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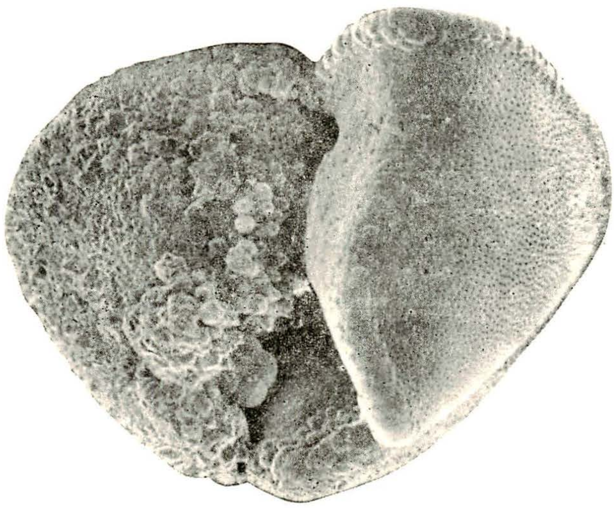

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Fossils on the cover is *Globorotalia truncatulinoides* (D'ORBIGNY, 1839). The photograph was taken on a scanning electron microscope, JEOL-JSM-2, ×100.

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552. FOSSIL SPORES AND POLLEN GRAINS FROM THE NEOGENE DEPOSITS IN NOTO PENINSULA, CENTRAL JAPAN—II

A PALYNOLOGICAL STUDY OF THE MIDDLE MIOCENE YAMATODA MEMBER*

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能登半島新第三系産化石胞子・花粉—II；中新世中期山戸田層の花粉学的研究：能登半島に広く分布する新第三系に含まれている化石胞子・花粉について研究を行った。今回はその第 II 報として，能登半島中央部に，局部的ではあるが，その堆積環境の点で，他に例をみない中新世中期の山戸田層について，14層準からの 18 試料について，各層準毎に化石群集の構成・変化を明らかにし，併せて，山戸田層堆積時の古気候・古地理的環境，および山戸田層の時代について，くわしい考察を行った。 藤 則雄

Introduction

The present writer has been studying the fossil pollen grains and spores found from the diatomaceous deposits of Neogene age in the Hokuriku Region of Central Japan since 1960.

The present article is the second report on the palynological researches of the diatomaceous deposits and treats the pollen grains and spores collected from the Middle Miocene Yamatoda Member distributed in and around Nakajima Town, Kashima-gun of the central part of Noto Peninsula.

The scope of the investigation based on the microfossils is the systematic determination of the microfossils, and the decision of the palaeoclimatic condition and palaeoecological environment under which the Yamatoda Member was deposited in the Middle Miocene. Further, correlation and comparison of the conditions and environment of the Yamatoda Member with the Wakura, Tsukada and I'ida diatomaceous Members distributed in the northern and central parts of Noto Peninsula were also under taken.

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macroplants found from the Yamatoda Member.

Appreciation is expressed to Professor Yoshio KASENO of the Institute of Earth Sciences, Faculty of Science, Kanazawa University, for his suggestions and informations on the stratigraphical evidences and tectonic movements in the studied area during the Middle Miocene age. The writer takes this opportunity to express his deepest gratitude to Dr. Wataru ICHIKAWA and Mr. Kazuo KOJIMA of the Laboratory of Earth Sciences, Ishikawa Scientific Institute of Education, for their valuable suggestions on the diatom researches. Thanks are also due to Mr. Yukio KITAMURA, who cooperated with the writer as the student of the Institute of Earth Sciences, Faculty of Science, Kanazawa University.

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Outline of the Geology

Many diatomaceous mudstones of Neogene age are widely in the central and northern parts of Noto Peninsula. They are mainly composed of homogeneous silty mudstone characterized with the dominance of fossil microorganisms. In the southern part of the peninsula the diatomaceous deposits are distributed locally and their rock-facies are variable.

These diatomaceous deposits are classified into four horizons, ranging from the Middle to Late Miocene in age. These four horizons differ from one another in their sedimentary environmental condition, namely, one is nonmarine in origin, whereas the other three are marine. The diatomaceous deposit which is a non-marine in origin, is only the Middle Miocene Yamatoda Member. The Yamatoda Member is distributed locally in the western part of Nakajima Town of the central part of Noto Peninsula.

In and around Nakajima Town the Neogene deposits which overlie the Early Miocene Anamizu Formation with unconformity are classified into five members in ascending order as follows: the Araya conglomerate, Kusaki alternation, Yamatoda diatomaceous mudstone, Hamada mudstone and Kasashio muddy siltstone Members. These strata are locally in and around Nakajima and Sammyo in the central part of the peniusula. Each stratigraphic unit is described below, in ascending order.

The Anamizu Formation: This formation is distributed locally along the western coast of the Nanao Bay near Nakajima, although it occurs widely in the area west of Kasashio and Nakajima. This formation is generally classified into two parts, namely, one is of pyroxene andesite or hornblend pyroxene andesite, and the other consists of andesitic pyroclastic rocks intercalated with dacitic tuffaceous layers. This formation may be the Early Miocene in geological age.

-----unconformity-----

Araya conglomerate Member: This member is observed typically at Araya area of Togi Town, and is distributed locally in the areas northernwest of Sammyo and north of Araya. This member consists of cobble and gravel of andesite which are derived from the Anamizu Andesite Formation. The member interfingers with the Kusaki alternation and Yamatoda diatomaceous mudstone Members. The thickness of this member is about 20 meters.

———interfingering with the Kusaki and Yamatoda Members———

The Kusaki sandstone and mudstone alternation Member: The member occurs locally at Sammyo and Kusaki areas west of Sammyo. The member has been studied by K.

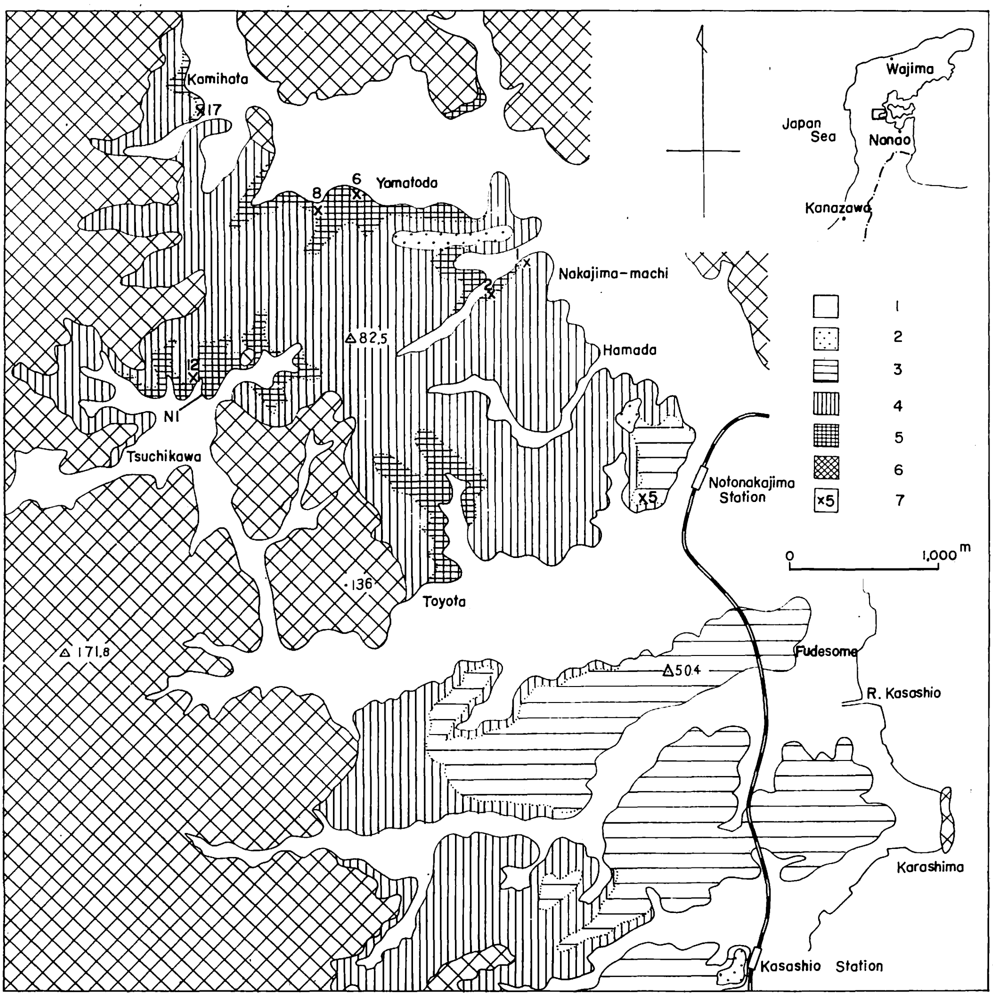


Fig. 1. Geological map of the Nakajima area, central part of Noto Peninsula, Japan. 1: Holocene deposits, 2: Pleistocene deposits, 3: Kasashio Member, 4: Hamada Member, 5: Yamatoda Member, 6: Anamizu Formation, 7: sampling localities (After KASENO, Y., HANAYAMA, R., KOJIMA, K., KITAMURA, Y. and FUJI, N.).

SUZUKI and U. KITAZAKI (1949) from the viewpoint of stratigraphy. The type locality is an outcrop at Kusaki of Togi Town. The member consists of generally a sandstone and mudstone alternation. The sandstone is a fine-grained sandstone which is derived from a pyroxene andesite of the Anamizu Andesite Formation intercalated with thin granule and lignite layers. On the other hand the mudstone is dark blue shaly mudstone with plant fragments. The Kusaki alternation Member is 20 to 25 meters in thickness and contains thin layers of lignite, some of which have been worked out in Sammyo area. It has yielded rarely molluscan fossils such as *Cristaria* aff. *plicata* apparently indicating a fresh-water environment in origin.

———interfingering with the Araya and Yamatoda Members———

The Yamatoda diatomaceous mudstone Member: This member was studied by K. SUZUKI and U. KITAZAKI (1949), W. ICHIKAWA (1950) ; R. HANAYAMA (1955, MS) ; K. KOJIMA, W. ICHIKAWA and Y. KASENO (1953) ; Y. KASENO (1963) and H. MATSUO (1963). The member named by ICHIKAWA is correlated with a diatomaceous mudstone bed of the Tanoshiri mudstone Member surveied by SUZUKI and KITAZAKI. The member is distributed locally at Kita-menden, Yamatoda, Tsuchikawa and Kammachi where are settlements distributed in the foot of hills of Nakajima Town. It overlies the Anamizu Andesite Formation with unconformity. The rock-facies is generally homogeneous fragile light bluish gray (on a fresh surface) or light yellowish gray (on a weathered surface) diatomaceous clayey mudstone intercalated with thin tuffaceous sandstone (ca. 10 centimeters in thickness). The member yields amount of non-marine diatom remains as *Melosira granulata*, diatoms as *Actinocyclus biternarius*, *A. quaternarius* and *A. septenarius* of marine origin, and well preserved macroplant fossils known as "Notonakajima Flora" (MATSUO, H., 1963) which contains several warm climatic elements as *Liquidambar miosinica*, *Machilus nathorsti*, *Metasequoia occidentalis*, *Glyptostrobus europaeus*, *Cunninghamia protokonishii*, *Keteleeria* cf. *ezoana* and *Podocarpus* sp. The member is about 15 meters in thickness.

-----unconformity-----

The Hamada mudstone Member: The member has been studied first by K. SUZUKI and U. KITAZAKI (1949), and is distributed widely at Kamibatake, Yachi, Yamatoda, Kammachi, Tsuchikawa and Hamada areas west of the Noto-nakajima Station. The rock-facies is generally homogeneous dark bluish gray (on a fresh surface) or yellowish brown (on a weathered surface) mudstone intercalated with three continuous tuff layers. It preserves molluscs as *Chlamys* sp., *Crenella* sp., *Crassalellites* sp., *Lucina acutilineata* and *Nassarius* sp., echinusnis (*Schizaster* sp.) ; sponge spicule (*Aphrocallistes* sp.) and silicoflagellates. The member is about 30 meters thick.

———conformity———

The Kasashio muddy siltstone Member: This member has been studied by K. MOCHIZUKI (1931), and is distributed in Shiozu, Kanagasaki, Kasashio, Kurotsume and Shirahama of Nakajima Town. The rock-facies of this member is generally light yellowish bluish gray muddy siltstone or silty mudstone. The member contains amount of diatom remains of marine origin as *Actinoptychus senarius*, *Coscinodiscus marginatus*, *C. radiatus* and *Stephanopyxis appendiculata* and sponge spicules. It is correlated with the Late Miocene Wakura Member.

-----unconformity-----

The Pleistocene deposits: The deposits are distributed locally in the hill between Kammachi and Yamatoda, and in the area situated about 500 meters of northernwest of Noto-nakajima Station. They are classified into two beds, namely, the lower part (1-1.5 meters in thickness) of the deposits is gravel, and the upper part (3.5-4 meters in thickness) of the deposits is mud and sand. The deposits are leaning to east side with low angle, and cover the Yamatoda and Hamada Members with unconformity.

The deposits which are named the Kammachi terrace deposits in Kammachi, Nakajima Town may be correlated with the Late Pleistocene (? the Riss/Würm interglacial stage) Okuhara Member which is distributed widely in Nanao City, the central part of Noto Peninsula.

Palynological Research

(1) Foreword

As already stated different kinds of diatomaceous deposits occur in the Noto Peninsula, and there have yielded abundant microfossils as diatom, flagellates, pollen grains and spores. Although several papers have been published on the deposits, these were concentrated to stratigraphical investigations, and no literature has appeared concerning the fossil pollen grains and spores until comparatively recently. The writer has been studying the Neogene system, especially diatomaceous deposits, and previous works (FUJI, 1964, 1966 & 1968) have been summarized on the Middle Miocene Hojuji, I'ida, I'izuka and Hijirikawa Members, and also the first detailed report (a palynological study of the Late Miocene Wakura Member) of fossil spores and pollen grains from the Neogene deposits in Noto Peninsula has been stated recently. The present paper is the second report.

