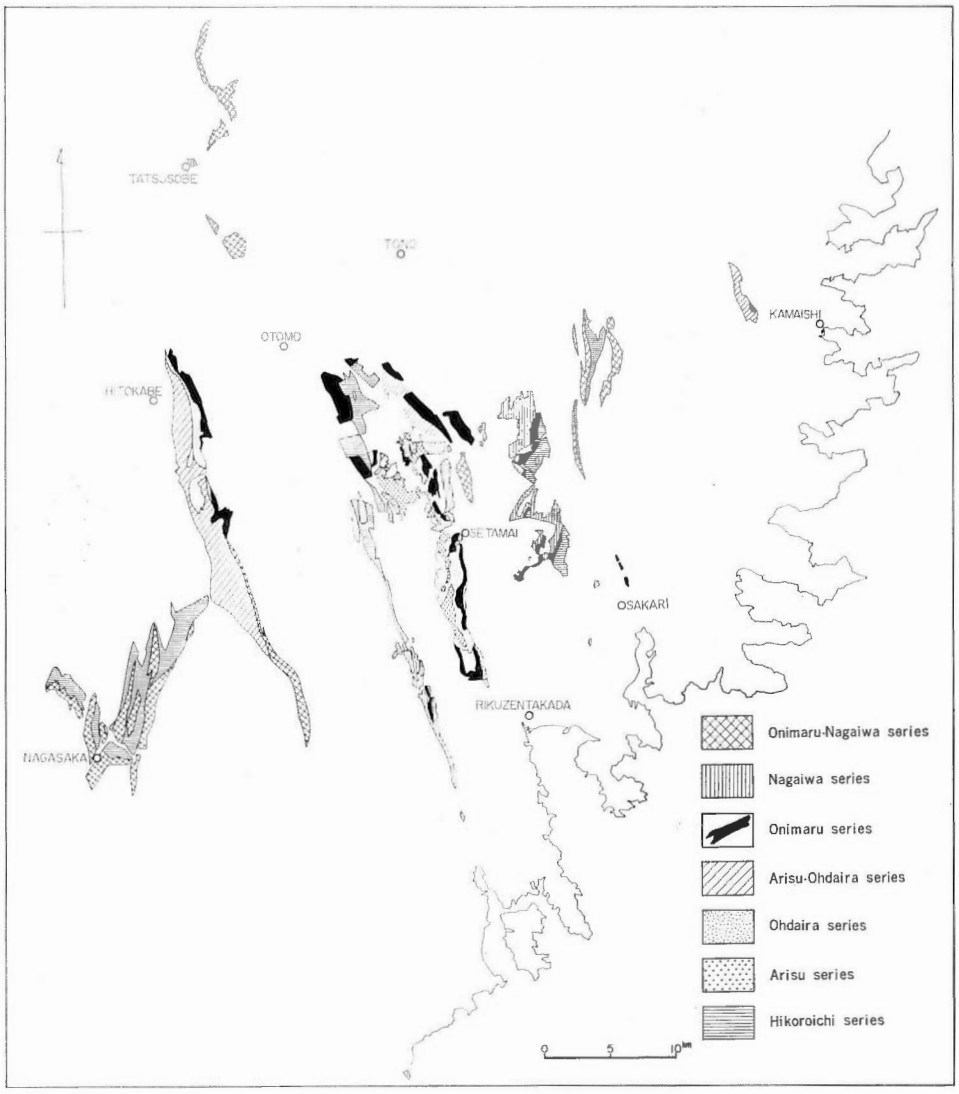


Fig. 5 The distribution of the Carboniferous deposits in the southern Kitakami Mountains (compiled by M. MINATO, M. KATO, M. MURATA and D. R. CHOI)

Carboniferous in age. A large part of the Upper Carboniferous is missing in the Setamai-Hikoroichi and in the rest of the Kitakami Mountains.

The Carboniferous formations begin with a basal conglomerate in the Hikoroichi Series, which rests unconformably upon the Middle Devonian.

From the Hikoroichi to the Ohdaira Series the Carboniferous deposits are markedly geosynclinal in aspect. They are represented by thick marine sediments with frequent intercalations of submarine effusives and pyroclastics, and occasional lenses of limestone. The Onimaru and Nagaiwa Series, however, are calcareous, the latter containing a small amount of tuff. They are fossiliferous and may be regarded as epicontinental deposits.

The sequence from the Hikoroichi up to the Ohdaira Series is conformable, but the Onimaru Series cuts across the Lower Carboniferous strata with a clinouncon-

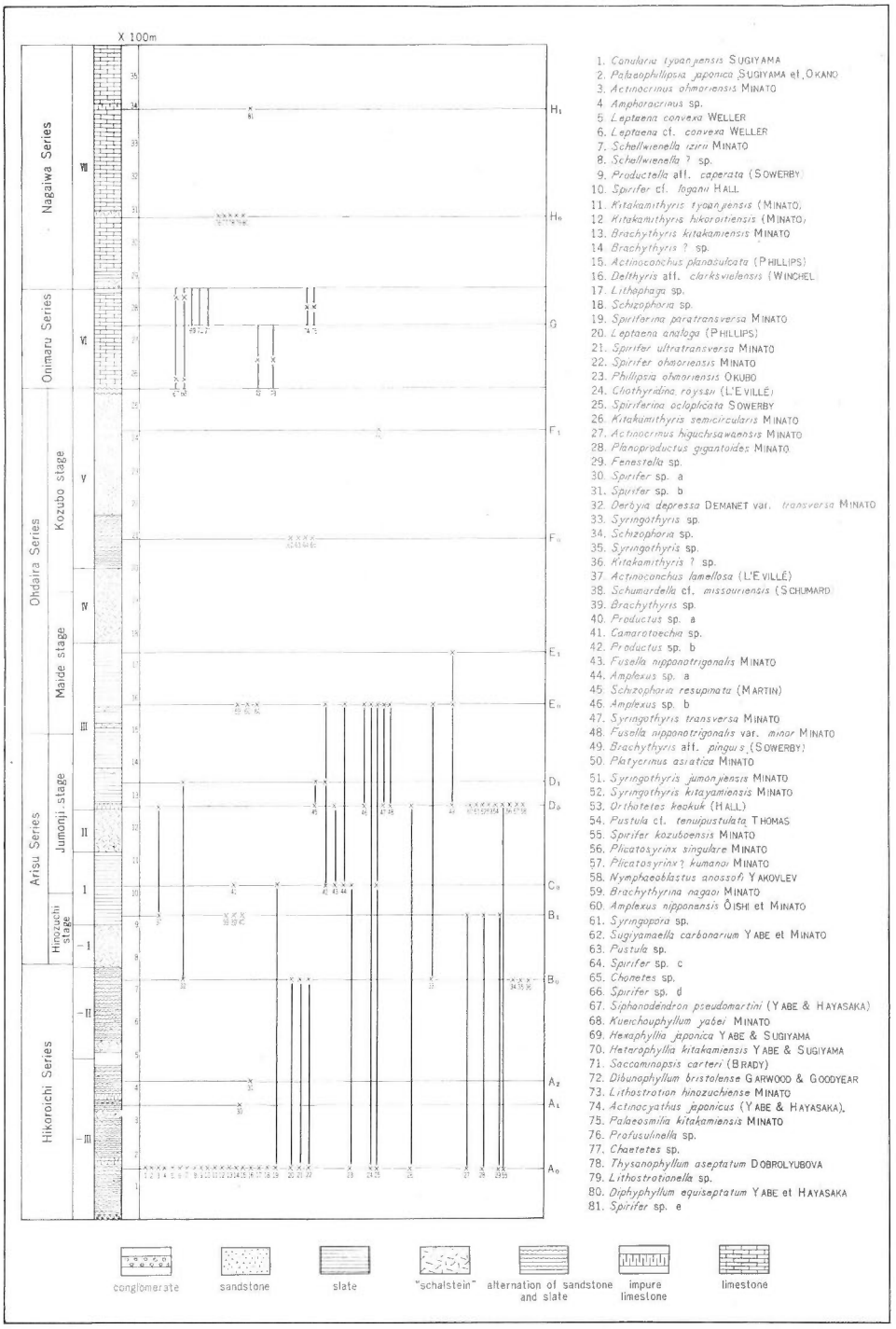
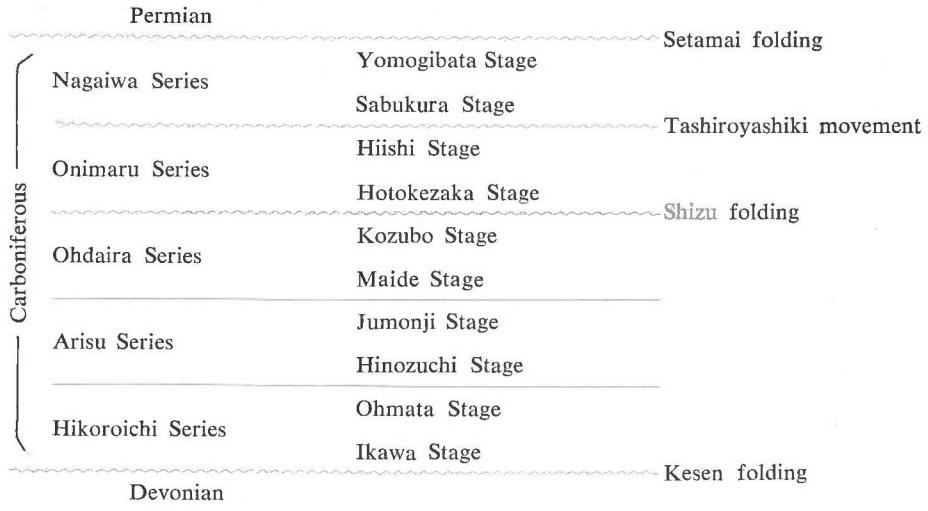


Fig. 6 Columnar section of the Carboniferous deposits in the southern Kitakami Mountains (mainly after MINATO *et al.*, 1953; ranges of fossils are amended)



formity. The Onimaru Series often rests directly upon the Hikoroichi Series where the Arisu-Ohdaira Series has been entirely eroded away. The relationship between the Onimaru and Nagaiwa Series is inferred to be a parallel unconformity.

MINATO (1960) proposed the term Abean orogenic movement for this series of crustal disturbances, also traceable in the Permian, in the southern Kitakami Mountains.

Fossil evidence suggests that the Hikoroichi and Arisu Series are Tournaisian in age. Fossil brachiopods (MINATO, 1950, 1951) and bryozoans (SAKAGAMI, 1962) show affinity to the Australian, North American, and Russian faunas. They seem to be only remotely related to the Chinese fauna. Also *Nymphaeoblastus* originally described from Russia (FAY, 1961) was found in the Arisu Series.

The Ohdaira Series, situated between the Tournaisian Arisu Series and the upper Viséan Onimaru Series, has been considered to represent lower Viséan, though it lacks any significant index fossils. Further study is desired in this connection. It may still represent a part of the upper Tournaisian, since *Sugiyamaella*, which characterizes the Ohdaira Series, is known from the Chinese upper Tournaisian (KATO, 1968).

The Onimaru Series is mainly of upper Viséan, but its upper part may correspond to lower Namurian since it contains *Aulina rotiformis* and *Pseudodorlodotia*. Related species have been reported from the Namurian of Europe. Also the series may range down to a part of the lower Viséan, because comparable strata bearing the *Kueichouphyllum* fauna in China are sometimes so correlated.

The Onimaru fauna is decidedly Tethyan in its aspect. Both European and Chinese elements have been detected in the fauna.

The Nagaiwa Series is mostly Bashkirian, but the lower part may be equivalent to the Lowest Pennsylvanian and lower Namurian, if not the lowest.

1. 2. 2 The Standard Succession (Setamai-Hikoroichi region)

The Hikoroichi Series mainly consists of thin alternations of slates and tuffs, with some intercalating lenses of impure limestone (Fig. 7). In the type Hikoroichi region the series unconformably covers the Middle Devonian Nakazato Series (OKUBO, 1951) with a basal conglomerate. Total thickness of the Hikoroichi Series is about 800 m. At a horizon about 500 m above the base there exists a bed of andesitic tuff about

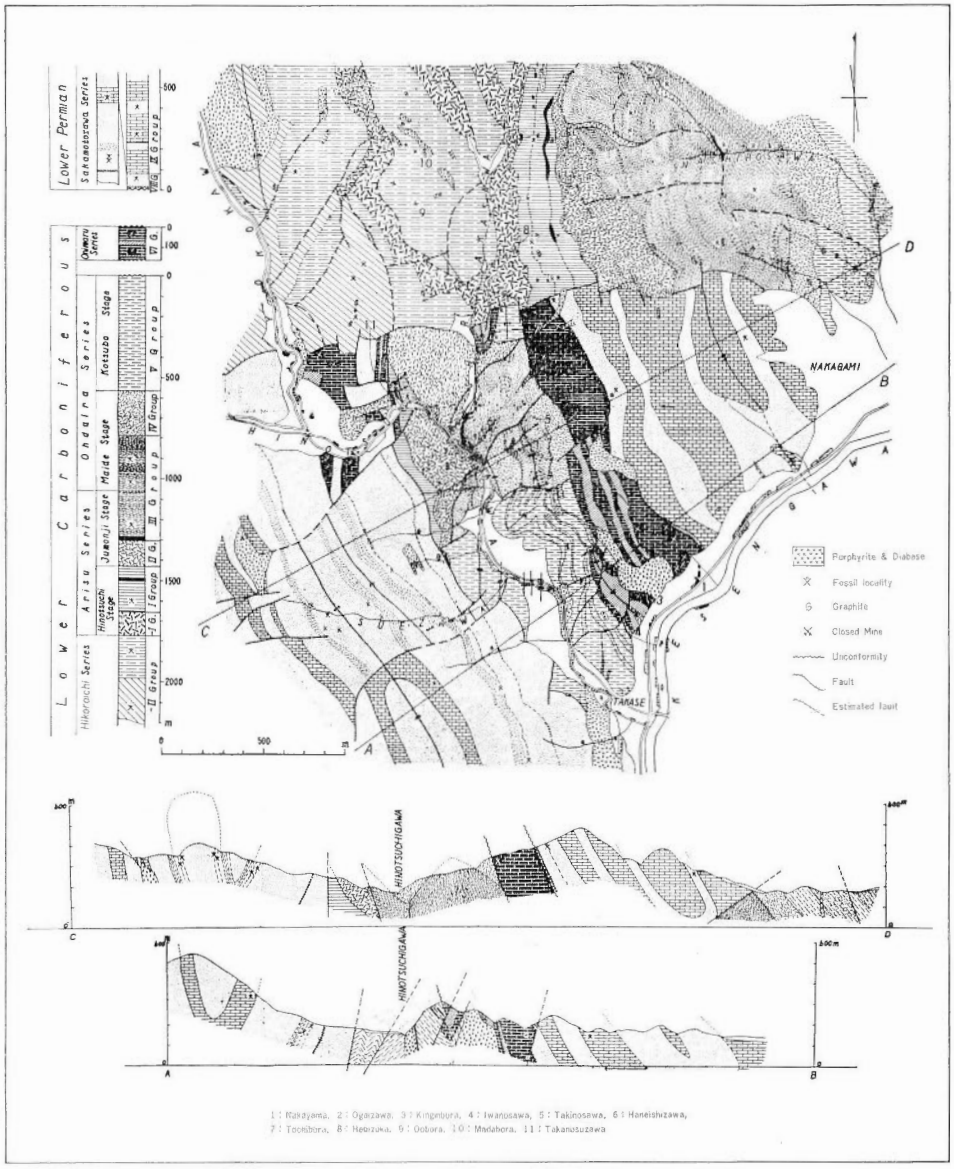


Fig. 7 Geological map of a part of Sumita-cho, Iwate Prefecture (after TAKEDA, 1960)

30 m thick. At the base of the tuff bed the Hikoroichi Series is subdivided into a lower part, the Ikawa Stage, and an upper part, the Ohmata Stage. Numerous fossils such as *Kitakamithyris tyoanjiensis* (MINATO), *Spirifer kozuboensis* MINATO, *Phillipsia ohmoriensis* OKUBO, *Actinocrinus higuchisawaensis* MINATO, *Amygdalophyllum* sp. and *Caninia* ex. gr. *cornucopiae* MICHELIN occur in the Ikawa Stage. The Ohmata Stage has yielded *Spirifer ultratransversa* MINATO, *Derbyia transversa* MINATO and others.

