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Geology and Paleontology of the Takakurayama-Yaguki Area, Yotsukura-cho, Fukushima Prefecture

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ABSTRACT

Geological and paleontological studies were made of the structurally complex and paleontologically little known Takakura-yama—Yaguki area situated in the hilly region west of Yotsukura-cho, Iwaki City, Fukushima Prefecture. The terrain, made geologically complex by the many major reverse and thrust faults accompanied with normal ones and intimately associated with large intrusive rock bodies has been classified into two groups and six formations and one member. Of the two groups, the lower or Niidagawa (Devonian-Carboniferous) chiefly consists of metamorphic rocks whereas the upper or Takakura-yama (Early to Middle Permian) is of normal sedimentaries. Paleontological evidences (mainly fusulinids, brachiopods and molluscs) for geological age determination are found in the Takakura-yama Group but not in the Niidagawa, which age is judged based upon correlation with formations in the northern part of the Abukuma Massif (adjoining the present area) and the southern part of the Kitakami Massif of similar geostructure, lithological resemblance and stratigraphical relationship with subjacent and superjacent units. The metamorphic rock series (Niidagawa Group) seems to have originally been of marine neritic origin, but it is also assumed that the original sedimentary environment was not favorable to shallow water marine organisms. The sedimentary environment of the Takakura-yama Group was not an excellent one for the growth and flourishing of marine organisms, judged from the abundant dwarf forms. From the occurrence of many planktonic organisms (fusulinids, ammonites, nautiloids) collected from the muddy sediments, it is judged that the sedimentary basin had free connection with the open sea.

CONTENTS

INTRODUCTION

The purpose of the present paper is to work out the stratigraphy, geological structure and paleontology of the area surrounding Mt. Takakura (293 m above sea level) which is situated at about eight km north of Taira, Iwaki City and about six km west of Yotsukura-cho, Iwaki City. This area is of particular interest because of the metamorphic rock facies of unknown geological age in its western part and in exact stratigraphical position, a well known fossil locality of Permian age in the southeastern part, and sedimentary rocks of undetermined geological age in the northern part. The area is complex in structure owing to the many large thrust, reverse and normal faults and to the igneous rocks which intrude between the faults or occur in different stratigraphic positions.

The writer, besides stratigraphical work, studied the boring cores and data from drilled wells of the Nittetsu Mining Company and of other companies which were made available by the members of those companies. Other valuable data are found in the unpublished works (graduation thesis) in the Institute of Geology and Paleontology, and of the Institute of Mineralogy, Petrology, and Economic Geology both of the Faculty of Science, Tohoku University. Further, many specimens of invertebrate fossils of Permian age and samples of sedimentary, igneous and metamorphic rocks from the Mt. Takakurayama area stored in the collection of the Institute of Geology and Paleontology, Tohoku University from many localities, were also studied.

Although problems may remain, it is thought and hoped that the present work may contribute to the geology and paleontology of the area mentioned above.

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PREVIOUS WORKS ON THE GEOLOGY AND PALEONTOLOGY OF THE TAKAKURA-YAMA AREA

There are several works on the ore deposits, geology and paleontology of the present area that deserve mentioning.

The first work is by Hirabayashi (1904) on the geology of the ore deposits of the

Yaguki Mine followed by Watanabe's (1922) studies on the Yaguki and Ono Mines. Subsequently, Nishiwaki (1960) published on the ore deposits of the Yaguki Mine, and also on the geology of the vicinity. Hayashi (1937, MS) and Sugahara (1961, MS) studied the Paleozoic geology of the area which included the Yaguki and Ono Mines, Takakura-yama and the vicinity. Iwao and Matsui (1961) published on the geology and issued a geological map in the scale of 1/50,000 (Taira to Kawamae Sheet), whereby the distribution of the different rocks became rather well known. Seki (1962) wrote on the crystalline schists of the vicinity of the Yaguki Mine, and made clear the geological relationship between the intrusives and the Paleozoic rocks.

Concerning paleontological work, the first report is by Nagao (1931) who recorded the occurrence of a Trilobite, and subsequently, Endo and Matsumoto (1962) described a new species of Trilobite from the Permian of the Takakurayama area. Hayasaka (1957, 1965) described two species of Nautiloids and eight species of Ammonites from the Permian of the Takakura-yama area. Murata (1964) described some fusulinids from the Kashiwadaira and Motomura Formations in the Takakura-yama area and his studies are being continued. Recently Onuki (1966) wrote on the stratigraphic sequence of the different rocks and the geological structure of the vicinity of the Yaguki Mine. He also correlated the formations in the southeastern part of the Abukum Massif with those in the southern part of the Kitakami Massif.

With regard to stratigraphy of the southerastern part of Abukuma Massif, the writer (Yanagisawa, 1958; Yanagisawa and Nemoto, 1961) published on the geology of the Takakura-yama area and Yaguki Mine area.

GEOLOGY

The present area, called for the sake of convenience, the Takakura-yama—Yaguki area, is situated at about eight km north of Taira, Iwai City and about six km west of Yotsukura-cho, Iwaki City, Fukushima Prefecture. The area is bounded on its western side by the Nekonaki fault of approximately longitudinal trend and on whose western side is distributed the Yokokawa granodiorite, on the eastern side by the Yaguki fault which is parallel with the Nekonaki fault, but split in its northern part by the extension of the Katakura fault, and on whose eastern side is distributed the Obisagawa granodiorite, and, at the southern side by the Futatsuya fault of northwest—southeast trend and on whose southern side is distributed strata of Tertiary age. The northern part of the present field is deliminted at the central hilly area situated north of the Yaguki Mine. Thus, the present area is bounded on its western, southern and eastern sides by faults of signfiicant structural importance, and at its northern part by the hilly area already mentioned. (Fig. 1).

The metamorphic, igneous and sedimentary rocks distributed in the fault bounded area can be classified into the units given in Table 1.

The stratigraphic units are described below in the order from the older to the younger.

A. Niidagawa Group

The type locality of the Niidagawa Group is along the Niidagawa River in the vicinity of Yaguki, west of Yotsukura—cho, where the Shobudaria Formation and Yaguki Limestone with its Ryokushozawa Member can be observed in upward sequence although cut by many faults. The lowest exposed formation is the Shobudaira, but its base is not exposed anywhere in the present field. The group is composed of metamorphic rocks and attains a thickness of more than 3000 m. From the rock facies the group is classified as shown in Table 1.

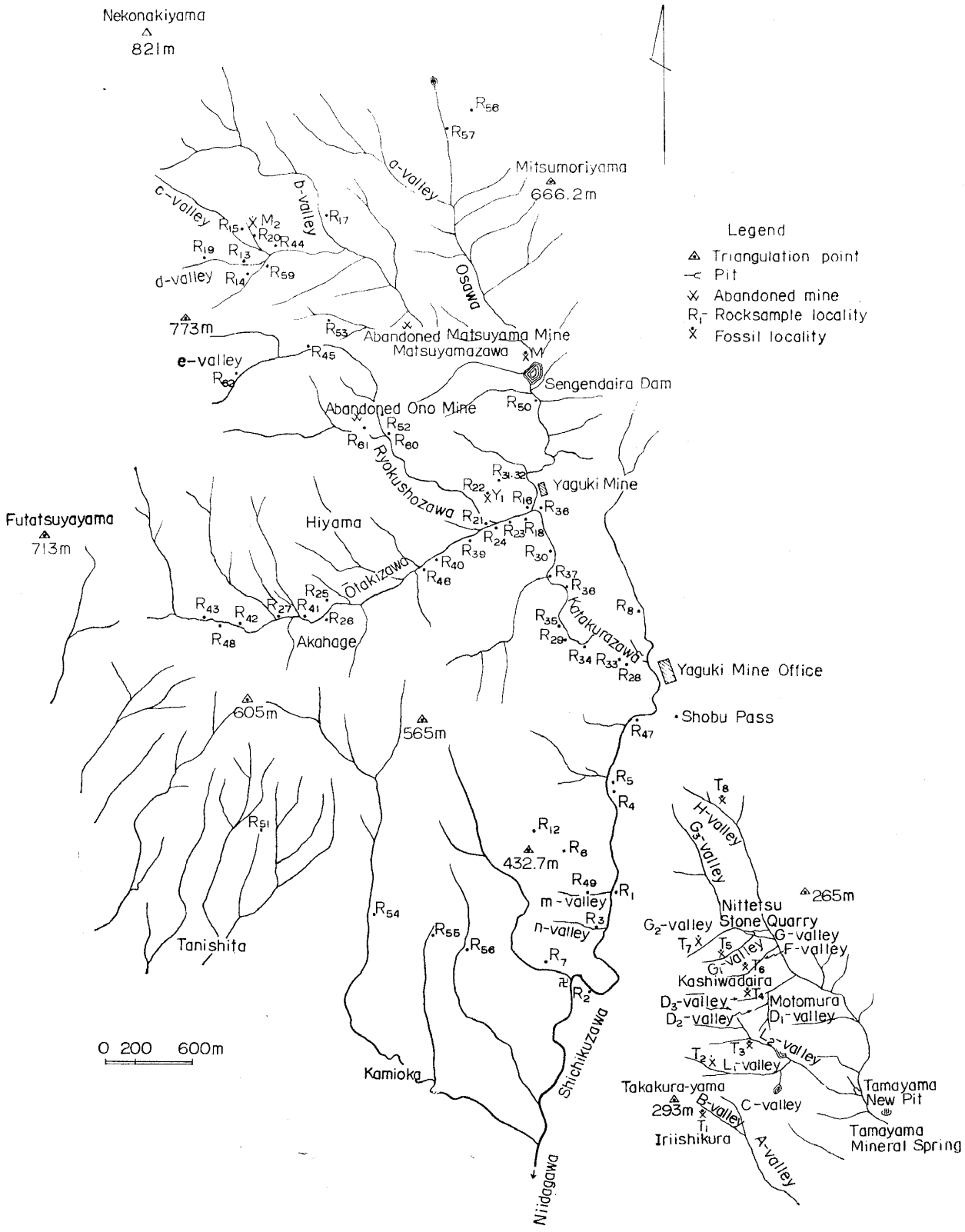

Fig. 1. Drainage Pattern, Fossil and Rock-sample Localities and Geographic Names.

Table 1. Stratigraphic Sequence of the Rocks distributed in the Takakura-yama—Yaguki Area, Yotsukura-cho, Iwaki City, Fukushima Prefecture

Age	Group	Formation	Thickness (in meters)	Lithology
Permian	Takakura-yama	Kashiwadaira	420–530	Black slate
		Motomura	70–170	Sandstone, slate, conglomerate
		Iriishikura	90–170	Black slate
		fault		
		Matsuyamazawa	1500–1600	Black slate, green siliceous slate, phyllite
Carboniferous	Niidagawa	Yaguki Limestone	78–190	Crystalline limestone, black slate, hornfels
		Ryokushozawa member	50–80	Actinolite chlorite schist
		fault		
Devonian		Shôbudaira	2500–3000+	Biotite quartz schist, chlorite two mica quartz schist, chlorite quartz schist

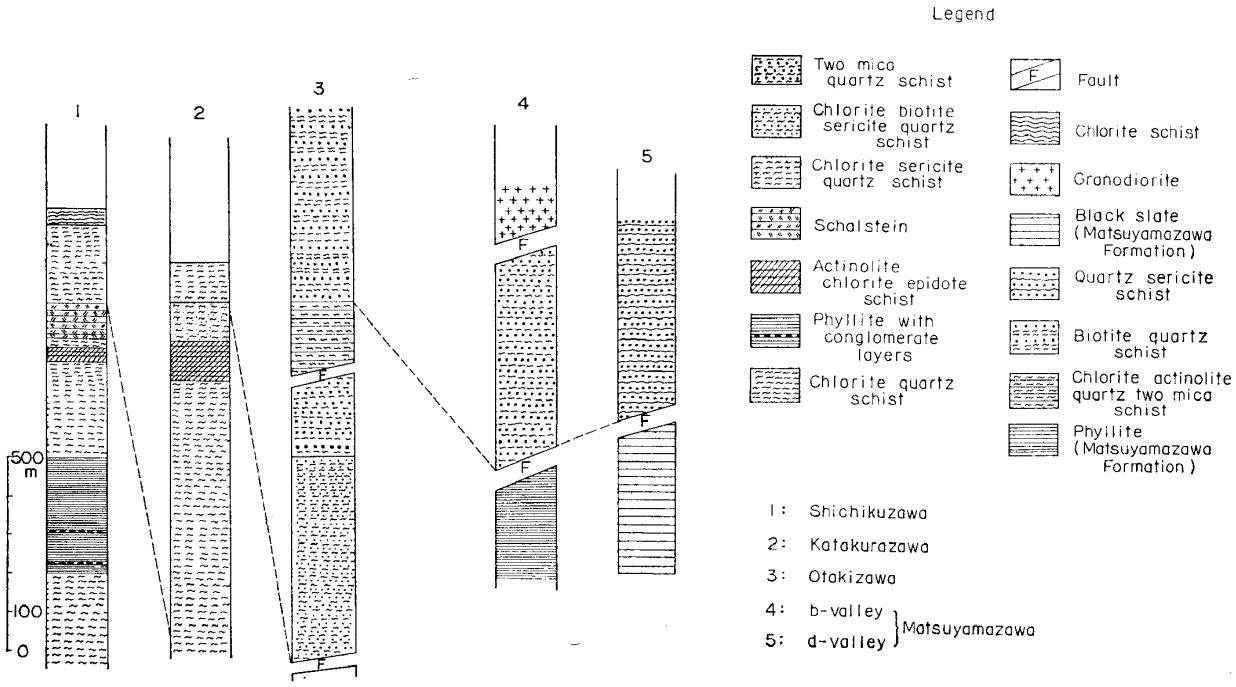

Fig. 2. Columnar Sections of the Shôbudaira Formation in the Vicinity of the Yaguki Mine.

A-1. Shobudaira Formation (Fig. 2).

The type locality of the Shôbudaira Formation is the Shichiku valley, Katakura valley and the Otaki valley, all of which are tributaries of the Niidagawa River.

The formation consists of chlorite quartz schist, actinolite chlorite epidote schist, chlorite two mica quartz schist and biotite quartz schist; the whole amounting to more than 2,500–3,000 m, although the true thickness would be greater because the base is not exposed anywhere in the present field. These metamorphic rocks are all dark colored. Of those rocks, the biotite quartz schist is distributed chiefly along the western side of the field adjacent to the Nekonaki fault, and on its western side is distributed the Yokokawa granodiorite of Cretaceous age. The other metamorphic rocks are distributed mainly along

the eastern side of the field in north to south trend and cut more or less longitudinally by the Katakura and Yaguki reverse faults and others of minor magnitude. On the eastern side of the faults mentioned is distributed the Obisagawa granodorite.

In the western side of the field the biotite quartz schist is cut at its southern end by the north western extension of the Futatsuya fault where it comes into contact with the Goyasu and Mizunoya Formations of the Miocene series of the Joban coalfield, Fukushima Prefecture. The northern extension of the biotite quartz schist is intruded and covered by the Nekonaki-yama gabbro and diabase. In the eastern side of the field the chlorite quartz schsits are in contact with the Katakura fault at the southwestern part, bounded on the eastern side by the Yaguki fault on which eastern side is distributed the Obisagawa granodiorite, of Cretaceous age, and at the northern part of the eastern side by the extension of the two faults which intersect each another. Serpentine is developed as a narrow belt or as elongated patches in the fault-zone of the Yaguki fault and also partly in the zone of the Shichiku fault.

The major faults adjacent to or in contact with the metamorphic rocks are parallel with one another and trend roughly north-north-west to south-south-east, whereas the minor ones which are developed within the distribution of the metamorphic rocks are of north-north-east to south-south-west trends. The Nekonaki fault is considered to be a reverse fault dipping steeply towards the west. The Yaguki fault has high dip and is a reverse fault, judged from the complicate geostructure of the deposits on its western side.

The Katakura fault with dip of about 80°W is also considered to be a reverse fault judged from the complex geostructure on its western side, features of the slickensides. Both of the just mentioned faults have serpentine developed in their fault zones in narrow belt or elongated patches. Another feature suggesting the reverse or thrust nature of the faults is the development of numerous thrust and reverse faults of small magnitude, of gouge between the planes, and of the bending and dragging of the laminae, quartz veins, and the intricate folding of quartz laminae or strings in the biotite quartz schist and chlorite quartz schist distributed on the western and eastern sides of the present field.

The Shôbudaira Formation comes into contact with the next younger Yaguki Limestone with the Dôzan fault of NNE-SSW trend and the Ryokushozawa Member of the Yaguki Limestone is also in fault contact with the Shôbudaira Formation by the fault just mentioned. The Yaguki Limestone is covered by the Matsuyamazawa Formation.

A—2. Yaguki Limestone.

The type locality of the Yaguki Limestone is the vincity of the abandoned Yaguki Mine office on the northeastern side of the Ryokushozawa, a small valley. At the type locality, the lower part of the Yaguki Limestone is represented by the Ryokushozawa Member, whose type locality is along the Ryokushozawa valley just mentioned.

A—3. The Ryokushozawa Member is composed mainly of actinolite chlorite schist of about 50–80 m in thickness. The schist is of low grade and upwards it gradually loses the schistosity to change into black slate of hornfels, then become calcareous, and finally changes upwards into the Yaguki Limestone proper. Therefore, the stratigraphic relation between the Member and the main part of the formation is a conformity. The Member is distributed only along the Ryokushozawa, coming into contact with the underlying Shobudaria Formation by the Ryokushozawa fault of NNE-SSW trend along its basal part of NW-SE distribution and with the Dozan fault at its southwestern part. Northwards the Ryokushozawa is cut by the northwestward extension of the Ryokushozawa fault. Upwards the Ryokushozawa Member changes into the limestone already mentioned. The thickness of the Yaguki Limestone is about 78–190 m and is composed of hornfels, skarn, black slate show-

ing in part very weak schistosity and crystalline limestone. The Yaguki, which is a massive limestone body, in a small area in the east central part of the field, is limited by the Dôzan fault at its eastern and southeastern sides, overlies with conformity the Ryokushozawa Member along its southern to southwestern side, and is covered with unconformity by the Matsuyamazawa Formation along its northern and western sides.

Only indeterminable Crinoid stems were collected from the Yaguki Limestone.

The Yaguki Limestone including its Ryokushozawa Member shows folding structure of NNE-SSW trend, but the dip is disturbed greatly owing to the influence of the faults which cut the formation.

The Niidagawa Group occupies the larger part of the field and is distributed in north to south direction, whereas the next younger Takakura-yama Group is distributed in a very limited area in the southeastern corner of the field. The stratigraphic relation between the Niidagawa and Takakura-yama Groups is both fault and unconformity.

B. Takakura-yama Group (Fig. 3)

The Takakura-yama Group is distributed in the area in the northern and eastern sides of Mt. Takakura-yama. The type locality of the group is taken from three small valleys named in the order from south to north as B-valley, L-valley and G-valley (refer to locality map). From the lithology the group has been classified into the Matsuyamazawa-, Iriishikura-, Motomura-, and Kashiwadaira Formations in upward sequence. These formations amount to about 2400 m in thickness and lithologically they comprise argillaceous and clastic rocks and therefore, are quite contrasting with the rocks of the Niidagawa Group.

B–1. Matsuyamazawa Formation

The type locality of the Matsuyamazawa Formation, which is 1500–1600 in thickness is the Matsuyamazawa valley situated in the north of the Yaguki Mine. At the type locality the formation overlies the Yaguki Limestone with structural unconformity and is composed of black slate, green siliceous slate, green schist and phyllite. The general strike of the formation is about north—south with slight deviation to the west or to the east, and the dips are about 50°–70°W. Limestone lenses, skarn deposits, siliceous slate, and green schists are also found as lenticular deposits. The formation is distributed in the northern part of the Yaguki Mine, delimited at its eastern side by the Yaguki fault in which zone are found serpentine intrusions, at the western and northern sides by the Matsuyamazawa reverse fault (north—south trend with dip of 30°–70°W) along which is developed a phyllite zone of the same trend. The southern limit in distribution of the formation is bounded by the Hiyama normal fault of east—west trend with north dip.