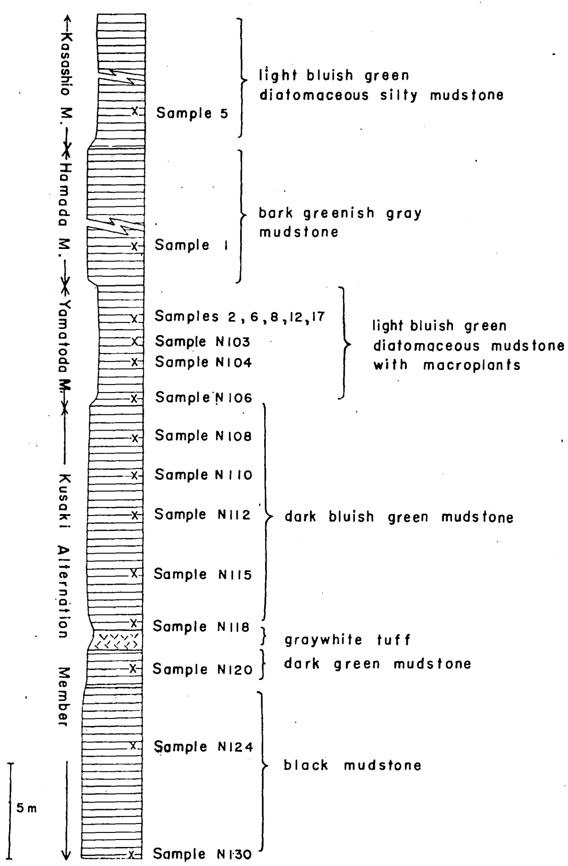


Fig. 2. Columnar section of the Yamatoda Member showing the sampling horizons.

The purpose of the present study is to interpret the significance of the pollen grains and spores from the samples collected from the Middle Miocene Yamatoda Member, mainly in terms of palaeoclimatic condition and palaeogeographical environment. These records, which are thought to reflect, in a relative manner in general, the fluctuation of atmospheric temperature in the central part of Noto Peninsula during the Middle Miocene, is based on the criteria gained by the writer during his about ten years palynological researches.

(2) Sampling

Among the samples analysed seven (Sample Nos. 1, 2, 5, 6, 8, 12 and 17) were collected by K. KOJIMA and R. HANAYAMA in the summer season of 1954 from outcrops judged to be a same horizon for the analysis of the palaeoenvironmental condition under which the Yamatoda Member was deposited. The other samples (N 1-3.00 meters, N 1-4.00 m., N 1-6.00 m., N 1-8.00 m., N 1-10.00 m., N 1-12.00 m., N 1-15.00 m.,N 1-18.00 m., N 1-20.00 m., N 1-24.00 m., N 1-30.00 m., 11 samples in total) were obtained from a well drilled for the research of the diatom earth distributed widely in Noto Peninsula. The sampling localities and stratigraphical horizons in the Yamatoda, Hamada and Kasashio Members are shown in Figs. 1 and 2.

(3) Preparation of Materials

Of the samples collected from outcrops, one sample consisted of three to five pieces of rock were collected at random along the length of one meter, measured parallel to the stratification of the member. The rock pieces were mixed together to from a composite sample which is taken here to represent the outcrop. The present study is based on the composite samples. Many rock samples and separate specimens for reference at the writer's disposal, materially facilitated the present work in checking the distribution and confirming the identification of the pollen grains and spores.

The analytical procedure of the samples is the same as was stated previously by the writer (FUJI, 1965 and 1969). The composite samples were treated by the NaOH-HF-acetolysis method.

(4) Method of Study

To record the position of a specimen in the slide for taxonomical and biostratigraphical studies, Maltwood's finder or England finder were used to register the necessary specimens in this investigation. The specimen registered in this study can be easily brought under the microscopic field whenever necessary by placing the slide which includes the specimen registered with the finder. The counting is made along the chosen lines with use of a mechanical stage and finder. All of the specimens which appeared while traversing the slide along the chosen line are observed and counted. The counting is continued until 200 specimens, and identified. When the specimens counted from one slide are less than 200, the counting is proceeded on another slide prepared from the same sample to count a total number of 200. Therefore, more than 10 slides must be prepared from each sample to count 200 specimens.

The frequency of each genus obtained by the count of 200 specimens from every sample is recorded on the distributed diagram. All of the strewn slides are examined under the same magnification 600 times in counting and 600 or 1,200 times in identification.

The slides containing the registered specimens are deposited in the collection of the Institute of Earth Science, Faculty of Education, Kanazawa University (register abbreviation: EKZJ), Kanazawa City, Japan.

(5) Description of the Pollen Grain and Spore Assemblages

(a) General Statement

The present flora is composed of the species which are adapted to the physical condition and to biological phenomena which constitute the environment. But the fossil assemblage of any locality may be the total accumulation composed of a biocoenosis and/or a thanatocoenosis. Therefore, to interpret the geological and palaeoecological significances of the fossil assemblage it is necessary to make an analysis of the fossil composition from the viewpoint of the presence or absence, abundance and distribution of every climatic element to know the palaeoclimatic condition and palaeogeographical environment at the time of deposition.

(b) Stratigraphical Relations of the Samples

The localities of the samples studied are distributed in the present field and the depths from the surface in the wells drilled may be correlated to the exposures on the surface. They can be illustrated as a columnar section and for the sake of convenience are called horizons in this study. Here, the term horizon is used to denote the same or nearly same stratigraphic position or level within the stratigraphic unit.

The samples analysed in the present study can be classified into 14 horizons shown as the columnar section (Fig. 2).

(c) Description of the Assemblages

The assemblage of the fossil pollen grains and spores found from the analysed 18 samples is shown in Figs. 3-8, and is explained as follows in ascending order.

Sample N 1-30.00 m: This sample which belongs to the Kusaki alternation Member is the lowermost horizon in samples collected for the present work. It was taken from the well drilled at Locality No. N 1 situated at Tsuchikawa about 3,500 meters west of Noto-nakajima Station, Nakajima Town, Kashima-gun, Ishikawa Prefecture. A depth of the sample is about 30 meters below the present ground surface.

It yielded, Gymnosperm - six genera and one family; Dicotyledon - two genera and two subgenera; and Pteridophyta - one genus. Among them, *Liquidambar* and *Picea* are very abundant, more than 20 per cent in frequency, being the highest concentration in this sample. *Metasequoia*, *Cunninghamia*, *Glyptostrobus*, *Taiwania*, the evergreen *Quercus* and *Liquidambar* are the representative plants of a warm temperate and subtropical regions and are denoted by "B" in Fig. 5. Fossil pollen grain of *Picea* may be corresponded with *Picea kaneharai*, of which the modern equivalent macroplant is presumed to be *Picea polita*. The modern *Picea polita* is distributed in the warm temperate region as Kyushu, Shikoku and Southwest Honshû.

The plants denoted by B are a very high frequency of 60 per cent in total.

The plants which are distributed in the cold climatic region are denoted by "A" in Fig. 5, and are *Larix*, *Abies*, *Fagus* and *Betula*. According to the result, "A" is appeared with a very low frequency of 6 per cent. On the contrary, the cool temperate climatic plants denoted by "C" are 34 per cent of the total. The phenomena seen in the sample will be explained in later pages in the discussion on the palaeoclimatic condition and palaeogeographical environment. To facilitate considerations on the ecological environments under which some ancient plants lived, the modern equivalents of the fossil species are grouped into four habitats, namely, mixed-slope, stream-side or riparian, and lake or marshy elements. From the viewpoint of the above-mentioned significant statistics the fossil pollen grains and spores from the sample can be classified into uplands, mixed-slope and stream-side elements, occupying respectively 17 per cent, 51 per cent and 32 per cent.

Sample N 1-24.00 m: The sample belongs to the Kusaki alternation Member. It was taken from the well drilled at Locality No. N 1 and its depth is about 24.00 meters below the present surface.

This sample yielded four genera of Gymnosperm (60 per cent in total frequency), five genera and two subgenera of Dicotyledon (32 per cent in total frequency), one genus of Pteridophyta (2 per cent in total frequency) and the other genera. Among them, *Picea* and *Pinus* are very abundant, 34 per cent and 20 per cent respectively in frequency, being the highest concentration in this sample.

The plants (B) distributed in the warm climatic region, plants (A) in the boreal region and the other plants (C) are respectively 4 per cent, 57 per cent and 39 per cent.

The upland, mixed-slope and stream-side elements are severally 22 per cent, 64 per cent and 14 per cent.

This horizon is characterized with the low frequency of *Liquidambar* and a small number of genus and/or family.

Sample N 1-20.00 m: The sample belongs to the middle part of the Kusaki

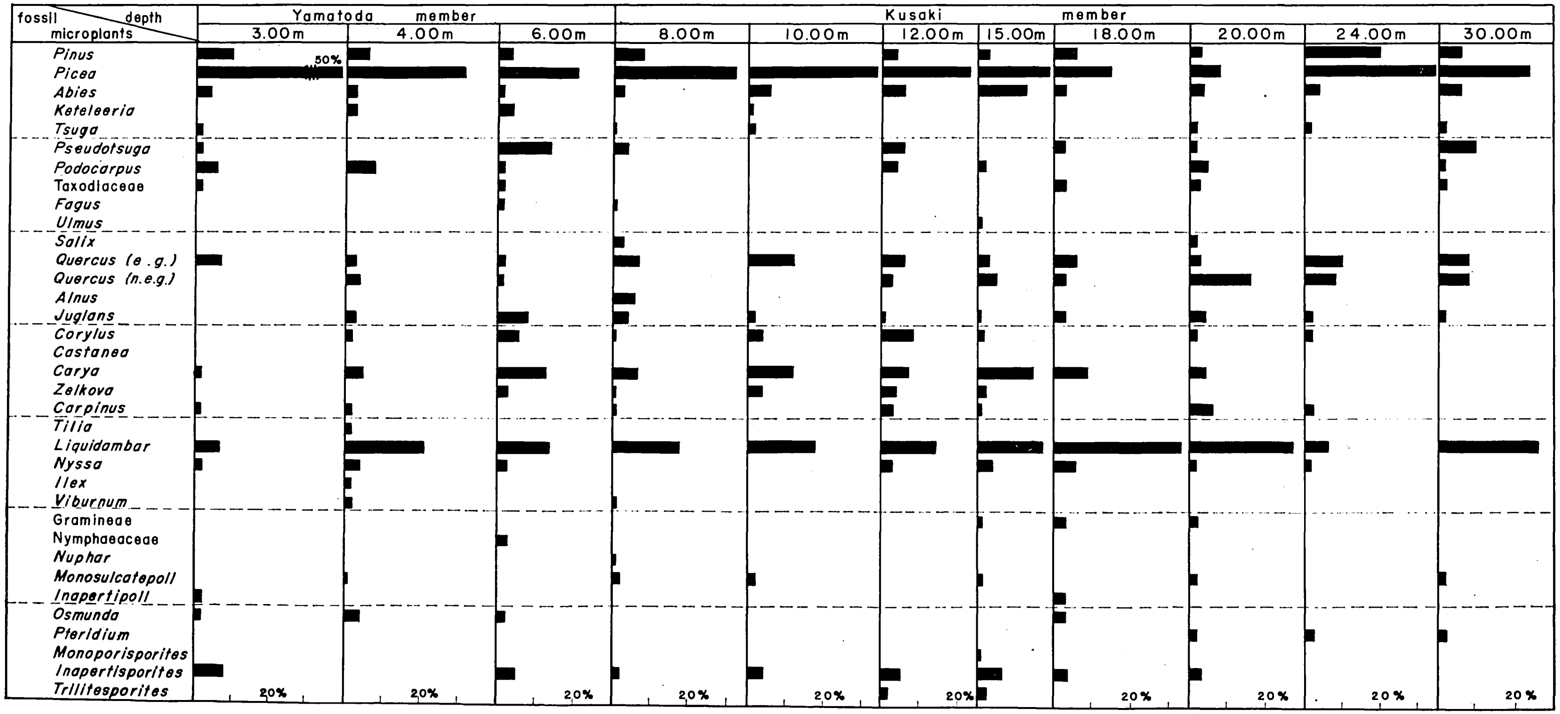


Fig. 3. Pollen diagram (1) of the Kusaki and Yamatoda Members. Numbers refer to Figs. 1 and 2.

alternation Member. It was taken from the well drilled at Locality No. N 1 and its depth is about 20.00 meters below the present surface.

Among the pollen grains and spores from the sample, Gymnosperm - six genera and one family - (25 per cent), Monocotyledon - two genera (4 per cent), Dicotyledon - eight genera and two subgenera (67 per cent) and spores (4 per cent). Among them, *Liquidambar* is very abundant (27 per cent); *Picea* and the deciduous *Quercus* are abundant, respectively 8 per cent and 16 per cent. The boreal, warm and temperate climatic elements are respectively 4, 50 and 46 per cent. A frequency of the warm and/or subtropical climatic elements of this sample is the lowest numerical value in the samples collected for this study.

On the other hand, in respect to the palaeoecological environment, the upland, mixed-slope and stream-side elements are respectively 6 per cent, 41 per cent and 53 per cent. A frequency of the stream-side and/or riparian elements of this sample is the highest numerical value in the samples collected, except for Sample N 1-18.00

The pollen-flora of this sample is represented by *Liquidambar* and *Picea*, which are found 33 per cent and 15 per cent respectively.

The sample yielded, Gymnosperm - four genera and one family (30 per cent in total); Dicotyledon - four genera and two subgenera (60 per cent); Monocotyledon - one genus (3 per cent); Pteridophyta - one genus (3 per cent) and the other spores - two genera (4 per cent). Among them, as mentioned above, *Liquidambar* is very abundant in frequency and *Picea* abundant.