The Arisu Series conformably succeeds the Hikoroichi Series, and consists mainly of black slates and thick tuffs. Its total thickness is as much as 700 m. The lowest part of the series is a bed of andesitic tuffs about 100 m thick. In the middle of the

stratigraphic sequence of the Arisu Series there is a layer of basaltic tuff. The thickness of this bed is also about 100 m. At the base of this basaltic tuff the Arisu Series is divided into a lower portion, the Hinozuchi Stage, and an upper portion, the Jumonji Stage. From the Hinozuchi Stage *Fusella nipponotrigonalis* MINATO etc. have been described, and from the Jumonji Stage *Syringothyris jumonjiensis* MINATO, *Platycrinus asiatica* MINATO, and *Nymphaeoblastus anossofi* (YAKOVLEV) were reported.

The Ohdaira Series conformably overlies the Arisu Series. Lithologically it is com-

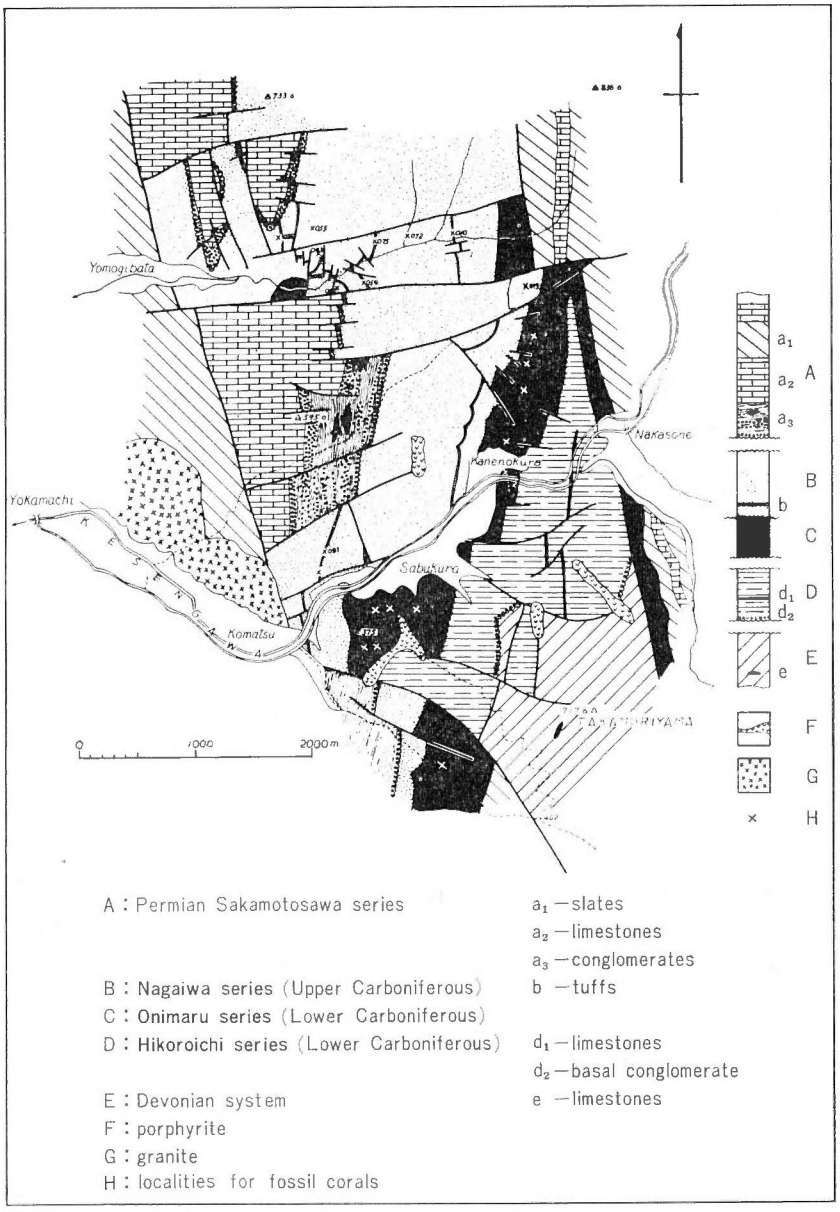


Fig. 8 Geological map of the Kamiarisu district, southern Kitakami Mountains (after MINATO, TAKEDA, KAKIMI and KATO, 1959)

posed of slates, sandy slates and tuffs, and it reaches 1,100 m in thickness. The series is divided into a lower Maide Stage and an upper Kozubo Stage. The boundary between the two stages has been designated as the upper surface of the 200 m thick basaltic tuffs situated near the middle of the Ohdaira Series. The Maide Stage yields *Brachythyris nagaoi* MINATO and *Amplexus nipponensis* OISHI and MINATO, while *Sugiyamaella carbonarium* YABE and MINATO is characteristic of the Kozubo Stage. Palaeomagnetic measurement on the basaltic tuffs of the Maide Stage reveals that the palaeolatitude of the Kitakami Mountains at that time was about 22°N (MINATO and

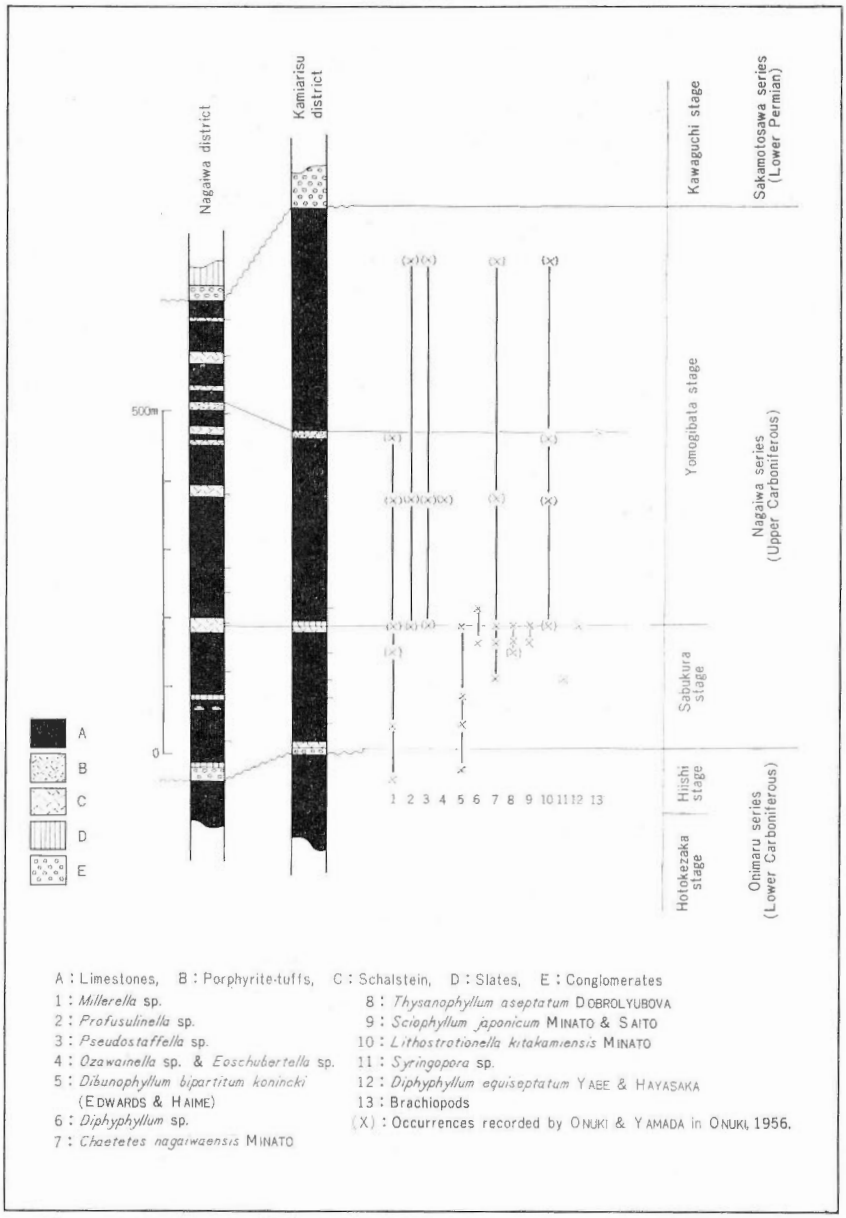


Fig. 9 Columnar section of the Nagaiwa Series and stratigraphical distribution of fossils (after MINATO, TAKEDA, KAKIMI, KATO, 1959)

FUJIWARA, 1965).

The Onimaru Series is composed of well bedded black limestones and slates, and is rich in coralline fossils. It covers with a clinounconformity the Hikoroichi, Arisu, and Ohdaira Series. To the crustal movement causing the unconformity MINATO (1944) proposed the name Shizu folding. From the stratigraphic distribution of fossils the series is divided into a lower unit, the Hotokezaka Stage, and an upper unit, the Hiishi Stage. *Lithostrotion hinozuchiense* MINATO etc. occur in the Hotokezaka Stage, while *Actinocyathus japonicus* (YABE and HAYASAKA), *Palaeosmilia kitakamiensis* MINATO etc. occur in the Hiishi Stage. *Kueichouphyllum, Dibunophyllum* and *Siphonodendron* occur through the entire Onimaru Series. The total thickness of the series is only about 300 m.

The Nagaiwa Series is composed mainly of white to gray massive limestones, which often contain cherty nodules, and are intercalated by beds of andesitic tuffs (Fig. 8). One of these tuff beds (Ho horizon of MINATO *et al.*, 1953) is stratigraphically situated about 200 m above the base of the series, and is widely traceable. This has been taken as the boundary between the Sabukura below and the Yomogibata Stage above (Fig. 9). Faunally the Sabukura Stage is in the *Millerella* Zone yielding such corals as *Thysanophyllum aseptatum* DOBROLYUBOYA and *Sciophyllum japonicum* MINATO and SAITO together with foraminifera and some relict forms from the underlying Onimaru Series. On the other hand the Yomogibata Stage is characterized by *Profusulinella, Pseudostaffella,* and *Lithostrotionella.* A thin conglomerate bed is locally developed at the base of the Nagaiwa Series. The Nagaiwa Series is almost always developed in close association with the Onimaru Series. This conglomerate probably indicates the presence of a parallel unconformity between the two series. The Tashiroyashiki movement of YAMADA (1958) is named for this unconformity.

No Westfalian or Stephanian deposits are known in the southern Kitakami Mountains. This has been generally considered to be due partly to non deposition of sediments of these ages, and partly due to an erosion interval between the Carboniferous and Permian. Carboniferous formations were folded and faulted prior to the Permian transgression, resulting in a marked clinounconformity between the two systems. The Setamai folding of MINATO (1944) is the term used for this movement. The Lower Permian Sakamotosawa Series bearing the *Pseudoschwagerina* fauna rests on the Carboniferous.

Quite recently, however, some Uralian (= Stephanian) fusulinids were found in limestone pebbles contained in the Upper Permian conglomerate (CHOI, 1972). Therefore at least a part of Uralian marine sediments might have been deposited in or around the realm of the southern Kitakami Mountains.

1. 2. 3 Other regions in the Southern Kitakami Mountains

Formations which can be correlated with the type Hikoroichi, Onimaru, and Nagaiwa Series are fairly extensively developed in the southern Kitakami Mountains. The Arisu and Ohdaira Formations and their correlatives, however, are somewhat restricted in distribution.

In the Nagasaka region (TACHIBANA, 1952), about 30 km west of the Hikoroichi region, the Karaumedate Formation consisting mainly of slates and sandstones is equivalent to the Hikoroichi Series. This formation is unconformably covered by limestone of the Takezawa Formation, which should correlate with the Onimaru plus Nagaiwa Series in the type area. Strata corresponding to the Ohdaira to Arisu Series are lacking between the two formations mentioned above.

In the Hitokabe (OTOMO) region (YOSHIDA, 1951), northwest of the type area, a thick sequence, the Yonesato Formation, composed chiefly of basic tuffs probably includes some strata correlative with the Hikoroichi, Arisu, and Ohdaira Series. The Yonesato Formation is overlain by the Shiba Formation of Onimaru age. A lithologic sequence similar to the Yonesato Formation has been called the Nakazai Formation in the Tatsusobe region (HIROKAWA and YOSHIDA, 1956). Also the Ohzasa Formation in the same area probably corresponds to the Nagaiwa Formation in the type area.

1. 2. 4 Northern Kitakami Mountains

In the northern Kitakami Mountains, several fusulinids and corals of Lower Carboniferous in age have been discovered in limestone float or pebbles found in younger formations.

Only in the Kamaishi region is there a thick sequence of pyroclastics named the Kogawa Formation (YOSHIDA, 1961) which is probably genuinely Carboniferous in age. It contains at least some limestone lenses with corals of Onimaru age. The rest of the Kogawa Formation may range down to the Hikoroichi, Arisu and Ohdaira Series, but no fossil evidence has been discovered from it as yet.

Generally speaking, we believe a geosynclinal condition was prevailing in the area of the northern Kitakami Mountains during the major part of the Carboniferous.

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1. 3 The Carboniferous in the Abukuma Mountains

Masao MINATO *and Makoto* KATO

The development of Carboniferous formations has been ascertained in only two regions in the Abukuma Mountains, the Soma-Tateishi region, and in the Hitachi mine region. Besides, a metamorphosed stratigraphic sequence found around the Yakuki mine may in part correlate with the Carboniferous, but this has not yet been confirmed by fossil evidence.

In the Tateishi region (SATO, 1956) Carboniferous deposits are lithologically divided into the Mano and the Tateishi Formations in ascending order (Fig. 10 and 11).

The Mano Formation consists of thinly bedded sandstones and slates in alternation, measures about 130 m in thickness, and contains some brachiopods including *Scizophoria*. The formation has an unconformable relationship with the underlying Ainosawa Formation, which bears a *Sinospirifer* faunule (HAYASAKA and MINATO, 1954) and is correlative with the type Tobigamori Series of the Upper Devonian. The Mano Formation is Tournaisian in age and is equivalent to the Hikoroichi Series. The Mano Formation is overlain by the Tateishi Formation with a presumed unconformity.

The Tateishi Formation is composed almost entirely of limestones carrying many coralline fossils of Onimaru age. Yet it may still contain rocks corresponding with somewhat younger formations, since *Ozawainella* and the other fusulinids of younger aspect have been found within the Tateishi Formation. The total thickness of the Tateishi Formation is 150 m.