The Matsuyamazawa Formation is in structural unconformable relationship with the subjacent formation and the exact stratigraphical relation with the next younger Iriishikura Formation could not be determined in the field. However, it is evident that the lithofacies of the Matsuyamazawa and the Iriishikura are remarkably of similar geostructure, and both are lithologically distinct from any other units of the Niidagawa Group, and intimately related with each one of those included into the Takakura-yama Group. For this reason the Matsuyamazawa Formation should be included into the Takakura-yama Group and be distinguished from the Niidagawa Group as already stated. And, although the Matsuyamazawa Formation is geographically separated from the area of distribution of the Iriishikura Formation, their intimate geostructural and remarkably similar lithological features all suggest that they were, before being cut by faults and broken into blocks, originally continuous in deposition, but whether they are in vertical relationship or one merely a lateral facies of the other, remains to be settled.

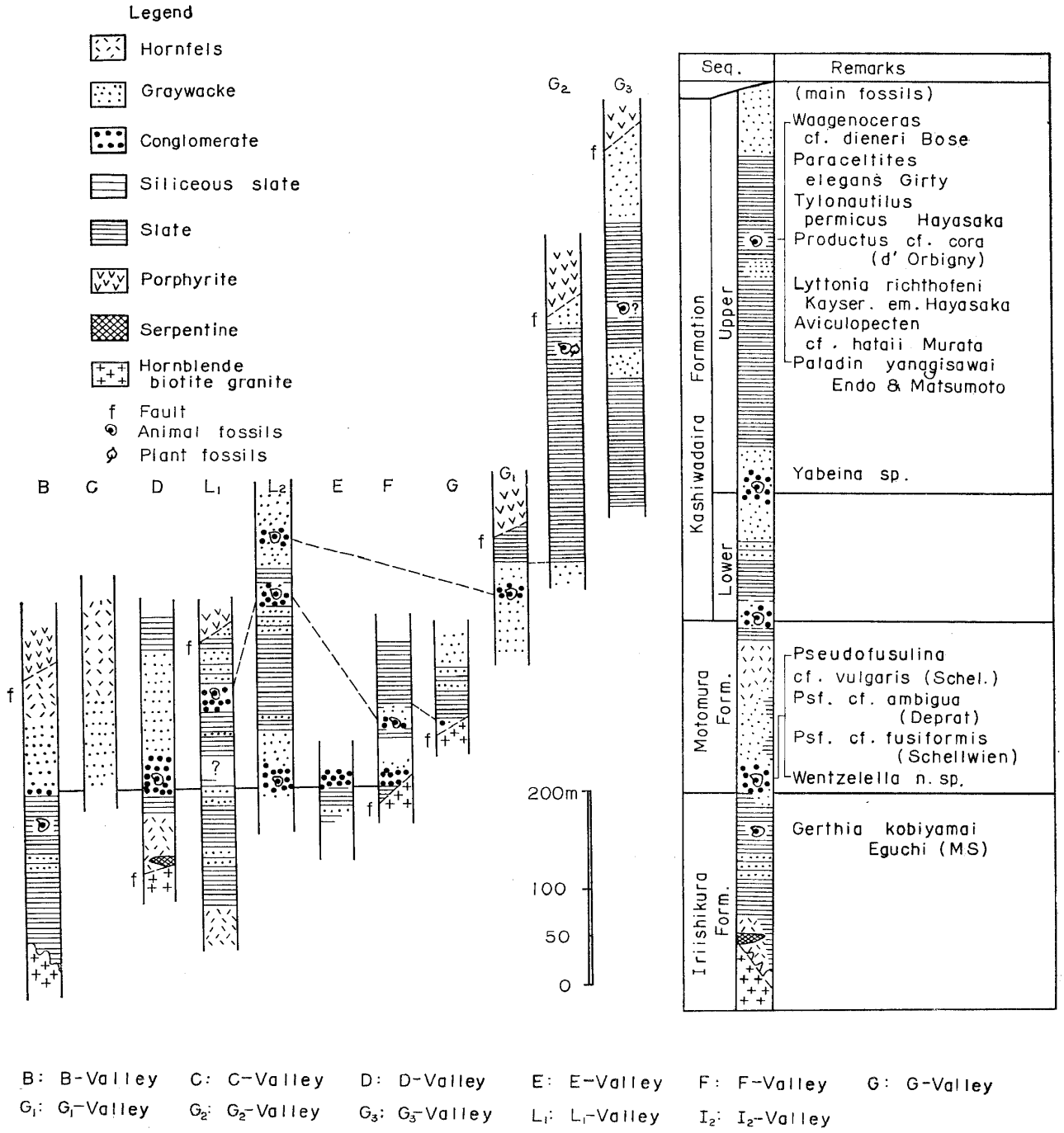

Fig. 3. Columnar Sections of the Takakura-yama Group.

B-2. Iriishikura Formation

The type locality of this formation is along the B-valley in the southeastern part of the field near Iriishikura, Tamayama in Yotsukura-cho. The formation at the type locality does not have its base exposed because of being intruded by granodiorite in the southeastern part of distribution and cut by the Futatsuya fault at its southwestern side. It is covered with conformity by the Motomura Formation at its northwestern and northern sides. The formation consists predominantly of black slate, with subordinate siliceous slate and graywacke, and has yielded abundant specimens of *Gerthia* n. sp., and poorly preserved ones

of *Bellerophon* sp., and *Paraceltites* aff. *elegans* Girty. The formation is judged to be about 90–170 m thick. The distribution is restricted to the southeastern part of the field where it occurs in almost north to south trend with strike deviation towards the east, occurring as inliers in the Futaba Formation of Cretaceous age. The dips of the strata are about 35–80 degrees, changing at places according to position whether near faults or near places of intrusion of the Cretaceous granodiorites.

This formation is succeeded by the Motomura Formation with conformity as can be seen in the exposures in B-valley, L_1-valley, and D-valley in the southeastern part of the field, where the graywacke at the top of the Iriishikura Formation changes gradually upwards into the conglomerate at the base of the next younger Motomura Formation.

B–3. Motomura Formation

The type locality of the Motomura Formation is the outcrops along the D-valley and L_2-valley in the southeastern part of the field. The formation consists of conglomerate, sandstone, slate, and with thin hornfels in the upper part. It is about 70–170 m in total thickness and conformable with the underlying Iriishikura and the overlying Kashiwadaira. The black slate in the upper part of the Motomura grades upwards into fine grained sandstone which in turn merges into the conglomerate at the base of the Kashiwadaira Formation. The Motomura Formation is distributed in narrow belt form parallel with subjacent and overlying formations in approximately north to south trend with slight deviation in strike towards the east and the dips are about 36 to 64 degrees. This formation like the underlying and overlying is generally homoclinal in structure. Its northern limit in distribution is cut by the Yaguki fault and its southern limit by the Takakura-yama shear zone.

The formation, particularly from L_2-valley, has yielded fossils of fusulinids, bryozoans, corals and calcareous algae, but no Brachiopoda. These fossils are shown in the list in Part 2.

B–4. Kashiwadaira Formation

The type locality of the Kashiwadaira Formation is along the G_1-valley and G_2-valley at Kashiwadaira in the southeastern part of the field. The formation is composed of black slate, conglomerate, and an alternation of slate and sandstone in the middle part. The whole amounts to about 420–530 m in thickness. The formation is distributed in north to south direction almost parallel with the underlying Motomura Formation. It can be divided into two parts, the lower of which is distinguished from the upper by the conglomerate at the base of the upper and the alternation of sandstone and slate at the upper part of the lower. The upper part of the formation is intervened by the Shobudaira Formation with two faults, parallel with one another and trending NE-SW. The northern limit in distribution of the lower and upper parts of the formation are limited by the Yaguki fault, the western side by the Takakura-yama shear zone, and at the north the upper part is cut by a fault trending in NNE-SSW direction. The general trend of the strata of the lower part of the formation is north to south but with deviations eastwards according to whether near places disturbed by faults, and the dips are about 30–50 degrees westwards. The upper part of the formation trends north to south but with deviation either eastwards or westwards and with dips of 30–75 towards the west. The formation has yielded fossils of corals, Bryozoa, Brachiopoda, Pelecypoda, Scaphopoda, Gastropoda, Cephalopoda, Arthropoda, Trace fossils and Problematica besides some very poorly preserved plant fossils. The generic and specific names of these fossils are shown in the list given in Part 2.

C. Geological Structure

The geological structure of the present field can be classified into reverse, thrust and normal faults, shear zone, folding, unconformity, and disturbances by intrusions of batholithic rocks. These are described below.

C–1. Nekonaki Fault

This fault, in the western side of the field, separates the Late Cretaceous Yokokawa granodiorite on the western side from the biotite quartz schist of the Shobudaira Formation on the eastern side. This major fault trends about north to south with slight deviations of about 10–15 degrees towards the west, and the dip is about 70 degrees towards the west. The zone crushed by the reverse fault measures about ten meters in width in maximum, consists of well crushed granitic material, the granodiorite on the western side of the fault is crushed as if by the development of cleavage parallel or almost so with the general dip of the fault, as observed at the upper course of the Otakizawa. There are no igneous rocks penetrating the fault zone. This fault can be traced for more than seven km in length and extends beyond the present field. This is a major reverse fault riding over the biotite quartz schist of the Shobudaira formation, a part of the Yokokawa granodiorite and the Nekonaki-yama gabbro and diabase. The geological age of this fault is judged to be post-Late Cretaceous because the grandiorite, according to Kawano and Ueda (1965) is by K-A dating method dated to be $90+10^5$ years before the present, or Late Cretaceous.

C–2. Futatsuya Fault

The Futatsuya fault is in the southern part of the field. It trends N 40–60 W with dips of 60–70°S. This is a normal fault which cuts the Yokokawa granodiorite, biotite quartz schist, serpentine, and chlorite quartz schist of the Shôbudaira Formation. It also cuts the hornblende prophyrite that invaded the Takakurayama shear zone, the Iriishikura Formation, Obisagawa granodiorite, and the Cretaceous Futaba Formation on its northern side and on its southern side the Oligocene Shirasaka Formation, Goyasu Formation, Mizunoya Formation, Kamenoo Formation all of Miocene age and Quarternary deposits. The age of this fault is post-High Level Terrace and is still active. As observed on the right bank of the Niidagawa in the southeast of Shichiku-dera, Yotsukura-cho, where the fault cuts both the chlorite quartz schist of the Shôbudaira Formation and the Oligocene Shirasaka Shale, the width of of the fault zone is about 3–5 meters and in it is developed fault clay with abundant breccia of chlorite quartz schist measuring about 5–10 cm in diameter. At about two kilometers northeast of Shibahara, Ogawa-cho, Iwaki City, the biotite quartz schist of the Shôbudaira Formation comes into contact with the Miocene Mizunoya Formation by about five meters wide fault zone filled with breccia derived from the biotite quartz schist without the development of fault clay. The Futatsuya fualt extends more than seven kilometers because it exists in areas outside the present field.

C–3. Matsuyamazawa Thrust

This fault is developed on the eastern side of the Nekonaki fault and almost parallel with it although of less extension. Its northern side is cut by the Ryokushozawa fault and its southern limit by the Futatsuya fault. Throughout its distribution its strike is almost N-S with slight deviations either to the west or east and the dips are 30–70° W, thus being a thrust in part and a reverse in its larger part. By this fault the biotite quartz schist of the Shôbudaira Formation rides over the serpentine developed in the southern part of the field, and the Matsuyamazawa Formation. Porphyrite intrudes along the fault in the upper course of the Otakizawa at about 400 meters west of Akahage. A rather broad fault zone is observed between the biotite quartz schist of the Shôbudaira Formation and

the serpentine body on its eastern side, at about 700 meters northeast of Tanishita, Ogawa-cho. This fault zone of five meters width is characterized is its wedge shape, and contains breccia of serpentine only probably because the gouge was washed away later. The fault is cut by the Ryokushozawa fault to be displaced and trend in NW-SW direction with dips of 70° NW. It is of interest that breccia are developed only where the fault is in contact with serpentine. This fault measures about six kilometers in length.

C–4. Ryokushozawa Fault

This fault of NW-SE trend extends from Ryokushozawa at the south where it is cut by the Dôzan fault northwestwards to the Yaguki Mine. The fault dips 60–70°E and is a normal one. This fault cuts the Matsuyamazawa thrust fault in its northwestern part, is cut by the Dôzan fault in its southeastern part, and cuts the Hiyama fault near the middle course of the Ryokushozawa at Asahiko. The Hiyama fault is a normal one with almost eastwest trend (N 70E) and dips about 40°N. The Ryokushozawa fault cuts the phyllite of the upper part of the Matsuyamazawa Formation, the black slate of the same formation, the Yaguki Limestone, the Shôbudaira Formation and the basal part of the Ryokushozawa Member of the Yaguki Limestone. It measures only about four kilometers in length. Several small fault blocks are developed.

C–5. Dôzan Fault (including the Akahage Faut).

The Dôzan fault as well as the Akahage fault are normal ones and define the northern limit of the serpentine mass developed in the central southern part of the field. The Dôzan fault trends N 40–60E and dips 60–65°W. Its delimits the southward distribution of the Shôbudaira Formation and cuts the southern part of the slightly metamorphosed granitic rocks, and also a part of the Matsuyamazawa Formation. The Akahage fault which is also a normal one trends N 40–50W with dips of 50–60° westwards. This fault delimits the northern part of the serpentine mass, the western part of the Shôbudaira Formation and a part of the Matsuyamazawa Formation. Taken together the Dôzan and Akahage seem to form a sort of semitriangular structure. Both of small extension.

C–6. Mitsumori—Katakura Fault

As the name indicates these are two faults, one a continuation of the other, but cut obliquely by the Yaguki fault. The Mitsumori fault, distributed in the norh of the Yaguki fault, trends N–10E with dips of about 55°W and is cut by the Yaguki fault which is characterized by having serpentine in its fault zone. The Katakura fault, the extension of the Mitsumori fault is situated on the southwestern side of the Yaguki fault and separates the serpentine body from the Shôbudaira Formation and also cuts in its southern part a body of granodiorite, which may belong to the Yokokawa granodiorite. The trend of the Katakura fault is N 10E to almost N-S with dip of 60°W. It measures more then four kilometers in length because of extending outside of the present field. An amphibolite schist of lenticular shape is found intruding the fault at the triangular point (432 meters) about 400 meters west of Shichikuzawa, Yotsukura-cho. This fault is delimited by the Futatsuya fault at its southern part.

C–7. Shichiku Fault

This fault is of N-S trend with dips of 65–75°W, and is a reverse fault in which serpentine has intruded in a width of about 10–20 meters. The fault itself measures about three and a half kilometers in length and by it the chlorite quartz schist of the Shôbudaira Formation ridesover the same rock of the same formation, whereby the formation is repeated in this area. The intruded serpentine occurs as north—south elongated lenticular

structures detached from one another and extending nearly throughout half of the length of the fault. This fault also cuts phyllite and schalstein of the formation. In the northern extension of the fault, the trend changes to about ten degrees eastwards where it cuts a small mass of granodiorite porphyry. The granodiorite porphyry occurs within the fault in the northern part in narrow belt like or dike-like shape. The fault is limited at the north by the Yaguki fault and in the south by the Futatsuya fault. A fault valley is developed. Slickensides are beautifully developed in many of the outcrops.

C–8. Takakurayama fault zone

This fault zone is distributed on the eastern side of the Shichiku fault mentioned above. Its trend is approximately north to south with dips of about 70 degrees westwards and is thought to be a combination of reverse and normal and to represent a shear zone. In this zone which measures about 100–300 meters in width is found the development of sheared and crushed rocks of hornblende porphyrite, and on the western side the chlorite quartz schist of the Shôbudaira Formation and on the eastern side from the south northwards, the Iriishikura Formation, Motomura Formation, Kashiwadaira Formation, the Shôbudaira Formation and its northern part is headed by granodiorite prophyry. The southern end of the shear zone is limited by the Futatsuya fault. This shear zone measures only about three kilometers in length. In the central northern part of the fault zone, the Late Cretaceous Futaba Formation is developed almost horizontally in narrow belt form and measures about 800 meters in length and only about 4–5 meters in thickness.

C–9. Shôbudaira Fault

This fault is distributed on the northeastern side of the Takakurayama shear zone, and is a branch of the Yaguki fault and merges into the northeastern side of the Shichiku fault already mentioned. This fault trneds N 10–20 W with dips of 50°W and cuts the upper part of the Kashiwadaira Formation, a part of the Shôbudaira Formation, and the granodiorite porphyry on the western side and the Obisagawa granodiorite on the eastern side. A small lenticular shaped serpentine body intrudes the eastern side along the Yaguki fault, which is the eastern side of the Shébudaira fault. This fault measures only about two kilometers in length. The best outcrop of the fault is the Shobu-toge (Pass), where the granodiorite prophyry and upper part of the Kashiwadaira Formation show a ten meters wide crushed zone cut by the Shôbudaira fault and in which breccia are found. This crushed zone extends in N 60–70 E with dip of about 50°NW. This crushed zone cuts the northern part of the upper part of the Kashiwadaira Formation, the northern part of the Takakurayama fault zone, the northern part of the Shôbudaira Formation and is situated on the southern side of the granodiorite porphyry already referred to.

C–10. Yaguki Fault

The Yaguki fault is developed on the eastern side of the field and separates the Permian formations from the Obisagawa granodiorite, the Shôbudaira Formation from the same granodiorite in the southern half of its length, the Matsuyamazawa Formation from the Shôbudaira Formation, and the biotite quartz schist of the Shôbudaira Formation from the chlorite quartz schist of the Shôbudaira Formation. This fault measures more than eight kilometers in length because it extends beyond the present field. The strike is about N 20–30W with dips of 80–85 to almost vertical and towards the west. The fault is intruded by 10–30 meters wide serpentine of elongate belt shape. The serpentine is not continuous in development, but found in patches in the southern part, almost as a continuous belt in the central part and is almost absent in the northern part. The rocks bordering the fault, especially on the western side are crushed, sheared or badly disturbed, whereas the rocks on the

eastern side show less disturbance. In the fault are found developed chloritization where in contact with the Obisagawa granodiorite, and although breccia of the rocks with which it comes into contact are found in the fault, gouge and fault clay have been observed only at a few places. The breccia are of various sizes and the smallest may be of nearly silt-grain size. Because of water flowing along the fault and small falls being developed, it may be that much of the original fault clay or gouge was washed away. However, it is characteristic that the formations on the western side of the fault show complex structure or the evidence of having been crushed or deformed compared with the rocks on the eastern side of the fault this shows that the fault is a reverse one even though the dip could not be measured at all of the outcrops. Also on the western side of the fault the rocks often show very weak or slight cleavage development. Slickensides are not so commonly observed at the outcrops of the fault.

C–11. Tamayama Fault

This fault trends N 10 W with dip of about 60–70°W and is a normal fault cutting the Cretaceous Futaba Formation. Although fault breccia and fault clay have not been observed, westward dipping beautiful slickensides have been found in almost all of the outcrops of the fault. The fault measures almost two kilometers in length, extends southwestwards beyond the present field and northwards it is lost in the Obisagawa granodiorite. This fault is the easternmost one of the present field, it cuts the Cretaceous Futaba Formation and the Cretaceous granodiorite.

There is another normal fault of N 10E with dips of 60°W on the western side of the Tamayama fault. This fault cuts the Cretaceous Futaba Formation, is lost northwards in the Obisagawa granodiorite, and cuts the chlorite quartz schist of the Shôbudaira Formation which occur in this area as the lowest or oldest rocks, and are exposed only in the stream bed of the valleys eroded into the Cretaceous Futaba Formation, and therefore on the map appear as inliers.

C–12. Age of the Faults

The faults described above fall into several categories such as of reverse and normal, of approximately north to south trend but with deviation either to the west or east, and of transverse ones with trends of northeast—southwest, southeast—northwest, and almost eastwaest. Some, especially the major ones are intruded by serpentine or have developed in them hornblende porphyry, granodiorite, granodiorite porphyry, porphyrite, and amphibolite schist. The minor ones even though of structural importance generally do not have igneous rocks intruding them.

The faults are thought to be of several different ages, the oldest being probably post-Shôbudaira pre-Takakurayama or post-Carboniferous—pre-Permian, the next younger being post-Takakurayama or probably post-Permian—pre-Mesozoic, the next being post-Obisagawa and Yokokawa granodiorites of Late Cretaceous age (by K-A dating) or pre-Tertiary, and the youngest which is probably still active may be post-High Level Terrace or Pleistocene.