The cold, warm and temperate climatic elements contain 3 per cent, 70 per cent and 27 per cent respectively. A frequency of the warm temperate climatic elements as the evergreen *Quercus* and the subtropical climatic elements as *Liquidambar* found from this sample is the highest numerical value in the samples, except for Sample N 1-3.00 m, collected for this study.

The upland, mixed-slope and stream-side elements are respectively 10 per cent, 31 per cent and 59 per cent.

Sample N 1-15.00 m: The sample is about 15.00 meters below the present surface, and belongs to the middle part of the Kusaki alternation Member. The sample yielded, Gymnosperm - four genera (37 per cent); Dicotyledon - eight genera and two subgenera (51 per cent); Monocotyledon - one genus (1 per cent); spores - three genera (1 per cent); and the other pollen grain - one genus (1 per cent).

Among them, *Picea*, *Liquidambar*, *Carya* and *Abies* are abundant, attaining 19 per cent, 17 per cent, 15 per cent and 13 per cent respectively.

In respect to the palaeoclimatic condition, the warm, boreal and temperate climatic plants are respectively 51 per cent, 15 per cent and 34 per cent. On the other hand, in this connection of the palaeoecological environment, the upland, mixed-slope and riparian plants are 4, 54 and 42 per cent respectively.

In this horizon, a very abundant pollen grain or spore does not contain, and also, it is noteworthy that the warm and/or subtropical climatic plants are the lowest numerical value, except for Sample N 1-20.00 m, in the samples collected for this study.

Sample N 1-12.00 m: This sample which belongs to the upper part of the Kusaki alternation Member yielded, Gymnosperm - five genera (43 per cent in total frequency); Dicotyledon - seven genera and two subgenera (60 per cent) and the spores except for Pteridophyta -

two genera (7 per cent). Among them, *Picea* is very abundant, and *Liquidambar* abundant in relative frequency. They are respectively 23 per cent and 14 per cent. *Abies*, *Pseudotsuga*, the evergreen *Quercus*, *Corylus* and *Carya* are common, ranging 6 per cent to 9 per cent in frequency.

The cold and/or cool, temperate, and warm and/or subtropical climatic elements are 6 per cent, 60 per cent and 34 per cent respectively. And also, on the view point of the palaeoecological environment, the upland, mixed-slope and stream-side elements are 12 per cent, 57 per cent and 31 per cent respectively.

Sample N 1-10.00 m: The sample belongs to the upper part of the Kusaki alternation Member, and its depth is 10.00 meters below the present ground surface. It yielded Gymnosperm - four genera (33 per cent in total frequency), Dicotyledon, five genera and one subgenus, (51 per cent), the indeterminable pollen grain (2 per cent) and the indeterminable spore (4 per cent). Among them, *Picea* is very abundant and *Liquidambar*, the evergreen *Quercus* and *Carya* are abundant, occupying respectively 34 per cent, 17 per cent, 12 per cent and 12 per cent of the total. *Abies* is common in relative frequency, being 6 per cent.

The warm, boreal and temperate climatic elements are respectively 0 per cent, 66 per cent and 34 per cent.

On the view point of the palaeoecological environment, it is noteworthy that the mixed-slope plants are the highest concentration in the samples collected for the present study, except for Sample N 1-3.00 m.

Sample N 1-8.00 m: This sample belongs to the uppermost horizon of the Kusaki alternation Member, and its depth is about 8.00 meters below the present surface. The rock-facies of this sample is a dark bluish green (on a fresh surface) mudstone intercalated with thin dark bluish gray sandy siltstone.

The sample yielded, Gymnosperm - five genera (48 per cent); Dicotyledon - ten genera and one subgenus (47 per cent); the indeterminable pollen grains - two pollen types (3 per cent); and the indeterminable spore - one spore type (2 per cent). Among them, *Picea* is 32 per cent of the total and *Liquidambar* is 18 per cent. The other pollen grains and spores are common (ranging from 6 per cent to 9 per cent) or rare (1 per cent to 5 per cent), namely, *Pinus* (8 per cent), the evergreen *Quercus* (7 per cent), *Carya* (7 per cent) and *Alnus* (6 per cent) belong to common, and the other grains as *Abies*, *Salix*, *Juglans*, *Inapertipollenites* and *Trilitesporites* rare.

The boreal (A), temperate (C) and warm (B) plants are respectively 4 per cent, 33 per cent and 63 per cent. And also, the upland, mixed-slope and stream-side elements are severally 12 per cent, 46 per cent and 42 per cent.

Sample N 1-6.00 m: The sample belongs to the lowermost horizon of the Yamatoda diatomaceous mudstone Member. Its depth is about 6.00 meters below the present surface. This sample yielded, Gymnosperm - six genera and one family (43 per cent of the total); Dicotyledon - eight genera, two subgenera and one family (50 per cent); Pteridophyta - one genus (2 per cent); and the other spore except for Pteridophyta - one spore type (5 per cent). Among them, *Picea* is very abundant (21 per cent of the total), and *Liquidambar*, *Pseudotsuga* and *Carya* are abundant (respectively 14, 14 and 13 per cent).

The warm and/or subtropical, boreal and temperate climatic elements are severally 58 per cent, 40 per cent and 2 per cent. And also, in respect to the palaeoecological environment, the upland, mixed-slope and riparian-elements are 19 per cent, 39 per cent and 42 per cent.

Sample N 1-4.00 m: The sample belongs perhaps to the middle part of the Yamatoda Member, and its depth is about 4.00 meters below the present ground surface.

Thiss ample yielded, Gymnosperm - five genera (50 per cent of the total); Dicotyledon - nine genera and two subgenera (45 per cent); the indeterminable pollen grain - nine genera and two subgenera (45 per cent); the indeterminable pollen grain - one type (1 per cent) and Pteridophyta - one genus (4 per cent). Among them, *Picea* and *Liquidambar* are respectively 31 per cent and 20 per cent, and the other pollen grains and spores are common.

The warm and/or subtropical, temperate and boreal elements are severally 70 per cent, 26 per cent and 4 per cent. And also, the upland, mixedslope and stream and/or riparian elements are 7 per cent, 59 per cent and 34 per cent respectively.

Sample N 1-3.00 m: The sample belongs to the middle part of the Yamatoda Member. Its depth is about 3.00 meters below the present surface. It yielded, Gymnosperm - six genera and one family (73 per cent Dicotyledon - four genera and one subgenus (16 per cent); the indeterminable pollen grain - one pollen type (2 per cent); and the other spore - one spore type (9 per cent). Among them, *Picea* is very abundant in relative frequency, being 50 per cent of the total. *Pinus*, the evergreen *Quercus* and *Liquidambar* are respectively 10 per cent, 7 per cent and 6 per cent.

The boreal, warm and/or subtropical and temperate elements are severally 4 per cent, 77 per cent and 19 per cent. And also, the upland, mixed-slope and stream-side plants are 13 per cent, 74 per cent and 13 per cent respectively. It is noteworthy that the frequency of *Picea* and the warm and/or subtropical climatic plants found in this sample are the highest numerical value in all of the samples collected for this study.

Sample 2: The mixed sample is from an outcrop of Locality No. 2, situated at about 1,000 meters northwest of Hamada, Nakajima Town. It belongs to the upper part of the Yamatoda Member, and also may be correlated with Samples 6, 8, 12 and 17 explained in later pages on that point of stratigraphical horizon.

This sample yielded, Gymnosperm - six genera and one family (73 per cent of the total); Dicotyledon - five genera and two subgenera (25.5 per cent); and Pteridophyta - one genus (1.5 per cent). Among them, *Picea* and *Liquidambar* are very abundant (respectively 43 per cent and 20 per cent in relative frequency). *Pseudotsuga* and *Pinus* are abundant.

The boreal, warm and temperate climatic elements are respectively 5 per cent, 78 per cent and 17 per cent, and also in respect to the palaeoecological environment, the upland, mixed-slope and stream-side plants are 10 per cent, 72 per cent and 18 per cent.

Sample 6: This mixed sample is from an outcrop of Locality No. 6 situated at Yamatoda, Nakajima Town. It yielded, Gymnosperm - seven genera and one family (74 per cent of the total); Dicotyledon - three genera and one subgenus (23 per cent); and Monocotyledon - one family (3 per cent). Among them, *Picea* is very abundant (44 per cent). *Pinus* and *Liquidambar* are abundant (both 12 per cent), and also the evergreen *Quercus* and Taxodiaceae are common (respectively 8 per cent and 6 per cent). The fossil spores are not found from this composite sample.

The warm and/or subtropical (B), boreal (A) and temperate (C) climatic plants are respectively 86 per cent, 4 per cent and 10 per cent. It is noteworthy that the warm and/or subtropical climatic plants are the highest numerical value in the samples collected for this study, and the sample contains many genera belonging to Gymnosperm, though Dicotyledon is only a few genera.

The upland, mixed-slope and riparian plants are respectively 15 per cent, 64 per cent and 21 per cent.

Sample 8: This sample was collected from Locality No. 8 situated at about 350 meters west of Locality No. 6, Yamatoda.

The sample yielded, Gymnosperm - four genera and one family (62 per cent of the total); Dicotyledon - four genera and one subgenus (23 per cent); the indeterminable pollen grain - one pollen type (1 per cent); Pteridophyta - one genus (2 per cent); and the indeterminable spore - one spore type (12 per cent).

Among them, *Picea* is very abundant (39 per cent), and also, *Pinus* and *Inapertisporites* are respectively 15 per cent and 13 per cent in frequency.

The boreal (A), warm (B) and temperate (C) climatic plants are contained in the sample, attaining respectively 8 per cent, 69 per cent and 23 per cent.

The upland, mixed-slope and streamside plants are severally 17 per cent, 62 per cent and 21 per cent.

Sample 12: The mixed sample is from an outcrop of Locality No. 12 situated at Tsuchikawa, Nakajima Town.

It yielded, Gymnosperm - six genera (67 per cent of the total); Monocotyledon - two families (5 per cent); Dicotyledon - seven genera and two subfamilies (23.5 per cent); Pteridophyta - one genus (3 per cent); the indeterminable pollen grain - one pollen type (0.5 per cent): and the indeterminable spores - two spore types (1 per cent).

The boreal, warm and temperate climatic plants are 5 per cent, 60 per cent and 35 per cent respectively, and also the upland, mixed-slope and streamside elements are respectively 16 per cent, 64 per cent and 20 per cent.

Sample 17: The mixed sample is collected from Locality No. 17 situated at Kamihata, Nakajima Town.

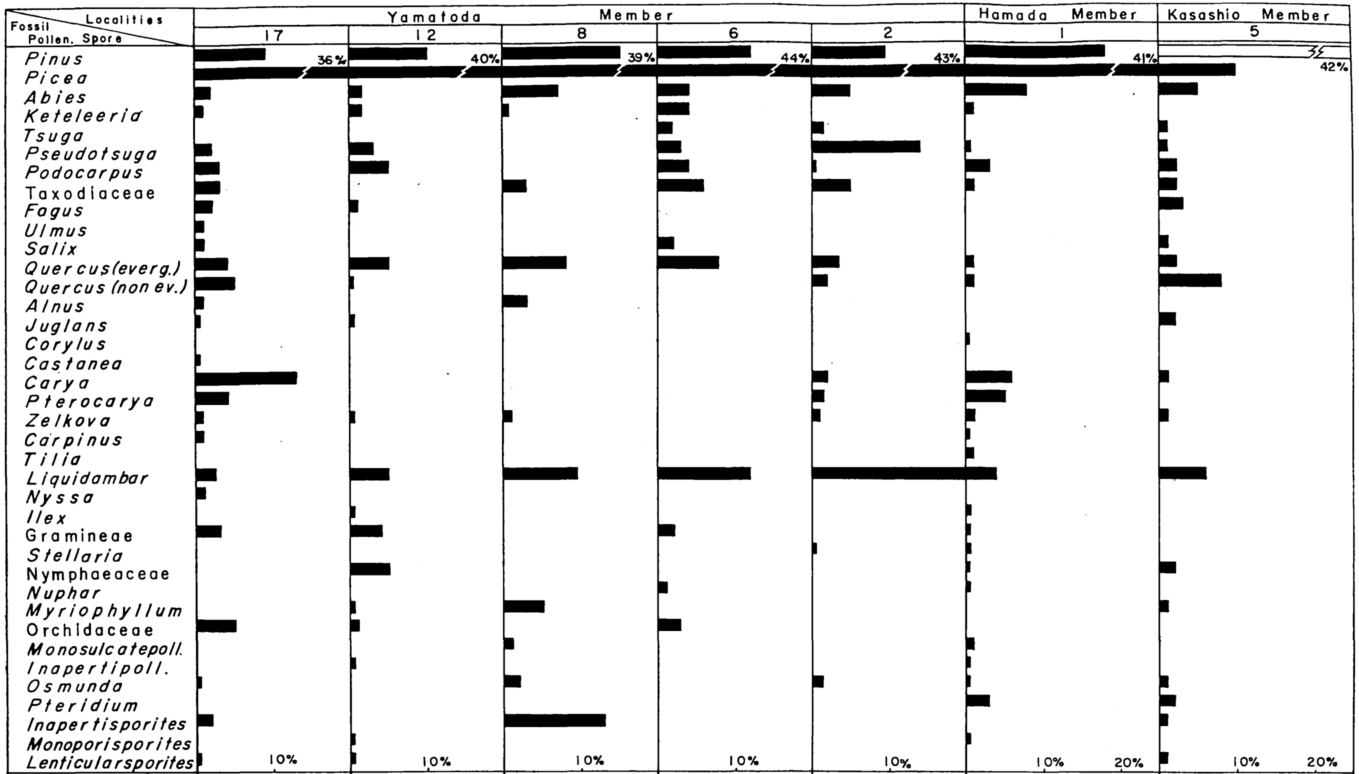
It yielded, Gymnosperm - six genera and one family (53 per cent of the total); Monocotyledon - two genera (8 per cent); Dicotyledon - 12 genera and two subgenera (26 per cent); Pteridophyta - one genus (0.5 per cent); and the indeterminable spores - two spore types (2.5 per cent).