Around the Hitachi mine some Viséan corals were found in metamorphic rocks a

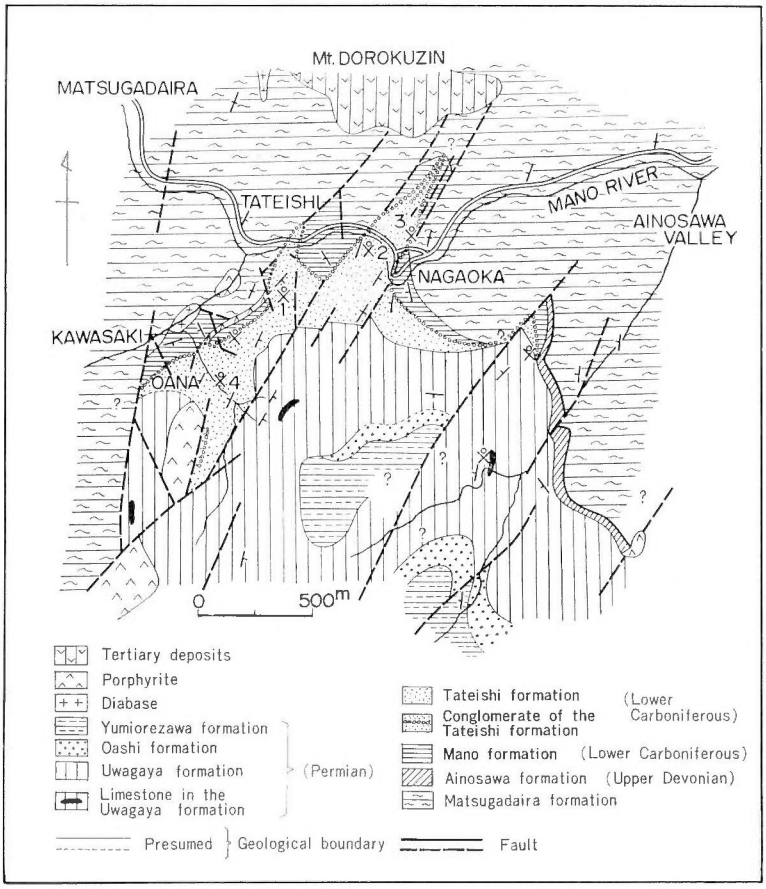

Fig. 10 Geological map of the Soma-Tateishi region, Abukuma Mountains (after SATO, 1956)

comparatively long time ago (FUJIMOTO, 1925). Since then these metamorphic rocks (Ayukawa Formation) have been considered to represent Carboniferous and even older formations. Quite recently, however, some Lower Permian fusulinids and a conglomerate bed lithologically characteristic of the Upper Permian have been found within the so-called Ayukawa Formation. Thus a revised stratigraphic nomenclature had to be decided upon taking these changes into account. WATANABE (1971) renamed the Viséan coralline limestone formation the Sugimoto Formation. It may have an unconformable relationship with the underlying metamorphics also named by WATANABE (1971) as the Ohkadoya Formation etc. The Ayukawa Formation is to be restricted to the Permian. The new Sugimoto Formation is correlative with the type Onimaru Series.

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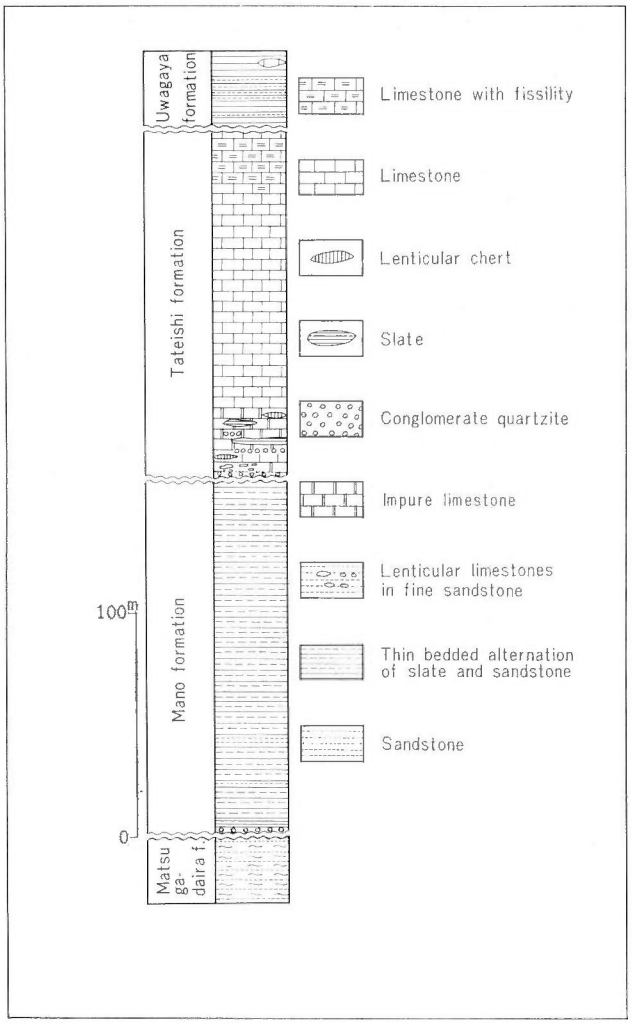

Fig. 11 Composite columnar section of the Tateishi and Mano Formations, Abukuma Mountains (after SATO, 1956)

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2. The Carboniferous of Southwest Japan

2.1 The Carboniferous in the Kwanto and Ashio Mountains

Hisayoshi IGO

The Carboniferous System is distributed in several restricted areas in the Kwanto Region.

Arachnolasma cfr. *sinense* (YABE and HAYASAKA) was reported (MINATO, 1955) from a small limestone patch in Mesozoic deposits near Shiroi, Kwanto Massif, Gunma Prefecture. Its detailed stratigraphic position remains unknown, but this coral indicates an upper Viséan age.

The next younger Carboniferous deposits are in the Kawamo Formation near Omama, Ashio Massif, Gunma Prefecture. This formation consists mainly of the so-called schalstein, sometimes intercalated by thin layers of limestone, chert and sandstone. The formation is in fault contact with Permian rocks, and so the stratigraphic relations between them can not be settled. *Amygdalophyllum naosoidea* MINATO, *Siphonodendron pseudomartini* (YABE and HAYASAKA) and *Chaetetes* sp. come from the limestone lenses. FUJIMOTO (1960) correlated these corals with the upper Viséan, but the formation may be equivalent to a part of the Namurian.

Westphalian or Upper Carboniferous rocks are distributed in the Kwanto Massif and represent a part of the classic "Chichibu System". These Permo-Carboniferous rocks have been designated the Mamba Formation (FUJIMOTO, 1936). This formation overlies the Kashiwagi and Sakahara Formations which are quite barren of reliable index fossils. From both a lithologic and stratigraphic point of view, these formations represent the Lower Carboniferous or older. Owing to a lack of paleontological evidence, however, a definite conclusion must be reserved. The Mamba Formation consists mainly of the so-called schalstein which is comprised of tuff, agglomerate, and other pyroclastics; plus lava, black slate, sandstone, and limestone lenses. The limestone lenses are occasionally fossiliferous and yield both Carboniferous and Permian fusulinids, corals and other fossils. Based upon the paleontological evidence, the Mamba Formation apparently includes Namurian to Upper Carboniferous and also extends higher into the Permian.

Huge limestone masses, separated from the Mamba by a pronounced fault, crop out in the Okuchichibu district, these are typified by the Futagoyama, Tatoro, Shiroishi and other limestones. Among them, the first mentioned has a rich Carboniferous fusulinid fauna (TAKAOKA, 1966). A formation equivalent to the Mamba, but of a different facies, is also distributed in the Okuchichibu district in the Kwanto Massif. The Ishifune Formation consists mostly of sandstone and alternations of sandstone and clayslate and intercalations of chert, schalstein, and limestone. The limestone occasionally attains considerable thickness and yields rather abundant fusulinid species of the *Fusulinella–Fusulina* Zone, *Triticites* Zone and Lower Permian (A. ISHII, 1962).

Deposits similar to the Ishifune Formation are also distributed along the upper part of the Tama River, Nishitama-gun, west of Tokyo, in the southern part of the Kwanto Massif (Fig. 12). These rocks are in the Kitaosogi Formation (T. OZAWA, MS). This formation is a narrowly distributed belt within the Permian and Triassic formations. The total thickness of the Kitaosogi is about 200 m and its lower 150 m is

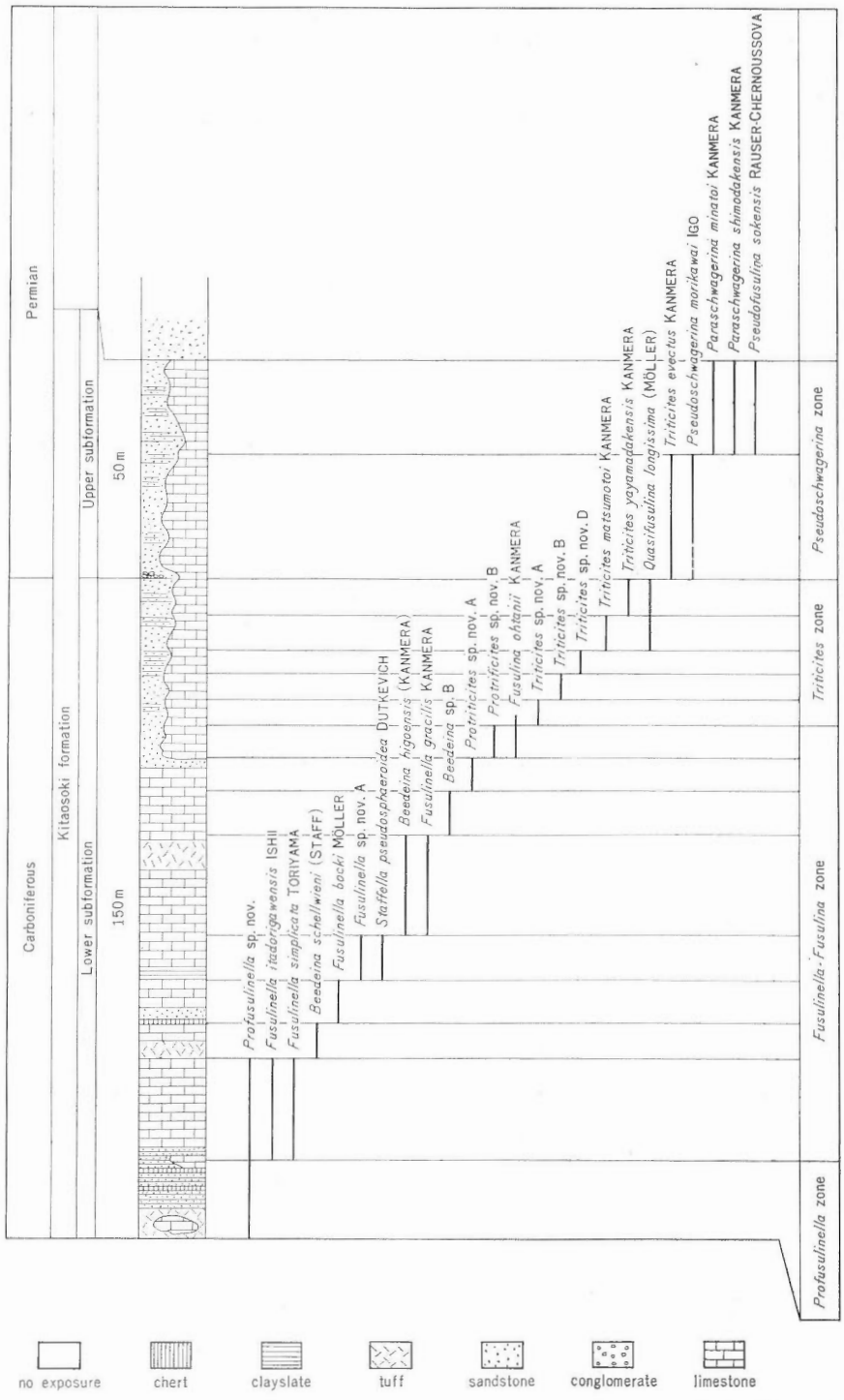

Fig. 12 Geologic column of the Kitaosoki formation and distribution of significant fossils (OZAWA)

Carboniferous. Limestones intercalated at various levels yield numerous fusulinids. T. OZAWA studied the fusulinid zones and further subdivided them into 16 assemblage zones, as follows.

Pseudoschwagerina Zone
- *Paraschwagerina minatoi* Zone
- *Pseudoschwagerina morikawai-Triticites evectus* Zone

Triticites Zone
- *Triticites yayamadakensis* Zone
- *Triticites* sp. nov. D Zone
- *Triticites* sp. nov. B Zone
- *Triticites* sp. nov. A Zone

Fusulinella-Fusulina Zone
- *Protritictites* sp. nov. B–*Fusulina ohtanii* Zone
- *Fusulina gracilis* Zone
- *Beedeina* sp. nov. B Zone
- *Beedeina higoensis-Fusulinella prolifica* Zone
- *Fusulinella* sp. nov. A–*Staffella pseudosphaeroidea* Zone
- *Fusulinella bocki* Zone
- *Beedeina schellwieni-Fusulinella* cfr. *laxa* Zone
- *Fusulinella simplicata* Zone

Profusulinella Zone–*Profusulinella* sp. nov. A Zone

These detailed biostratigraphic subdivisions may make this one of the most important standard sections in the Kwanto Massif.

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2. 2 The Carboniferous in Chubu Province

Hisayoshi IGO

The Carboniferous System is distributed in several mountainous districts in the Chubu Region, or central part of Japan.

Lower Carboniferous fossils were found in the lowermost part of the lower Omi Limestone Group. This limestone is rather extensively distributed near Omi, Niigata Prefecture (Fig. 13). HAYASAKA (1924) first described the occurrence of the Lower Carboniferous brachiopods and corals from this limestone. Several subsequent opinions concerning the geological age of the lowermost part of this limestone group have diverged somewhat. A recent investigation of conodonts (WATANABE, 1969 MS), as shown in Fig. 14, reveals that the lowermost part of this limestone is represented by the *Gnathodus bilineatus* assemblage zone and is therefore correlated with the upper Viséan.

The lower part of the Ichinotani Formation distributed in Fukuji, Yoshiki-gun, Gifu Prefecture, yields such Lower Carboniferous corals, as *Lithostrotion*, *Siphonodendron*, *Arachnolasma*, *Palaeosmilia*, *Heterocaninia* and others (MINATO and KATO, 1957; FUJIMOTO and IGO, 1957; KATO, 1959). Primitive fusulinids, such as *Eostaffella* and *Millerella* are also characteristic in the lowest part of the Ichinotani Formation (IGO,

1957).

The Arakigawa Formation which crops out northeast of Takayama City, Gifu Prefecture, consists mainly of pyroclastics and limestone lenses. The limestone lenses are mostly crystalline and contain poorly preserved corals, such as *Diphyphyllum* and *Koninckophyllum*? *Goniatites* (s. s.) is obtained from the calcareous tuff in Hongo (IGO, 1964). This fossil evidence is insufficient to settle the geological age of the Arakigawa Formation, but it seems to be equivalent to the uppermost Lower Carboniferous.

Lower Carboniferous rocks are also found in the Kotakigawa Formation (KONISHI, 1956) which is distributed very narrowly in the upper part of the Kotaki River, Niigata Prefecture. Details remain unknown, but KONISHI has described some characteristic late Early Carboniferous calcareous algae (KONISHI, 1956).