C–13. Folding

The only noteworthy folding structures are the one anticline and two synclines found in the area of distribution of the Yaguki Limestone and of the Matsuyamazawa Formation. Here the general folding axis trends NNE-SSW and the dips of the wings are different, the eastern one being generally about 60 degrees and the western one about 65–70 degrees. The syncline in the Matsuyamazawa Formation in the vincity of the abandoned Ono Mine in the middle course of the Ryokushozawa valley has the axis trending NNE-SSW and both wings dip at about 60 degrees. No other anticlinal or synclinal folding structures

were observed in the present field, except for the homoclinal ones.

C–14. Unconformity

The major unconformity observed in the present field is the structural one between the Yaguki Limestone and the Matsuyamazawa Formation. The strata above and below and near to where the contact would occur show different strike and dips. The underlying Yaguki Limestone strikes N 10–15E with dips of about 70°W whereas the overlying Matsuyamazawa Formation strikes N 40–55W with dips of 50–70°NW. This shows that the stratigraphical relation is a structural one. Another major unconformity is between the Iriishikura—Motomura Formation of the Takakurayama Group and the Futaba Formation of Cretaceous age. This unconformity is structural and also represents a long time break from Permian to Cretaceous.

D. Metamorphic, Intrusive and Extrusive Rocks

In the present field are found metamorphic, plutonic or intrusive and extrusive rocks, among which the first mentioned two are of importance. These will be described below.

D–1. Yokokawa Granodiorite

This intrusive mass is distributed in the western side of the present field west of the Nekonaki fault. The granodiorite is grayish white in color and hornblende and biotite occurs as colored minerals. The biotite minerals are chloritized. A part of the grandiorite is distributed on the eastern side of the fault in the central western part of the field. It is also found in the upper reaches of the Matsuyamazawa, and at the entrance to the Hiyamazawa.

D–2. Obisagawa Granodiorite

This granodiorite is distributed in the eastern part of the field and on the eastern side of the Yaguki fault. It is salmon pink and according to Seki (1962), the colored minerals are biotite, and hornblende, associated with plagioclase, kalifeldspar, quartz with some apatite, titanite, zircon, and magnetite.

D–3. Metamorphosed Granitic Rocks

This rock is found along the middle course of the Otakizawa in the central eastern part of the field. It is gray to grayish white and the colored minerals are epidotized and chloritized biotite according to Dr. S. Suzuki of the Mining Department of the Faculty of Technology, Tohoku University.

D–4. Otakizawa Biotite Granite

This granite occurs in the upper reaches of the Otakizawa, Ogawa-cho. It is whitish orange in color and the colored minerals consists of abundant biotite, orthoclase, and quartz.

D–5. Shôbudaria Granodiorite Porphyry

This rock is found at two localites, one is the upper reaches of the Shichiku-zawa and the other is in the north of Shichiku-dera, Yotsukura-cho. It is characterized by its grayish color, with large crystals, the colored minerals are hornblende, biotite with plagioclase, and quartz, it should be called biotite hornblende granodiorite porphyry.

D–6. Katakurazawa Actinolite Chlorite Epidote Schist

This rock is distributed in belt form in the chlorite quartz schist of the Shôbudaira Formation at the middle course of the Katakurazawa, near Yaguki in Yotsukura-cho. It

is characterized by being dark green in color, very compact, and its width is about 100 meters or thereabout. It strikes N 25 E and dips at about 60 degrees to the west.

D–7. Akahage Serpentine

This body of serpentine is distributed in the southern part of the field, being limited at its southern side by the Futatsuya fault, on the western side by the Matsuyamazawa reverse fault, on the eastern side by the Katakura fault and at the northern side by the Akahage and Dôzan faults, thus it is bounded on all sides by faults. The body measures about 1.5 kilometers in eastwest direction and 2.5 kilometers in north to south direction. It is characterized by its black to dark greenish black color, very compact and hard except along each of the faults where it is crushed. At some places it is talcized, especially along the the Dôzan fault. In the southern part of its distribution there is developed a very basic rock, probably peridotite.

D–8. Shichiku Amphibolite Schist

This schist occurs in two localities, both in elongated lenticular form. The one at the eastern side of the serpentine body is developed along the Katakura fault, where it measures about one kilometer in length and from 100 to 200 meters in width. This amphibolite is characterized by its dark green color, very compact and hard aspect, except along the fault just mentioned where it is crushed. The other locality is in the central western part of the Akahage Serpentine where it is also of elongate form in north to south direction, measuring about one kilometer in length and nearly 50 meters in width. Its color is quite the same as the one already mentioned and its characteristics are also the same. The strike is N 5 E and it dips at about 60–70 degrees towards the west.

D–9. Nekonaki Gabbro and Diabase

These rocks are distributed in the northwestern part of the field where they measure about two kilometers in north to south direction and about 1.5 kilometers in east to west direction. They are cut by the Ryokushozawa fault along the eastern side and by the Nekonaki fault along the western side. The rock of gabbro is dark green, with large crystals of hornblende, pyroxene and feldsapr, and the diabase is also dark green but with smaller crystals. It is difficult to draw any sharp boundary between the two rocks in the field and so they were mapped together.

D–10. Other rocks and Schistose Rocks.

The other kinds of igneous rocks observed in the present field are; skarn is found distributed at the abandoned Ono Mine in the middle course of the Ryokushozawa, where it occurs in the Matsuyamazawa Formation. Another locality is Hiyama near the one just mentioned and this is also in the Matsuyamazawa Formation of the lower course of the Matsuyamazawa.

Green schists are found in the vincity of the abandoned Matsuyama Mine; they appear to be basic volcanic rocks which are of lenticular shape, about 300 meters in length in maximum width. It strikes N 50 E and dips 50 degrees to the west.

Green siliceous slate is found at two localities in the upper course of the Matsuyamazawa and in the Matsuyamazawa Formation. The characteristics are the pale green to greenish, very hard and compact aspect, and measure about 30 meters in thickness, 400 meters in length and about 40 meters in width. The stike is N 30E and dip 50–65° to the west.

Chlorite two-mica-quartz schist is found in the Shôbudaira Formation in the vicinity of the Otaki-zawa in the central part of the field, where the formation is delimited by faults. It is characterized by having 1-3 millimeters thick quartz veins with good development of laminations, showing microfolding, and the strike is N 30–40 E with dip

of 50–75°W. From the rather uniform dip and strike together with the good development of laminae and microfolding and schistosity parallel with the Dôzan fault, it is inferred that the microfolding had some relation with the compressive forces of the fault.

The chlorite quartz schist occupying the larger part of the Shôbudaira Formation is distributed extensively along the eastern part of the field. The distribution is everywhere delimited by faults. The color is dark green, green, very compact, hard and with good development of laminae of quartz and show microfolding. At the entrance of the Katakurazawa in the eastern part of the field there is developed remarkable microfolding. The quartz laminae in the schist are about 2–3 millimeters in thickness.

Biotite quartz schist is found in the Shôbudaria Formation especially in the western part of the field along the Nekonaki fault. The color is dark brown to black, with about 5 millimeters to one centimeter thick quartz lenses in the rock, microfolding is developed, being especially remarkable in the south of the Otakizawa. Near the central western part of the field, the biotite quartz schist grades into biotite schist.

Actinolite chlorite schist is found in the Ryokushozawa Member of the Yaguki Limestone. This schist is dark green in color in general, very compact and hard, and is megascopically easily mistaken for black slate in the field. This is the only occurrence known in the present field.

A remarkable mass of hornblende porphyrite is in the Takakurayama fault zone. It is greenish in color and very compact and hard, but along the margin in contact with the faults delimitting it from the surrounding rocks, the prophyrite become friable, easily crushable and brecciated.

Pyroxene porphyrite is found in the Matsuyamazawa Formation at the upper course of the Matsuyamazawa. It is dark green in color, compact and hard. It strikes N 15–30 with dips of 50–54 degrees to the west and occurs in lenticular shape.

Phyllite occurs in the upper part of the Matsuyamazawa Formation in the northwestern part of the field. It is dark colored and there is a general change from black slate to west direction, showing that the forces acting were from the west. This measures about 2.2 kilometers in length in north to south direction and about 200 to 100 meters in east to west direction. A limestone lense, one to two meters long with a Crinoid stem was discovered in the northernmost distribution of the phyllite.

Hornfels is found developed thinly between the limestone lenses and phyllite mentioned in the above paragraph. The hornfels contains diopside and epidote and occurs in lenticular form. Hornfels is also found along the marginal part of the Yokokawa granodiorite in the vicinity of the Hiyama and in the middle to upper reaches of the Ryokushozawa. It is also found at the lower part of the Yaguki Limestone in the Yaguki Mine.

A thin, lenticular body of porphyrite is found in the Shôbudaira Formation in the M-valley of the Shichikuzawa, Yotsukura-cho. The color is green, very compact and hard, and of small occurrence. It strikes N 10 E with dip of 70°W. It contains abundant minute feldspar crystals, calcite veins, and the feldspars are calcitized or sericitized.

Schalstein is found in the upper course of the Shichiku valley, Yotsukura-cho. The rock is purplish in color, and under the microscope its origin is thought to be hornblende andesite. It is about 20 meters in thickness and is intercalated in the Shôbudaira Formation.

The Tertiary Shirasaka Mudstone is a rock which was deposited during volcanic activity, that is to say, during ash falls. This rock is distributed in the southernmost part of the field south of the Futatsuya fault.

E. Geological Ages of the Formations and Correlation

The geological ages of the formations referred to the Niidagawa Group are difficult to

determine owing to that no fossil has been found from any of its units. However, from stratigraphical relationships it is evident that the age of the group is pre-Takakura-yama Group and since the latter is Permian in age, the Niidagawa may be dated as pre-Permian. Also from the good development of metamorphic rocks as biotite quartz schist and others, the lithological similarity and general geostructural resemblance with the Matsugadaira Formation distributed and well developed in the north of the present area, it has generally been accepted that the former is a correlative of the latter. The Matsugadaira Formation is distributed in the north—central part of the Abukuma Massif immediately north of the present area. From almost the same reasons as the development of similar kinds of metamorphic rocks, related geostructure, analogous kinds of lithology and in being pre-Permian in geological age the Motai Group distributed in the southern part of the Kitakami Massif can also be correlated with the Niidagawa Group even though no fossils have been found from either of the two groups just mentioned. It may be added that the good development of metamorphic rocks (Niidagawa Group, Matsugadaira Formation, Motai Group) in north-eastern Japan, their intimate relationship with intrusive batholithic bodies (granodioriorite, granite, etc.), remarkably similar geostructure (reverse, thrust, normal faults, shear, crushing, etc.), and pre-Permian geological ages, are features related with one another and generally accepted by Japanese geologists as a phenomena of nearly similar age.

With regard to the geological ages of the stratigraphic units included into the Takakura-yama Group, their stratigraphical relationship with superjacent and subjacent units in the southern part of the Abukuma Massif, and similarity in paleontological elements, it seems justified that the Matsuyamazawa-, Iriishikura-, Motomura, and Kashiwadaira Formations of the Takakura-yama Group can be correlated with the Oashi Formation and Uwagaya Formation in the north—central part of the Abukuma Massif. It may be added that their general lithological characters (as abundant black slates, subordinate clastics) are more or less similar to each other, although the number of stratigraphic units in the two areas are different owing to difference in local lithology, and also the Permian deposits of both areas are superposed upon metamorphic rocks with structural unconformity, and both areas have yielded similar kinds of invertebrate fossils. From the remarkable similarity in lithofacies, geostructural relationship with superjacent and subjacent stratigraphical units and with one another, the Yaguki Limestone which yielded no fossils of importance or value for correlation purpose or even geological age determination, is correlated with the Tateishi Formation developed and distributed in the north—central part of the Abukuma Massif. The geological age of the Tateishi Formation is referred to Carboniferous. The fossils of brachiopods derived from the Mano Formation and Ainosawa Formation indicate that the geological age of these formations range from upper Devonian to lower Carboniferous, and since those stratigraphical units can be correlated with the Niidagawa Group as already stated above, it may be safe to say that the Niidagawa Group ranges in age from the Devonian to the Carboniferous, but as to how low in Devonian and how high in the Carbonifeous the group may range, must be settled by the discovery of fossils from those parts of the stratigraphical units.

The correlation of the formations of the Takakura-yama Group with the Oashi Formation and Uwagaya Formation in the north—central part of the Abukuma Massif, and also with Kanokura Formation and Sakamotozawa Formation distributed and well developed in the southern part of the Kitakami Massif, is upheld by the paleontological evidence of fusulinids, brachiopods, cephalopods (Ammonites and Nautiloids) and also by the pelecypod fauna. These fossils are described and listed latter part of the present work.

From the fossils collected from the different formations of the Takakura-yama Group, it is evident that the geological age of the Takakura-yama Group may be assigned to Early to Middle Permian. The Upper Permian does not seem to be present in the area studied at

least there is no paleontological evidence to prove its existence. Among the fusulinids collected from the present field, *Pseudofusulina* cf. *ambigua*, *Pseudofusulina* cf. *fusiformis* and *Pseudofusulina* cf. *vulgaris* are of importance because they are almost indistinguishable from the ones from the Sakamotozoawa Formation of the southern part of the Kitakami Massif.

As shown in the correlation table (Table 2), the structural relation of the Tobigamori and Karaumedate Formations and Takezawa Formation of the southern part of the Kitakami Massif to the Ainosawa Formation, Mano Formation and Tateishi Formation of the north—central part of the Abukuma Massif are similar and paleontologically quite the same, whereas the underlying Shôbudaira Formation, Matsugadaira Formation and Motai Groups are related with one another in lithofacies, geostructure and non-fossiliferous features.

Both the Shôbudaira and Matsugadaria metamorphic rock units are thought to have originally been coarse clastic rocks deposited in the shallow sea of Late Devonian to Carboniferous age.

After regression of the shallow seas and a short period of denudation and crustal disturbance, marine transgression was renewed and it brought into the present area a marine fauna of benthonic and planktonic animals, the former living in a muddy environment and the latter drifted into the area. The marine fauna although not a small one, is characterized by the abundant individuals of Brachiopoda which seem to not have attained full growth because of being influenced strongly by the muddy sea bottom which may have caused stunting of their shells. The pelecypods and gastropods (rare) also show the same characteristics of not attaining full browth. Calcerous lithofacies are rare, but where they are developed, corals and fusulinids can be found.

After a rather quiet period ranging from Early to Middle Permian, the seas of the present area again commenced regression followed with uplift, crustal disturbance and a long period of erosion. Deep-seated rocks of granodiorite and others intruded along the weak zones and gave rise to metamorphic zones whereas earlier volcanic outbursts resulted in the deposition of tuffaceous rocks and some lava beds, but the latter had no influence upon the metamorphism mentioned above. Crustal movements of faults, slight foldings and block development seem to characterize the geostructure of the present area.

PALEONTOLOGY

A. The Fauna and Correlation

Various kinds of invertebrate fossils are rather common and individually abundant in a few restricted localities of the Permian formations distributed in the region of Takakura-yama in the southern part of the Abukuma Massif west of Yotsukura-cho, Fukushima Prefecture, Japan. Although the determined invertebrate fossils amount to only 19 species of Brachiopoda, 12 of Pelecypoda, 1 of Scaphopoda, 5 of Nautiloidea, 7 of Ammonoidea, 3 of Bryozoa, 8 of Anthozoa, 6 of the Fusulinacea, 1 of Crinoid, 1 of Trilobite, 1 trace fossil and 1 Problematica, many of them are not identified to species rank because of their state of preservation. However, the ones identified to species rank including the ones that could be compared with known forms, all point to the Permian age of the fauna.

The entire list of the fossils is given in Table 2, with their localities and name of formation from which they were found in systematic arrangment of the class or phylum, but in alphabetic order within each systematic rank.

The several features recognized, from the fauna are given in the following.

a) Sedimentary environment and sedimentary basin

The fauna consists of both benthonic and planktonic forms, the former represented largely by the brachiopods, gastropods, pelecypods and others, whereas the latter is composed

Table 2. Fossils from the Takakura-yama Group

Genus and Species \ Formation	Iriishikura		Motomura		Kashiwadaira		
Locality	B	L_2	D_3	F	G_1	G_2	H
Fossil Locality Number	T_1	T_3	T_4	T_5	T_6	T_7	T_8
Foraminifera							
Nagatoella aff. *kobayashii* Thompson		+					
Pseudofusulina cf. *ambigua* (Deprat)		+					
Pseudofusulina cf. *vulgaris* (Schellwien)		+					
Pseudofusulina cf. *fusiformis* (Schellwien)		+					
Pseudofusulina sp.		+					
Schubertella sp.		+					
Parafusulina ? sp. indet.		+					
Anthozoa							
Gerthia kobiyamai Eguchi (MS)	+						
Lophophyllum aff. *pendulum* Grabau		+	+				
Lophophyllum ? sp. indet.						+	
Tachylasma magnum Grabau					+	+	
Tachylasma sp.					+	+	
Wentzelella minor Eguchi (MS)		+					
Zaphrentis sp.						+	
Bryozoa							
Fenestella cf. *assumpta* Reed						+	
Fenestella cf. *perelegans* Meek		+	+			+	
Polypora aff. *gigantea* Waagen						+	
Echinoderma							
Crinoid stem	+	+	+	+	+	+	+
Brachiopoda							
Alispirifer laminosus transversa Maxwell							+
Anidanthus abukumaensis Yanagisawa, n. sp.						+	
Cancellospirifer maxwelli Campbell						+	
Chonetes blanfordi lata Hayasaka						+	
Ch. uralicus Moeller						+	
Derbyia cf. *crassa* Meek & Hayden							+
Hustedia cf. *remota* (Eichwald)						+	
Lyttonia richthofeni Kayser emend. Hayasaka							+
Linoproductus ? cf. *mammatus* (Keyserling)	+						
Marginifera typica septenrionalis Tschernyschew							+
Neospirifer cf. *fasciger* (Keyserling)						+	
N. aff. *cameratus* Morton							+
Productus cora (d'Orbigny)						+	
Prod. gruenewaldti Krotow						+	
Prod. cf. *sinensis* Tschernyschew						+	
Schuchertella ? sp.						+	
Spiriferella saranae (Verneuil)							+
Spiriferella cf. *saranae* (Verneuil)						+	
Spiriferina cristata Schellwien						+	
Pelecypoda							
Acanthopecten cf. *carboniferous* Stevens						+	
Anthraconeiolo aff. *taffiana* Girty						+	
Astartella cf. *permocarbinica* Tschernyschew							+
Aviculopecten cf. *hataii* Murata						+	
Conocardium kansuensis Chao						+	
Liebea aff. *mapingensis* Grabau			+				
Lima cf. *retifera* Schumard							+
Limipecten cf. *burnettensis* Maxwell							+

Table 2. Continued.

Genus and Species	Formation	Iriishikura	Motomura			Kashiwadaira		
	Locality	B	L_2	D_3	F	G_1	G_2	H
	Fossil Locality Number	T_1	T_3	T_4	T_5	T_6	T_7	T_8
Nucula aff. *subnuda* d'Orbigny							+	
Nucula sp.							+	
Solemya aff. *costellata* M'coy							+	
Streblochondria cf. *stantonensis* Newell							+	
Gastropoda								
Bellerophon sp.		+					+	
Euconopsira sp.							+	
Phanerotrema sp.							+	
Pleurotomaria sp.							+	
Nautiloidea								
Cibolites cf. *uddeni* Plummer & Scott								+
Foordiceras gregarium (Miller)							+	
Michelinoceras sp.							+	
Tainoceras sp.								+
Tylonautilus permicus Hayasaka							+	
Ammonoidea								
Agathiceras cf. *suessi* Gemmellaro							+	
Medlicottia cf. *costllifera* Miller & Furnish							+	
Paraceltites elegans Girty								+
Paraceltites aff. *elegans* Girty		+					+	
P. sp.							+	
Propinacoceras aff. *knighti* Miller & Furnish							+	
Waagenoceras cf. *dieneri* Bose							+	
Arthropoda								
Paladin yanagisawai Endo & Matsumoto							+	
Trace Fossil								
Notakulites toyomensis Kobayashi							+	
Problematica								
Tentaculites sp.							+	
Algae								
Epimastopora sp.			+	+	+			
Hikorocodium elegantae Endo			+	+	+			
Stenopora sp.			+	+	+			
Succodium sp.			+	+	+			
Filicinae								
Taeniopteris sp.							+	

of the Nautiloids and Ammonoids to which probably some of the Fusulinids may be included. The lithological characters of the sediments which yielded the fossils just mentioned is mostly of mudstone (shale) but at places of muddy sandstones (shaly sandstone or sandy shale to sandstones), a lithofacies in which benthonic invertebrates flourish.