Among them, *Picea* is very abundant (36 per cent), and *Carya* abundant (13 per cent). The other pollen grains and spores belong to common (ranging from 5 per cent to 9 per cent) or rare (ranging 1 per cent to 4 per cent).

The boreal, warm and temperate climatic plants are respectively 4, 58 and 38 per cent, and also the upland, mixed-slope and streamside elements are 10 per cent, 59 per cent and 31 per cent. It is noteworthy that *Liquidambar* is only 4 per cent of the total.

Sample 1: The mixed sample is from an outcrop of Locality No. 1 situated about 1,000 meters northwest of Hamada and about 300 meters northeast of Locality No. 2. It belongs to the lowermost part of the Hamada dark greenish gray mudstone Member. The sample is collected in comparison with the palaeoclimatic condition and palaeoecological environment of the Yamatoda and Kasashio Members.

The composite sample yielded, Gymnosperm - six genera and one family (72 per cent in frequency); Dicotyledon - ten genera, two subgenera and one family (23 per cent); Monocotyledon-one family



		17	12	8	6	2	1	5
Climate	A	4 %	5	8	4	5	8	9
	B	58 %	60	69	86	78	56	30
	C	38 %	35	23	10	17	36	61
Habitat	U	10 %	16	17	15	10	15	46
	M	59 %	64	62	65	72	66	35
	S	31 %	20	21	20	18	19	19
AP		89 %	88	84	94	98	92	92
NAP		11 %	12	16	6	2	8	8
Diatom	F	2 sp.	5	8	10	5	2	2
	B	0 sp.	0	2	2	1	1	2
	M	0 sp.	0	6	5	4	8	13

Fig. 4. Pollen diagram (2) of the Yamatoda and Kusaki Members. Numbers refer to Figs. 1 and 2; climate, A: boreal climatic elements, B: warm-temperate and subtropical climatic elements, C: cool-temperate climatic elements; habitat, U: upland, M: mixed-slope, S: streamside or riparian elements. AP: arboreal pollen grains, NAP: non-arboreal pollen grains; diatom, F: fresh water, B: brackish water, M: marine water elements (After ICHIKAWA, W., KASENO, Y. and KOJIMA, K., 1955).

(0.5 per cent); the indeterminable pollen grains - two genera (1.5 per cent); Pteridophyta - two genera (3.5 per cent); and the indeterminable spore - one spore type (0.5 per cent). Among them, *Picea* is very abundant (41 per cent) and *Pinus* abundant (13 per cent).

The boreal, warm and temperate climatic plants are 8 per cent, 56 per cent and 36 per cent, and also, the upland, mixed-slope and stream-side elements are respectively 15 per cent, 66 per cent and 19 per cent.

Sample 5: This sample is from an outcrop of Locality No. 5 situated about 200 meters west of Noto-nakajima Station. It belongs to the lowermost horizon of the Kasashio light bluish green diatomaceous silty mudstone Member. This sample is collected for the comparison with the palaeoclimatic condition and palaeoecological environment under which the Yamatoda and Hamada Members were deposited in the Middle Miocene.

This mixed sample yielded, Gymnosperm - six genera and one family (67 per cent); Dicotyledon - seven genera, two subgenera and one family (28 per cent); Pteridophyta - two genera (3 per cent); the indeterminable spores - two spore types (2 per cent).

Among them, *Pinus* is very abundant (42 per cent) and *Picea* is abundant (10 per cent). In the other genera or families, the deciduous *Quercus* and *Liquidambar* are common, attaining respectively 8 per cent and 6 per cent.

The boreal (A), warm (B) and temperate (C) climatic plants are 9 per cent, 30 per cent and 61 per cent, and also, the upland, mixed-slope and stream-side elements respectively 46 per cent, 35 per cent and 19 per cent.

In comparison with the pollen frequency of the Kusaki, Yamatoda and Hamada Members, the temperate climatic plants are 61 per cent of the total, and most of its numerical value are occupied by *Pinus*.

(6) Discussion

From an analysis of the fossil pollen grains and spores a general interpretation is made of the physical conditions prevailing during the growth of the sedimentary basin in which they were found. In this section, the writer will discuss the palaeoclimatic condition, palaeogeographical environment and geological age of the stratigraphical units based upon the palynological and field researches.

(a) Palaeoclimatic Condition

The pollen and spore assemblages have been analysed and from the results the general characters of the paleoclimatic condition can be presented. The methods of analysing the assemblages for palaeoclimatic interpretation have been proposed by ERDTMAN (1954), FAEGRI and IVERSEN (1963), besides palynologists. The writer from his method for palaeoclimatic analysis of his palynological researches on the Neogene deposits and Holocene deposits distributed along the coastal region of the Japan Sea, reported that his results had agreed well with the climatic indications deduced by other methods (FUJI, 1964, 1969). The methods used by the writer are classified into a warmth index, and triangular and quadrilateral diagrams.

There are many references to the living species of pollen grains and spores which most closely resemble the fossil species. The writer will here attempt to reach some tentative conclusions regarding the palaeoclimatic condition under which the Notonakajima forest lived, judged from the occurrence of similar living plants.

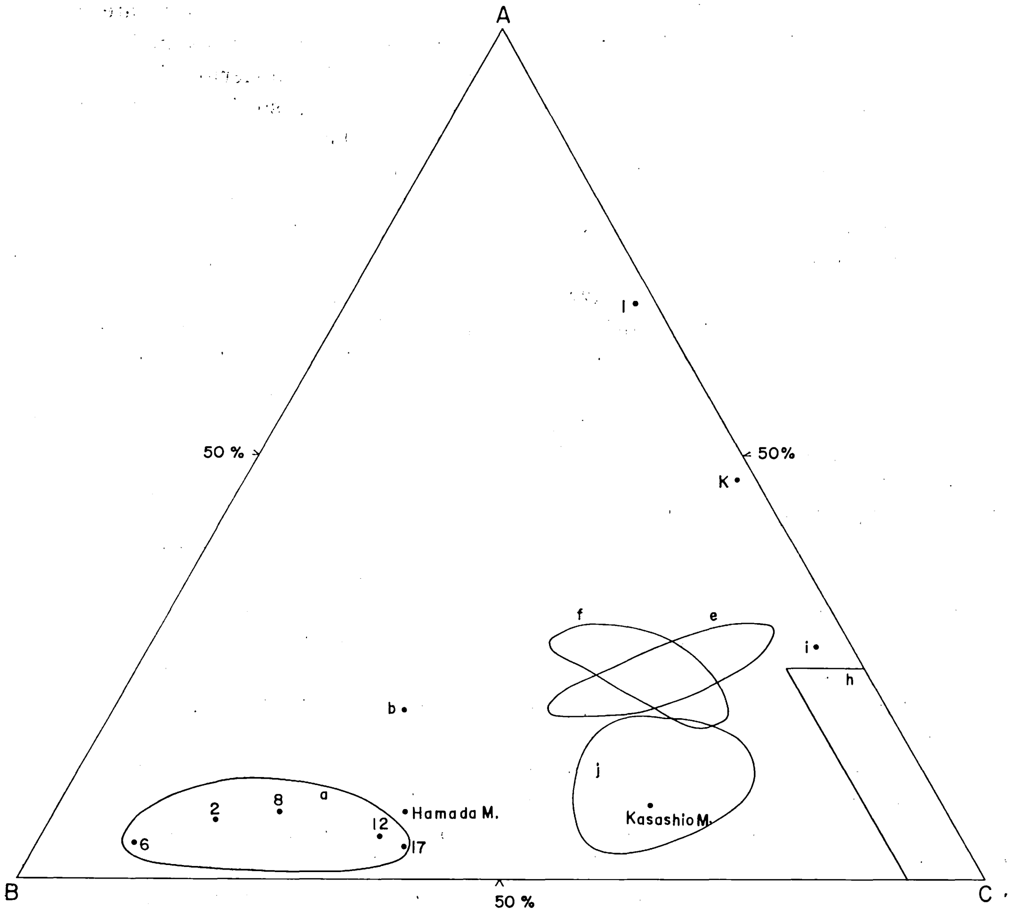


Fig. 5. Pollen diagram (3): Triangular diagram showing the relationship between cold and cool climatic (A), temperate climatic (C) and warm climatic (B) elements found from several samples of the Yamatoda Member and the other members distributed in Noto Peninsula. Numbers refer to Figs. 1 and 2; b: Sunagozaka Member, e: Hojuji Member, f: I'ida Member, h: present deposit of Lagoon Hojozu-gata, i: Nakayama-toge Member, j: Hijirikawa Member, k: Takakubo Member, 1: Omma Member.

The palaeoclimatic conditions of the fossil floras must be analysed by consideration of the association of their dominant genera or species. According to the writer's investigation, as shown in the triangular diagram (Fig. 5), quadrilateral diagram (Fig. 6) and other environmental analyses (Figs. 7 and 8), such subtropical climatic plants as *Liquidambar* and *Metasequoia*, and warm climatic plants as the evergreen *Quercus* and *Machilus* from the Middle Miocene Yamatoda Member exceed in number of genera and specimens those from the Wakura, Hijirikawa, I'ida, I'izuka, Hojuji and Kasashio Members which belong to the latest Middle Miocene to Late Miocene in geological age.

In short, the latters yielded warm-temperate and subtropical climatic plants as follows: Wakura Member - 8 per cent to 16 per cent; Hijirikawa Member - ca. 26 per cent; I'izuka Member - ca. 20 per cent; Kasashio Member - 30 per cent of the total specimens, and the former 61 per cent to 85 per cent. The present result is closely similar to the analytical result on the pollen assemblage from the Sunagozaka Member which yielded *Operculina complanata japonica* HANZAWA and abundant marine molluscs belonging to the so-called " Yatsuo-Kadonosawa fauna ".

With respect to the relative frequency of the warm-temperate and subtropical climatic elements found throughout the Yamatoda Member, it can be said that the higher the horizon is, the higher the frequency becomes. However, the same climatic elements from the lower and upper horizons of the Kusaki Member which underlies the Yamatoda Member with conformity, show a frequency lower than from the Yamatoda Member, though the same elements from the uppermost and lowermost horizons of the Kusaki Member attain a frequency higher than from the Yamatoda Member. And, it is interesting and important that the relative frequency of the warm-temperate and subtropical climatic elements from Samples 2, 6, 8, 12 and 17 are different at every locality, though these samples belong to the same horizon of the Yamatoda Member. Consequently, it seems that the change of the climatic elements found in the Yamatoda Member suggests the difference of plant-association at every locality rather than the change of palaeoclimatic condition.

Comparison between the fossil plants and similar living equivalents whose climatic requirements are known is frequently used for climatic analysis of a fossil flora. Where the modern relationships are known definitely, this method is probably useful for accurate information. The plant species in Neogene are comparatively modernized in morphological fearures, so it is not difficult to compare them with their living equivalents with some exceptions. The genera comprising the Neogene floras in the Japanese Islands are mostly distributed now in East Asia, and nearly all of the temperate Dicotyledons genera in the fossil flora are now growing in the Japanese Islands. And, exotic genera are sometimes common in the fossil flora. The exotic coniferous genera as *Metasequoia*, *Glyptostrobus*, *Sequoia*, *Pseudolarix* and *Keteleeria* are found throughout the Neogene floras of Japan, and they are mostly living now in China, and some of them are known in the western part of North America. The nearest living equivalents of the pollen-floras from the Yamato Member and their modern distribution in East Asia are shown in Table 1. According to this table, the Yamatoda pollen-flora consists mainly of the warm-temperate and subtropical climatic genera, associated commonly with cool-temperate climatic elements. The dominant genera among the warm-temperate and subtropical climatic ones are *Liquidambar*, the evergreen *Quercus*, *Pseudotsuga* and *Keteleeria*. Their macroremains have been recognized only in the Middle Miocene floras throughout the Neogene floras of the Hokuriku Region in where they are abundant in number of specimens. Furthermore, such phenomenon is recognized also in the other districts of the Japanese Islands.

The modern species equivalent to the fossil warm-temperate and subtropical climatic plants are mostly distributed in Formosa, Loochoo Islands, Southwestern China and the southern part of the Japanese Islands. They are not abundant in

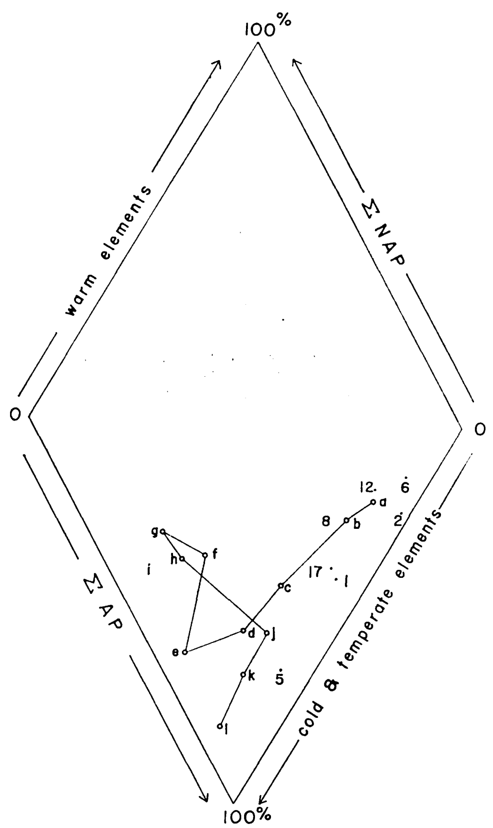


Fig. 6. Pollen diagram (4): Quadrilateral diagram showing the palaeoclimatic condition and palaeoecological environment during the sedimentation of the Yamatoda Member. Numbers refer to Figs. 1 and 2; a : Yamatoda Member, b : Sunagozaka Member, c: Higashi-in'nai Member, d: Najimi Member, e: Hojuji Member, f: I'ida Member, g: Wakura Member, h: I'izuka Member, i: Nakayama-toge Member, j: Hijirikawa Member, k: Takakubo Member, l: Omma Member, AP: arboreal pollen grains, NAP: non-arboreal pollen grains.

number of specimens in the Hojuji, I'ida and Wakura Members of latest Middle Miocene to Late Miocene age. Relicts which survived from the previous Middle Miocene age are found in the later age.