The Namurian to Upper Carboniferous rocks are rather well developed in this region. The Omi Limestone, mentioned previously, is also contained in the sequence from the Namurian to Upper Permian (KAWADA, 1954; FUJITA, 1956; HASEGAWA, 1969; WATANABE, op. cit.). The C2 and C3 Formations and the upper part of the C1 Formation are equivalent to the Namurian, Westphalian and Stephanian. WATANABE worked out the detailed biostratigraphy of both fusulinids and conodonts. He established the *Millerella*, *Profusulinella*, *Fusulinella-Fusulina*, and *Triticites* Zones in the Carboniferous division of the Omi Limestone. The *Declinognathodus noduliferus*, *Streptognathodus expansus-S.suberectus*,and *Gnathodus roundyi-Idiognathodus delicatus* Zones are representative Carboniferous conodont zones in this limestone. "*Echigophyllum*" *giganteum* HAYASAKA, *Amygdalophylloides gracile* (HAYASAKA), *Omiphyllum confertum* KATO, *Taishakuphyllum rostfer* MINATO and other corals were obtained from the upper part of the C1 or lower part of the C2 (MINATO, 1955; KATO, 1967; ROWETT and MINATO, 1968).

The C2 Formation corresponds with the *Profusulinella* and *Fusulinella-Fusulina* Zones and is characterized by *Profusulinella daiyamensis* HASEGAWA, *Fusulinella biconica* (HAYASAKA) and other fusulinids. An interesting ammonite, *Eoasianites* cfr. *orientalis* (YIN) and many bryozoans were described from the C2 (KATO and NAKAMURA, 1962; SAKAGAMI, 1962–1963). IGO and KOIKE (1964) reported a rich lower Pennsylvanian conodont fauna from just below the *Profusulinella* Zone.

The C3 Formation yields several species of *Triticites* and is Upper Carboniferous, but the fauna has not yet been described.

A nearly complete succession ranging from the Namurian to Lower Permian is represented by the Ichinotani Formation (Fig. 15). It consists mainly of well-bedded limestones and intercalations of thin red shale (Fig. 16). The fusulinid zones were established by IGO (1957) as follows:

Pseudoschwagerina Zone ..... *Pseudoschwagerina morikawai* Zone

Triticites Zone ..... *Triticites exsculptus–T. hidensis* Zone; *Triticites* sp. A Zone

Fusulinella–Fusulina Zone ..... *Beedeina ichinotaniensis* Zone; *Fusulinella asiatica* Zone; *Fusulinella kamitakarensis* Zone

Profusulinella Zone ..... *Profusulinella fukujiensis* Zone

Millerella Zone ..... *Millerella bigemmicula-Pseudostaffella kanumai* Zone; *Eostaffella kanmerai* Zone

These biostratigraphic units were deposited without any remarkable hiatus, but a disconformity was observed between the *Profusulinella* and *Fusulinella-Fusulina* Zones (IGO, 1961). Interesting corals were reported by KATO (1959) and IGO (1961b). The

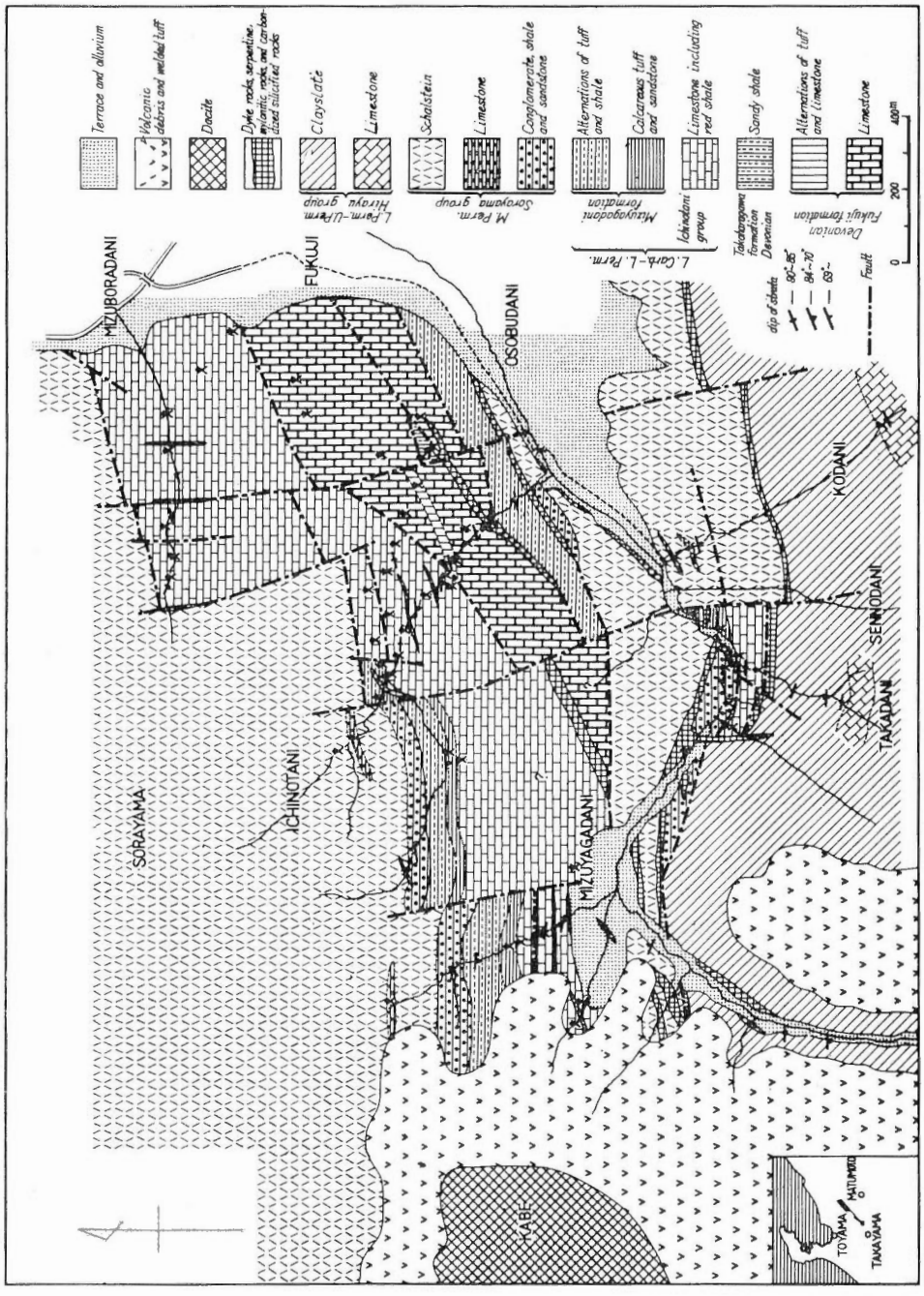

Fig. 15 Geological map of the Fukuji area, Gifu Prefecture (Igo, 1956)

important ones are *Neokoninckophyllum, Koninckocarinia, Ivanovia,* and *Dorlodotia.*

The Nakahata Formation crops out very narrowly at Nakahata, east of Takayama City and is in fault contact with the Permian Nyukawa Group. This formation yields *Fusulinella* and *Protriticites* and is in the middle part of the Upper Carboniferous (ISOMI and NOZAWA, 1957; ISHIZAKI, 1963).

The Upper Carboniferous rocks are distributed in the Mino Massif, southern part of Gifu Prefecture and were worked out by KANUMA (1953, 1958). The Akiyama and Oppara Formations, introduced by KANUMA, consist of sandstone, clayslate, limestone, and schalstein. The Akiyama yields *Fusulinella bocki* MÖLLER, and others, while the Oppara is characterized by a rich occurrence of *Triticites.*

Among other Upper Carboniferous sediments is there the Otaki Formation which was first designated by SEKI (1938). It is distributed at Otaki, southern Gifu Prefecture. This formation consists mostly of phyllitic slate, chert, pyroclastics and fossiliferous limestone lenses. *Fusulinella, Triticites* and some rugose corals come from this formation (ISOMI, 1955; KANUMA, TAKAHASHI and MORI, 1961).

The Shimozaisho Formation (KONISHI, 1954) and Nagano Formations (TSUKANO, 1968) are Upper Carboniferous formations distributed in the upstream area of the Kuzuryu River, Fukui Prefecture. The Shimozaisho has mainly calcareous facies which are intercalated with black shale. *Beedeina lanceolata* (LEE and CHEN) and other poorly preserved fusulinids and corals were found in the limestone beds. The Nagano Formation is predominantly pyroclastics and yields *Fusulinella* and other fusulinids from limestone lenses.

The Yunoo Formation is distributed in the mountainous Nanjyo area, western Fukui Prefecture. This formation is comprised of alternations of sandstone and clayslate, chert, schalstein and limestone lenses (ISOMI, 1955; NISHIDA, 1962). *Fusulinella bocki* MÖLLER and other fusulinids which are common representatives from the *Profusulinella* to *Fusulinella-Fusulina* Zones are found here.

The Sugihashi Formation crops out in the Tsuruga area, southwestern Fukui Prefecture, and consists of clayslate and intercalated sandstone and limestone. The limestone yields *Fusulinella* and *Triticites* and is Upper Carboniferous.

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2. 3 The Upper Carboniferous in Kii and Shikoku Provinces

Ken-ichi ISHII

Upper Carboniferous strata, as ascertained by the presence of fossils, are locally distributed in the Chichibu belt of Kii and Shikoku provinces (Fig. 17). They are tectonically intercalated along faults in strata of different ages. Therefore a complete stratigraphic sequence of the Upper Carboniferous is not represented at any of the localities.

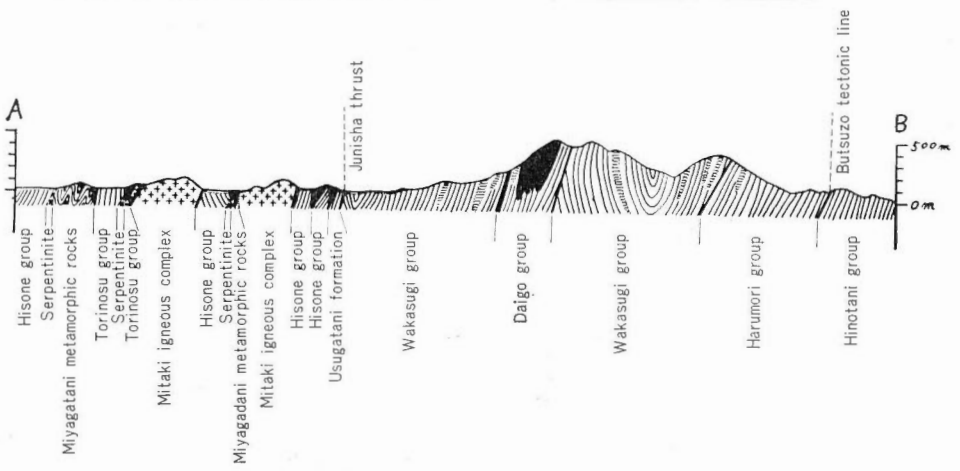
The Upper Carboniferous strata consist of sandstones, shales, cherts, limestones and pyroclastic rocks. Undoubted Lower Carboniferous strata have not yet been discovered from these provinces. The Chichibu belt is subdivided into the northern, middle, and southern sub-belts.

The limestone masses of Tatego situated in the southern sub-belt, western Kii, are found in Mesozoic terrain either as thrust or tectonic masses (ICHIKAWA *et al.*, 1971). Some are characterized by the presence of smaller fusulinids such as *Millerella, Eostaffella* and *Mediocris* and endothyroid which belong to the *Eostaffella-Millerella* Zone. The age seems to be lower Kamitakaran which is equivalent to the Namurian-lower Bashikirian. Some other Tatego and Kaimori limestone masses in the same area are characterized by *Pseudostaffella, Profusulinella* and "*Akiyoshiella*", therefore these limestones are referable the *Pseudostaffella-Profusulinella* Zone of the upper Kamitakaran age (upper Bashikirian).

Moscovian strata occur more commonly in each sub-belt in Kii and Shikoku as follows; in the northern sub-belt, Ryuzen Group (NAKAGAWA *et al.*, 1959) in Fig. 18, Oyabu Formation (KASHIMA, 1969) in Fig. 19, lower Shogase Formation (KATTO and KAWASAWA, 1958) in Fig. 20; in the middle sub-belt, Itadorigawa Group (ISHII, 1961) in Fig. 18, Horikiri Formation (YAMAGIWA, 1957) in Fig. 22, in the southern sub-belt, Daigo Formation (SUYARI, 1954) in Fig. 21, Oshimayama Limestone (YAO, Ms), Ouchiyama Formation (OTSUKA *et al.*, 1964). These strata consist mostly of pyroclastic rocks in which fossil-bearing limestones occur. The lenticular bodies of Moscovian strata are more widely distributed in the northern and southern sub-belts than in the middle sub-belt. The maximum thickness of the Moscovian strata, now preserved as lenticular bodies, is estimated to be 1080 m + (Oyabu Formation) in the northern sub-belt, 500 m + (Daigo Formation) in the southern sub-belt, and about 22 m (Itadorigawa Group) in the middle sub-belt. Many specimens of *Fusulinella, Fusulina, Beedeina* and other species occur in the limestones. Therefore these strata belong to the *Fusulinella-Fusulina* Zone of the Akiyoshian and Kurikian ages (Moscovian).

Fig. 21 Geoogical map in the vicinity of Kamodani, Tomioka Town, Tokushima Prefecture (SUYARI, 1958)

Geologic profile near Kamodani, Tomioka Town, Tokushima Prefecture



The Gzhelian (Stephanian) strata are distributed in the northern and the middle sub-belts in Kii and Shikoku Provinces, but they have not yet been discovered in the southern sub-belt. They are more widely distributed in the northern sub-belt than in the middle sub-belt. These strata are as follows; in the northern sub-belt, Kaifuki Formation (IKEBE, 1936, KASHIMA, 1969) in Fig. 19, the lower part of the Sawadani Group (KANMERA, 1969) in Fig. 23, the upper Shogase Formation (KATTO and KAWASAWA, 1958), Isobe Formation (KUSAKABE and MIYAMURA, 1958); in the middle sub-belt, Miyanokuchi Formation (KATTO and SUYARI, 1956) in Fig. 24. These strata consist of sandstones, shales, cherts, pyroclastic rocks and limestones. The maximum thickness of the Gzhelian strata is 500 m (lower Sawadani Group) in the northern sub-belt, and 250 m (Miyanokuchi Formation) in the middle sub-belt. Two species-zones of *Triticites*, namely the zones of *T. matsumotoi* and *T. yayamadakensis* are represented. They belong to the *Triticites* Zone of the Hikawan age (the early Gzhelian).