From the fauna and lithfoacies it can be judged that the sedimentary environment was probably of an embayment with entrance broad enough to permit the free entering of pelagic forms of molluscs and drifting of planktonic life. In the shallower parts of the embayment benthonic animals represented largely by the brachiopods and pelecypod—gastropod molluscs lived luxuriantly in the rather calm sea-bottom of muddy to mud—sandy sediments rich in organic nutrients, as can be judged from the abundant individual number

Geological Map of the Takakura-yama – Yaguki Area, Fukushima Prefecture

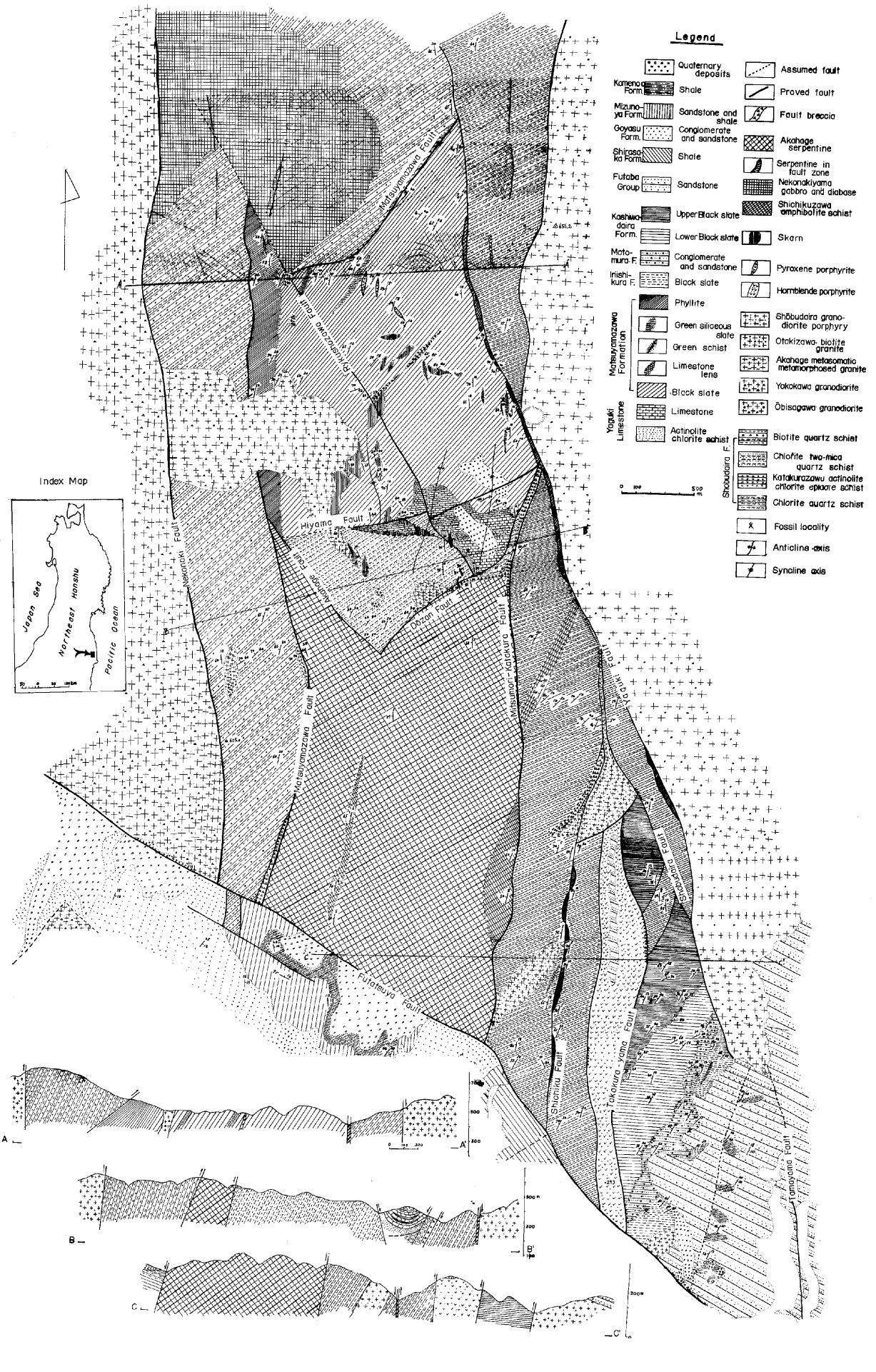

Table 2. Continued.

Group	Formation	Fossil Locality Number	Locality List
Takakura-yama	Iriishikura	T_1	The slope of B- valley, about 1.1 km north west of the Tamayama Mineral Spring, Yotsukura -cho Fukushima Prefecture. Iriishikura Formation of the Takakura-yama Group
	Motomura	T_3	The slope of L_2- valley, about 1.2 km north west of the Tamayama Mineral Spring, Yotsukura -cho, Fukushima Prefecture. Motomura Formation of the Takakura-yama Group
		T_4	The slope of D_3- valley, about 1.5 km north west of the Tamayama Mineral Spring, Yotsukura -cho, Fuskushima Prefecture, Motomura Formation of the Takakura-yama Group.
		T_5	The slope of F-valley, about 1.7 km north west of the Tamayama Mineral Spring, Yotsukura -cho, Fukushima Prefecture, Motomura Formation of the Takakura-yama Group
	Kashiwadaira	T_6	The slope of G_1- valley, about 2.0 km north west of the Tamayama Mineral Spring, Yotsukura -cho, Fukushima Prefecture, Kashiwadaira Formation of the Takakura-yama Group
		T_7	The slope of G_2- valley, about 2.2 km northwest of the Tamayama Mineral Spring, Yotsukura -cho, Fukushima Prefecture, Kashiwadaira Formation of the Takakura-yama Group
		T_8	About 500 m, north G_2- valley, 2.2 km northwest of the Tamayama Mineral Spring, Yotsukura -cho, Fukushima Prefecture, Kashiwadaira Formation of the Takakura-yama Group

of those organisms. The pelagic or planktonic fauna points to that the embayment faced the open sea and had a wide entrance, so that the currents entering the embayment caused no concentrated flow strong enough to develop current or eddy marks on the shallow sea bottom.

The sedimentary basin seems to have been a rather stable one at least during deposition and development of the rich invertebrate fauna because of the rather uniform lithology of muddy sediments, non-development of coarse clastic rocks as conglomerates and coarse grained sandstones, restricted development of limestones and limited distribution of sandy sediments. Secondary sedimentation as slumping structures are either very rare or absent thoughout the stratigraphic sequence of the Permian sediments, and this also suggests the stability of the hinterland and also of the basin itself.

However, from the non-development of Early Permian and Late Permian sediments determined from paleontological evidence, it appears that crustal movements had taken place during those particular ages.

b) General climatological conditions

From the development of rather thick limestone, although restricted in distribution both vertically and horizontally, rather abundant coral genera, large encrusting bryozoans, abundant individual and specific as well as generic number of brachiopods, and fusulinids, it is inferred that the thermal conditions must have been mild to warm throughout the time of the Middle Permian in the present area. The abundant nautiloid and ammonoid genera also point to warm water conditions prevailing during deposition of the Middle Permian formations of the area.

c) Geological significance

The geological age of the fossiliferous strata is considered to be approximately Middle Permian based upon the marine invertebrate fauna. The geological age of the fauna and correlation with other Permian formations of Japan is shown in Table 3.

Table 3. Correlation of the Takakura-yama Group with the Permian Formations in the Kitakami Massif, Northeast Honshu, Japan

Locality / Age		Abukuma Massif		Kitakami Massif
		Southern Part	Northern Part	Southern Part
		Takakura-yama-Yaguki District Yanagisawa, 1967	Sôma District Sato, 1956	Motai-Tobigamori District Onuki, 1966
Permian	Takakura-yama Group	Kashiwadaira Formation	Yumioreza Formation Oashi Formation	Toyoma Formation Kanokura Formation
		Motomura Form. *Psf.* cf. *ambigua* *Psf.* cf. *fusiformis* *Psf.* cf. *vulgaris*	Uwagaya Formation	Sakamotozawa Form. *Psf. ambigua* *Psf. fusiformis* *Psf. vulgaris*
		Iriishikura Formation fault Matsuyamazawa Formation	*Pseudoschwagerina*	*Pseudoschwagerina*
Devonian Carboniferous	Niidagawa Group	Yaguki Limestone (Ryokushozawa member) fault	Tateishi Formation	Takezawa Formation
			Mano Formation	Karaumedate Formation
			Ainosawa Formation	Tobigamori Formation
		fault Shôbudaira Formation	Matsugadaira Formation	Motai Group

B. Descriptions of the Important Species

Brachiopoda
Family Schuchertellidae Williams, 1953
Genus *Schuchertella* Girty, 1904
Schuchertella ? sp. indet.
Pl. 3, fig. 12

Compared with:
Streptorhynchus semiplanus Waagen, Richthofen, 1911, pp. 173, pl. 26, fig. 5.
Schuchertella sp. *probabilis* Hayasaka, 1922, p. 74, pl. IV, fig. 2.
Streptorhynchus kayseri Schellwien, Huang, 1933, p. 15, pl. II, figs. 11–12.

Remarks: – This specimen is represented by an incomplete external mold. The valve (85 mm in length) is semicircular in outline, rather small, slightly convex; the convexity of the posterior portion is stronger than the anterior portion. The umbonal region is not preserved, and the test is thin. The surface is characterized by fine radiating striae, which increase in number anteriorly by bifurcation. About 11 radial striae occupy a space of 5 mm near the anterior margin. The radial striae are more or less wider than the interspaces and bifurcate near the anterior margin, and are crossed by very fine concentric growth lines. The hingeline is not preserved, but it seems to have been shorter than the greatest width

(13.0 mm) of the shell. According to Huang (1933, p. 15.), "This species has been found by Dr. V.K. Ting in in the Permian coal bearing beds of Laowangch'ung, Ts'ingchensien, Kueichow. Associated with this species is a specimen of *Lyttonia* sp."
Locality and Horizon: – Loc. no. T_7, Kashiwadaria Formation. IGPS coll. cat. no. 86647.

Family Orthotetidae Waagen, 1884
Genus *Derbyia* Waagen, 1884
Derbyia cf. *crassa* Meek and Hayden
Pl. 3, figs. 5, 8

Compared with:
Derbyia crassa Meek and Hyden. Tschernyschew, 1902, p. 209, pl. XXVI, fig. 2.
Derbyia cf. *grandis* Waagen, Shimizu, 1961, p. 315, pl. 15, figs. 6–7.

Description: – Shell moderate in size, semicircular. Hinge line long, straight, as long as maximum width of valve; beak well preserved, extending slightly beyond hinge line, test thin. Characterized by remarkable coarse radiating striae, which increase in number by bifurcation near anterior margin. Concentric wrinkles present. Median septum extends from umbonal region to anterior margin, becoming wider toward anterior margin. Seven radial striations occupy a space of 5 mm at anterior margin.
The single specimen at hand measures (in mm): –

Length of shell	29.0–30.0
Width of shell	27.0
Length of hingeline	26.5–27.0

Remarks: – The present specimen is more or less compressed, but resmebles Tschernyschew's *Derbyia crassa* Meek and Hayden (1902, p. 207) in the surface ornamentation, although it differs in some details.
Locality and Horizon: – Loc. no. T_8. Kashiwadaira Formation. IGPS coll. cat. no. 86650.

Family Chonetidae Brown, 1862
Genus *Chonetes* Fischer de Waldheim, 1830
Chonetes blanfordi lata Hayasaka
Pl. 1, figs. 3, 17

Chonetes blanfordi Reed var. *lata* Hayasaka, 1925, p. 92, pl. V, figs. 3–4.

Description: – Shell small, semicircular, convex, hingeline straight. Surface ornamentation characterized by radial plications. About 16 of them occupy a space of 0.5 cm; median sinual depression preserved.
The three specimens at hand give the following measurements (in mm): –

Length from hingeline to anterior margin	6.0	6.0	6.1
Approx. length of hingeline	12.0	12.0	13.0

Remarks: – According to Hayasaka (1952, p. 82), "The species *Chonestes blanfordi* is one of the new species described by Cowper Reed (1925, p. 37) from the Upper Carboniferous of Chitral, India. The surface relief of the Japanese specimen appears almost to coincide with that of *Chonetes blanfordi*, having the characteristic median sinual depression and the alar undulations". The specimens at hand are more or less deformed and flattened, but the specimen B coincides with the one from the Kitakami Mountains described by Hayasaka (1925). The specimens of this species are comparatively abundant in the Kashiwadaira Formation of the Takakura-yama Group.
Locality and Horizon: – Loc. no. BT_7 Kashiwadaira Formation. IGPS coll. cat. no. 86644. (A), IGPS coll. cat. no. 86644. (C).

Chonetes uralicus Moeller
Pl. 1, fig. 11

Chonetes uralicus Grabau, 1936, p. 96, pl. X, figs. 8–9.

Description: – Shell small in size, almost squarish in outline, hinge-line longer than maximum width of shell. Beak projecting beyond hinge-line. Characterized by reticulate sculpture of ventral valve and median sinus. Ventral valve convex, with well developed median sinus, extending from umbonal region to anterior margin. Shell with rather coarse radial ribs near ears; ears large and longer, distinct. Reticulation extends anteriorly fan like on each side of median fold; more less geniculated.

Measurements (in mm): –

Length from beak to anterior margin	4.8
Approx. length of hinge line	7.0
Approx. width of shell	5.0

Remarks: – The specimens described by Tschernyschew (1902, pl. LXIII, figs. 4–6) were referred by him to *Chonetes uralicus* Moeller. The present specimen resembles *C. uralicus* figured by Tschernyschew in the general outline. The present specimens have, (1) the median sinus well preserved, and it extends from the umbonal region to the anterior margin, which in the latter is not so distinct, (2) the ears in the former are longer and larger than those of the latter, and (3) the hinge line of the former is longer than that of the latter, and stronger. Judging from those data, the present material coincide with Grabau's species (1936, p. 96, pl. X, figs. 8–9) mentioned above.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86645.

Family Marginiferidae Stehli, 1954
Genus *Marginifera* Waagen, 1884
Marginifera typica septentrionalis Tschernyschew
Pl. 2, fig. 2

Marginifera typica Waagen var. *septentrionalis* Tschernyschew, 1902, p. 646, pl. XXVI, figs. 10–12; pl. LVIII, figs. 13–16.

Marginifera typica Waagen var. *septentrionalis* Tschernyschew, Chao, 1927, p. 163, pl. XVI, figs. 34–47.

Description: — Shell medium in size, wider than long, deformed, transversely subquadrate in outline. Straight hinge-line forming greatest width of shell. Pedicle valve highly inflated, strongly geniculated toward anterior margin, median furrow deep and comparatively wide. Beak pointed, slightly projecting beyond hinge-line, ears well developed. Surface ornamentation characterized by many radial plications, fine concentric growth lamella on flanks, especially near anterior margin. About 10 radial plications occupy a space of 0.5 mm at anterior margin.

The specimen at hand measures (in mm): –

Height from hinge-line to anterior margin	6.5
Length of curvature	16.5–17.0
Length of hinge-line	18.5
Width of pedicle valve	16.5

Remarks: – According to Chao (1927, p. 149–165.), "*Marginifera* is one of the few subgenera among the Producti, which occur abundantly in the younger Paleozoic formations of Eastern Asia. The difference between *Marginifera typica* and its variety *septentrionalis* is very slight". The present specimen also resembles *Marginifera longispina orientalis* Chao (1927, p. 161.) in general outline. But the former can be distinguished from the latter by the wider and deep median furrow.

Locality and Horizon: – Loc. no. T_8, Kashiwadaira Formation, IGPS coll. cat. no. 86656.

Family Productidae Gray, 1840
Genus *Productus* Sowerby, 1814
Productus cora (d'Orbigny)
Pl. 1, fig. 4

Productus cora (d'Orbingy), Tschernyschew, 1902, p. 621, pl. LIV, figs. 1–5.
Productus cora (d'Orbigny), Girty, 1903, p. 364, pl. IV, figs. 1–2.
Productus cora (d'Orbigny), Hayasaka, 1925, p. 94, pl. V, figs. 7–9.

Description: – Shell small in size, deformed, convex. Specimen A is an internal mold of ventral valve. About 7 wrinkles of concentric growth developed. Surface characterized by 15 or more prominent radial striae in a space of 10 mm at anterior margin. Beak small, projecting beyond straight hinge line; about 27 mm or more in length.

The described specimen measures (in mm): –

Length	Width
14.0	27.2

Remarks: – There are only a few specimens from the Kashiwadaira Formation of the Takakura-yama Group. According to Hayasaka (1926), "*Productus cora* is a species very widely distributed in the world, both in the geological and the geographical sense. But it is noteworthy that the type called *Prod. lineatus* has never been reported to occur in America, while it has very often been recorded from the Upper Carboniferous or the Permian systems of Europe and especially of Southern Asia."

The specimen from the Kitakami Massif described by Hayasaka (1926), was referred by him to *Productus cora*. This species has been recorded from the *Productus*-limestone of India, Timor, South China and Ussuri regions. The present specimen is closely related to *Productus cora* described by Hayasaka (1926) from the southern Kitakami Massif, but the former has the shell wider than that of the latter. However, this difference may be within the range of variation within a species.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86640.

Productus cf. *sinensis* Tschernyschew
Pl. 2, fig. 6

Compared with:
Productus cora (d'Orbigny), Hayasaka, 1922, p. 86, pl. V, figs. 3–4.
Productus (*Linoproductus*) *sinensis* Tschernyschew, Reed, 1927, p. 13, pl. 1, figs. 13–13a.
Productus (*Linoproductus*) *sinensis abrupta*, Reed, 1944, p. 57, pl. XII, figs. 1–1a.

Description: – Shell medium in size, subquadrate in outline; hinge-line straight, more or less shorter than greatest width of valve; ears small, umbo slightly overhanging hinge-line. Disc of brachial valve with several concentric wrinkles. About 6 radial straie occupy a space of 5 mm at anterior margin.

Measurements of the specimen are as follows (in mm): –

Length of shell	27.0
Width of shell	27.0
Wdith of shell	26.0
Length of hinge line	26.5

Remarks: – The present specimen resembles *Productus sinensis* Tschernyschew in surface marking and general shape, but can not be identified with it. *Productus* (*Linoproductus*) *sinensis* Tschernyschew var. *abrupta* of Reed (1944, p. 67.) may be included into the species from the *Productus* Limestone of the Salt Range. *Productus sinensis* Tschernyschew recorded by Reed (1927, p. 13.) is from the Upper Carboniferous of Afganistan, and can be distinguished

from the former by the smooth surface ornamentation (no median depression), and from the latter by the circular anterior margin.
Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86651.

Productus gruenewaldti Krotow
Pl. 1, fig. 5

Productus gruenewaldti Krotow, Tschernyschew, 1902, p. 608, pl. XXXIII, fig. 3; pl. LXI, fig. 3, 5–7; pl. LXII, figs. 4–5.
Productus gruenewaldti Krotow, Chao, 1927, p. 57, pl. III, figs. 6–12.

Description: – Specimen A compressed. Hinge line straight, ears large and flattish. Radiating costae almost straight, about 10–11 within a space of 10 mm at anterior margin. Surface ornamentation characterized by many concentric growth lines; radiating costae crossed by strong concentric plication at sides.
Measurements (in mm): –

Length from hinge-line to anterior margin	15.0
Width of body of shell	18.0
Approximate length of hinge-line	20.0

The specimen B is an internal mold of the ventral valve. About 16–17 of the radiating costae occupy a space of 10 mm. at anterior margin.
Remarks: – According to Chao (1927, p. 59–61), "Loczy's (1878–1880) *Pr. semireticulatus* from Yang-Hu-kou, Shan-Tan-Hsien, Kansu and Schellwien's *Pr. semireticulatus* var. *bathykolpos* from Sin-Ho of the same district really belong to *Pr. gruenewaldti* Krotow, as is shown by an actual study of the rich material obtained from the same localities. *Pr. gruenewaldti* is an important and wide-spread species in the Higher Carboniferous of Asia. In the Ural and Timan, it first appears in the *Cora*-Horizon and extends up to the Artinskian".
Locality and Horizon: – Loc. no. T_7, Kashiwadaria Formation, IGPS coll. cat. no. 86643.