In short, according to the writer's research, the pollen-flora of the Yamatoda Member comprises warm-temperate and subtropical climatic plants mingled in floristic composition.

Such presumption regarding the palaeoclimatic condition during the Yamatoda age is supported by the fossil macroplants from the Yamatoda Member.

Geologists, especially R. HANAYAMA (1958, MS), H. MATSUO (1963) and the writer (1966), have investigated the composition and components of the flora from the Yamatoda Member distributed locally at Tsuchikawa and Kammachi in Nakajima Town. On the basis of these investigations MATSUO (1963) has named the assemblage "the Notonakajima flora". The plants which make up the Notonakajima flora are: *Nitella notoensis*, *Plenasium lignitum*, *Lygodium mioscandens*, *Pteris mioinequalis*, *Podocarpus* sp., *Abies honshuensis*, *Keteleeria* cf. *ezoana*, *Picea kaneharai*, *Pinus miocenica*, *Pseudotsuga* cf. *ezoana*, *Cunninghamia protokonishii*, *Glyptostrobus europseus*, *Metasequoia occidentalis*, *Sequoia langsdorfii*, *Taiwania* sp., *Fokienia notoensis*, *Potamogeton* sp., *Smilax trinervis*, *Najas* (?) sp., *Salix masamunei*, *Comptonia naumanni*, *Pterocarya miocenica*, *Carpinus subyedoensis*, *Castanopsis miocuspidata*, *Quercus mandraliscae*, *Q. nathorstii*, *Q. praegilva*, *Q. protosalicina*, *Q. sinomiocenicum*, *Zelkova ungeri*, *Ficus mioretusa*, *Ranunclus mioaquatilis*, *Cinnamomum oguniense*, *Lindera paraobutusiloba*, *Machilus nathorsti*, *Magnolia miocenica*, *Liquidambar miosinica*, *Gledistchia tanaii*, *Maackia onoei*, *Ailanthus yezoensis*, *Dodonaea japonica*, *Sapindus miocenicus*, *Camellia protojaponica*, *Ternstroemia maekawai*, *Alangium aequalifolium*, *Diospyros miokaki*, *Osmanthus chaneyi*, *Phyllites* sp. A, *P.* sp. B, and *Carpolithes* sp.

Table 1. Modern equivalents of the Yamatoda pollen-flora and their modern dis-
Honshû, 5: Southwestern Honshû, 6: Kyushû and Shikoku, 7: Formosa and Loochoo
China, 13: Manchuria and Primorskaya Prov. Frequency of macroplants by MATSUO,

Fossil microplants	Related fossil macroplants from Yamatoda Member	Modern equivalent macroplants
Pinus	*P. miocenica*	*P. thunbergii*
Picea	*P. kaneharai*	*P. polita*
Abies	*A. honshuensis*	*A. homolepis*
Keteleeria	*K.* cf. *ejoana*	*K. davidiana*
Tsuga	(*T. miocenica*)	*T. longibraeteata*
Pseudotsuga	*P. sp.*	*P. japonica*
Taxodiaceae	*Cunning. protokonishii*	*C. konishii*
	Glypto. europaeus	*G. pensilis*
	Meta. occidentalis	*M. glyptostroboides*
Fagus	(*F. antipofi*)	*F. americana*
Ulmus	(*U. longifolia*)	*U. lanceofolia*
Salix	*Salix masamunei*	*S. sacchalinensis*
Quercus (small)	*Q. mandraliscae*	*Q. longinux*
	Q. nathorstii	*Q. glauca*
	Q. protosalicina	*Q. salicina*
Quercus (large)	*Q. sinomiocenicum*	*Q. accutissima*
Alnus	· (*A. miojaponica*)	*A. japonica*
Juglans	(*J. shanwangensis*)	*J. ailanthifolia*
Corylus	(*C. macquarii*)	*C. heterophylla*
Castanea	(*C. miomollissima*)	*C. mollissima*
Carya	(*C. miocathayensis*)	*C. cathayensis*
Zelkova	*Zelkova ungeri*	*Z. serrata*
Carpinus	*C. subyedoensis*	*C. tschonoskii*
Tilia	*T. protojaponica*	*T. japonica*
Liquidambar	*L. miosinica*	*L. formosana*
Nyssa	(*N. japonica*)	
Ilex	(*I. daijimaensis*)	*I. crenata*
	(*I. heeri*)	*I. pedunculosa*
	(*I. ohashii*)	*I. rotunda*
Viburnum	(*V. uttoensis*)	*V. brachyandrum*
	(*V.* sp. A)	*V. plicatum*
	(*V.* sp. C)	*V. japonicum*
Podocarpus	*P. sp.*	*P. macrsphyllus*

Nearest species

tribution; 1: Saghalien and Kurile Is., 2: Hokkaidô, 3: Northern Honshû, 4: Central Is., 8: Korea, 9: North China, 10: Central China, 11: Southeast China, 12: Southwest H., 1963.

1	Japan					7	8	China					% among macroplant	% among microplant
	2	3	4	5	6			9	10	11	12	13		
		×	×	×	×		×						16.91	4
			×	×	×								1.03	20
		×	×	×	×								0.11	2
						×			×	×	×		0.04	4
											×			
				×	×		×						9.15	12
						×							0.26	} 2
										×			0.11	
									×					
														2
										×				
×	×												0.29	
						×							0.88	} 2
		×	×	×	×	×							11.64	
	×	×	×	×		×							0.15	
		×	×	×	×								3.19	2
	×	×	×	×	×							×		
×	×	×	×	×	×									7
														6
								×	×	×	×			
									×	×				12
		×	×	×	×		×		×		×		1.10	3
		×	×	×	×		×		×				1.47	
	×	×	×	×	×									
						×							0.22	14
														3
	×	×	×	×	×									
			×	×	×									
			×	×	×	×								
			×											
			×	×	×	×								
			×	×	×									
			×	×	×	×							0.15	
2	*6*	*11*	*18*	*18*	*17*	*9*	*4*	*1*	*6*	*5*	*4*	*1*		

The Notonakajima flora is composed of 29 families, which include Characeae, thre families of ferns, four families of Conifers, and 21 families of Angiosperms.

To secure suggestive data regarding the relative abundance of the members of the Notonakajima flora, a leaf count of about 3,000 specimens, of cours at random, was made by MATSUO (1963). The results of this count are as follows:

Pinus miocenica 19.91%,
Diospyros miokaki 15.07%,
Quercus nathorstii 11.64%,
Fokienia notoensis 10.44%,
Pseudotsuga cf. *ezoana* 9.15%,
Machilus nathorsti 6.43%,
Maackia onoei 4.59%,
Camellia protojaponoca 4.19%,
Quercus sinomiocenicum.............. 3.19%,
Magnolia miocenica.................. 1.69%,
Lindera paraobtusiliba 1.51%,
Carpinus subyedoensis 1.46%,
Ficus mioretusa...................... 1.32%,
Comptonia naumanni 1.21%,
Castanopsis miocuspidata 1.10%,
Zelkova ungeri 1.10%,
Picea kaneharai .... 1.03%.

In the 50 species found from the Yamatoda Member, the 17 species listed above amount to over 75 per cent of the plants found from the Member.

From numerical analysis of the fossil macroplants, it seems reasonable to conclude that the Notonakajima forest was made up of a mixture in which the evergreen broad-leaved warm-temperate trees were more numerous than the cool-temperate broad-leaved trees.

The comparison between the fossil pollen grains and macroplants is shown in Table 1. Reference to the figures given in the table shows that there is some differences between the pollen grains and macroplants. These differences occur from such various sources as production, dispersal and preservation. For instance, though the ratio of preservation between *Pinus miocenica* and *Picea kaneharai* (macroremains as fascicle, staminate ament, pistillate cone and seed) is shown with 16.91:1.30 in Table, 1, it may be not concluded that the ratio between both trees in the Notonakajima forest during the Middle Miocene was similar to the ratio of preservation between both macroremains. Namely, in comparison with the foliage between *Pinus* and *Picea*, the former is better in preservation than the latter, for the reason that the foliage of *Pinus* is longer than that of *Picea*. Consequently, this difference suggests that conclusions about the palaeoclimatic condition and palaeoecological environment must depend upon more data regarding both fossil macroplants and microplants from each flora.

With respect to the microflora, palaeobotanists must consider the production and extent of dissemination of both the pollen grains and spores.

① Pollen production: Pollen output per flower (POHL, F., 1936):

Pinus nigra ....1,480,000 grains,
Picea excelsa ....590,000 grains.

The total pollen output in millions of grains (relative values equal to the product of the average pollen output of ten year old branch systems and the number of cubic meters of branches and stems, less than 7 centimeters in diameter, from pure and high grade stands; ERDTMAN, G., 1954):

Pinus silvestris............12,500 grains,
Picea excelsa..............11,000 grains.

② Extent of dissemination: HESSELMAN (1919) exposed plates to trap pollen grain on lightships in the Gulf of Bothnia. The experiments were carried on from 24th May to 26th June, 1918. In one of the ships, 30 kilometers off the coast, 103,037 pollen grains were trapped. This makes an average per square millimeter of about 16.2 grains of which 7 were *Picea*, 6.8 *Betula*, and 2.4 *Pinus*. In the other ship, 55 kilometers off the coast, 56,075 grains were trapped, averaging 8.8 per square millimeter, of which 4.1 were *Picea*, 3.6 *Betula*, 1.1 *Pinus*. Namely, *Picea* is generally less than *Pinus* in respect to production of pollen grain, besides the extent of dissemination, greater is in the former than in the latter. However, the production of the pollen grain of Conifers may vary widely according to the size of the strobilus; as for example in a large strobilus ERDTMAN (1954) found 605,000 pollen grains, and in another as many as 1,800,000. This suggests that the size of the strobilus is related with the number of grains it will contain and probably also to the conditions of growth.

The Notonakajima flora which yielded various kinds of pollen grains and spores was probably distributed near a sedimentary basin. This inference is supported by the following palaeobotanical evidence. Namely, *Pinus miocenica* is abundant in number of foliage, though this species is very rare in the Tertiary flora of the Japanese Islands. It may be said in this connection, as the needles of *Pinus* can not readily be transported widely, it seems that *Pinus* found from the Yamatoda Member was one of the abundant members of the flora that lived on the border of the site of deposition. Accordingly, as judged by the numerical

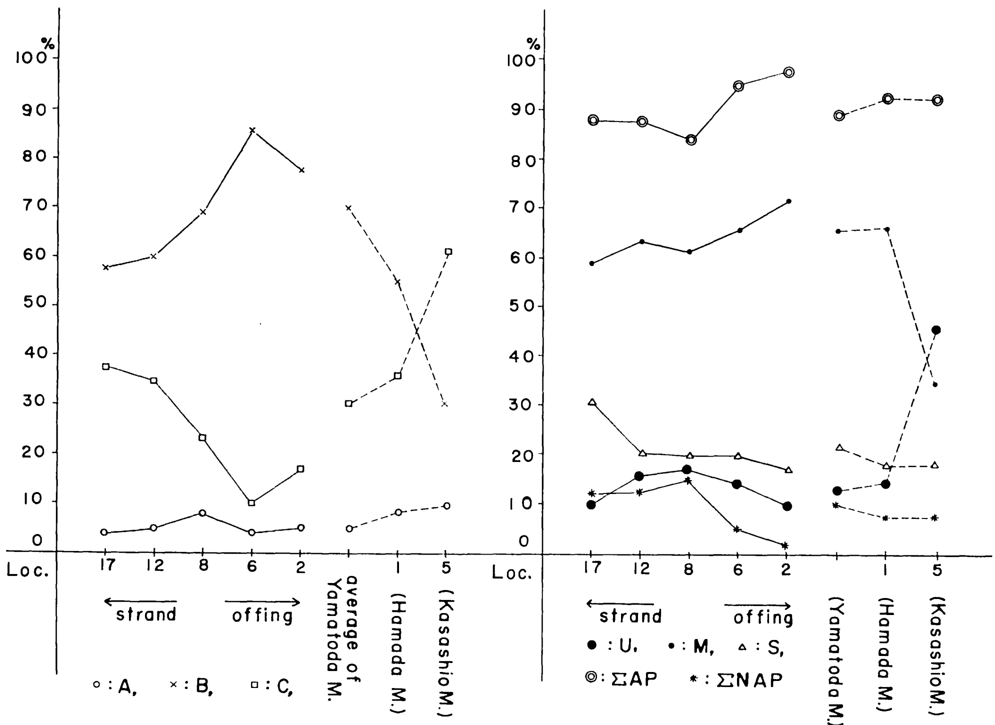


Fig. 7. Pollen diagram (5) of the Yamatoda, Hamada and Kasashio Members; A: cold and/or cool climatic plants, B: warm-temperate and/or subtropical climatic plants, C: temperate plants; U: upland plants in habitat, M: mixed-slope plants, S: streamside and/or riparian plants; AP: arboreal pollen grains, NAP: non-arboreal pollen grains.

result of the palynological investigation, it may be concluded that *Picea* was a dominant tree of the Notonakajima flora.