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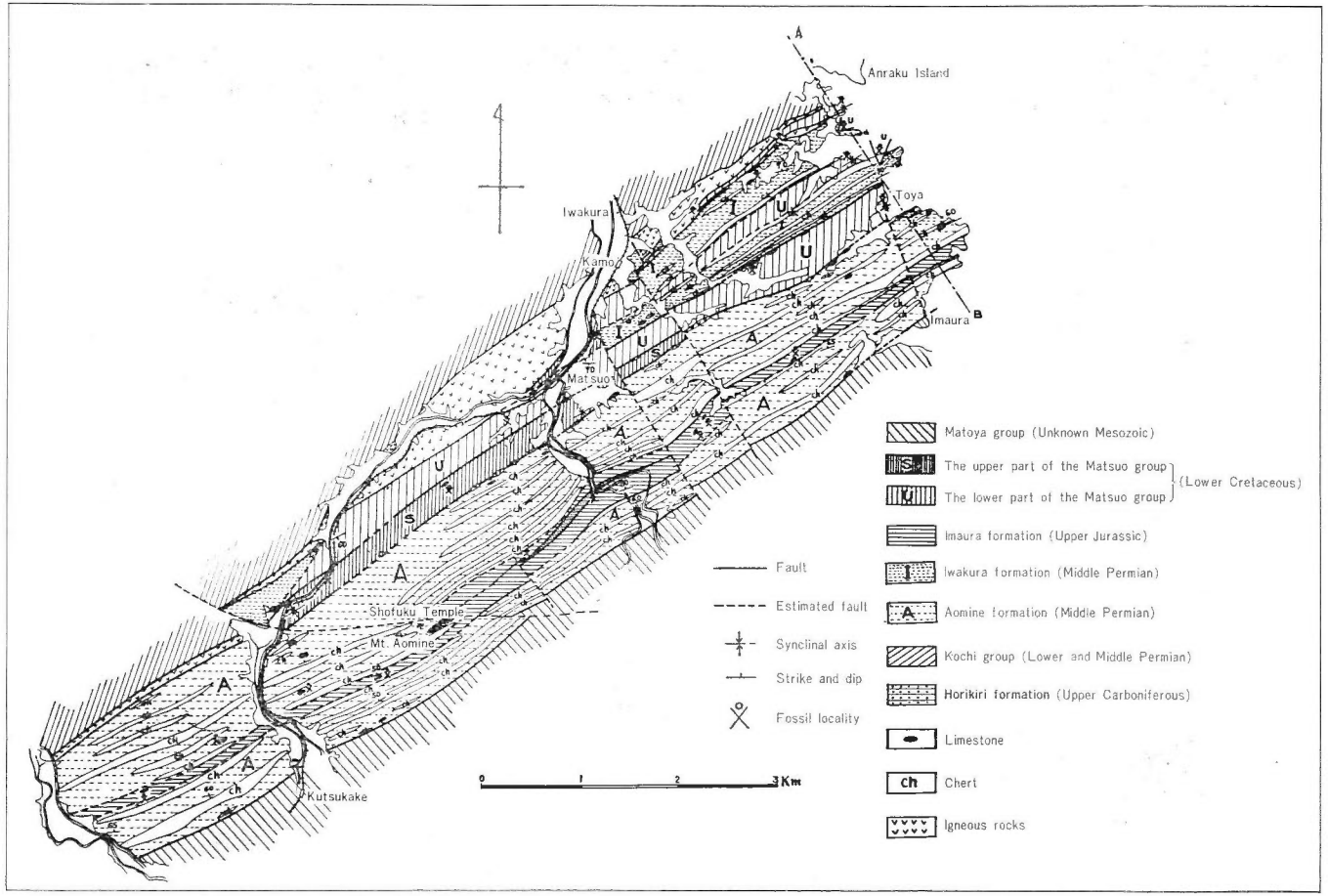

Fig. 22 Geological map of the eastern region of the Shima Peninsula (YAMAGIWA, 1957)

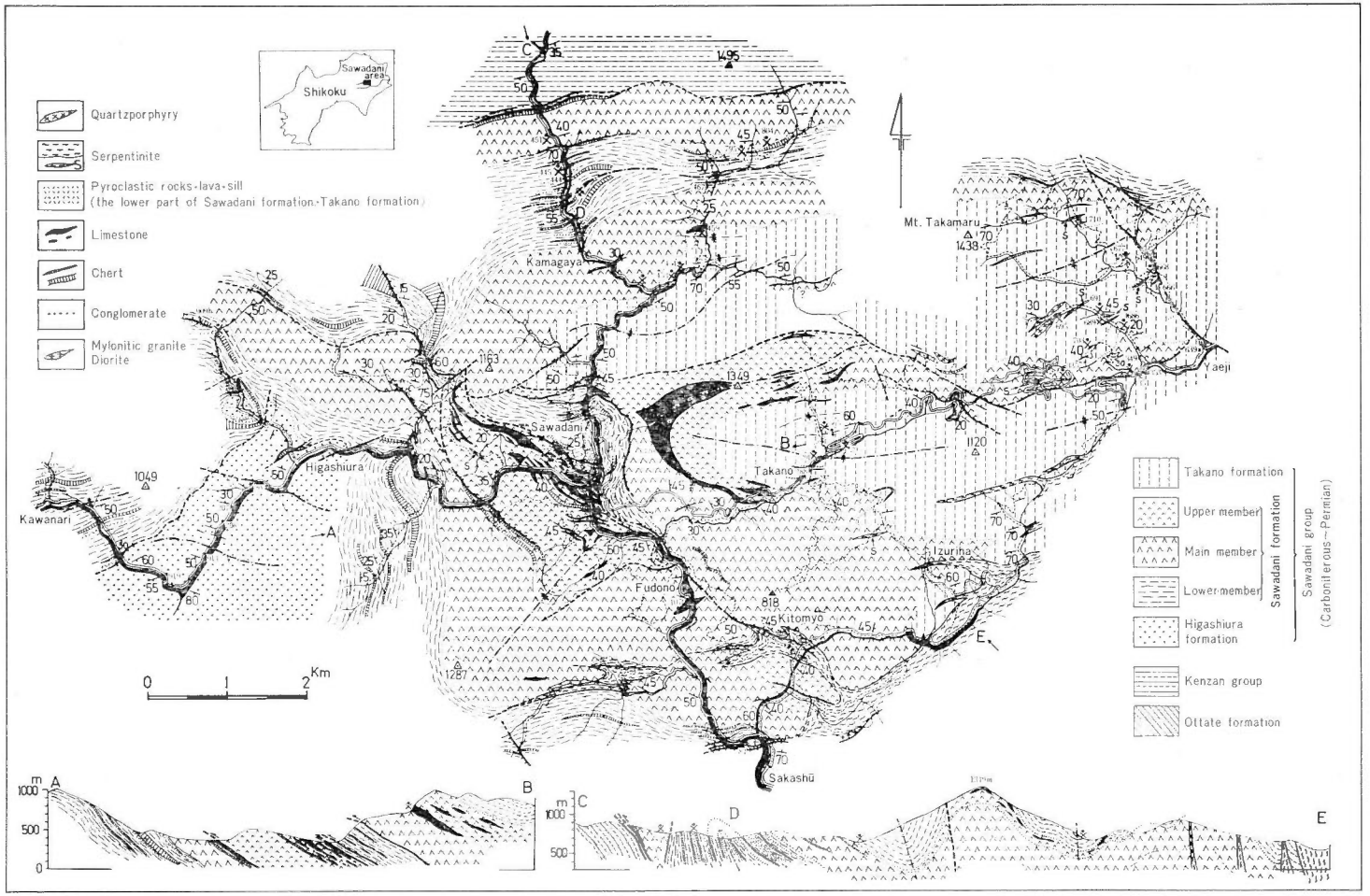

Fig. 23 Geological map of the Sawadani area, on the upper course of the River Naka, Tokushima Prefecture (KANMERA, 1969)

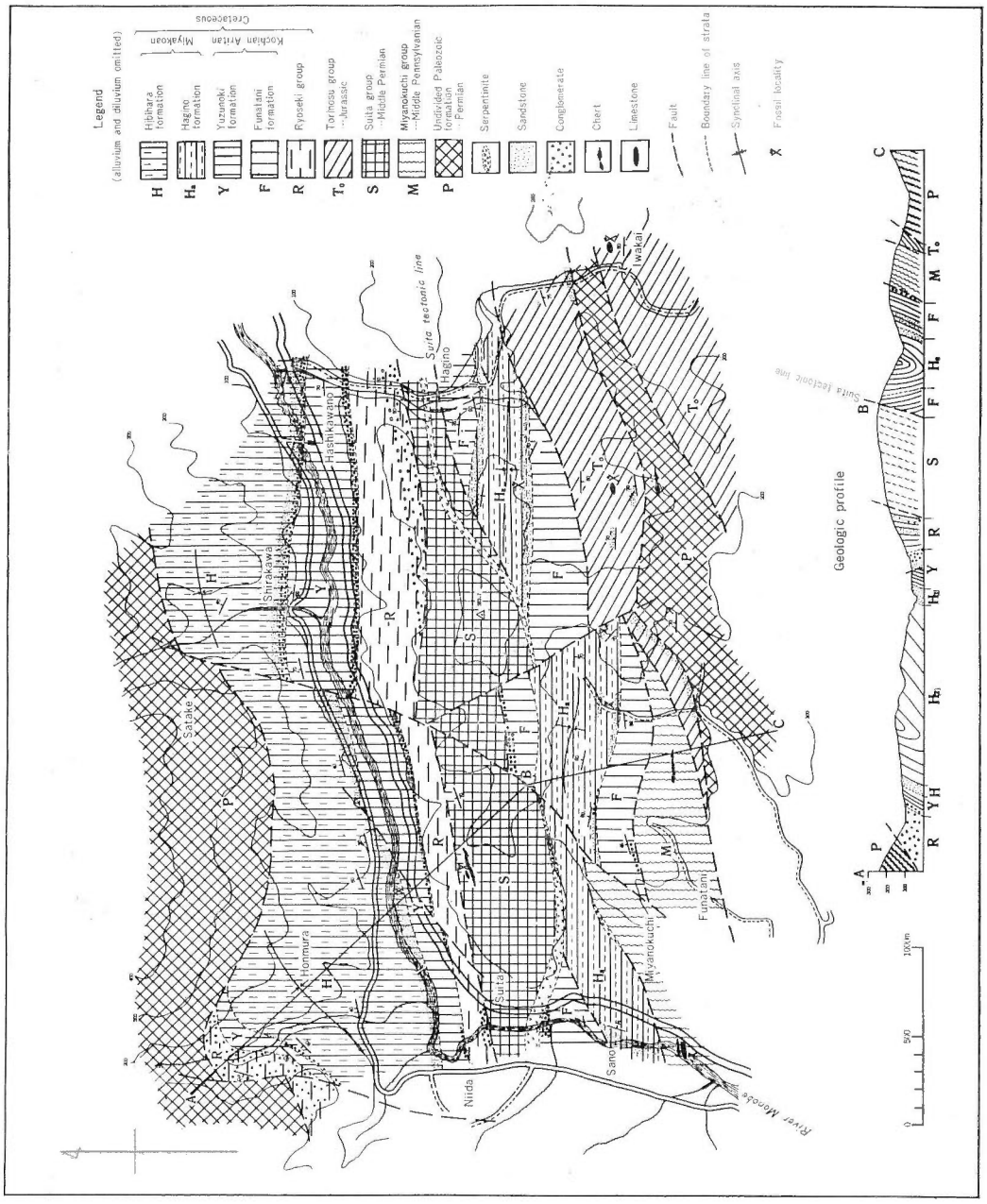

Fig. 24 Geological map in the vicinity of Suita, Kochi Prefecture (KATTO and SUYARI, 1956)

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2. 4 The Carboniferous in Chugoku Province

Ryūzo TORIYAMA

The Carboniferous is fairly well developed in the lower part of a thick carbonate sequence of marine facies in the western part of the Chugoku Province.

Although opinions are diverse concerning the stratigraphic position of the basal part of thick limestone series, the Tournaisian has been found very recently in the basal part of the Akiyoshi Limestone Group (YANAGIDA, personal communication). It occurs in the tuffaceous limestone intercalated in the basic tuff in the north central part of the Akiyoshi Limestone (Fig. 25 and 26).

The Viséan is well demonstrated in the Clα–Clβ zone of the Akiyoshi Limestone Group and the lower part of the Nagoe Formation in the Atetsu area (Fig. 27 and 28), and the Dangyokei Formation in the Taishaku area (Fig. 29, 30 and 31). In the Akiyoshi Limestone Group, the *Delepinea sinuata, Clisiophyllum awa atetsuense*, and *Millerella yowarensis* Zones are respectively referred to the early middle and late Viséan (YANAGIDA *et al.*, 1971). The age assignment to the lower part of the Nagoe Formation differs between the smaller foraminifera and the conodont assemblages. The age given by the conodonts (*Gnathodus bilineatus—G. texanus* Zone and the lower part of the *G. bilineatus—G. commutatus nodosus* Zone) indicates only the upper Viséan (KOIKE, 1967), whereas the age given by the smaller foraminifera (*Endostaffella delicata* Zone and *Endothyra* sp. A Zone) denotes the lower Viséan. The Dangyokei Formation of the Taishaku area does not have the *Endothyra* sp. A zone in the basal part.

The fusulinacean zonation is the best key to the biostratigraphic division and correlation of the Upper Carboniferous; the conodont zonation is especially effective in the lower part of the Upper Carboniferous.

The *Eostaffella-Millerella* Zone (the uppermost Viséan to the lower part of the Bashkirian) is found in the Akiyoshi Limestone (Clα–Cmβ zone), Taishaku Limestone (lower part of the Eimyoji Formation), and Atetsu Limestone (lower part of

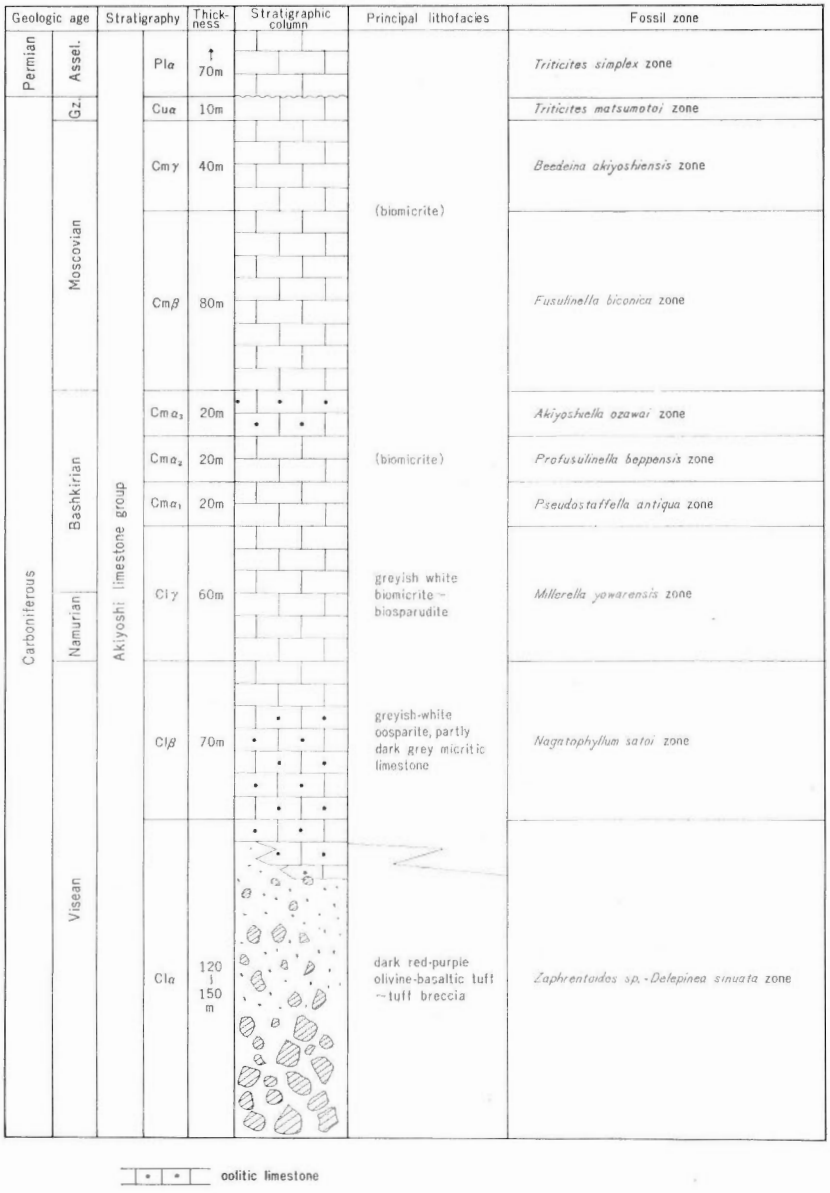
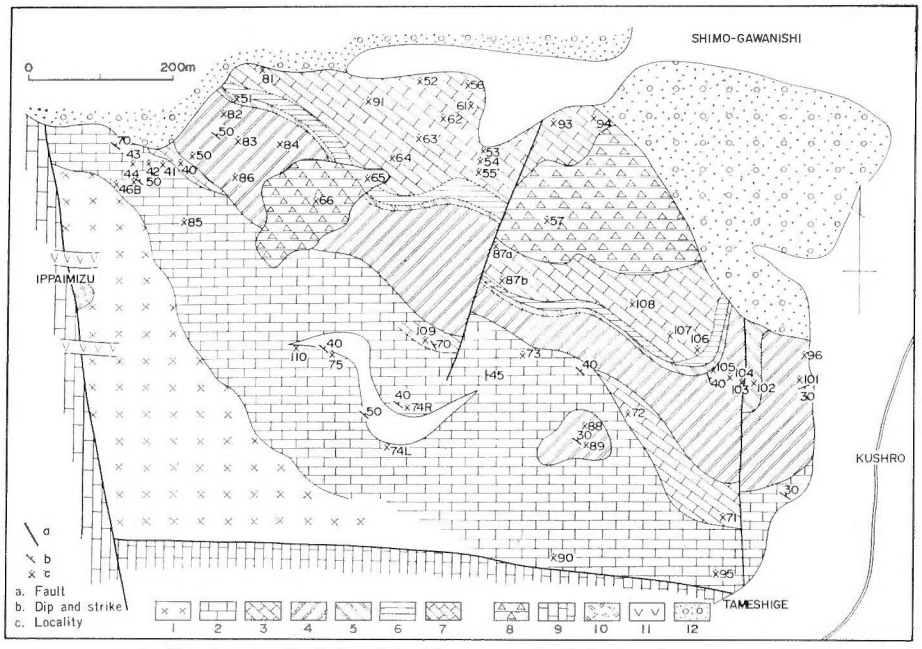