Family Linoproductidae Stehli, 1954
Genus *Linoproductus* Chao, 1927
Linoproductus cf. *mammatus* (Keyserling)
Pl. 2, fig. 7

Compared with:
Prodcutus mammatus Keyserling, Tschernsychew, 1902, p. 631, pl. XXXV, figs. 4–6.
Linoproductus ? *mammatus* (Keyserling) Chao, 1927, p. 146, pl. XV, figs. 10–14.

Description: – Shell medium in size, hinge line straight, longer than greatest width of shell. Ear large and flat. Brachial valve flattish, abruptly sloped from central portion of valve towards anterior margin. Median sinus commencing from central portion of shell. Surface characterized by numerous radiating striae. About 11–12 radial striae occupy a space of 5 mm at anterior margin. Concentric wrinkles and spines absent.
The single specimen at hand measures (in mm): –

Length of hinge line	39.0
Length of shell	22.5

Remarks: – The present specimen is characterized by its very transverse outline. There are numerous fine radiating striae and a well developed median sinus. According to Chao (1927, p. 147), the original specimens of this species are described from Russia. Tschernyschew obtained his shell from the *Schwagerina*-Kalk of Ural and Timan. Also this species was obtained from the Permian limestone of Mongolia by F.K. Morris (*Marginifera*-bed)."

Locality and Horizon: – Loc. no. T_1, Iriishikura Formation, IGPS coll. cat. no. 86649.

Genus *Anidanthus* Hill, 1950
Anidanthus abukumaensis Yanagisawa, n. sp.
Pl. 2, fig. 16

Description: – Shell rather small, spiriferid in outline. Shell substance well-preserved. Shell wider than long. No spines preserved. Concentric ribs of growth well developed, extending from beak to anterior margin, about 11–12 concentric ribs on ventral valve. Radial ribs comparatively regular and uniform thoughout, very acute near beak; not splitting, beak small, slightly projecting beyond hinge-line. Hinge-line straight, and ears wide; much longer than maximum width of shell.

The single specimen at hand measures (in mm): –

Length	Width
14.0	28.0

Remarks: – The shell of the present specimen is apparently thinner than those of the other similar species. The present specimen is more or less compressed and flattened, and resembles *Productus* (*Marginifera*) *semigranosus* from the Permo-Carboniferous deposits at Ta-li-Shao, Yun-Nan, but (1) the former is less convex than the latter, (2) the radial ribs of the former extend to the beak, whereas in the latter they are interrupted by concentric ribs, and (3) hinge-line of the former is longer than that of the latter, and is straight. Judging from those features, it is thought best to distinguish the present one as a new species here named as *Anidanthus abukumaensis*.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86641.

Family Lyttoniidae Waagen, 1883
Genus *Lyttonia* Waagen, 1883
Lyttonia richthofeni Kayser em. Hayasaka, 1922
Pl. 2, Fig. 1

Lyttonia nobilis Waagen, Noetling, 1904–1905, p. 140, pl. XVII, figs. 1–2; pl. XVIII, figs. 1–11.
Lyttonia richtofeni Kayser em. Hayasaka, 1922, p. 62, pl. XI, figs. 1–6.
Lyttonia richthofeni Kayser em. Hayasaka, 1922, p. 103, pl. IV, figs. 12, 13.
Lyttonia nobilis Waagen, Huang, 1932, p. 89, pl. VII, fig. 9–10; pl. VIII, figs. 8–9; pl. IX, fibs. 1–8.

Description: – Shell elongate ovate, moderate in size, widest at middle, tapering towards both margins. Specimen an external mold of slightly convex brachial valve, with a median furrow, median lobes and parallel lateral lobes. Median lobes marked off by deep median incision, developed on each side of median furrow. Width of median furrow slightly larger than lateral lobes. Both ends of anterior and posterior portions lacking, but six lateral lobes occupy a space of about 22 mm . If complete, it would measure more than about 40 mm in length. Numerous granulations on shell surface. Pedicle valve not preserved.

The single specimen at hand measures (in mm): –

Length of shell	22.0
Greatest width of shell	27.5
Width of median furrow	1.6–2.0
Width of lateral lobe	1.5

Remarks: – The present specimen is characterized by the median furrow, median lobes and lateral lobes. This species is a widespread and an important Permian index fossil of the Indo-Pacific region, Siberia and Japan, etc.

The present specimen was collected by Sugahara (1961, MS), and is the first record of

species from the Abukuma Massif. This species closely resembles *Lyttonia nobilis* Waagen (1932, p. 89). According to Hayasaka (1922, p. 107), "As to the specific name Noetling adopted Waagen's nomenclature *nobilis*, while Frech used the term *richthofeni* according to Kayser's original report. In this respect the writer should like to follow the latter author, because, on the one hand differing from the generic name neither *richthofeni* nor *nobilis* signifies any of the characteristic of the fossil under consideration and on the other hand, Kayser's nomenclature has priority. And in addition of the merit of von Richthofen may be recognized by adopting the specific name proposed by Kayser."
Locality and Horizon: – Loc. no. T_8, Kasiwadaira Formation, IGPS coll. cat. no. 86648.

Family Syringothyrididae Frederiks, 1926
Genus *Alispirifer* Campbell, 1861
Alispirifer aff. *laminosus transversa* Maxwell
Pl. 2, fig. 3

Compared with:
Alispirifer laminosus var. *transversa* Maxwell, 1964, p. 28, pl. 5, figs. 33–38.

Description: – Shell medium in size, strongly transverse, triangular in outline; hinge-line straight and long, much longer than maximum width of shell. Length/width ratio 1:2. Ventral valve convex. Surface ornamentation characterized by deep, steep sided sinus and comparatively large striated delthyrium. About 8–9 acute radial plications on valve; plications separated by angular furrows, median fold comparatively broad, and microscopic ornamentation absent.

The single specimen at hand measures (in mm): –

Maximum width along hinge-line	40.1
Length of shell	20.5
Length/width	1:2

Remarks: – According to Maxwell (1964, p. 29.) "*Alispirifer laminosus* var. *transversus* shows the closest affinity with the genotype *A. laminosus* s.s. Campbell. However it may be distinguished from these by the more transverse shell, few plications, and somewhat more acutely triangular cardinal area". The material at hand is identified with the named species with some doubt because of the state of preservation.
Locality and Horizon: – Loc. no. T_8, Kashiwadaira Formation. IGPS coll. cat. no. 86652.

Family Spiriferidae King, 1846
Genus *Neospirifer* Fredericks, 1919
Neospirifer cf. *fasciger* (Keyserling)
Pl. 2, fig. 18

Compared with:
Spirifer fasciger, Keyserling, 1846, p. 231, pl. VIII, figs. 3, 3a-3b.
Spirifer fasciger Keyserling, Tschernyschew, 1902, p. 141, pl. XXXVIII, figs. 3–4.
Spirifer (*Neospirifer*) *fasciger paucicostulata* Reed, 1930 p. 32, pl. 11, fig. 1, 1a.
Neospirifer sp. Campbell, 1953, p. 8–9, figs. 1–8.
Neospirifer fasciger (Keyserling), Hayasaka, 1960, p. 42, pl. 1, figs. 1–7; pl. 11, figs. 1–2.
Neospirifer sp. Shimizu, 1961, p. 340, pl. 18, figs. 11–13.

Description: – Specimen rather small in size, wider than long. Cardinal extremities angular; fold and sulcus of pedicle valve distinct, median sulcus well developed, valve not strongly convex, ventral umbo moderate in size, flatly triangular; beak projecting beyond hinge-line. Median fold of ventral umbo narrow, 2 or 3 distinct folds and sulcus on each side

of median fold. Brachial valve lost. Hinge line almost straight, slightly shorter than maximum width of shell. Ribs of ventral valve sharp, bundled into about 11–12 plications which occupy a space of 17 mm at anterior margin. Anterior margin not well preserved. Muscle impression not exposed.

Measurements (in mm): –

Specimen	Length	Width	Hinge line
A	12.0 (approx.)	18.0	15.0

Remarks: – The specimen from the Takakura-yama Group is smaller than the one recorded from the southern part of the Kitakami Massif by Hayasaka (1960). But the characters of the shell, such as the surface ornamentation, especially the ventral umbo are quite the same.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86637. (A).

Neospirifer aff. *cameratus* Morton
Pl. 2, fig. 11

Compared with:
Spirifer (*Neospirifer*) *cameratus* Morton, var. Reed, 1944, p. 204, pl. XXVII, fig. 4.

Description: – Internal mold of pedicle valve, rather large, incomplete. Surface ornamentation characterized by many fine radial ribs. Fold and median sulcus of pedicle valve distinct. About 3 ribs arranged in fascicles on each side of median sulcus. About 11 radial plications occupy a space of 10 mm at anterior margin. Concentric growth lamellae traceable on valve. Brachial valve absent, anterior margin deformed.

The specimen measures (in mm): –

Maximum width along hinge-line	65.0
Length from umbonal region to anterior margin	42.0

Remarks: – The present specimen resembles *Spirifer* (*Neospirifer*) *cameratus* Morton, var. in physiognomic feature and shape, but the former is distinguished from the latter by the surface ornamentation of the shell.

Locality and Horizon: – Loc. no. T_8, Kashiwadira Formation. IGPS coll. cat. no. 86653.

Family Brachythyrididae Fredericks, 1919 (1924)
Genus *Spiriferella* Tschernsyhew, 1902
Spiriferella saranae (Verneuil)
Pl. 2, figs. 10, 12

Spirifer saranae Verneuil, 1845, p. 169, pl. V, fig. 15.
Spiriferina (*Spiriferella*) *saranae* Verneuil, Tschernyschew, 1902, p. 121, pl. XII, fig. 4.

Description: – Specimen A rather large, deformed. Anterior margin of pedicle valve lost. Fold and sulcus on valve distinct; especially median furrow clear, deep, hinge-line generally short, umbonal region highly convex. Length of shell longer than width. About 4 radial plciations on each side of median furrow; radial plications very strong, 2nd order costella near median furrow, well preserved, and many fine concentric growth lamella on valve. Shell substance well observed.

Specimen B (plastotype), complete. Shell medium in size; highly convex, hinge-line short, straight. Surface oranmentation characterized by prominent radial plications. Median sulcus distinct, 4 radial plications on each side of median furrow; 2nd order costella near median furrow, well preserved, parallel. Hinge-line short, straight. Beak slightly

projecting beyond hinge-line, overhanging. Many fine concentric growth lamella near anterior margin.

The specimens measures (in mm): –

Length of shell	48.0	21.1
Approx. width of shell	43.0–44.0	21.0

Remarks: – The present specimen is identical with *Spiriferina* (*Spiriferella*) *saranae* (Verneuil) described by Tschernyschew. (1902, p. 102).

Locality and Horizon : – Loc. no. T_8, Kashiwadaira Formation, IGPS coll. cat. no. 86654.

Spriferella cf. *sarane* (Verneuil)
Pl. 2, fig. 19

Compared with:
Spiriferina (*Spiriferella*) *saranae* Verneuil, Tschernyschew, 1902, p. 121, pl. XII, fig. 4.

Remarks: – The specimen is moderate in size, slightly deformed, and the shell is wider than long. The fold and sulcus on the pedicle valve are distinct, and especially the median suclus of the pedicle valve is well developed. The ventral umbo is comparatively highly convex. The hinge-line of this specimen is very short. About 4–5 distinct radial ribs along each side of the median fold. The brachial valve is lost. The ribs are wider than the interspaces. Near the anterior margin, the width of radials measures 2–3.0 mm.

The single specimen at hand measures (in mm): –

Length	Width
29.0	25.1

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86638. (A).

Genus *Cancellospirifer* Campbell, 1953
Cancellosprifer ? *maxwelli* Campbell
Pl. 3, fig. 16

Compared with:
Cancellospirifier maxwelli Campbell, 1953, p. 10–11, pl. III, figs. 1–9.

Description: – A spiriferoid specimen of internal mold of ventral valve. Ventral umbo pointed, slightly incurved, and slightly overhanging hinge-line. Hinge-line straight, longer than maximum width of shell. Median groove well defined, extending to umbo. Four radial plications on each side of median groove, reach to near umbo.

The single specimen at hand measures (in mm): –

Width of shell	Length of ventral valve.
15.0	185.–19.0

Remarks: – This specimen is from the Kashiwadaira Formation of Takakura-yama. The described specimen resembles *Spiriferella* in the surface ornamentation, but the hinge-line and other details are closer to the one known as *Cancellospirifer maxwelli*.

Locality and Horizon: – Same as *Anidanthus abukumaensis*, IGPS coll. cat. no. 86642.

Family Spiriferinidae Davidson, 1884
Genus *Spiriferina* d'Orbigny, 1847
Spiriferina cristata Schellwien
Pl. 1, fig. 12, pl. 3, fig. 6

Spiriferina cristata Schellwien, Tschernyschew, 1902, p. 517, pl. XXXVII, figs. 1–2.

Description: – Specimen A is characterized by prominent deep and acute radial ribs. Shell semielliptical in shape, punctate and with many prominent concentric growth lines. A deep median groove runs from beak to anterior margin. Four or 5 plications on each side of median groove. Median ribs divided near center of median plate. Umbo of ventral valve not exposed. Prominent radial ribs. Fold acute. Punctae of shell prominent. Abundant fine granulated punctations on concentric growth lines. Specimen B deformed and compressed.

The two specimens mentioned above give the following measurements (in mm): –

Specimen	Length	Width
A	19.0 (approx.)	29.5
B	10.0	15.0

Remarks: – The southern Kitakami specimen described by Hayasaka (1922) as *Spiriferina cristata* Schellwien is identical with the present specimens.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86639. (A), IGPS coll. cat. no. 86639. (B).

Pelecypoda
Family Nuculidae Gray, 1824
Genus Nucula Lamarck, 1799
Nucula aff. *subnuda* d'Orbigny
Pl. 1, fig. 14

Compared with:
Nucula subnuda d'Orbigny, Bittner, 1895, p. 141, pl. XVII, fig. 40.
Nucula anodontoides Meek ? Girty, 1915, p. 111, pl. XIII, figs. 1–5.

Description: – Shell small in size, ovate, umbonal region moderatly convex, ventral margin semielliptical in outline. Beak pointed, nearly central. Lunule, escutcheon and teeth not prevserved. Surface characterized by fine regular, closely arranged concentric striae at ventral margin. About 4–5 fine concentric striae occupy a space of 1 mm at ventral margin. Measurements (in mm): –

Length of shell	14.0
Height of shell	10.5
H/L	0.75

Remarks: – The described specimen resembles *Nucula subnuda* d'Orbigny described by Bittner (1895), p. 141, pl. XVII, fig. 40.) in the surface ornamentation, especially in the general outline, although it differs in some details. And because the specimen is incomplete, it can not be identified strictly with the named species.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86663.

Nucula sp. indet
Pl. 2, fig 4

Compared with:
Nucula strigilata Goldfuss, Bittner, 1895, p. 137, pl. XVII, figs. 1–17.
Nucula anodontodies Meek ?, Girty, 1915, p. 111, pl. XIII, figs. 1–5.

Description: – Shell ovate, internal mold of right valve, beak pointed, overhanging; subcentral, about 8 posterior teeth well preserved, escutcheon slightly anterior, preserved. Surface smooth, concentric striae traceable at ventral margin; ventral margin rounded. Antero-

dorsal margin longer than of postero-dorsal, nearly straight.
Measurements (in mm): –

Length of shell	15.7
Height of shell	11.5
H/L	0.73

Remarks: – The specimen resembles *Nucula anodontoides* Meek ? described by Girty (1915, p. 111, pl. XIII, figs. 1–5.) from the Wewoka Formation (Pennsylvanian) of Oklahoma. However, this species differs from the one described by Girty, by the longer postero-dorsal margin, and surface ornamentation.
Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 8664.

Family Conocardiidae Miller, 1889
Gneus *Conocardium* Brown, 1835
Conocardium kansuensis Chao
Pl. 3, fig. 9

Conocardium kansuensis Caho, 1927, p. 23, pl. 1, figs. 32–33.

Description: – Shell rather small, internal mold of left valve, moderately convex. Beak small, pointed, slightly arched, hinge-line straight; hinge-line a little longer than maximum length of shell. Anterior end longer than posterior, slightly produced alate; gradually differentiated from shell. Surface characterized by angular concentric folds, not uniform; interspaces between concentric fold wide toward ventral margin. Surface marked by very faint radiating striae at ventral margin. About 7 concentric folds occupy a space of 5 mm at ventral margin.
Measurements (in mm): –

Height of shell	12.0
Length of shell	16.0
H/L	0.74
Length of hinge-line	17.5

Remarks: – According to Chao (1927, p. 23.) "surface sculpture is very characteristic and it can be easily distinguished from all the other species among this genus. In the common type of *Conocardium* the surface is radially costated, whereas in the present species, concentric folds are the dominant sculpture". The present specimen is characterized by the prominent concentric folds and the faint radial striae. The shell is compressed and more or less flattened. However, this species is considered identical with *C. kansuensis* Chao (1927, pl. 1, figs. 32–33) in the surface sculpture and general outline, especially in the concentric folds.
Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86667.

Family Myalinidae Frech, 1891
Genus *Liebea* Waagen, 1881
Liebea aff. *mapingensis* Grabau
Pl. 2, fig. 5

Compared with:
Liebea indica Waagen, 1881, p. 295, pl. XX, fig. 5a.
Liebea sinenesis Frech, Hayasaka, 1925, p. 14, pl. VIII, (1), figs. 11–13.
Liebea mapingensis Grabau, 1936, p. 296, pl. XXVIII, fig. 2, pl. XXIX, fig. 2.

Description: – Shell moderate in size, more or less mytiliform, elongate oval. Left valve higher than long, slightly convex. Umbonal region deformed, anterior margin broken, hinge teeth not observed. Surface characterized by very fine concentric growth lines, otherwise quite smooth. About 9–10 concentric growth line occupy a space of 5 mm at posterior margin.

Measurements (in mm): –

Max. length of shell	12.0
Height of shell	22.3
H/L	1.8

Remarks: – According to Grabau (1936, p. 298.), "This species is readily distinguished from *Liebea indica* Waagen of the Lower *Productus* limestone of the Salt Range by its general form, the Indian species being more mytiliform with anterior beak." The present specimen resembles *L. mapingensis* Grabau in the general outline. However, (1) the shell of the former is much more oblong than the latter, and (2) the latter shell is rather strongly convex. Judging from these data, the present specimen can not be strictly identified with *L. mapingensis* Grabau.

Locality and Horizon: – Loc. no. T_4, Motomura Formation. IGPS coll. cat. no. 86665.

Family Aviculopectinidae Etheridge Jr., 1906

Genus *Aviculopecten* McCoy, 1851

Aviculopecten cf. *hataii* Murata

Pl. 2, fig. 13

Compared with:

Aviculopecten interstitialis (Phillips), Hayasaka, 1925, (non Phillips, 1936), p. 7, pl. 8, figs. 3–5.

Aviculopecten janus Gemmellaro, Grabau, 1936, p. 289, pl. XXVIII, figs. 5a–5b.

Aviculopecten hataii Murata, 1964, p. 221, pl. 34, figs. 10a-10d.

Description: Shell medium in size, represented by left valve, longer than high. Valve slightly convex. Posterior auricle apparently small but not well shown. Hinge line shroter length. Valve characterized by many radial costae; about 10 radial costae occupy a space of 10 mm ,2nd order costae 5–6 in number. Concentric growth lines not well preserved, ventral margin obscure.

Measurements (in mm): –

Height of shell	24.3
Length of shell	33.5
H/L	0.72
Length of posterior aurcile	3.5
Max. length of radial costae	26.5

Remarks: – The specimen from the Takakura-yama Group is more incomplete than the one recorded from the southern Kitakami Massif by Murata (1964). But the characters of the shell, such as the surface ornamentation and general size of the shell are similar to the original figures, and the incomplete 2nd costae. But because of the state of preservation, this species is identified as *A.* cf. *hataii* Murata.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation. IGPS coll. cat. no. 86657.

Genus *Limipecten* Girty, 1904

Limipecten cf. *burnettensis* Maxwell

Pl. 2, figs. 14, 15

Compared with:

Deltopecten vanvleeti Beede, Girty, 1909, p. 88, pl. IX, fig. 5.

Limipecten burnettensis Maxwell, 1964, p. 14, pl. 1, figs. 14–17.