On the basis of discussion offered in the previous paragraphs, the climatic condition indicated by the flora is briefly summarized as follows. The Notonakajima flora contains a large number of evergreen broad-leaved trees, frequently accompanied with subtropical plants. The flora is closely similar to the present lowland vegetation growing in Central to Southern China, or in Loochoo to Formosa. However, compared with many of the Neogene floras of the Japanese Islands, the Juglandaceae and Betulaceae are represented only meagerly, and no fossils of the Aceraceae have been found. The Fagaceae is well represented, but largely by the evergreen *Quercus* and there are only a few records of either *Castanea* or *Fagus*. Furthermore, the Notonakajima flora includes typical temperate plants less than the other Middle Miocene floras of the Japanese Islands. The present day climatic condition in Southern China, Loochoo and Formosa is warm-temperate or subtropical with well distributed precipitation, and the annual mean temperature is in excess of 20°C. However, the common occurrence of temperate deciduous broad-leaved trees in the Notonakajima flora indicates that such a subtropical climatic condition may not be necessary for their growth.

Thus, the palaeoclimatic condition of the Notonakajima flora was evidently far warmer in temperature than that of the latest Middle to Late Miocene and Pliocene floras (FUJI, 1964, 1965a-b, 1966 and 1969) distributed in the Hoku-

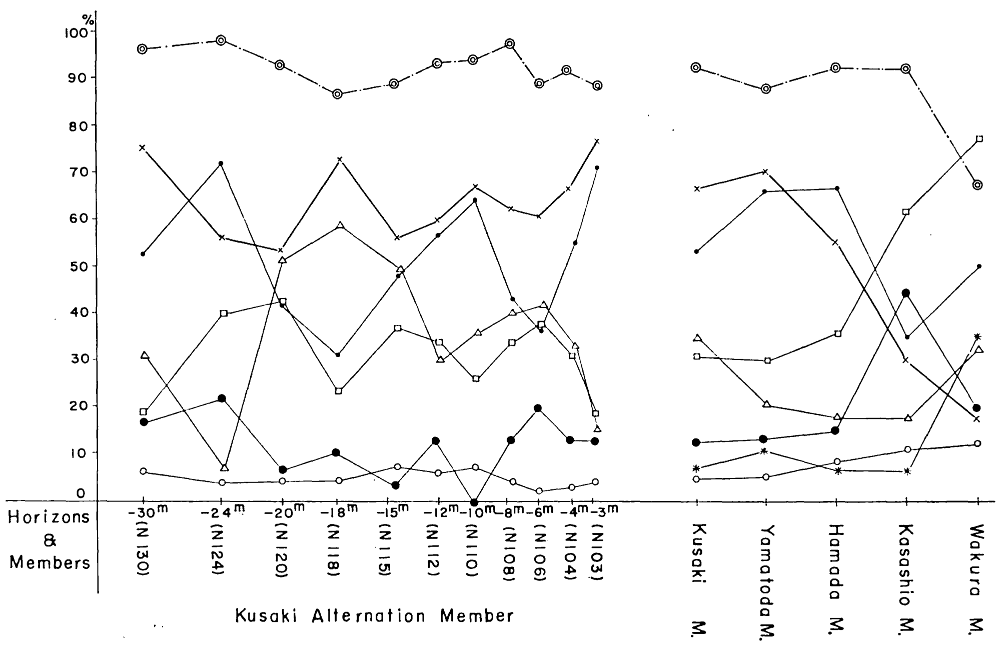


Fig. 8. Pollen diagram (6) showing the relationship between the Kusaki, Yamatoda, Hamada and Kasashio Members in respect of palaeoclimatic condition and palaeogeographical environment; alphabetical denotation refers to Fig. 7.

riku Region, Central Japan.

(b) Palaeogeographical Environment

To facilitate the consideration on the probable ecological environments under which some ancient plants lived, the modern equivalents of the fossil species can be grouped according to their habitats, four types of upland, mixed-slope, stream-side or riparian, and lake or marshy elements.

The Yamatoda pollen-flora is in number of speciments mainly comprised of mixed-slope or mixed-slope—riparian plants, and also contains more or less upland elements. Namely, this flora seems to represent a mixed-slope to riparian forest. For instance, the mixed-slope plants amount to 67 per cent in frequency on average, stream-side and/or riparian plants 22 per cent and the remainder of upland plants. That is to say, most of the Yamatoda pollen-flora are most abundant in lowland plants grown near coastal areas. On the other hand, most of the Early Miocene floras are composed principally of elements from mountain-slope, further the Late Miocene floras are of mixed-slope type.

That the Yamatoda pollen-flora consists mainly of lowland plants is evidently related to the environment of the deposition of the plants-bearing rocks.

By a detailed research (ICHIKAWA, W., KASENO, Y. and KOJIMA, K., 1955) on the diatom remains in the samples from Localities 2, 6, 8, 12 and 17 which belong to the same horizon of the Yamatoda Member, it is revealed that the marine diatom species as *Actinocyclus biternarius*, *A. nonarius*, *A. octonarius*, *A. quaternarius*, *A. quinarius*, *A. septenarius* and *A. undenarius* are frequently found at Localities 2, 6 and 8 in the eastern half of the area of distribution of the Yamatoda Member, while the western half, in which Localities 12 and 17 are situated, is characterized only by such fresh-water species as *Melosira granulata*.

On the other hand, with respect of the writer's palynological analysis on the same samples, the writer can summarize as follows:

① The nearer the sea is, the less the frequency of the stream-side and/or riparian plants bacome. This is shown by the facts that the plants living in the coastal area and stream-side are generally have small pollen size and little pollen output in comparison to such upland or mixed-slope trees as *Pinus*, *Picea*, *Fagus*, *Quercus* and *Betula* which are always dominant in marine deposits.

Table 2. Volume and production of several pollen grains (After POHL, F., 1937). M: mixed-slope, U: upland, S: stream-side or riparian.

Name of Pollen Grain	Habitat	Volume (μ^3)	Production (ten year old branch) (× millions)
Picea	M	132,200	11,000
Fagus	M	51,770	2,050
Pinus	U—M	47,030	12,500
Betula	M—U	7,537	5,570
Alnus	S	9,070	6,950
Juniperus	S	9,460	——

② The nearer the sea is, the less the frequency of the non-arboreal pollen grains, of which most are living always in the stream-side and/or riparian areas, become.

③ The farther the strand is, the more the mixed-slope plants become, inasmuch as these plants include plants of larger size and higher production as *Picea*, *Keteleeria*, *Tsuga*, *Podocarpus*, *Fagus*, *Ulmus*, *Quercus* and *Tilia* etc. In respect of the non-arboreal pollen grains, no doubt, the contrary phenomenon will be recognized. In short, regarding the distance from a strand, the relationship between the frequency of the arboreal and non-arboreal pollen grains is the interrelation negative.

④ Frequency of the plants that lived in the upland area is almost unchangeable from horizon to horizon.

The results stated above are supported by the writer's palynological research on the present bottom-deposits of Lagoon Hojozu in Toyama Prefecture. Therefore, palynologists can use the results above-mentioned in case of the inference on the palaeogeographical environment.

As already stated the Notonakajima flora consists of lowland plants, and is related to the environment of deposition. With respect to the geological occurrence of this flora, most of the lacustrine sediments were formed in a position very near to the marine sedimentary basin.

Thus, judging from the palynological results, the fossil diatom assemblages, lithofacies and diversity in the thickness of the deposits, it may be concluded that the Yamatoda Member accumulated in a small lagoon which was connected with the sea. The basin in which the Yamatoda Member was deposited seems to have been a more or less closed embayment in the central part of Noto Peninsula. The spread of this lagoon is shown in Fig. 9.

(c) Geological Age

The Middle Miocene Notonakajima flora contains a large number of ever-

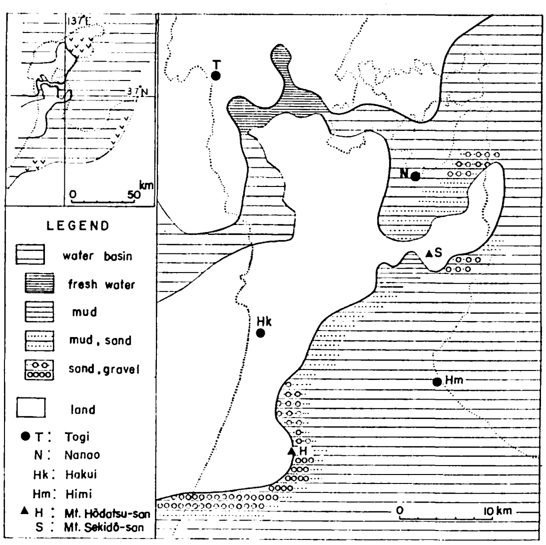


Fig. 9. Palaeogeographical map during the sedimentation of the Yamatoda Member (the Early Kurosedanian stage of Middle Miocene age) (After KASENO, Y., 1963).

green broad-leaved trees, frequently accompanied with subtropical plants. The flora is closely similar to the present lowland vegetation living in the southern part of China, Loochoo or the northern part of Formosa.

The Middle Miocene floras of the Japanese Islands consist largely of riparian plants which grew in hilly to riparian areas, followed by a mixed-slope and a few upland plants, and also are composed mainly of evergreen broad-leaved plants with deciduous broad-leaved trees, conifers as *Keteleeria, Pseudolarix, Cunninghamia, Taiwania, Metasequoia* and *Glyptostrobus* and subtropical trees.

However, the Early Miocene floras consist mainly of the deciduous broad-leaved trees as grown in temperate regions, and also, are composed principally of elements from the mountain-slope, followed by the plants growing in the mixed-slope to stream-side, which upland and riparian elements are generally few in number.

The Late Miocene floras of the Japanese Islands consist mainly of temperate deciduous broad-leaved trees, accompanied by several evergreen trees, and include a large number of Juglandaceae, Betulaceae, Fagaceae, Ulmaceae and Aceraceae.

Compared with the Early and Middle Miocene floras the broadleaved trees are considerably modernized, and their living equivalents are mostly distributed widely in the Japanese Islands. The floras belonging to the Late Miocene in general, in number of specimens and species, are composed of mixed-slope or mixed-slope and riparian plants, and also contain abundant upland and mixed-slope plants. Namely, the floras seem to represent a mixed-slope to riparian forest.

Compared with the floras belonging to the Early Miocene, Middle Miocene and Late Miocene ages, from analysis of the composition of each flora the Middle Miocene flora is distinguishable from the other floras as already stated.

Thus, in comparison with various floras of the Neogene age in the Japanese Islands and from the viewpoint of stratigraphical evidense the Yamatoda pollen-flora can be nearly correlated with the Daijima-type flora which is one of the Neogene floras of Japan classified by TANAI (1963) into six types, that is, the Ainoura-(Earliest Miocene), Aniai-(Early Miocene), Daijima-(Middle Miocene), Mitoku-(Late Miocene to Mio-Pliocene) Shinjô-(Early Pliocene) and Akashi-type (Late Pliocene) floras. And the geochronological position of the Yamatoda Member seems to be Middle Miocene.

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Explanation of Plate 7

Fig. 1. *Picea* (Cf. *P. kaneharai*), lateral longitudinal view, 82 μ; 13 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20083.

Fig. 2. *Picea* (Cf. *P. kaneharai*), lateral longitudinal view, 90 μ; 3 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20084.

Fig. 3. *Pinus* (Cf. *P. miocenica*), oblique polar view, 49 μ; 29 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20085.

Fig. 4. *Pinus* (Cf. *P. miocenica*), lateral longitudinal view, 58 μ; 27 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20086.

Fig. 5. *Pinus* (Aff. *P. miocenica*), polar view (distal face), 46 μ; Loc. No. 8, Yamatoda, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20087.

Fig. 6. *Podocarpus*, equatorial view, 65 μ; 19 meters below the present surface, Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20088.

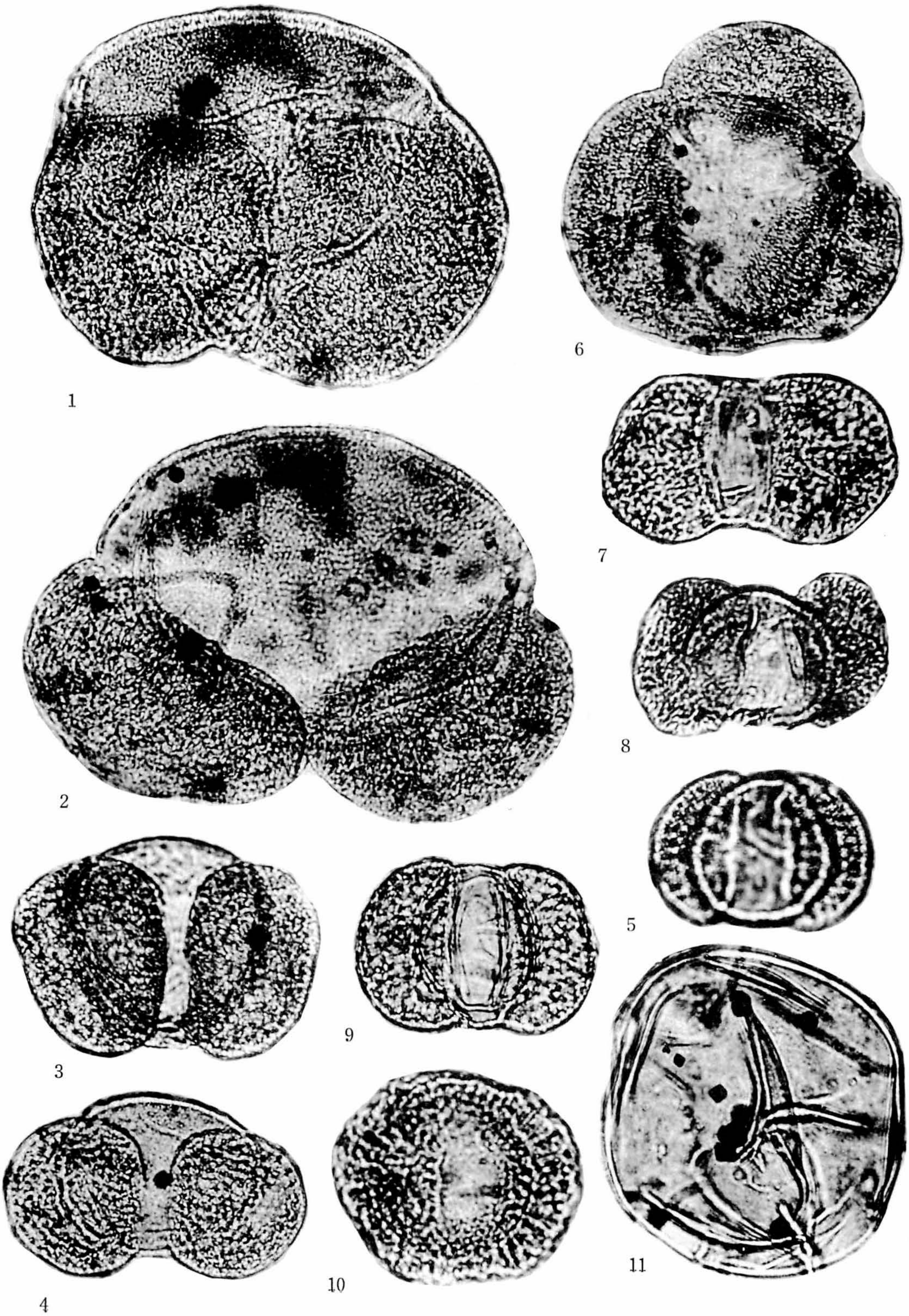
Fig. 7. *Podocarpus*, distal face, 42 μ; 30 meters below the present surface, Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20089.