Fig. 26 Geologic column of the Akiyoshi Limestone(Toriyama, 1958; Okimura, 1966; Ōta, 1968; Toriyama and Ōta, 1971; Yanagida *et al.*, 1971)

the Kodani Formation). The lower part of the *Eostaffella-Millerella* Zone is represented by the *Millerella yowarensis* Zone, M. sp. A Zone, and *Eostaffella* sp. A Zone resented by the *Millerella yowarensis* Zone, *M.* sp. A Zone, and *Eostaffella* sp. A Zone monly developed in the upper part of the *Eostaffella-Millerella* Zone in these limestones.

The *Profusulinella* Zone (the upper part of the Bashkirian) covers conformably the *Eostaffella-Millerella* Zone in the Chugoku Province. It is represented by the *Profusulinella beppensis* Zone and *Akiyoshiella ozawai* Zone of the Akiyoshi Limestone, *P. toriyamai* Zone of the Atetsu Limestone (middle part of the Kodani Formation),



1. Diabasic rock, 2. *Endostaffella delicata* zone, 3. *Mediocris mediocris* zone, 4. *Millerella* sp. A zone, 5. *Pseudostaffella antiqua* zone, 6. *Profusulinella* zone, 7. *Fusulinella* zone, 8. *Pseudoschwagerina* zone, 9. *Neoschwagerina-Yabeina* zone, 10. Permian "Schalstein", 11. Porphyrite, 12. Tertiary

Fig. 30 Geological map of the Taishaku-Tameshige area, Tojo, Hiroshima Prefecture (OKIMURA, 1966)

and an undefined zone of the Taishaku Limestone (middle part of the Eimyoji Formation) and in the Koyama Group of the Oga area (Fig. 32 and 33).

The *Fusulinella-Fusulina* Zone (Moscovian) is the widest in distribution among the Carboniferous in the Chugoku Province, although the *Fusulina* Zone (s. s.) is not present in most of the sequences. The *Fusulinella* Zone (s. s.) in the Chugoku Province is represented by the *Fusulinella biconica* Zone of the Akiyoshi Limestone, *F. eopulchra* Zone of the Handa Limestone (Fig. 34 and 35), *F.* zone of the Taishaku Limestone (upper part of the Eimyoji Formation), and the *F. imamurai* Zone of the Atetsu Limestone (upper part of the Kodani Formation).

No *Fusulina* Zone (s. s.) has been found in the Chugoku Province except for the *Beedeina akiyoshiensis* Zone of the Akiyoshi Limestone. The *Triticites matsumotoi* Zone of the Akiyoshi Limestone is the only representative of the *Triticites* Zone in the Chugoku Province. The upper part of the *Triticites* Zone (upper Gzhelian) has not been found in the Chugoku Province.

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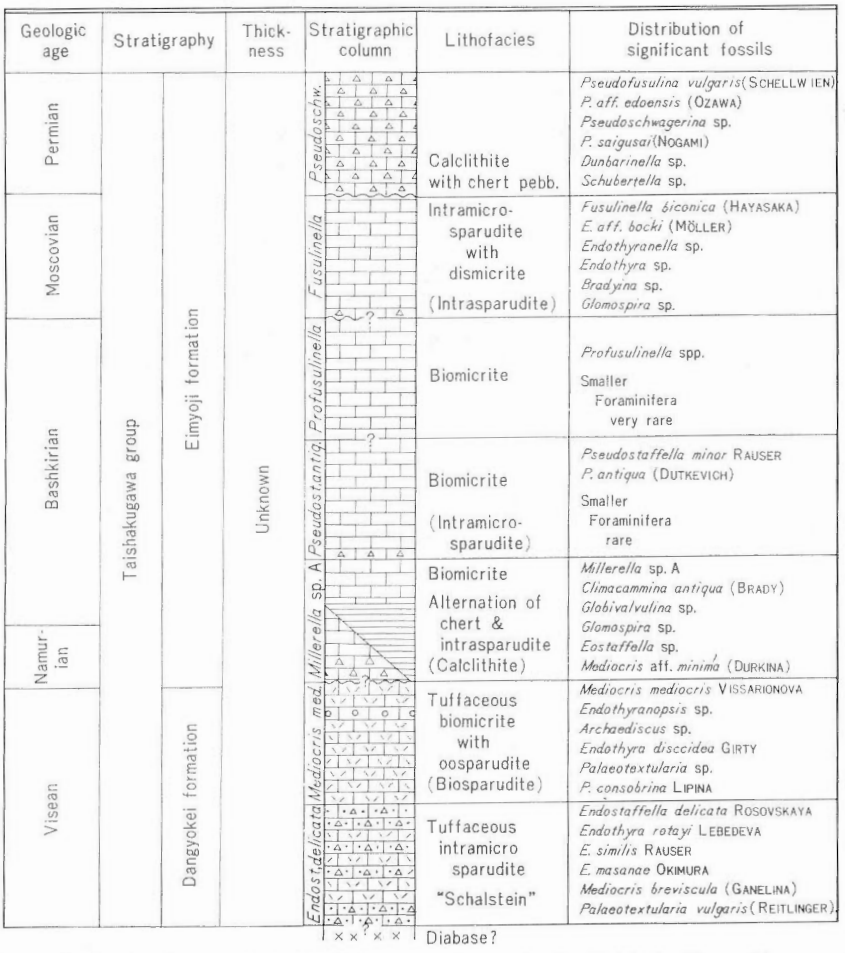

Fig. 31 Geologic column of the Taishakugawa Group in the Taishaku-Tameshige area, Tojo, Hiroshima Prefecture (YOKOYAMA, 1959 and OKIMURA, 1966)

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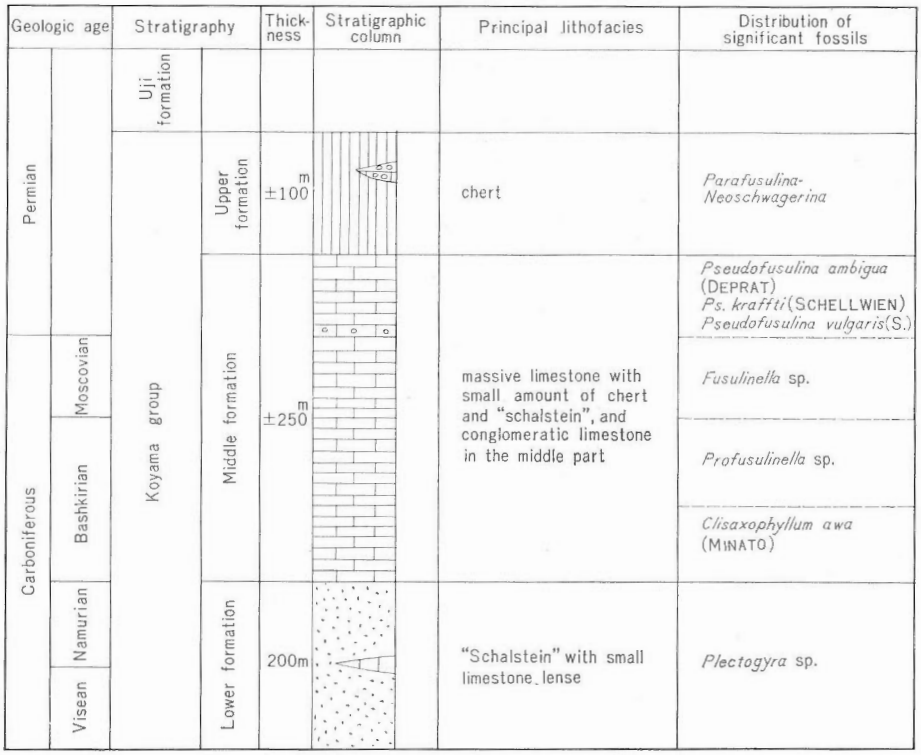

Fig. 33 Geologic column in the Ōga area (YOSHIMURA, 1961)

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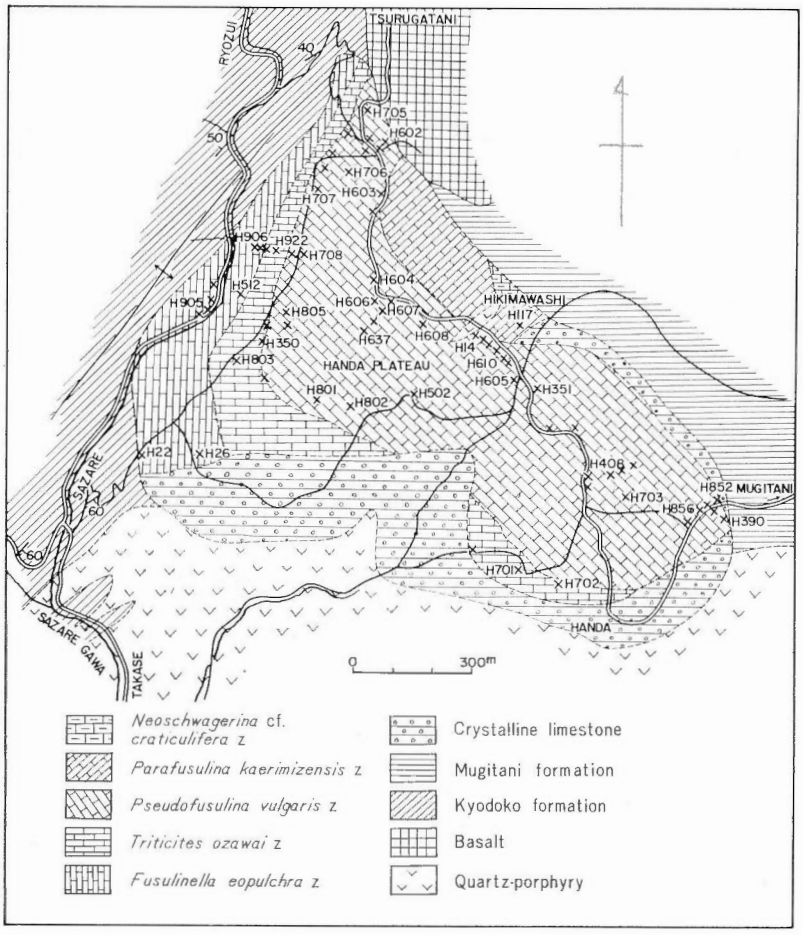

Fig. 34 Geological map of the Handa Plateau, Yamaguchi Prefecture and collection localities of fusulinids (KAWANO, 1961)

Geologic age		Stratigraphy	Thickness	Stratigraphic column	Principal lithofacies	Distribution of significant fossils
Permian	Artinskian	Handa Limestone	±250 m		limestone	*Neoschwagerina* cfr. *craticulifera* (SCHWAGER)
						Parafusulina kaerimizensis (OZAWA)
	Sakmarian					*Pseudofusulina vulgaris* (SCHELLWIEN)
						Triticites ozawai TORIYAMA
Carboniferous	Moscovian					*Fusulinella eopulchra* RAUSER-CHERNOUSSOVA

Fig. 35 Geologic column in the Handa area (KAWANO, 1961 and 1962)

2. 5 The Carboniferous in Kyushu Province

Kametoshi KANMERA

No index fossils of the Tournaisian have been found in Kyushu. The Viséan is represented by the Kakisako Formation which occurs in a narrow belt (800–1,300 m) in the upper reaches of the Hikawa river in the Kuma Mountains (Fig. 36 and 37).

It consists mainly of black slate with some thin lenticular beds of fine- to medium-grained feldspathic sandstone, but it is locally intercalated by a lenticular bed of limestone (60 m in maximum thickness) in the lower part, and a thick body (200–250 m thick) of basaltic and diabasic pyroclastic rocks and lava with some beds of chert and small lenses of limestone in the upper part.

The limestone of the lower part yields of tetracorals mainly from its lower part and fusulinids from its upper part, as shown in Fig. 38, and it is referred to the upper Viséan *Dibunophyllum* Zone. The main and upper parts of the formation may be assigned to the Namurian, but the precise age cannot be determined.

A nearly complete succession ranging from the Upper Carboniferous to the Lower Permian is represented by the Yayamadake Limestone which is distributed along the northern side of the Kakisako Formation mentioned above. It is about 550 m in maximum thickness and is intercalated as a lenticular body in basaltic and diabasic pyroclastics and lava of the Tobiishi Group. It is white to gray and massive, consisting mainly of biosparite predominantly containing fusulinids, calcareous algae and crinoid ossicles, and subordinately of oolite and pisolite.

The stratigraphic sequence of the limestone, and the contained fusulinids and corals are shown in Fig. 39. Based on diagnostic species which usually occur in great abundance the limestone is divided into the following zones:

Pseudoschwagerina minatoi Zone *Pseudoschwagerina morikawai* Zone	*Pseudoschwagerina Zone*
disconformity	
Triticites minatoi Zone *Triticites matsumotoi* Zone	*Triticites* Zone
Fusulina kurikiensis Zone *Fusulina ohtanii* Zone *Beedeina higoensis* Zone *Pseudostaffella pseudosphaeroidea* Zone	*Fusulinella-Fusulina* Zone

The *Fusulinella-Fusulina* Zone of the Yayamadake Limestone is correlated with the upper half of the Moscovian. The *Triticites* Zone conformably succeeds the *Fusulinella-Fusulina* Zone, but it is disconformably overlain by the Lower Permian *Pseudoschwagerina* Zone with a basal limestone conglomerate. Pebbles and cobbles of the conglomerate abundantly contain *Triticites* spp. which are distinguished from both *T. matsumotoi* and *T.yayamadakensis*. The two zones of Triticites are referable probably to the lower half of the Upper Carboniferous, the Kashimovian.