Description: – Shell moderate in size, elongate ovate, slightly convex, cardinal area extremely narrow, slender. Shell wider than long.

Specimen B: Shell small in size, slender, elongate ovate, slightly convex, cardinal area narrow, beak pointed. Characterized by extemely fine radial costae, fine concentric lamellation on valve. About 10–11 fine radial costae occupy a space of 2 mm at ventral margin.

Specimen C: Anterior anuricle of left valve poorly preserved.

Measurements (in mm): –

Specimen	A	B
Length (Max.)	7.2	7.5
Height (Max.)	10.8	9.0
H/L	1.5	1.2

Remarks: – The present specimens are characterized by the many radial costae, narrow beak, and elongate ovate shell. These specimens closely resemble *Limipecten* cf. *burnettensis* Maxwell, and also less so to *Deltopecten vanvleeti* Beede (1909, p. 86, pl. LX, fig. 5) in the surface ornamentation.

Locality and Horizon: – Loc. no. T_8, Kashiwadaira Formation, IGPS coll. cat. no. 86658. (B), IGPS coll. cat. no. 86658. (C).

Genus *Acanthopecten* Girty, 1903

Acanthopecten cf. *carboniferous* Stevens

Pl. 2, fig. 17

Compared with:
Acanthopecten carboniferous (Stevens), Girty, 1915, p. 134, pl. XVII, fig. 10.
Acanthopecten carboniferous (Stevens), Newell, 1937, p. 72, pl. 12, figs. 8–10.

Description: – Shell rather small, shell substance well preserved, margin partly observed, shape pectinoid with long straight hinge-line; anterior auricle with reticulation. Surface characterized by acute, subangular, radiating plications; fine ones intercalated between radial plications. Radial plications regular and uniform thoughout. About 7 radial plications occupy a space of 17 mm at margin of greatest height of shell. Ears large, hinge straight and large, slightly longer than maximum height of shell. Auricular costae not preserved, however, reticulation well preserved.

Measurements (in mm): –

Length of shell	19.5
Height of shell	15.5
H/L	0.79
Length of ant. auricle	9.3

Remarks: – The described specimen resembles *A. carboniferous* (Stevens) described and figured by Newell (1938, pl. 12, fig. 9) in the surface suculpture. However, this specimen is incomplete and thus it can not be strictly identified with *A. carboniferous* (Stevens), because of the state of preservation.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation. IGPS coll. cat. no. 86659.

Subfamily Streblochondriinae Newell, 1937

Genus *Streblochondria* Newell, 1937

Streblochondria aff. *stantoensis* Newell

Pl. 2, fig. 8

Compared with:
Streblochondria stantoensis Newell, 1937, p. 83, pl. 15, figs. 1a–1b, 3–4.
Streblochondria miyamoriensis Murata, 1964, p. 229, pl. 35, figs. 14a–14b.

Description: – Shell rather small, distinctly higher than long, opisthocline, beak sharp, narrow, pointed. Anterior auricle preserved, posterior auricle not preserved. Surface characterized by many fine radial costae and very faint concentric growth lines. Shell substance well preserved; postero-lateral ridges comparatively long the straight, antero-lateral ridge shorter, shell substance composed of two layers. About 8 radial costae occupy a space of 5 mm at postero-lateral margin, hinge area deformed.
Measurements (in mm): –

Length of shell	14.7
Height of shell	18.5
H/L	1.2
Length of ant. auricle (approx.)	2.5

Remarks: – The present specimen is characterized by many fine radial costae and faint concentric growth lamella. It resembles *S. stantonensis* Newell (1937) in the surface ornamentation. However, (1) in the former the umbonal angle is larger than the latter, (2) generally, the shell of the latter is larger than that of the former. Judging from those data, the present species can not be strictly identified with *S. stantonensis* Newell.
Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86660.

Family Limidae d'Orbigny, 1847
Genus *Lima* Bruguiere, 1797
Lima cf. *retifera* Shumard
Pl. 2, fig. 9

Compared with:
Lima retifera Shumard, Girty, 1915, p. 137, pl. XVII, fig. 8.

Description: – Shell small in size, external mold, obliquely ovate, beak subcentral, pointed. Ear very small, traceable. Shell surface characterized by prominent radial ribs and sulcus; radial ribs become gradually wider toward ventral margin. About 4 radial ribs occupy a space of 5 mm at ventral margin.
Measurements (in mm): –

Height of shell	9.1
Length of shell	7.0
H/L	1.3

Remarks: – The present specimen resembles *Lima retifera* Shumard described by Girty (1915) in the surface ornamentation, but the auricles are incomplete, and thus it is refered to the named species with doubt.
Locality and Horizon: – Loc. no. T_8, Kashiwadaira Formation, IGPS coll. cat. no. 86661.

Family Astartidae d'Orbigny, 1884
Genus *Astartella* Hall, 1858
Astertella cf. *permocarbonica* Tschernyschew
Pl. 3, figs. 10, 15

Compared with:
Astarte permocarbonica Tschernyschew, Jakowlew, 1903, p. 42, pl. III, figs. 8–14.
Astarte adenticulata Jakowlew, Chao, 1927, p. 14, pl. 1, figs. 18–20.

Description: – Shell rather small, external mold, subquadrilateral in outline, moderately convex, posterior margin straight, dorsal margin rounded. Beak small, pointed. Surface characterized by sharp concentric ridges, interspaces wider than concentric ribs. Thin ridges occur between concentric ridges near ventral margin. About 9 concentric ridges occupy a space of 5 mm at ventral margin.

Measurements (in mm): –

Height of shell	10.5
Length of shell	11.5
H/L	0.91

Remarks: – Only an external mold of a single valve of this species is at hand. The present specimen is characterized by the concentric ridges, separated by wide and deep valleys. The concentric ridge of this species are less than in Chao's specimens (1927, pl. 1). This species rather resembles *A. permocarbonica* Tschernyschew figured by Jakowlew (1903, pl. II, fig. 12.) in the surface sculpture.

Locality and Horizon: – Loc. no. T_8, Kashiwadaira Formation, IGPS coll. cat. no. 86668.

Cephalopoda
Nautiloidea
Family Orthoceratidae M'coy, 1884
Genus *Michelinoceras* Foerste, 1932
Michelinoceras ? sp. indet.
Pl. 4, fig. 9

Compared with:
Orthoceras guadalupense Girty, 1908, p. 21, 55, 490, 492, 493, 494.
Michelinoceras ? *guadalupense* (Girty), Miller and Yaungquist, 1949, p. 29–30, pl. 2, figs. 8–10; pl. 6, fig. 7.
Michelinoceras sp. Miller, 1945, p. 282, 283–284, pl. 44, fig. 7.

Description: – The conch is circular, rather small, gradually tapering, measuring about 30 mm in maximum length, about 7.5 mm in diameter at the top and 5.0 mm at the lower end. The specimen is fragmentary, crushed and deformed. The aperture, and protoconch are not exposed. Surface marked by concentric striae. Fourteen convex septa in a space of about 40 mm.

Remarks: – This specimen is deformed, but the preservation of the anterior end is rather good, although the posterior end is incomplete. The anterior margin is rounded. The ornamentation of the conch, especially of the lateral ribs resembles *Pseudoorthoceras* and *Mooreoceras*. However, the suture of this specimen differs from *Pseudoorthoceras* and *Mooreoceras* in being narrower; the incisions are deeper and the camera is less flat.

According to Miller and Youngquist (1949), "? *Michelinoceras guadalupense* (Girty) occurs in the Delaware Mountain Formation in the Guadalupe Mountain of Culbertson Country, Texas." The present specimen is more or less similar to that species, but because of the state of preservation, identification with it is not advisable.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86628.

Family Tainoceratidae Hyatt, 1883
Genus *Foordiceras* Hyatt, 1893
Foordiceras gregarium (Miller)
Pl. 1, fig. 9

Metacoceras cf. *gregarium* Miller, 1945, p. 283, 285, 286–287, pl. 45, figs. 5–8.

Description: – All of the specimens from the Takakura-yama Group are crushed and deformed, but a more or less well preserved one (Specimen A) attains a maximum length of about 35 mm, and shorter axis of about 20 mm. The ribs are prominent and measure about 10–13 mm in length and 1–2mm in width. The interspaces are wider than either the straight or slightly sigmoidal ribs, which are more or less stronger on the dorsal than on the ventral parts.

Remarks.: – This species was originally based on the specimens from a single horizon and locality in the Leonard Formation of West Texas. The most distinctive feature of this species is the prominent lateral ribs. Miller and Youngquist (1949, p. 98.) stated that this species can be distinguished from similar congeneric forms by the lateral ribs which extend across the lateral zone of the conch.

Locality and Horizon: – Loc. no. Kashiwadaira Formation, IGPS coll. cat. no. 86621. (A).

Genus *Cibolites* Plummer and Scott, 1937
Cibolites cf. *uddeni* Plummer and Scott
Pl. 1, fig. 13

Compared with:
Cibolites uddnei Plummer and Scott, Miller and Furnish, 1940, figs. 1–4.
Cibolites uddeni Plummer and Scott, Miller, 1945, p. 55, pl. 50, fig. 9.

Description: – This specimen is an internal mold with sublenticular conch and rounded whorls characterized by the smooth surface ornamentation. The evolute conch has about 3 1/2 volutions.

The specimen at hand measures (in mm): –

Longer diameter of evolute whorl	14.0
Width of last volution (estimated)	4.5–5.0
Thickness of last volution (estimated)	1.5–2.0
Number of whorl (estimated)	3 1/2

Remarks: – According to Miller and Furnish (1940), *Cibolites uddeni* Plummer and Scott is known to occur only in the upper Delaware Mountain Formation (Capitan zone) in the Gaudualupe Group of the Delware Mountain area of west Texas. Also, according to Gerth (1950), this species occurred in the *Waagenoceras* zone (Socio stage) with *Paraceltites* and others. The present specimen is closely related to *Cibolites uddeni* described by Hayasaka (1963) from the southern Kitakami massif, but the latter is flatter than the former.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86634.

Genus *Tylonautilus* Prongle and Jackson, 1928
Tylonautilus permicus Hayasaka
Pl. 1, figs. 1, 2

Tylonautilus permicus Hayasaka, 1957, p. 26–30, pl. 9, fig. 12.

Remarks: – According to Hayasaka (1957, p. 28), the specimen studied by him "measures about 8.5 cm along longer axis of elliptic form, approximately, at least, to the diameter of the conch before deformation: it measures about 1.5 cm in width, but the true dimension is not to be known because of deformation. The flanks of the specimen, as is revealed by the external mold are ornamented with radial series of prominent nodes that tend to form nodes radial ribs, each consisting of 4 nodes. The nodes, on the other hand, are so arranged as to appear like 4 spiral series, each of nodes being more or less elongated antero-posteriorly

Umbilicus is shallow, but the umbilical wall is rather abrupt: it is quite large, measuring about 3 cm across. Along the boundary between lateral and ventral areas there is a conpicuous, though rather narrow, longitudinal ridges on either side of relatively wide peripheral sulcus."

Hayasaka's specimen was collected by the writer and is reillustrated in the present work.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86636.

Ammonoidea
Family Agathiceratidae Arthaber, 1912
Genus *Agathiceras* Gemmellaro, 1887
Agathiceras cf. *suessi* Gemmellaro
Pl. 1, fig. 16, pl. 3, fig. 4

Compared with:
Agathiceras suessi Gemmellaro, Miller and Furnish, 1940 p 119, pl. 31, figs. 8–12.
Agathiceras cf. *suessi* Gemmellaro, Hayasaka, 1965, p. 8–27, pls. 2, 3. fig. 3.

Remarks: – Two specimens are in the collection, and of them, specimen A has the conch rather small in size, and unfortuately it is deformed and compressed. It is characterized by longitudinal spirals which are thin, slender and with the interspaces more or less narrower than the spiral lirae, which number 22 in the width of 0.9 cm on the shorter axis. The longer axis of the fragmentary specimen is about 17.0 mm.

Specimen B has the conch elliptical in outline. There are about 31–32 spiral lirae in the width of 7.0 mm. The ornamentation consists of very fine spiral lirae over the whorl surface. If complete, the spiral lirae would number about 50–60.

The two specimens mentioned above give the following measurements (in mm): –

Specimen	A	B
Length of longer axis	17.0	13.0
Length of shorter axis	9.0	/
Sprial lirae	22	31–32
Width of conch	/	7.0

Agathiceras is one of the most abundant Late Paleozoic ammonoids. According to Miller and Furnish, "It is not rare in the Lower Permian of Western and North Central Texas, Timor and the Urals. Lower and Middle Permian representatives have been found the Socio beds of Sicily ,the Artinsk of the Urals, the Bitauni and Basleo beds of Timor and Letti, Bonspring, and the Word Formation of Western Texas etc. —" The present specimens are related to *A.* aff. *suessi* Gemmellaro of Hayasaka (1963), from the southern Kitakami Massif, rather than to the original, and are therefore identified with *Agathiceras* cf. *suessi* Gemmellaro of Hayasaka (1963).

Locality and Horizon: – Loc. no. Kashiwadaira Formation, IGPS coll. cat. no. 86633. (A, B).

Family Cyclolobidae Zittel, 1903
Genus *Waagenoceras* Gemmellaro, 1887
Waagenoceras cf. *dieneri* Böse
Pl. 3, fig. 13

Compared with:
Waagenoceras dieneri Bose, Miller and Furnish, 1940, p. 170, pl. 39, figs. 1–6;
Waagenoceras cf. *dieneri richardsoni* Miller and Furnish, Hayasaka, 1965, p. 23–25, pl. 2, fig. 5.

Description: – The conch is moderate, compressed, subglobular; phragmonocone attains a maximum diameter of about 40 mm, the shorter axis is about 2 mm. Surface almost smooth. Umbilicus rather small, rounded, narrow, measuring about 233 mm across. Living chamber long, evolute whorl with umbilicus.

Measurements (in mm): —

Diameter of evolute whorl	22.0
Distance from bottom of hook ot opposite side of evolute whorl	40.0
Approximate diameter of umbilicus	2.0–3.0

Remarks: – According to Miller and Furnish (1940, p. 156), "*Waagenoceras* is a characteristic zone fossil of the upper part of the Middle Permian and occurs in that horizon in Sicily, West Texas, Coahuila, and Timor. The genus has not been found in beds older than Upper Middle Permian but ranges into the succeeding Upper Permian." The present specimen resembles Hayasaka's (1965) *Waagenoceras* cf. *dieneri richardsoni* Miller and Furnish in physiognomic appearance, but as precise comparison is difficult, the writer regards this species as *Waagneoceras* cf. *dieneri* Bose.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86629l

Family Medlicottiidae Karpinsky, 1889

Genus *Propinacoceras* Gemmellaro, 1887

Propinacoceras aff. *knighti* Miller and Furnish

Pl. 1, figs. 7, 8, 10

Compared with:

Propinacoceras knighti Miller and Furnish, 1940, P. 42, Pl. 5, figs. 1–4; pl. 6, fig. 7.

Remarks: – The lateral zone of the conch is flat and almost parallel. The specimens at hand are characterized by the two rows of transversely elongate, and slightly rounded ribs. The ventral zone has two rows of transverse tubercles intervened by distinct median groove.

The specimen B (figs. 8, 9) is a natural external mold. It is crushed and deformed, but characterized by two rounded lobes and very narrow median groove on the ventral zone. It attains a maximum length of about 30 mm, and a width of about 15 mm. The interspaces between the ribs are narrower than the ribs themselves. Sixteen ribs occupy a space of about 30 mm.

The specimen C (Fig. 10) is a crushed and deformed natural internal mold. Like B specimen it is characterized by two rounded narrow and sharp median grooves on the ventral zone. The specimen attains a maximum length of about 22 mm, and width of about 15 mm. The ribs are distinct, parallel, flat, and wider than those of specimen B. Eight of the ribs occupy a space of about 2 mm. The distinction between *Propinacoceras* and *Medlicottia* is somewhat obscure. Specifically, the rib pattern of the ventral zone of *Propinacoceras* resembles that of *Medlicottia costellifera* Miller and Furnish. However, this species can be distinguished from similar congeneric forms by the comparatively wider U-shaped median groove on the ventral zone. According to Miller and Furnish, this species is known from the following Permian strata; The Socio beds of Sicily, Kubergandy River beds of Pamirs, Bitauni Beds of Timor, and the Leonard and Bone Spring Formation of West Texas.

Locality and Horizon: – Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86625. (B), IGPS coll. cat. no. 86626.

Genus *Medlicottia* Waagen, 1880

Medlicottia cf. *costellifera* Miller and Furnish

Pl. 1, fig. 15

Compared with:
Medlicottia costellifera Miller and Furnish, 1940, pl. 7, figs. 2–4; pl. 8, fig. 4; pl. 9, fig. 3.

Description: – In general, the conch is sublenticular, with a narrow and deep groove along the venter. It is characterized by two rows of transversely elongate, and rounded ribs. The ventral zone has two rows of transverse tubercles intervened by distinct median groove. There are two rows of moderately prominent ventral node, whose lateral extension continues as ribs across the ventral protion of the flanks of the conch where there are two shallow longitudinals. The lateral portion of the conch is flat. The ribs are slightly sigmoidal and elongated to the ventro-lateral portion. Near the adoral end of the ventral portion, the maximum length of this specimen measures about 40 mm, and the ventral side is about 6 mm wide. The flat lateral portion is about 8 mm wide. The interspaces are narrower than the ribs, of which 15 occupy a space of about 40 mm.

Remarks: – The distinctive feature of this species are the prominence of both the lateral ribs on the conch and the narrow median groove on the ventral zone, the wide and sigmoidal transverse ventral ribs on either side of the median groove. According to Hayaska (1965), "In the Kitakami Permian fauna a species of somewhat doubtful *Medlicottia* has been recognized. Although it is also only a fragmentary specimen, it shows part of suture-lines naturally weathered out which suggest that the specimen belongs, or closely allied at least to *Medlicottia*. However, it and the Takakura-yama specimen are so distinctly different from each other in the mode of fossilziation that there are no means of correlating them. The lateral sides of the conch appear to be flat in general, but they approch to each other gradually toward venter so as to form slightly convex ventral zone which is not distinctive from the lateral zone, unlike the flattish ventral zone of *Propinacoceras* or *Artinskia*."
Locality and Horizon: — Loc. no. T_7, Kashiwadaira Formation, IGPS coll. cat. no. 86627.

Family Paraceltitidae Spath, 1930
Genus *Paraceltites* Gemmellaro, 1887
Paraceltites aff. *elegans* Girty
Pl. 3, fig. 1

d with:
Paraceltites aff. *elegans* Girty, Hayasaka, 1940, p. 423–424, figs. 2–3.

Description: — The specimen is an external mold, collected from the Kashiwadaira Formation of the Takakura-yama Group, and is well preserved. The conch is discoidal, transverse ribs terminate before reaching the ventral portion of the conch, and are flatly compressed. There are slightly wavy ribs on the last portion of the volution.

The specimen gives the following measurements (in mm): –

Longer diameter of evolute whorl	22.0
Width of last volution	6.0
Thickness of conch	/
Diameter of protoconch	0.5–0.7

Remarks: – The present specimen resembles *Paraceltites elegnas* Girty, and according to Hayasaka (1965), "The occurrence of of this species in Japan was recorded in 1940. There were several specimens, mostly external and internal molds preserved in a small boulder of a dark gray sandy shale found in one of the fossil localities in the southern Kitakami mountains. Now, in the fossil from Takakura-yama, there are two specimens that are likely to be identified with the Kitakami species just referred to: they are in a similary incomplete state of fossilization".

According to Miller and Furnish (1940, p. 65), typical species of *Paraceltites* have prominent surface ornamentation which consists of growth lines and sinous ribs. The specimens of A type are rather abundant in the Kashiwadaira Formation in the G-$_2$valley. The specimens are generally small in size and are compressed. According to Hayasaka (1965), "Girty's remarks in his description of *P. elegnas*, appear worthy of note in this place. After having identified his fossil with the genus *Paraceltites* and discussed the affinities between his *P. elegans* and the Sicilian species, he conclued that the former is not specifically identical with the latter. One difference which can be named is the more nearly transverse direction of the plication in *P. elegnas*, while in the Sicilian species they slope forward." The specimen A' is more strongly flattened laterally than that of *P. ornatus*.
Locality and Horizon: – Loc. no. T_7. Kashiwadaira Formation, IGPS coll. cat. no. 86630A.