Fig. 8. *Podocarpus*, lateral, longitudinal view, 36 μ; 21 meter below the present surface, Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20090.

Fig. 9. Cf. *Pinus* (Cf. *P. miocenica*), polar view (distal face), 32 μ; 18 meters below the present surface, Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20091.

Fig. 10. *Podocarpus*, aberrant grain, proximal face, 30 μ; 19 meters below the present surface, Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20092.

Fig. 11. Indeterminable pollen grain, 63 μ; 19 meters below the present surface, Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member, EKZJ coll. cat. no. 20093.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Ainoura-type	相 浦 型	Kurosedanian stage	黒瀬谷期
Akashi-type	明 石 型	Kurotsume	黒 詰
Anamizu Formation	穴水累層	Kusaki Member	草 木 層
Aniai-type	阿仁合型	Mitoku-type	三 徳 型
Araya Member	荒 屋 層	Mt. Hôdatsu-san	宝 達 山
Daijima-type	台 島 型	Mt. Sekidô-san	石 動 山
Hakui	羽 咋	Najimi Member	南志見層
Hamada Member	浜 田 層	Nakajima Town	中 島 町
Higashi-in'nai Member	東印内層	Nakayama-toge Member	中山峠層
Hijirikawa Member	聖 川 層	Nanao Bay	七 尾 湾
Himi	氷 見	Nanao City	七 尾 市
Hojuji Member	法住寺層	Noto-nakajima Station	能登中島駅
Hokuriku Region	北陸地方	Noto Peninsula	能登半島
I'ida Member	飯 田 層	Okuhara Member	奥 原 層
I'izuka Member	飯 塚 層	Omma Member	大 桑 層
Kamibatake	上 畠	Sammyo	三 明
Kammachi	上 町	Shinjô-type	新 庄 型
Kanagasaki	金 ケ 崎	Shiozu	塩 津
Kanazawa	金 沢	Shirahama	白 浜
Kasashio Member	笠師保層	Sunagozaka Member	砂子坂層
Kashima-gun	鹿 島 郡	Takakubo Member	高 窪 層
Kita-menden	北 免 田	Tanoshiri Member	田ノ尻層

Explanation of Plate 8

Fig. 12. *Pinus* (Cf. *P. miocenica*), lateral longitudinal view, 53 μ; Loc. No. 5, Noto-nakajima Station, Nakajima Town; Kasashio Member; EKZJ coll. cat. no. 20094.

Fig. 13. *Pinus* (Aff. *P. miocenica*), lateral longitudinal view, 66 μ; Loc. No. 2, Kammachi, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20095.

Fig. 14. *Podocarpus*, distal face, 22 μ; 6 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat no. 20096.

Fig. 15. *Podocarpus*, distal face, 27 μ; 3 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20097.

Fig. 16. *Podocarpus*, distal face, 52 μ; 30 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20098.

Fig. 17. *Podocarpus*, distal face, 62 μ; 19 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20099.

Fig. 18. *Tsuga*, distal face, 64 μ; Loc. No. 6, Yamatoda, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20100.

Fig. 19. *Osmunda*, lateral longitudinal view, 42 μ; 18 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20101.

Fig. 20. Taxodiaceae, gen. indet., equatorial view, 30 μ; 4 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20102.

Fig. 21. *Carya*, polar view, 43 μ; Loc. No. 1, Kammachi, Nakajima Town; Hamada Member; EKZJ coll. cat. no. 20102.

Fig. 22. *Carya*, polar view, 38 μ; Loc. No. 5, Noto-nakajima Station, Nakajima Town; Kasashio Member; EKZJ coll. cat. no. 20103.

Fig. 23. *Liquidambar*, equatorial view 40 μ; Loc. No. 5, Noto-nakajima Station, Nakajima Town; Kasashio Member; EKZJ coll. cat. no. 20104.

Fig. 24. *Liquidambar*, oblique equatorial view, 40 μ, Loc. No. 5, Noto-nakajima Station, Nakajima Town; Kasashio Member; EKZJ coll. cat. no. 20105.

Fig. 25. Cf. *Pteridium*, proximal face, 32 μ; Loc. No. 1, Kammachi, Nakajima Town; Hamada Member; EKZJ coll. cat. no. 20106.

Fig. 26. *Betula*, polar view, 36 μ; Loc. No. 5, Noto-nakajima Station, Nakajima Town; Kasashio Member; EKZJ coll. cat. no. 20107.

Fig. 27. *Acer*, oblique polar view, 26 μ; 10 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20108.

Fig. 28. *Zelkova*, oblique polar view, 40 μ; Loc. No. 17, Kamibata, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20109.

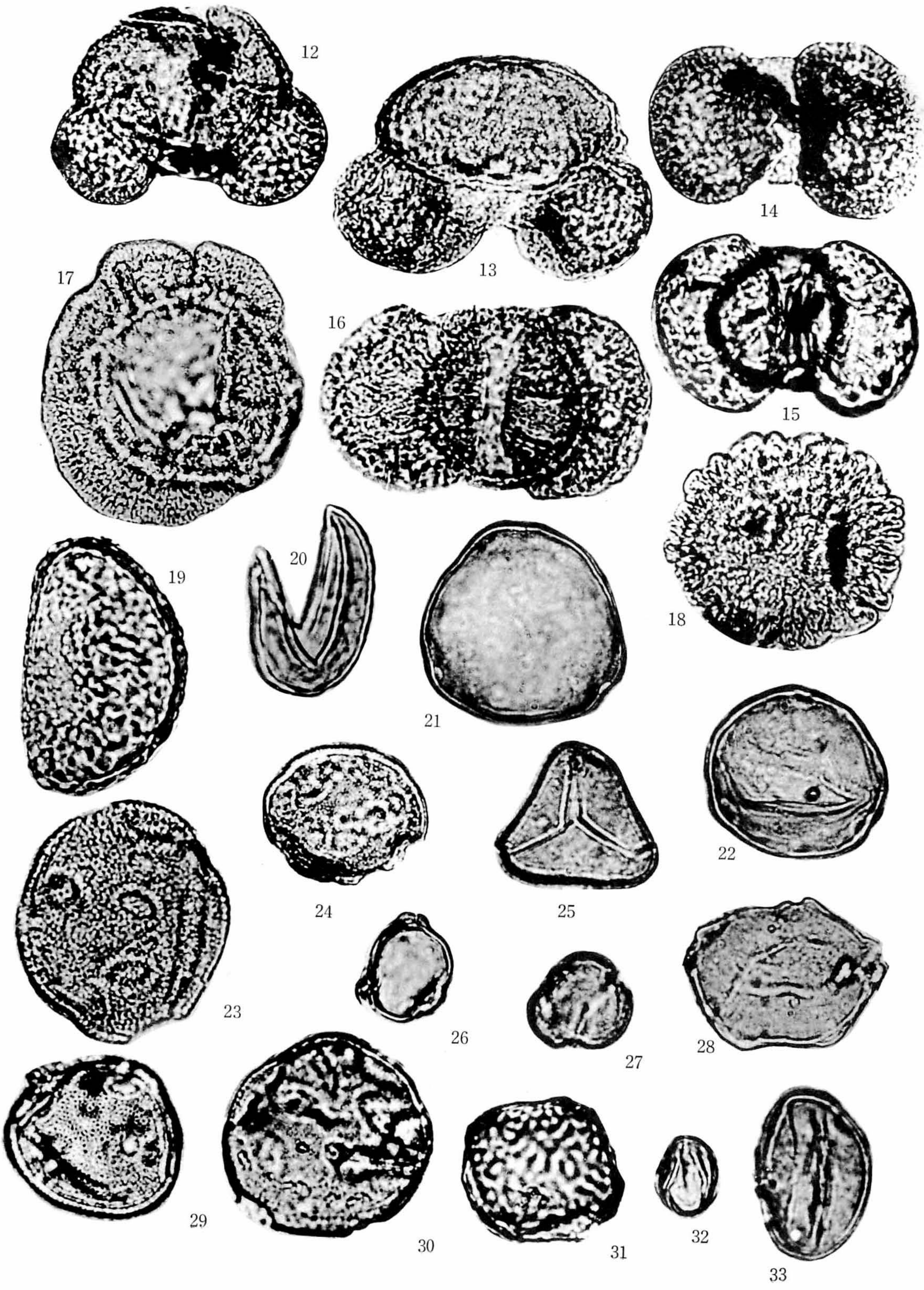
Fig. 29. *Liquidambar*, oblique equatorial view, 38 μ; 15 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20110.

Fig. 30. *Liquidambar*, oblique polar view, 38 μ; 30 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20111.

Fig. 31. Indeterminable pollen grain, polar view (?), 27 μ; 18 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20112.

Fig. 32. Tricolpopollenites, oblique equatorial view, 24 μ; Loc. No. 8, Yamatoda, Nakajima Town; EKZJ coll. cat. no. 20113.

Fig. 33. Tricolpopollenites, equatorial view, 35 μ; Loc. No. 1, Kammachi, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20114.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Togi Town	富来町	Wakura Member	和倉層
Tsuchikawa	土川	Yachi	谷内
Tsukada Member	塚田層	Yamatoda Member	山戸田層

Explanation of Plate 9

Fig. 34. *Pterocarya*, polar view, 43 μ; Loc. No. 17, Kamibata, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20115.

Fig. 35. *Pterocarya*, polar view, 43 μ; Loc. No. 1, Kammachi, Nakajima Town; Hamada Member; EKZJ coll. cat. no. 20116.

Fig. 36. Cf. *Carya*, polar view, 30 μ; Loc. No. 17, Kamibata, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20117.

Fig. 37. *Tilia*, polar view, 28 μ; Loc. No. 1, Kammachi, Nakajima Town; Hamada Member; EKZJ coll. cat. no. 20118.

Fig. 38. *Corylus*, polar view, 26 μ; Loc. No. 17, Kamibata, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20119.

Fig. 39. Cf. *Alnus*, polar view, 30 μ; Loc. No. 17, Kamibata, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20120.

Fig. 40. *Carya*, polar view, 43 μ; 6 meters below toe present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20121.

Fig. 41. *Carya*, polar view, 50 μ; 24 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20122.

Fig. 42. *Carya*, oblique polar view, 48 μ; Loc. No. 17, Kamibata, Nakajima Town; EKZJ coll. cat. no. 20123.

Fig. 43. *Carya*, oblique polar view, 52 μ; 10 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20134.

Fig. 44. *Liquidambar*, oblique polar view (?), 38 μ; Loc. No. 5, Noto-nakajima Station, Nakajima Town; Kasashio Member; EKZJ coll. cat. no. 20135.

Fig. 45. *Liquidambar*, oblique polar view, 40 μ; 6 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20136.

Fig. 46. *Liquidambar*, oblique equatorial view, 38 μ; Loc. No. 17, Kamibata, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20127.

Fig. 47. *Liquidambar*, oblique equatorial view, 38 μ; 8 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20128.

Fig. 48. *Liquidambar*, oblique equatorial view, 40 μ; 20 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20129.

Fig. 49. *Liquidambar*, polar view, 38 μ; 8 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat no. 20130.

Fig. 50. *Liquidambar*, oblique equatorial view, 36 μ; Loc. No. 2, Kammachi, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20131.

Fig. 51. *Stellaria*, oblique polar view, 30 μ; Loc. No. 8, Yamatoda, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20132.

Fig. 52. *Stellaria*, polar view, 32 μ; 18 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20133.

Fig. 53. *Nyssa*, polar view, 33 μ; Loc. No. 17, Kamibata, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20134.

Fig. 54. *Quercus* (deciduous), equatorial view, 32 μ; Loc. No. 12, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20135.

Fig. 55. *Quercus* (deciduous), equatorial view, 32 μ; 12 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20136.

Fig. 56. *Quercus* (evergreen), equatorial view, 23 μ; Loc. No. 5, Noto-nakajima Station, Nakajima Town; Hamada Member; EKZJ coll. cat. no. 20137.

Fig. 57. *Quercus* (evergreen), equatorial view, 24 μ; Loc. No. 1, Kammachi, Nakajima Town; Hamada Member; EKZJ coll. cat. no. 20138.

Fig. 58. Cf. *Quercus* (evergreen), equatorial view, 20 μ; 4 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20139.

Fig. 59. *Ilex*, equatorial view, 22×26 μ; Loc. No. 12, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20140.

Fig. 60. Dyadosporites, lateral view, 38 μ; Loc. No. 2, Kammachi, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20141.

Fig. 61. *Geranium*, polar view, 75 μ; 6 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Yamatoda Member; EKZJ coll. cat. no. 20142.