The Upper Carboniferous is also found in the Amatsuki and Futami Formations.

The Futami Formation is exposed in a limited area along a thrust zone in the western part of the Kuma Mountains. It consists of black slate with occasional thin beds of fine-grained sandstone, a chert bed, and a limestone lens (2 m thick) containing basic tuff patches (Fig. 40). The limestone contains *Fusulina* cf. *kanmerai* ISHII and *Fusulinella* sp., and is probably referable to the *Fusulinella biconica* Zone.

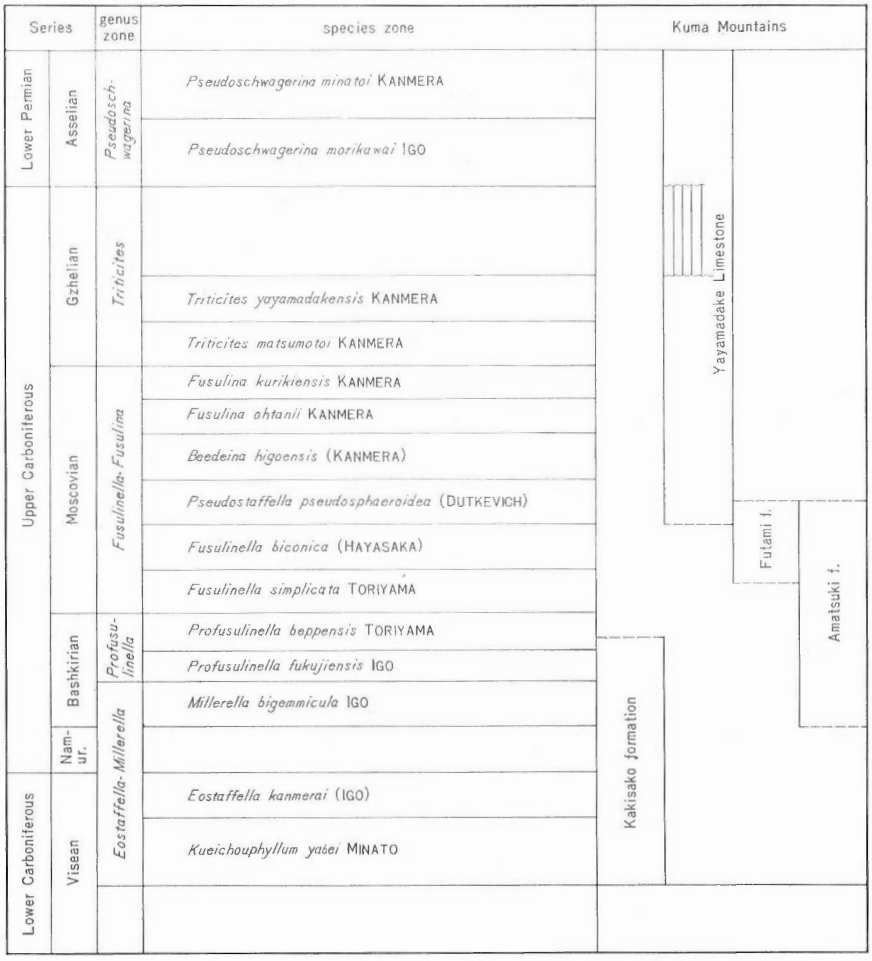

Fig. 36 Geologic column of the Kuma Mountains, Kyushu (KANMERA)

The Amatsuki Formation occurs in a narrow belt (1000–1,500 m) near the middle of the Kuma river basin. It is comprised of medium-grained sandstone with thin beds of slate in the lower part, and black slate and intercalated basic pyroclastics and limestone in the upper part, as shown in Fig. 41. No fossils have been found from the lower part, but *Fusulinella* sp. ex. gr. *bocki* MÖLLER, *Profusulinella*? sp., *Fusulina* sp., and *Staffella* sp. occur from the limestone of the upper part. This limestone is probably referable to the *Fusulinella simplicata* Zone.

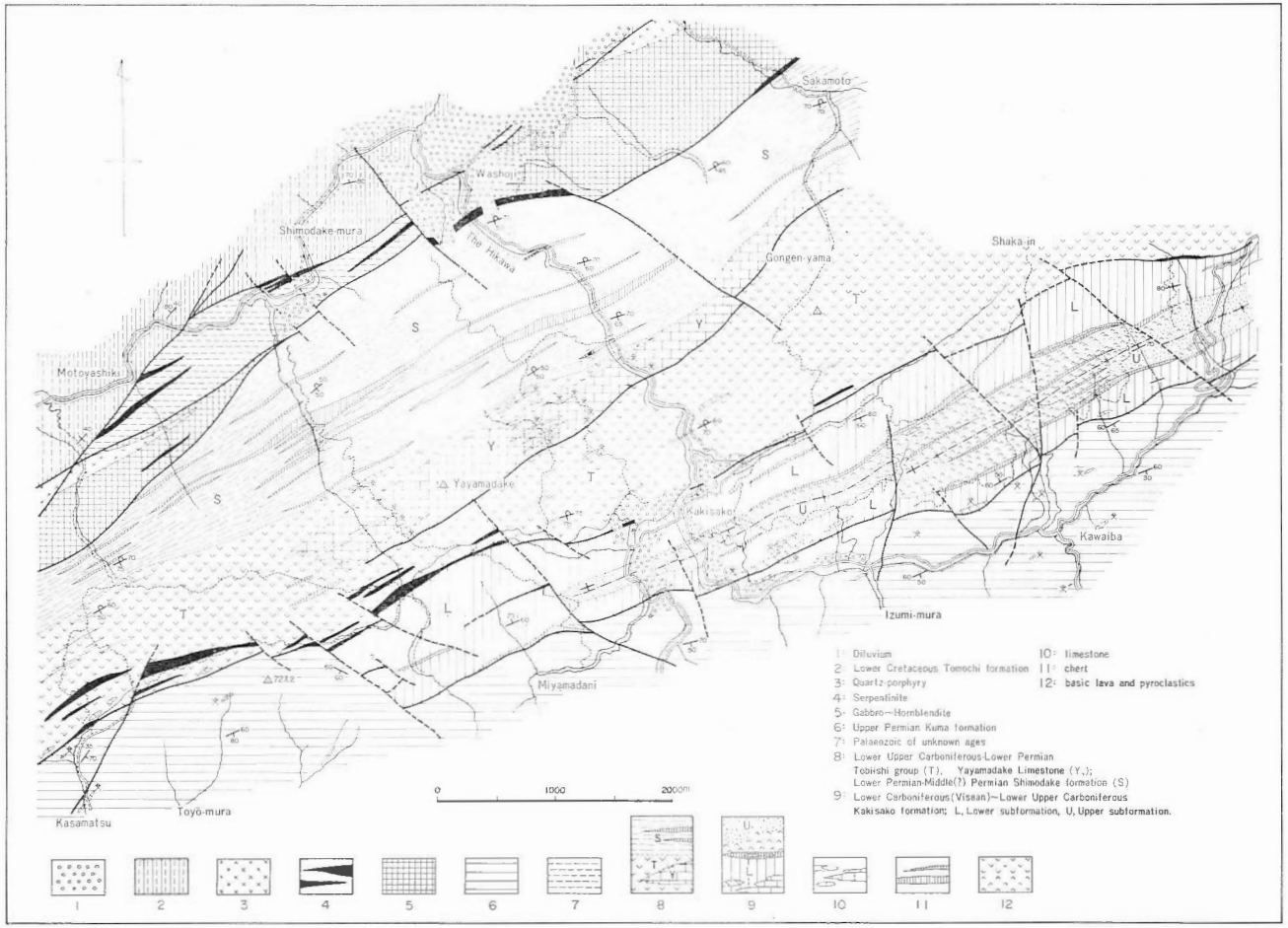

Fig. 37. Geological map of the Yayamadake-Kakisako area, Kuma Mountains, southern Kyushu (compiled from KANMERA, 1952a, b)

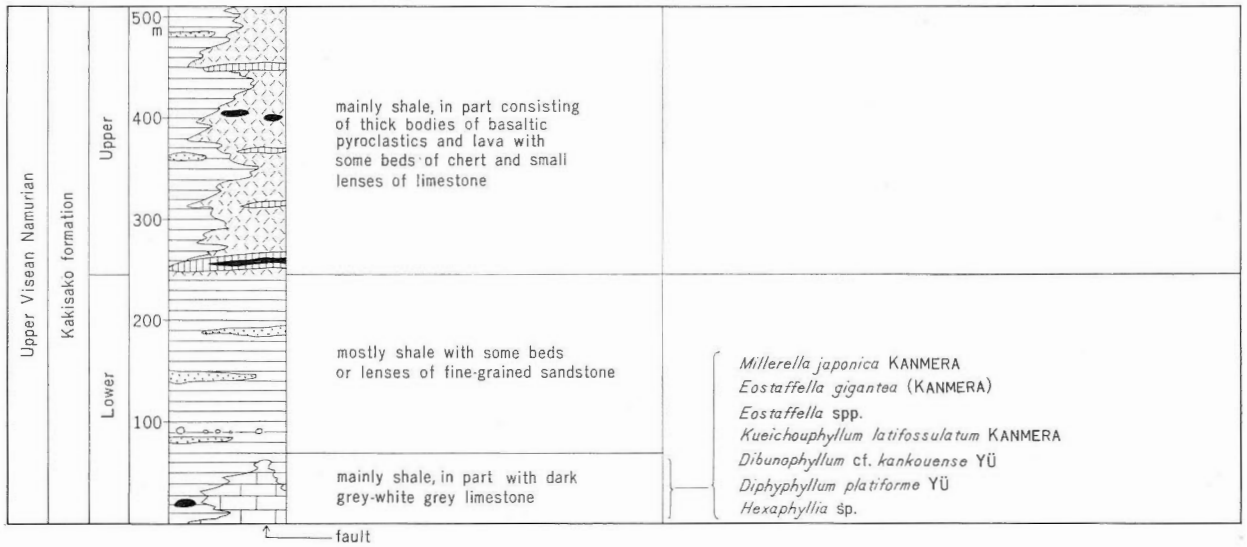

Fig. 38 Stratigraphic section of the Kakisako Formation in the Kuma Mountains, southern Kyushu (KANMERA)

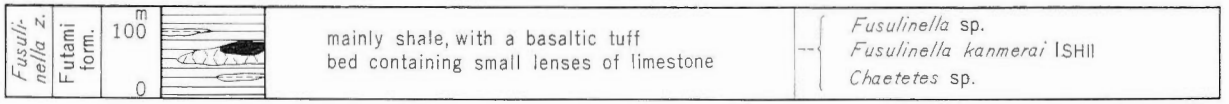

Fig. 40 Stratigraphic section of the Futami Formation in the Kuma Mountains, southern Kyushu (KANMERA)

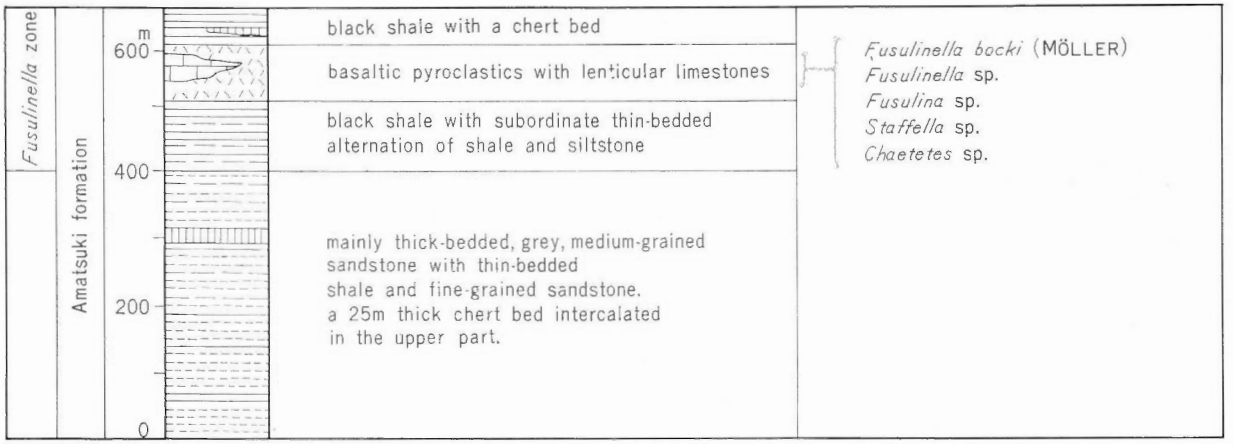

Fig. 41 Stratigraphic section of the Amatsuki Formation in the Kuma Mountains, southern Kyushu (KANMERA)

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3. Correlation of the Japanese Carboniferous

3.1 Correlation of the Japanese Lower Carboniferous

Masao MINATO *and Makoto* KATO

Fossil evidence has been too meager to indicate Lower Carboniferous ages for lithologic sequences in a number of places in Japan, which are otherwise lithologically comparable to the standard succession established in the southern Kitakami Mountains (Table 1).

In fact, the most complete lithologic succession of Lower Carboniferous found in the southern Kitakami Mountains furnishes the only reliable basis for correlating the Japanese Lower Carboniferous both faunally and lithostratigraphically.

Rocks of the Hikoroichi Series are known in the Abukuma Mountains as well as the type area, but nowhere else.

Fossiliferous rocks of the Arisu and Ohdaira Series are not known outside the southern Kitakami Mountains.

However, thick geosynclinal deposits developed below calcareous formations with the upper Viséan fauna (Onimaru fauna) in a number of places are often intercalated by large amounts of basic pyroclastics which are lithologically characteristic of the Arisu and Ohdaira Series in the type area.

Therefore the lower part of the Kogawa Formation in the northern Kitakami Mountains, the Ohkadoya Formation in the Abukuma Mountains, and the Hongo Formation (= Arakigawa + Kunimiyama Formation) in the Hida Mountains and so on may be largely Lower Carboniferous in age and are correlated with the Hikoroichi–Arisu–Ohdaira Series in the type area. The metamorphosed sequence of the Sangun suite on the inner side of Southwest Japan probably consists of, at least partially, Lower Carboniferous rocks. The Sambagawa crystalline schists may also contain parts which are Lower Carboniferous in age.