Paraceltites elegans Girty
Pl. 3, fig. 11

Paraceltites multicostatus Böse, Smith, 1932, p. 41, pl. 44, fig. 10.
Paraceltities elegans Girty, Miller and Furnish, 1940, p. 67, pl. 22, figs. 1–10.

Description: - The conch of this species is rather small and laterally compressed, flatly discoidal, evolute and with about 4 volutions. The lateral ribs are slightly convex and characterized by wavy sigmoidal striae. There are about 12 plciated ribs, 0.5 cm in length on the last volution.

The single specimen at hand measures (im mm): –

Longer diameter of evolute whorl	13.5
Width of last volution	4.0
Number of whorls	4
Lateral ribs of last volution	about 11–12

Remarks: – This specimen resembles *P. ornatus* Miller and Furnish, but the lateral ribs on the last volution are more strongly flattened laterally than *P. ornatus* Miller and Furnish.
Locality and Horizon: – Loc. no. T_8, Kashiwadaira Formation, IGPS coll. cat. no. 86631.

Crustacea
Family Phillipsiidae Oehlert, 1886 (Emend Hupe, 1953)
Genus *Paladin* Weller, 1936
Paladin yangisawai Endo and Matsumoto
Pl. 3, figs. 2, 3

Paladin yanagisawai Endo and Matsumoto, 1962, p. 158, pl. 2, figs. 1a–6.

Remarks: – The specimens now at hand comprise six pygidia, one cephalon with the eyes preserved, and a fragment of a probable pygidium. The pygidia are well preserved and show eight to about nine segments, though generally about eight is the most common number. The furrows are narrow and impressed. The pleural lobes number about six to seven segments separated from one another by shallow and rounded furrows. The cephalon is deformed by subsequent compression but the eyes are well preserved and show many distinct corneas. There is a deep and rather distinct groove at the base of the eyes.

So far as the present specimens are concerned, the all agree well with the description and illustrations published by Endo and Matsumoto in the above cited work.
Locality and Horizon: – Loc. no. Kashiwadaira Formation. IGPS coll. cat. no. 86672., (A.B).

Class Cricoconarida
Family Tentaculitidae Walcott, 1886
Genus *Tentaculites* Schlotheim, 1820
Tentaculites sp. indet.
Pl. 3, fig. 7

Compared with:
Tentaculites bellulus Hall, Fisher 1962, Treatise on Invertebrate Paleontology, Pt. W, Miscellaneus, p. W 110, fig. 1.

Remarks:– Shell small in size, conoidal in form, straight, external mold. The specimens at hand measure about 13 mm in length, 3 mm in width at anterior end and 1.7 mm in width at posterior side. Surface characterized by fine transverse rings, intervals between transverse rings becoming slightly wider toward aperture. About 12 transverse rings occupy a space of 5 mm. at anterior end.
Locality and Horizon: – Loc. no. Kashiwadaira Formation, IGPS coll. cat. no. 8669.

Trace Fossils
Genus *Notakulites* Kobayashi, 1945
Notakulites toyomensis Kobayashi, 1945
Pl. 4, fig. 10

Notakulites toyomensis Kobayashi, 1945, p. 15, pl. 2.

Remarks: – A single specimen about 10 cm in length, curved at both extremities and about 5mm broad is in the collection. The trail is similar to the one of *Notakulites toyomensis* described by Kobyashi (Op. cit). from the Middle Permian clay-slate exposed at the neck of the promontory of Iwaizaki about 10 km south of Kesennuma City in the northeastern part of Miyagi Prefecture. "The series of shallow concave depressions of crescentic outline inside of which faint streaks are sometimes disposed more or less radially" as described in the holotype by Kobayashi are very faint and almost obscure in the present specimen. However, from the preserved features, the specimen is considered to be referable to the trail named above.
Locality and Horizon: – Loc. no. Kashiwadaira Formation, IGPS coll. cat. no. 86671.

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PLATES 1~6

Plate 1

(All from the Kashiwadaira Formation of the Takakura-yama Group. Permian)

Figs. 1, 2. *Tylonautilus permicus* Hayasaka
1-gypsum replica, ×1. 2-gypsum replica, ×1, IGPS coll. cat. no. 86636.

Figs. 3, 17. *Chonetes blanfordi lata* Hayasaka
3-ventral valve, ×2. IGPS coll. cat. no. 86644A. 17-ventral valve, ×4. IGPS coll. cat. no. 86644C.

Fig. 4. *Productus cora* (d'Orbigny)
Ventral valve, ×1. IGPS coll. cat. no. 86640.

Fig. 5. *Productus gruenwaldti* Krotow
Ventral valve, ×3. IGPS coll. cat. no. 86643.

Fig. 6. *Zaphrentis* ? sp. indet.
All enlarged (×3) specimen B.

Figs. 7, 8, 10. *Propinacoceras* aff. *knighti* Miller and Furnish. 7-an internal mold, ×2. IGPS coll. cat. no. 86626C. 8-natural replica, ×2, 10-a gum model, ×2, IGPS coll. cat. no. 86625B.

Fig. 9. *Foordiceras gregarium* (Miller)
9-lateral view, ×1. IGPS coll. cat. no. 86621A.

Fig. 11. *Chonetes uralicus* Moeller
Ventral valve, ×3. IGPS coll. cat. no. 86645.

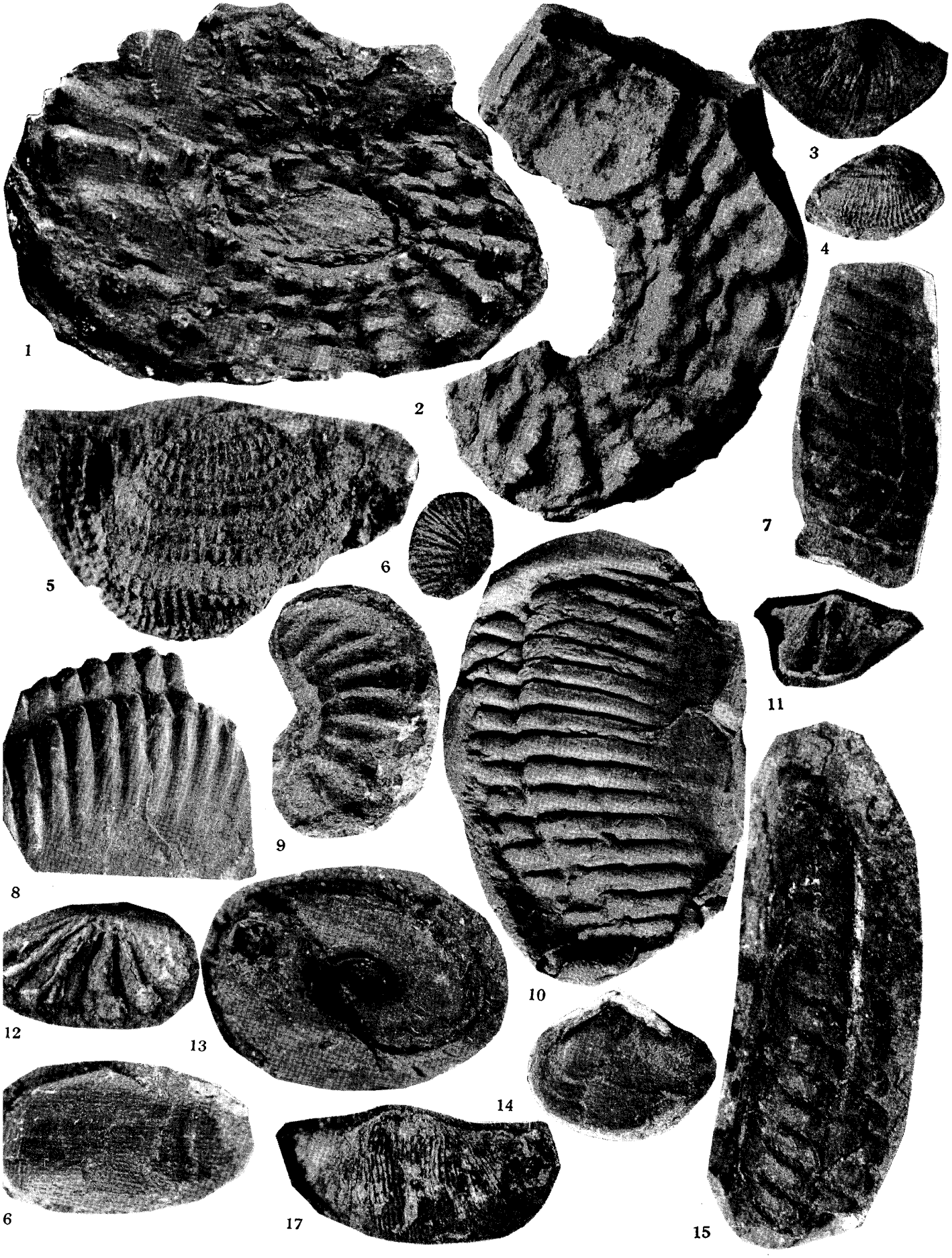
Fig. 12. *Spiriferina cristata* Schellwien
12-ventral valve, ×2. IGPS coll. cat. no. 86639B.

Fig. 13. *Cibolites* cf. *uddeni* Plummer and Scott
Lateral view, ×3.5. IGPS coll. at. no. 86634.

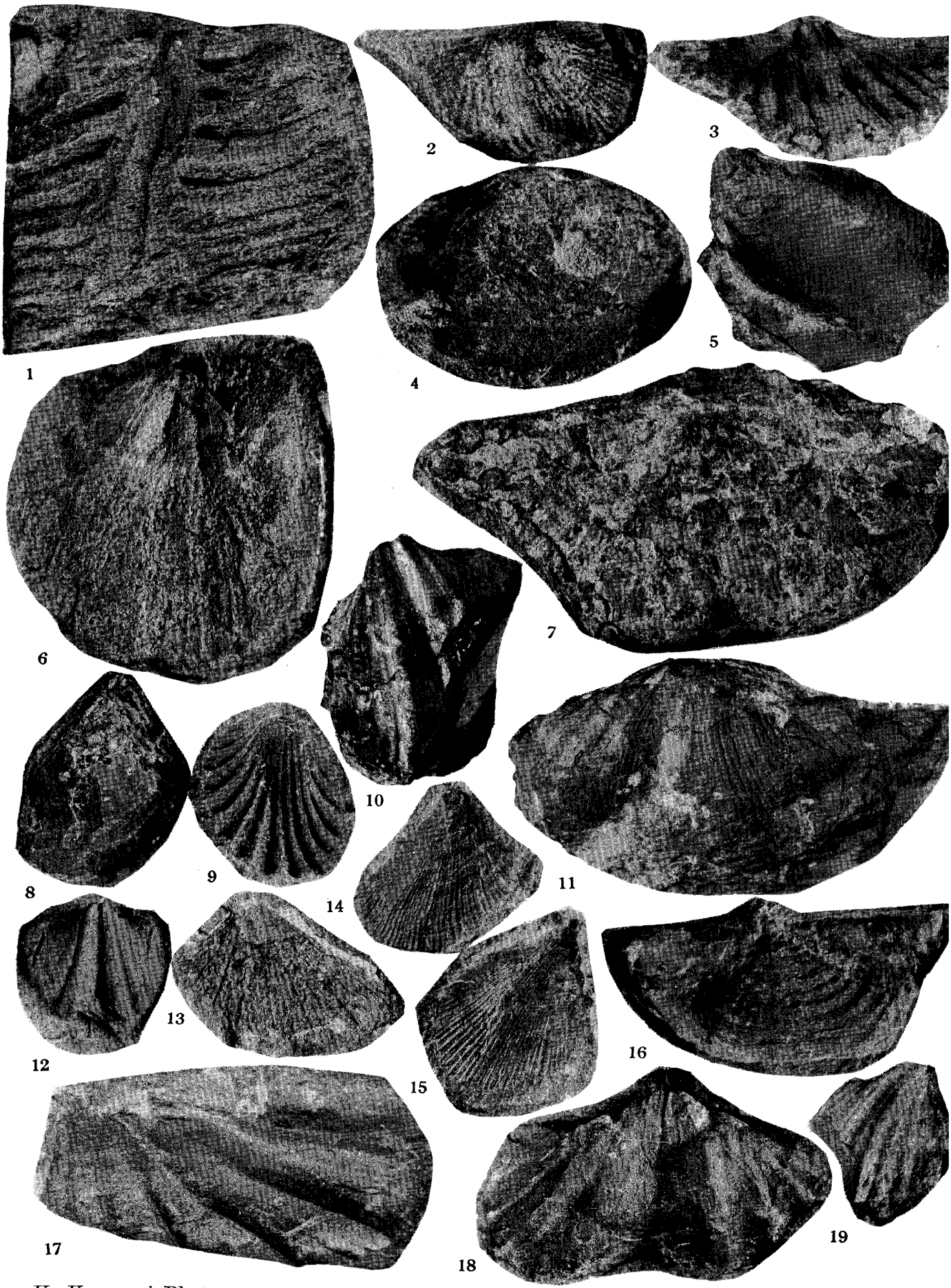
Fig. 14. *Nucula* aff. *subnuda* d'Orbigny
Left valve, ×2. IGPS coll. cat. no. 86663.

Fig. 15. *Medlicottia* cf. *costellifera* Miller and Furnish. Ventral view, ×2. IGPS coll. cat. no. 86627.

Fig. 16. *Agathiceras* cf. *suessi* Gemmellaro Ventral view, ×3. IGPS coll. at. no. 86633B.



K. Kumagai Photo



K. Kumagai Photo

Plate 2

(All from the Kashiwadaira Formation of the Takakura-yama Group. Permian.)

Fig. 1 *Lyttonia richthofeni* Kayser em. Hayasaka
An external mold of a brachial valve, ×3. IGPS coll. cat. no. 86648.

Fig. 2. *Marginifera typica septentrionalis* Tschernyschew. Ventral valve, ×2. IGPS coll. cat. no. 86656.

Fig. 3. *Alispirifer* aff. *laminosus transversa* Maxwell. Ventral valve, showing the surface sculpture, ×1. IGPS coll. cat. no. 86652.

Fig. 4. *Nucula* sp. indet
4-Right valve, ×3, IGPS coll. at no. 86664A.

Fig. 5. *Liebea* aff. *mapingensis* Grabau
Left valve, ×2. IGPS coll. cat. no. 86665.

Fig. 6. *Productus* cf. *sinensis* Tschernyschew
Brachial valve, ×2. IGPS coll. cat. no. 86651.

Fig. 7. *Linoproducts* ? cf. *mammatus* (Keyserling). Brachial valve, ×2. IGPS coll. cat. no. 86649.
Horizon-Iriishikura Formation of the Takakura-yama Group. Permian.

Fig. 8. *Streblochondoria* aff. *stantonensis* Newell
Right valve, ×2. IGPS coll. cat. no. 86660.

Fig. 9. *Lima* cf. *retifera* Shumard
9-An external mold, ×3. IGPS coll. cat. no. 86661.

Fig. 10. *Spiriferella sarane* Verneuil
10-Ventral valve, ×1. IGPS coll. cat. no. 86654A.

Fig. 11. *Neospirifer* aff. *cameratus* Morton
Ventral valve, ×1. IGPS coll. cat. no. 86653.

Fig. 12. *Spiriferella sarane* Verneuil
Plastotype of ventral valve, ×1. IGPS coll. cat. no. 86654B.

Fig. 13. *Aviculopecten* cf. *hataii* Murata
Left valve, ×1. IGPS coll. cat. no. 86657.

Figs. 14, 15. *Limipecten* cf. *burnettensis* Maxwell
14-An exterior of slightly convex valve, ×3.
IGPS coll. cat. no. 86658B.
15-An exterior of slightly convex valve, ×3.
IGPS coll. cat. no. 86658C.

Fig. 16. *Anidanthus abukumaense* Yanagisawa, n. sp.
L6-Ventral valve, ×2. IGPS coll. cat. no. 86641.

Fig. 17. *Acanthopecten* cf. *carboniferous* Stevens
17-Right valve, ×3. Showing the surface sculpture. IGPS coll. cat. no. 86659.

Fig. 18. *Neospirifer* cf. *fasciger* (Keyserling)
18-Enlarged (×3) view of ventral valve, IGPS coll. cat. no. 86637A.

Fig. 19. *Spiriferella* cf. *sarane* Verneuil
19-Ventral valve, ×1. IGPS coll. cat. no. 86638A.

Plate 3

(All from Kashiwadaira Formation of the Takakura-yama Group. Permian)

Fig. 1. *Paraceltites* aff. *elegans* Girty
Lateral view, ×3. IGPS coll. cat. no. 8663A).

Figs. 2, 3. *Paladin yanagisawai* Endo and Matumoto
2-An external mold of the holotype; dorsal view of the complete specimen, ×3. IGPS coll. cat. no. 86672 A. 3-An internal mold of the holotype; dorsal view of complete specimen, ×3. IGPS coll. cat. no. 86672B.

Fig. 4. *Agathiceras* cf. *suessi* Gemmellaro
4-An external mold, ×3. IGPS coll. cat. no. 86633A.

Figs. 5, 8. *Derbyia* cf. *crassa* Meek and Hayden
Brachial valve (1, 2.) ×1. IGPS coll. cat. no. 86650.

Fig. 6. *Spiriferina cristata* Schellwien
Ventral valve, ×2, IGPS coll. cat. no. 86639A.

Fig. 7. *Tentaculites* sp. indet.
×2, IGPS coll. cat. no. 86669.

Fig. 9. *Conocardium kansuensis* Chao
Left valve, X2. IGPS coll. cat. no. 86667.

Fig. 10, 15. *Astartella* cf. *permocarbonica* Tschernyschew
10-An external mold, ×3. IGPS coll. cat. no. 86668.
15-An external mold, ×2. The same specimen as fig. 10.

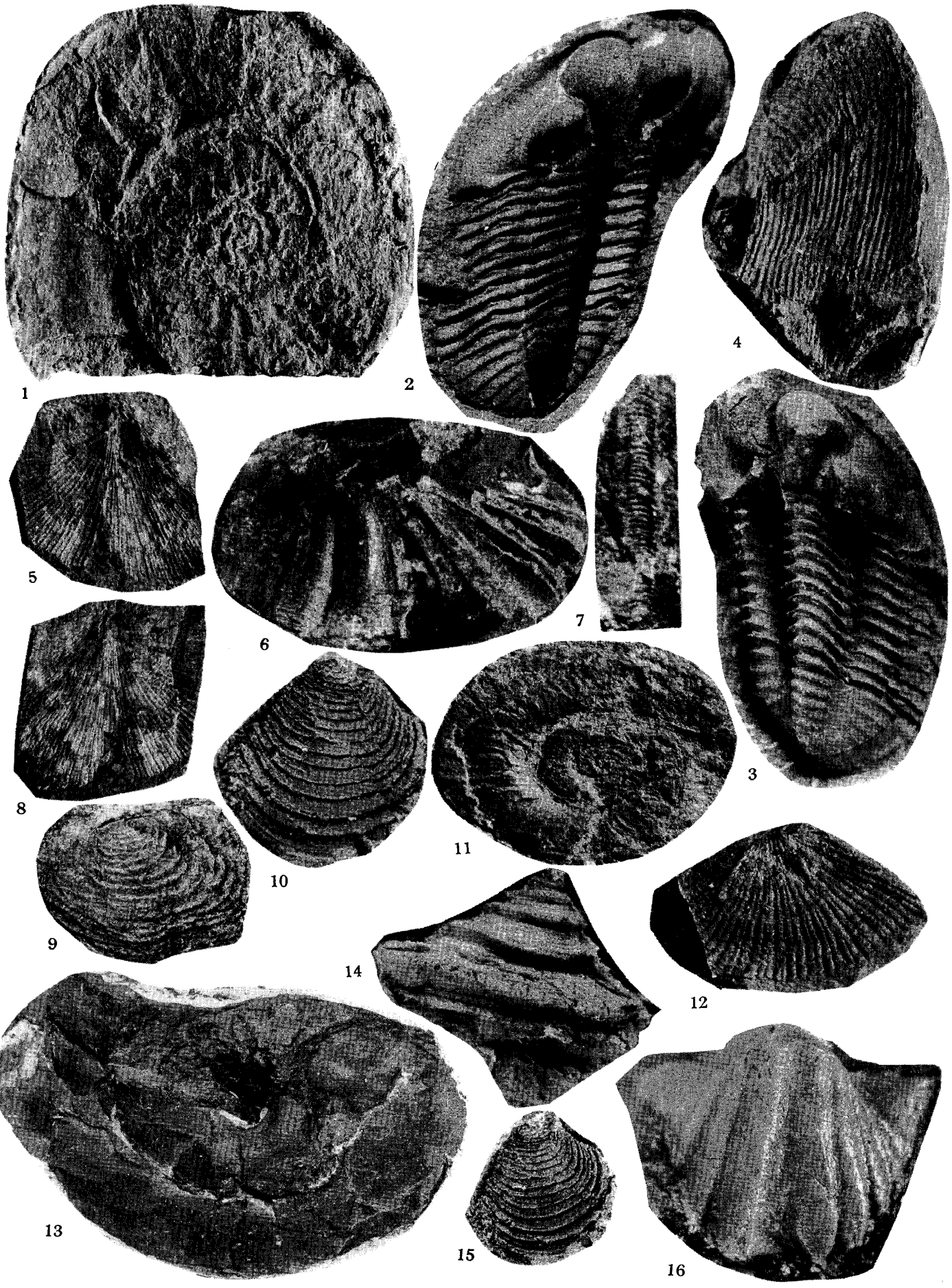
Fig. 11. *Paraceltites elegans* Girty
Lateral view, ×3. IGPS coll. cat. no. 86631.

Fig. 12. *Schuchertella* ? sp. indet.
An external mold, ×3. IGPS coll. cat. no. 86647.

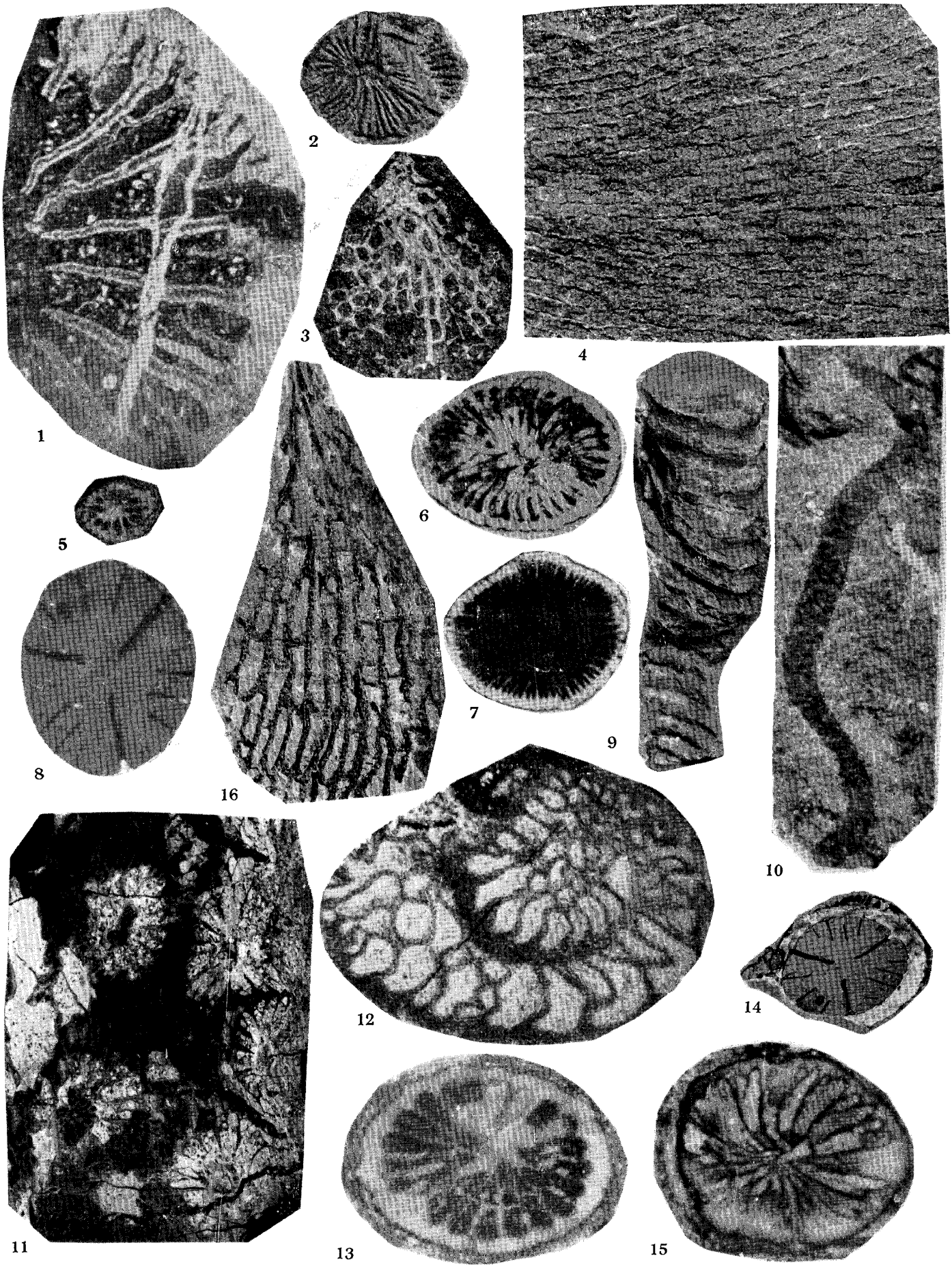
Fig. 13. *Waagenoceras* cf. *dieneri* Bose.
Lateral view, ×2. IGPS coll. cat. no. 86629.

Fig. 14. "*Pleurotomaria*" sp. A gum model, ×2.

Fig. 16. *Cancellosprifier* ? *maxwelli* Campbell
A gum model of ventral valve, ×3. IGPS coll. cat. no. 86642.



K. Kumagai Photo



K. Kumagai Photo

Plate 4

(All from Motomura Formation of the Takakura-yama Group. Permian.)

Fig. 1. *Lophophyllum*/? sp. indet.
An enlarged (×15) specimen C.

Fig. 2. *Zaphrentis* ? sp. indet.
2-An enlarged (×3) specimen A. Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.

Fig. 3. *Polypora* aff. *gigantea* Waagen.
Showing the main brached and cross bars, an enlarged (×5) surface. Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.

Fig. 4. *Fenestella* cf. *perelegans* Meek
An enlarged (×3.5) surface.

Fig. 5. *Lophophyllum* ? sp. indet.
An enlarged (×2) specimen B, Polished surface. Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian

Fig. 6, 7. *Tachylasma magnum* Grabau
6-Transverse section, ×1.6.
7-Transverse section, ×1. Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.

Figs. 8, 14. *Gerthia* sp.
8-An enlarged (×1.7) view of fig. 14 in plate 4, polished surface.
14-An enlarged specimen, X3, polished surface Horizon-Irrishikura Formation of the Takakura-yama Group. Permian.

Fig. 9. *Michelinoceras* ? sp. indet.
Showing the lateral part of a conch, ×2. IGPS coll. cat. no. 86628. Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.

Fig. 10. *Notakulites toyomensis* Kobayashi ×1. IGPS coll. cat. no. 86671.
Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.

Fig. 11. *Wentzelella* sp. indet.
An enlarged (×5) specimen B.

Fig. 12. *Pseudofusulina* ? sp. indet.
Specimen A, ×34.

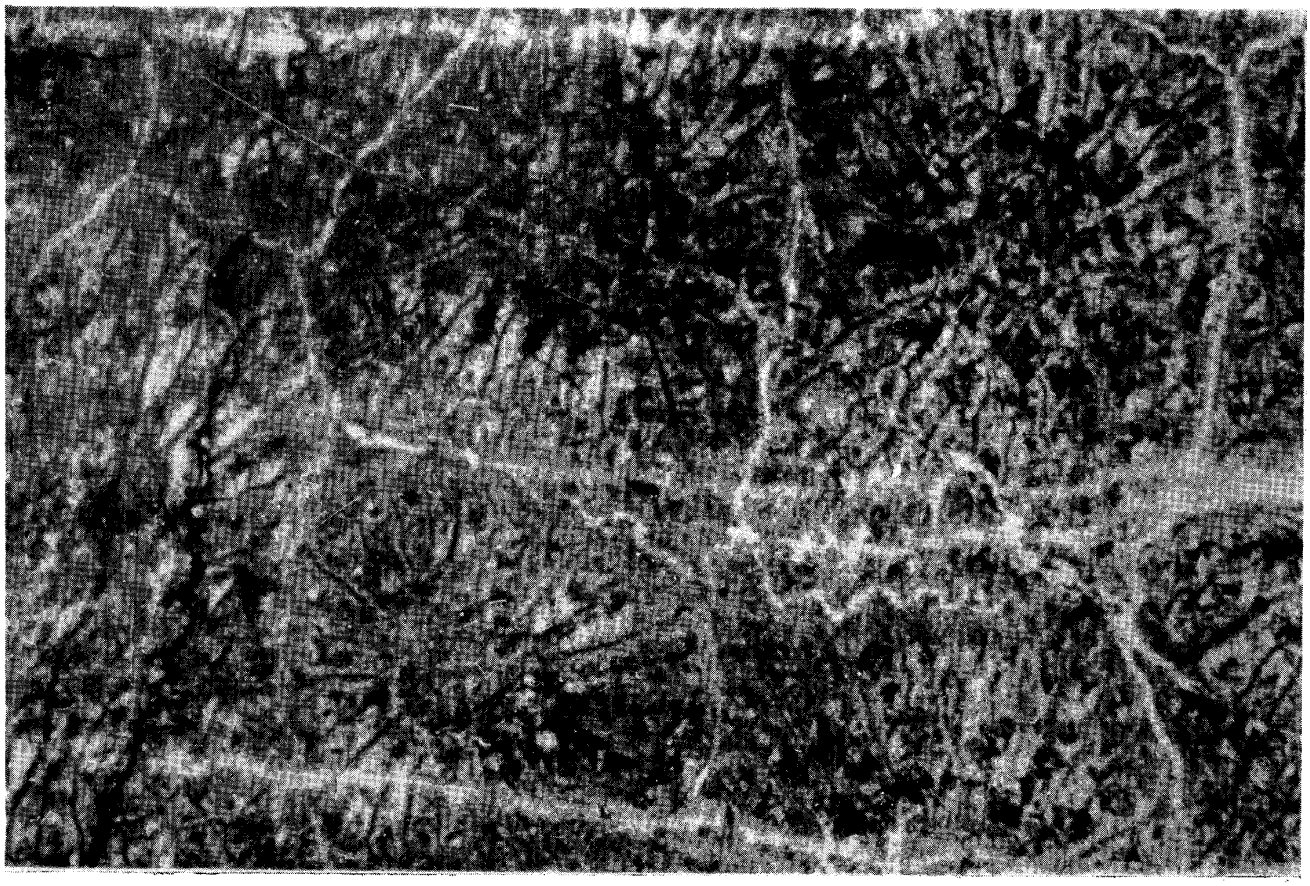
Fig. 13. *Lophophyllum* ? sp. indet.
An enlarged (×2) view of fig. 19 in plate 6.

Fig. 15. *Lophophyllum* ? sp. aff. *Lophophyllum pendulum* Grabau.
Polished surface, ×8.

Fig. 16. *Fenestella* cf. *assumpta* Reed
An enlarged (×3) surface, showing the main branches and cross bars.
Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.

Plate 5

Figs. 1,2. *Wentzelella minor* Eguchi (MS)
1-Transverse section, 2-Longitudinal section, ×12. Horizon-Motomura Formation of the Takakura-yama Group. Permian.



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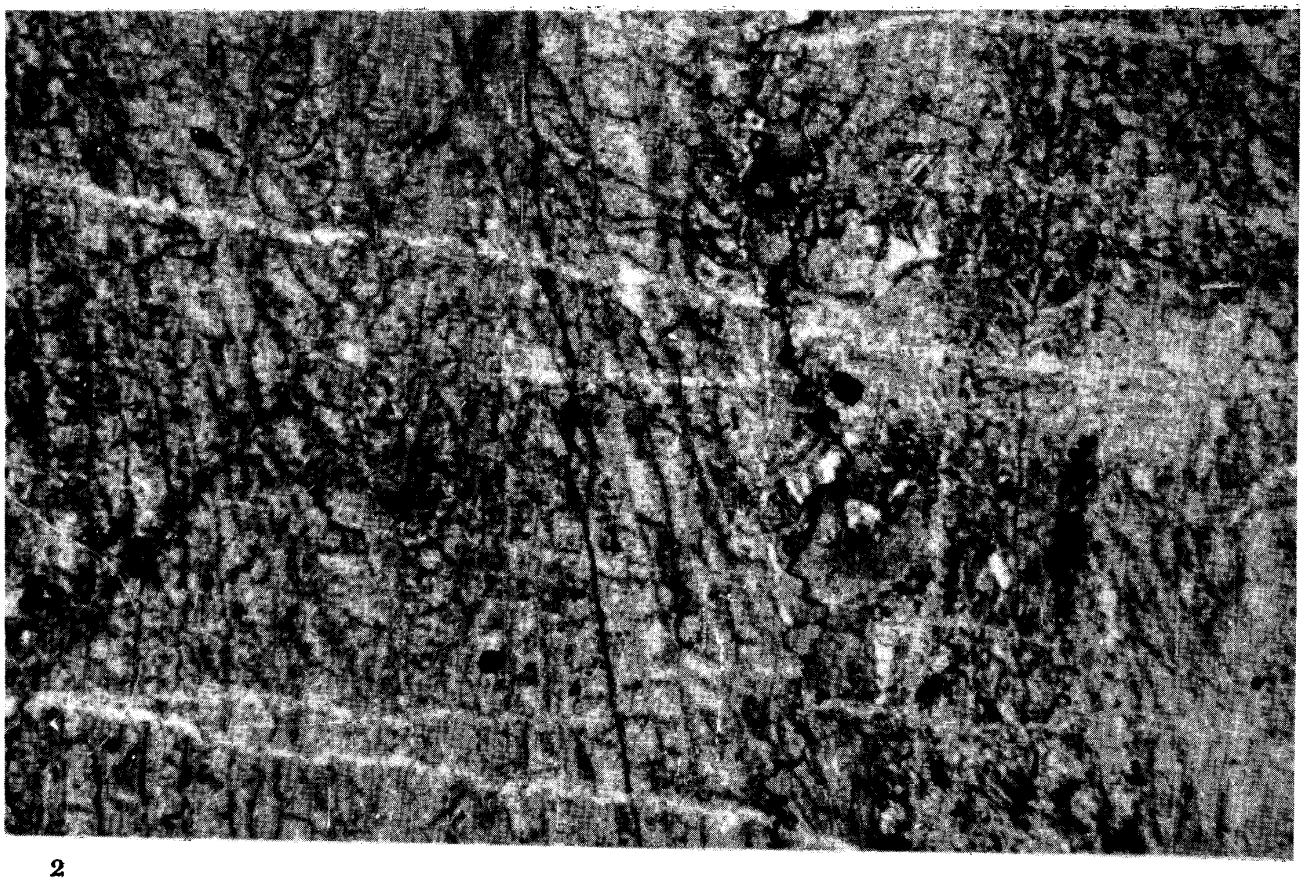

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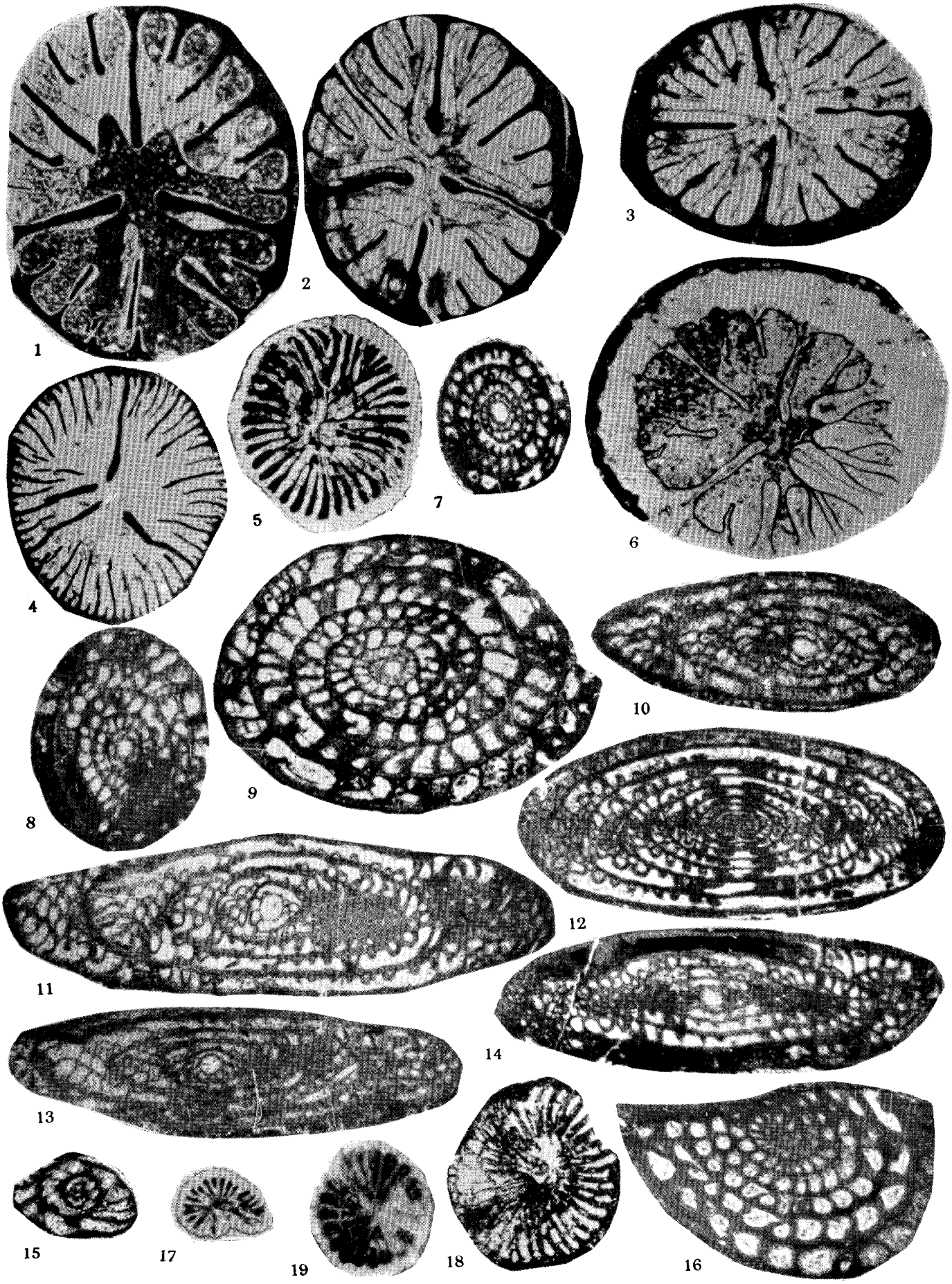

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Plate 6

Figs. 1, 2, 3, 6. *Gerthia kobiyamai* Eguchi (MS)
1-Transverse section, ×94.
2-Transverse section, ×8.5.
3-Transverse section, ×10.
6-Transverse section, ×0.9, Horizon-Iriishikura Formation of the Takakura-yama Group. Permian.

Figs. 4, 5, 17, 18. *Tachylasma magnum* Grabau.
4-Transverse section, ×1.6.
5-Transverse section, ×1.6.
17-Transverse section, ×1.6.
18-Transverse section, ×1.6. Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.

Figs. 7, 14. *Pseudofusulina* cf. *ambigua* (Depart)
7-Sagittal section, ×10.
14-Axial section, ×10.

Figs. 8, 10, 11. *Pseudofusulina* cf. *fusiformis* (Schellwien)
8-Sagittal section, ×10.
10–11 — Slightly diagonal axial section, ×10.

Fig. 9. *Pseudofusulina* cf. *vulgaris* (Schellwien)
Slightly deformed sagittal section, ×10.

Fig. 12. *Nagatoella* aff. *kobayashii* Thompson
Tangential section, ×10.

Fig. 13. *Pseudofusulina* sp.

Fig. 15. *Schubertella* sp. Axial section, ×50.

Fig. 16. *Parafusulina* ? sp. indet.
Specimen A, ×27.

Fig. 19. *Lophophyllum* ? sp. indet.
An enlarged (×3) specimen A, polished surface. Horizon-Kashiwadaira Formation of the Takakura-yama Group. Permian.