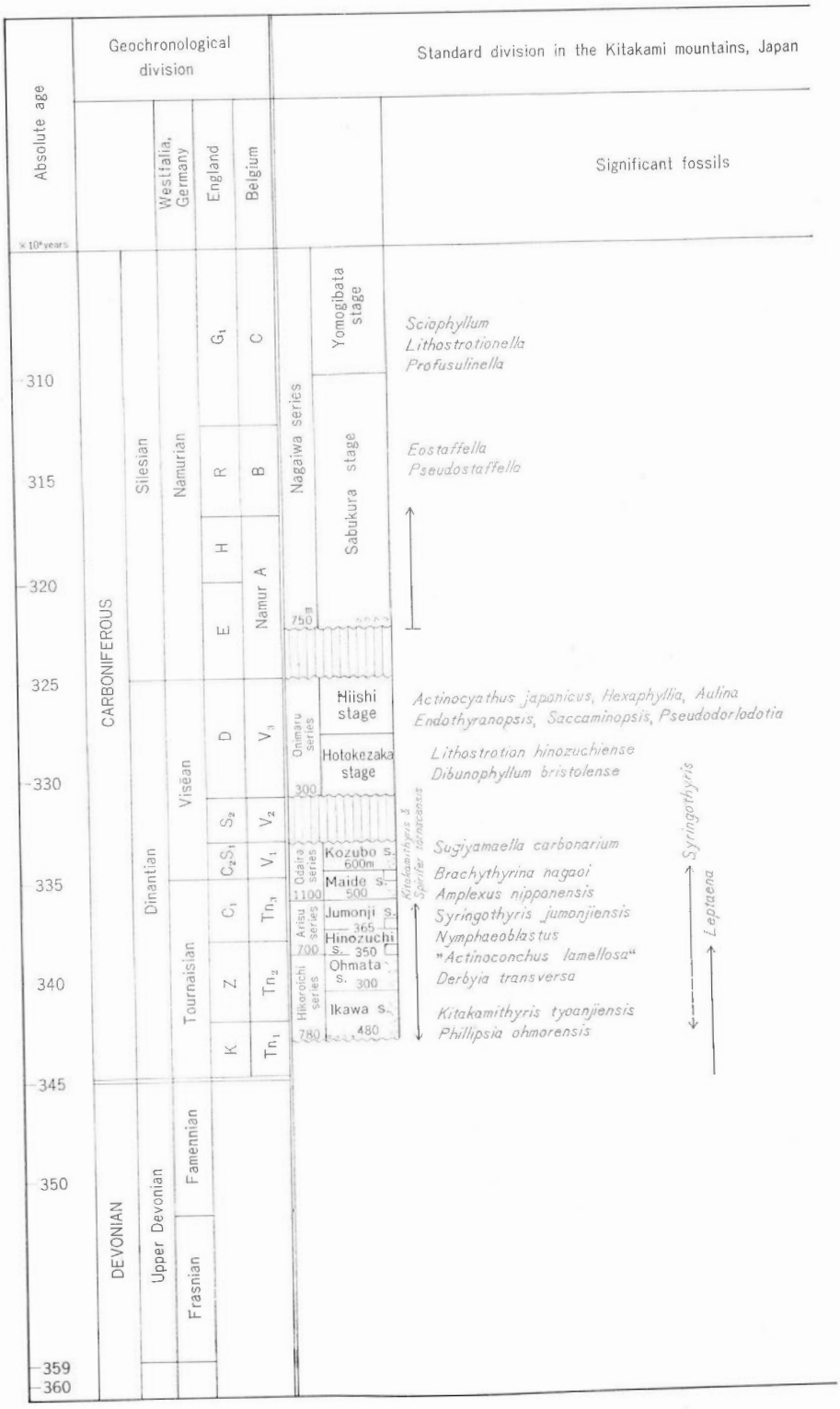
On the other hand, the Onimaru fauna has been widely traced in the Japanese Islands as stated above. The fauna being rich in coralline fossils is essentially of shallow sea origin, and is found in relatively thin calcareous formations scattered throughout Japan.

In the type area the Onimaru Series is divided into two stages. Most widely traceable is the fauna of the upper stage, the Hiishi Stage.

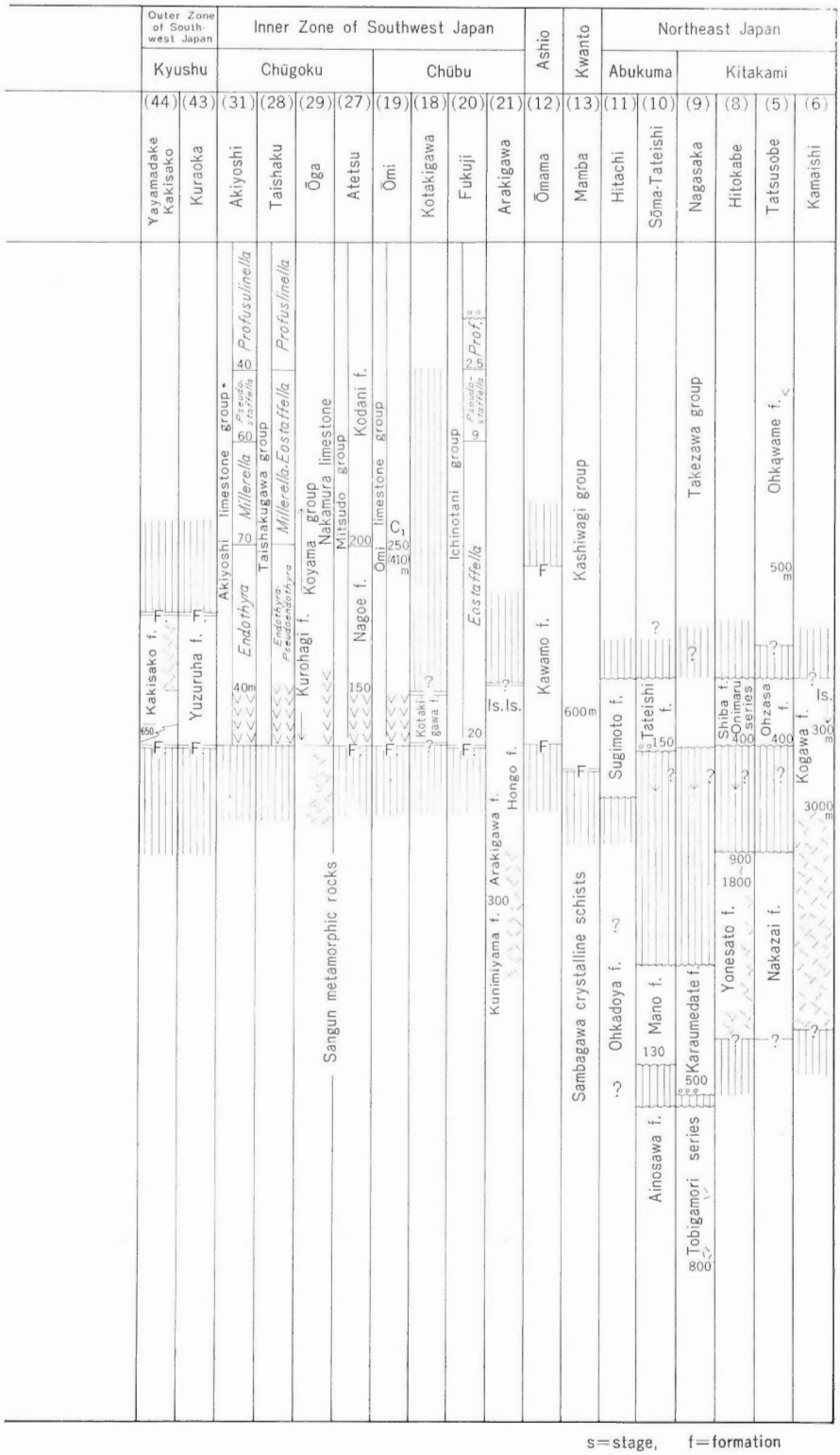
Besides these calcareous formations pyroclastic deposits developed just beneath the thick masses of Akiyoshi and Omi Limestones yield some brachiopods such as *Delepinea* of upper Viséan age.

To sum up the above description, a eugeosynclinal condition with submarine volcanism prevailed in the Japanese Islands region in the Tournaisian and probably in early Viséan (Hikoroichi–Arisu–Ohdaira ages). Then a great change occurred in lithofacies, since eugeosynclinal deposits were superseded by extensive development of epicontinental facies of upper Viséan (Onimaru age). The change must have been the result of a great crustal deformation, which in fact caused the pre-Onimaru unconformity detected at a number of localities.

Table 1 Correlation of the Japanese



Lower Carboniferous (MINATO and KATO)



3. 2 Correlation of the Japanese Upper Carboniferous

Ryūzo TORIYAMA

Correlation chart of the Upper Carboniferous in Japan is given in Table 2.

3. 3 The Boundary between the Lower Carboniferous and the Upper Carboniferous in Japan

Masao MINATO *and Makoto* KATO

To define the boundary between Lower Carboniferous (Dinantian) and Upper Carboniferous (Silesian) within a given stratigraphic sequence one has to seek places where Carboniferous Formations are developed conformably and the faunal changes in them have been successively traced (Table 3). Further, these faunal sequences ought to be precisely correlated to the known faunal successions in the standard areas in west Europe.

Very unfortunately it is normally difficult to define the boundary between Viséan (topmost Dinantian) and Namurian (lowermost Silesian) in terms of faunal changes even in the type areas of Europe. Large scale shifting of sedimentary facies from Viséan to Namurian often prevents continuous tracing of the stratigraphic ranges of many taxa. In fact conspicuous faunal change has been claimed to occur within the Namurian rather than at the end of the Viséan.

Taking all these things into consideration only conodont biostratigraphy in the Atetsu Limestone plateau (KOIKE, 1967) furnishes reliable dates in Japan for international correlation concerning to the Viséan–Namurian boundary problem.

HIGGINS and BOUCKAERT (1968) in their research on the conodont biostratigraphy in the type Namurian in Belgium say that in Japan the Viséan–Namurian boundary lies somewhere in the *Gnathodus bilineatus–G. commutatus nodosus* Zone of KOIKE in the Atetsu plateau.

DUNN (1970) worked out a similar conodont biostratigraphy in North America, and he correlates the Viséan–Namurian boundary to the base of the above mentioned zone of KOIKE.

This roughly corresponds to a horizon from which massive limestone facies began to develop in the Akiyoshi, Atetsu, and Omi regions etc.

Taking into consideration that the basal Namurian (E_1) is missing in Belgium, and that the conodont biostratigraphy is by no means finally settled in each area, and hence a precise international correlation may be made only with reservation, it may be said that the basal part of the Upper Carboniferous is situated somewhere around the basal part of the massive limestones of the Akiyoshi, Atetsu, and Omi in Southwest Japan.

This conclusion is in accordance with a previous opinion expressed by us, based on a number of reasons (MINATO, 1960; MINATO and KATO, 1963; KATO *et al.*, 1964). However some authors are in favour of placing their Viséan–Namurian boundary somewhat higher in the stratigraphic sequence, i.e. in the lower part of the Akiyoshi Limestone Group, based on foraminiferal and brachiopod studies (OKIMURA, 1966; OTA, 1968; YANAGIDA *et al.*, 1971).

In Northwest Japan, the Nagaiwa Series has been correlated mainly to the Bashkirian, while the underlying Onimaru Series has been correlated to the Upper Viséan. Therefore the Viséan–Namurian boundary has been designated at the stratigraphic boundary between the Nagaiwa and the Onimaru Series. However, the problem of

whether the upper part of Onimaru Series does contain strata correlative with the Lower Namurian or not still remains unsolved.

3. 4 The Devonian and Carboniferous Boundary in Japan

Masao MINATO *and Makoto* KATO

Nowhere in Japan are the Devonian and Carboniferous completely conformable.

In the Hikoroichi region of the southern Kitakami Mountains OKUBO (1951) detected a clinounconformity between the two systems. There the Middle Devonian Nakazato Series bearing *Calceola*, *Disphyllum* and *Phacops* is unconformably overlain by a member of fine conglomerate at the base of the Lower Carboniferous Hikoroichi Series. The lowest fossil horizon of the Hikoroichi Series (Ao zone of MINATO *et al.*, 1953) yields *Kitakamithyris*, *Phillipsia*, *Caninia* etc., and is correlative with Tournaisian. For this crustal deformation which resulted in the formation of an unconformity the name of Kesen folding has been proposed (OKUBO, 1951).

In the Takamoriyama region, north of the Hikoroichi region, the middle Devonian Takamoriyama Formation is in fault contact with the Lower Carboniferous Hikoroichi Series.

To the west, in the Nagasaka region there are also Devono–Carboniferous formations. An unconformable relationship between the Devonian and Carboniferous has also been ascertained here, which is called the Minamiiwairi unconformity of Tachibana (1964). He claims, however, that there are places where both Devonian and Carboniferous are conformable with each other. This point should be further studied in detail.

In the Nagasaka region the Devonian Tobigamori Series contains *Cyrtospirifer* and *Leptophloeum*, and is assigned to the Upper Devonian. While the Lower Carboniferous Karaumedate Formation yields *Kitakamithyris* and *Syringothyris*, and is Tournaisian.

The Tateishi region of the Abukuma Mountains provides another locality where Devonian and Carboniferous are inferred to be unconformable. There the Upper Devonian Ainosawa Formation with the *Sinospirifer* faunule (HAYASAKA and MINATO, 1954) is supposed to be unconformably overlain by the Mano Formation which has been generally correlated to the Hikoroichi Series of the Kitakami Mountains (SATO, 1956).

Thus the base of the Carboniferous formations in Japan is best taken at the lower surface of the basal conglomerate of the Hikoroichi Series and comparable formations.

3. 5 The Carboniferous and Permian Boundary in Japan

Ryūzo TORIYAMA

The Carboniferous—Permian boundary problem has not yet been settled. The major disagreement involves whether the Carboniferous—Permian boundary should be placed at the base of the Sakmarian (s. s.) or of the Asselian (the lower part of the Sakmarian (s. l.)).

Throughout the Japanese Islands there is no place where a completely continuous Carboniferous—Permian succession has been confirmed by paleontologic evidence. Even where the *Triticites* zone is developed, as in the type section of the Hikawan Series in South Kyushu, the Carboniferous is mostly covered by the Permian with a clino-unconformable relationship. Laying stress on the stratigraphic evidence, therefore, it is accepted by most stratigraphers of Japan that the Carboniferous—Permian

boundary should be placed beneath the *Pseudoschwagerina morikawai* Zone or its equivalent. It is noted that a rather prolific fauna of the *Triticites simplex* group is found in the basal part of the Permian.

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Postscript

After completed the final text, the following important papers concerning the Carboniferous stratigraphy and paleontology in Chapter 2.1 and 2.2 were published.

1) Ozawa's manuscript cited in p. 17 and Fig. 12 was printed;

OZAWA, T. (1975): Stratigraphy of the Paleozoic and Mesozoic strata in the Tamagawa Area, Southeastern Part of the Kwanto Mountains. Sci. Rep. Dept. Kyushu Univ., vol. 12, no. 2, pp. 57–76, pls. 7–10. (in Japanese with English abstract).

2) Watanabe's manuscript cited in Facing p. 18 and Fig. 14 was printed as the following two papers.

WATANABE, K. (1974): *Profusulinella* Assemblage in the Omi Limestone, Niigata Prefecture, Central Japan: Trans. Proc. Pal. Soc. Japan, N.S., no. 92, p. 371–394, pls. 51–53.

————, (1975): Mississippian conodonts from the Omi Limestone, Niigata Prefecture, Central Japan: Ibid. no. 99, p. 156–171, pls. 14, 15.

3) The writer cited an important conodont species as *Declinognathodus noduliferus* in Facing p. 20 and Fig. 16, however, this species is now referred to *Idiognathoides or Streptognathodus*.

Also, IGO listed *Triticites* sp. A. in Facing p. 20 and Fig. 16 as a guide fossil of the lower *Triticites* Zone of the Ichinotani Formation. This characteristic species is now considered as *Protriticites variabilis* BENSH, therefore, *Triticites* sp. A. Zone should be changed to the *Protriticites variabilis* Zone.

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- b. 岩石・鉱物
- c. 古生物
- d. 火山・温泉
- e. 地球物理
- f. 地球化学

B. 応用地質に関するもの
- a. 鉱　床
- b. 石　炭
- c. 石油・天然ガス
- d. 地下水
- e. 農林地質・土木地質
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C. そ の 他

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No. 257

HIRUKAWA, T., ANDO, N., SUMI, K. (ed.): Chemical composition of the thermal waters from thirty main Japanese geothermal fields (in Japanese with English abstract)

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