Fig. 62. Tricolporopollenites, equatorial view, 34 μ; 18 meters below the present surface at Loc. N1, Tsuchikawa, Nakajima Town; Kusaki Member; EKZJ coll. cat. no. 20143.

Fig. 63. *Osmunda*, lateral view, 52 μ; Loc. No. 5, Noto-nakajima Station, Nakajima Town; Hamada Member; EKZJ coll. cat. no. 20144.


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553. NOTES ON THE STRATIGRAPHIC DISTRIBUTIONS OF SOME PLANKTONIC FORAMINIFERAL SPECIES IN THE KAZUSA GROUP, BOSO PENINSULA*

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房総半島，上総層群におけるいくつかの浮遊性有孔虫種の層位学的分布について：熱帯地域でたてられた鮮新世—現世の浮遊性有孔虫分帯と比較し，房総半島における鮮新世の上下限を検討するための資料として，*Pulleniatina*, *Sphaeroidinella* および *Globorotalia* 属の8種の上総層群内の産出状況や形態変異を簡単に報告する。　青木直昭

Introduction

The base of the Pliocene in Boso, central Japan, has been accepted as the base of the Kazusa Group for the reason that some faunal changes, such as the extinction of the so-called Miocene forms and the appearance of the modern ones, were believed to occur in this horizon (ASANO *et al.*, 1957-1958). A rapid increase of *Globorotalia inflata* in abundance is recognized at a short distance above the base of the Group. This species was considered to have appeared in the basal Pliocene. The Miocene-Pliocene boundary is represented by unconformity in many depositional basins of Japan. Such relationship is also the case with Boso, which is another reason for drawing the boundary conventionally at the basal unconformity of the Kazusa Group from the viewpoint of tectonics and lithofacies variation.

The upper limit of the Pliocene in Boso has been discussed on the basis of the paleoclimatic interpretations of marine fossils. The planktonic foraminifera, in particular, furnish more reliable and useful data because of their temperature-sensitive character in distribution. The Pliocene-Pleistocene boundary, supposedly indicating the beginning of the Quaternary cold climate, was drawn at the base of the lowermost one of the cold water horizons, that is, at the base of the *Uvigerina akitaensis* Zone (ASANO, *et al.*, 1957).

With the recent progress in the study of the uppermost Cenozoic planktonic foraminifera, determination of these two important boundaries, as well as the world-wide zonation of the Pliocene and Pleistocene, is being proceeded by means of the vertical range, phylogenetical relation and morphological mutation of the planktonic foraminifera (BANDY, 1964; BANNER and BLOW, 1965 and 1967; BOLLI and BERMÚDEZ, 1965; BOLLI, 1966b; INGLE, 1967; PARKER, 1967). The work is carried on with taxonomic splitting and strict re-definition of the previously described species, and with proposition of new taxa.

In this paper, the stratigraphic distributions of some selected planktonic for-

* Received Dec. 26, 1968; read Sept. 22, 1968 at Kanazawa.

aminiferal species within the Kazusa Group are presented as the basic material for considering the upper and lower boundaries of the Pliocene in the Boso Peninsula.

All of the so-called guide species for zonation and correlation are exclusively dominant in the tropical-subtropical regions, whereas these are generally very rare and discontinuous in occurrence in the Boso sections. Moreover, the range of occurrence and the presence or absence of such warm water species in Boso are evidently influenced by the climatic fluctuation and deterioration of the Quaternary period, as seen particularly in the upper half of the Kazusa Group. The basal part of the Group in the eastern coastal sections east of the Isumi River is also very poor in the planktonic foraminifera. In spite of some hundreds grams of rock material examined, usually one to a few individuals of one of the index species are obtained from each sample. Newly re-collected samples added little to improve the present data. Owing to the rare and restricted occurrences, the results obtained from the study of the vertical range, coiling pattern and distributional trend of the planktonic foraminiferal species are not conclusive, so that they are preliminarily reported here in order to located the approximate position of these boundaries in Boso and to focus the future precise works on these horizons in question.

The material from the lower part of the Kazusa Group in the eastern coastal sections supplied very important data on the Lower Pliocene faunas and the initial appearance of the modern forms. These horizons are missing or very much condensed in the Yoro River (the type section) and the western sections. Therefore, the stratigraphic subdivision of the Kazusa Group is shown by the benthonic foraminiferal zones in the eastern coastal area as the standard succession (AOKI, 1968). The study of the planktonic foraminifera from the underlying Miura and Hayama Groups has not been completed yet, so that it is not mentioned in this paper.

Pulleniatina species

BANDY (1963a, b) studied the change of the coiling direction of *Pulleniatina obliquiloculata* during Late Miocene to Pleistocene in the Philippines, and showed the interesting results: two phases each of sinistral and dextral coilings of the *Pulleniatina* species are alternately recognized there. And, he proposed to settle the Miocene-Pliocene boundary at the base of the 2nd sinistral coiling zone. BOLLI (1966a), HUANG (1967), MATOBA (1967) and TAKAYAMA (1967) reported the similar coiling pattern of *Pulleniatina* in Java, southern Taiwan, Choshi and Boso, respectively. BANNER and BLOW (1967) subdivided the *Pulleniatina* species into 5 taxa, which had long been accepted as conspecific with *P. obliquiloculata*. They succeeded in the planktonic foraminiferal zonation of these ages based partly on the phylogenetical relations of these *Pulleniatina* species. Thus, the species of this genus appear to be one of the important planktonic foraminiferal indices for the Miocene-Pliocene boundary.

In Boso, *Pulleniatina obliquiloculata* appears first in the middle part of the *Gyroidina-Melonis* Zone of the Isumi River and East Coast sections, and its occurrence ranges upwards to the uppermost zone of the sections.

It is interesting to note that the all specimens obtained from the *Gyroidina-Melonis* and the overlying *Gyroidina* cf. *orbicularis* Zones have sinistrally coiled

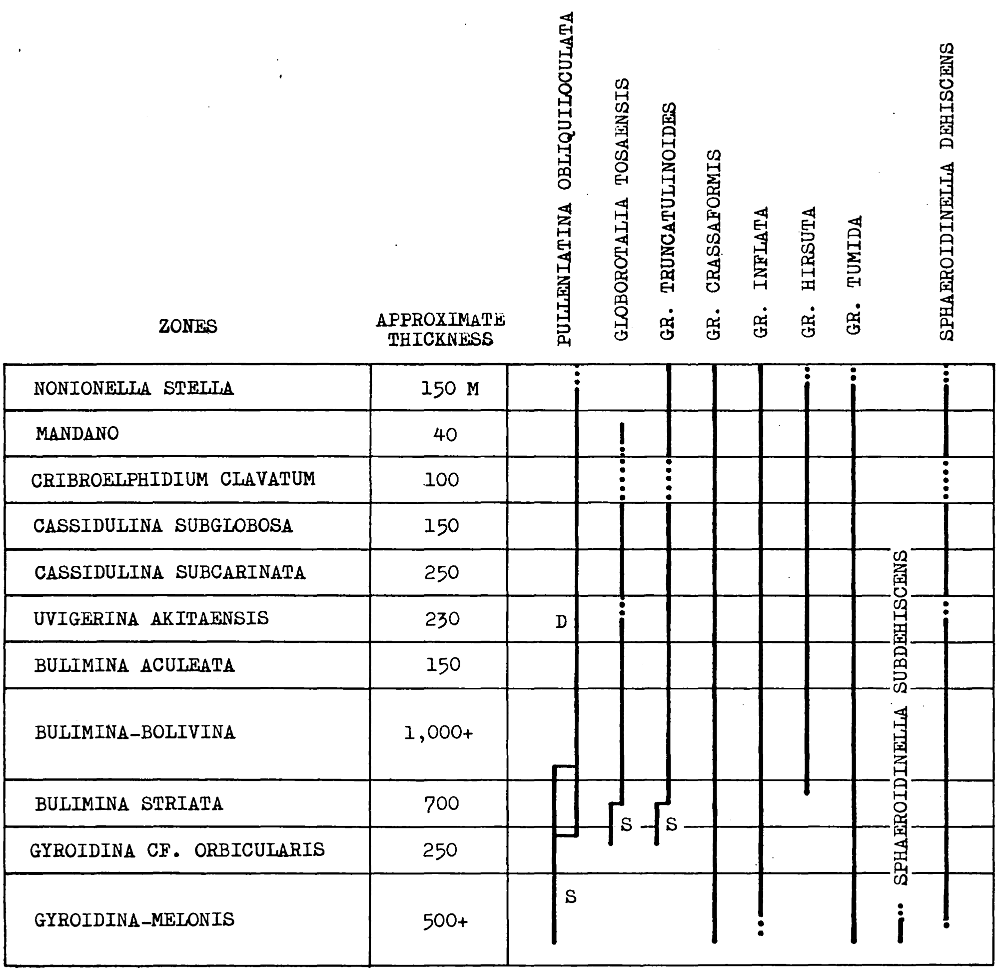

Fig. 1. Stratigraphic distributions of some planktonic foraminiferal species in the Kazusa Group. Boso Peninsula.
S: sinistral coiling, D: dextral coiling

tests. This character continues to the upper part of the *Gyroidina* cf. *orbicularis* Zone or to the basal part of the *Bulimina striata* Zone, then changes to dextral coiling. So far as my observation goes, however, specimens of the both coiling directions are intermingled in the interval ranging from the uppermost part of the *Gyroidina* cf. *orbicularis* Zone up to the lower part of the *Bulimina-Bolivina* Zone. Tnerefore, it seems probable that the sinistral coiling changes to the dextral through a short interval of the random coiling as already mentioned by HARTONO (1964) and TAKAYAMA (1967). The dextral coiling remains unchanged up to the higher horizons of the sections.

In the Kazusa Group of the Yokohama area, across Tokyo Bay from western Boso, the sinistrally coiled specimens of *Pulleniatina obliquiloculata* appear first in the middle part of the Nojima Formation, and this coiling direction continues up to the middle part of the overlying Ofuna Formation, from which upwards the test becomes dextrally coiled. *Pulleniatina* is almost absent in the upper part of the Kazusa Group in Yokohama, but it frequently occurs at the type locality of the Kakio Formation.

Dextrally coiled specimens have never been found in the basal part of the Group or in the underlying horizons. Therefore, the lower limit of this sinistral zone of *Pulleniatina* cannot be determined in either of the areas examined. MATOBA (1967) already recognized the sinistrally coiled zone of *Pulleniatina*, with its upper and lower boundaries sharply defined, in the basal part of the Iioka Formation in the Choshi area, about 80 km northeast of the eastern coast of Boso. TAKAYAMA (1967) also reported the same zone from the base of the Obitsu River section, central part of the Boso Peninsula.

All of the Boso specimens of *Pulleniatina* seem to be morphologically conspecific with *P. obliquiloculata*. Some of the sinistrally coiled specimens from the *Gyroidina-Melonis* Zone are more trochospiral and less involute in coiling than the typical (TODD, 1964; BANNER and BLOW, 1967).

Globorotalia truncatulinoides

Globorotalia tosaensis was first described from the so-called Lower Pliocene Nobori Formation, Shikoku, southern Japan (TAKAYANAGI and SAITO, 1962), as differing from the closely related *G. truncatulinoides* in having the following features:

(1) the less lobulate and more completely circular outline in the axial view,
(2) the slightly more protruded umbilical side,
(3) the less angulate periphery without a distinct peripheral keel,
(4) the slightly smaller number of low and broad chambers in the final whorl (typically four in number according to the original authors),
(5) the more oblique and more curved septal sutures on the dorsal surface, and
(6) the usually thicker-walled test.

Some workers (BANNER and BLOW, 1965; HUANG, 1966; PARKER, 1967; ASANO, 1968a, b) consider that *G. tosaensis* is phylogenetically an ancestral from of *G. truncatulinoides*. BANNER and BLOW (1965) stated that the first appearance of *G. tosaensis* marks the base of the Zone N. 21, the Upper Pliocene, and that the offshoot of *G. truncatulinoides* from the *G. tosaensis* stock occurs at the base of the Zone N. 22, which precisely corresponds to the Pliocene-Pleistocene boundary. As these two related species are regarded as important guide fossils, the specimens formerly assigned to *G. truncatulinoides* from Boso were re-examined in view of the world-wide applicability of this hypothesis.

G. tosaensis is a very rare species in the Boso Peninsula, as it is at its type locality. Its lowermost occurrence in Boso is the middle part of the *Gyroidina* cf. *orbicularis* Zone of the East Coast and the Isumi River sections. In this horizon the typical form of this species is associated with the thin-walled specimens which are characterized by the well-developed peripheral keel and are very similar to *G. truncatulinoides*. These two forms are sinistrally coiled below the middle horizon of the *Bulimina striata* Zone.

G. tosaensis is very rare in the bathyal zones (*Bulimina-Bolivina* zones) of the lower half of the Kazusa Group, and the thin-walled specimens are also found together.

The *G. tosaensis-truncatulinoides* group increases in abundance in the upper half of the group above the *Uvigerina akitaensis* Zone and it is more frequenet in the *Cassidulina* zones. In these horizons, the thin-walled form becomes more common and gradually changes to have the modernized morphology of *G. truncatulinoides*. Usually, thin- and thick-walled specimens appear to occur together, and the latter form, *G. tosaensis*, ranges upwards at least to the Mandano Zone. MATOBA (1967) reported the analogous range of occurrence and frequency distribution of these two species from the Kazusa Group distributed in the Choshi area.

The dextral coiling of the *G. tosaensis-truncatulinoides* group is prevalent throughout the interval from the *Bulimina striata* Zone up to the uppermost part of the sections. The sinistrally coiled specimens are sporadically found in several horizons.

G. tosaensis or *G. truncatulinoides* is very rare in Yokohama. The form of *G. tosaensis* occurs in the Ofuna and Nakazato Formations, but *G. truncatulinoides* is found in the Nakazato, Iimuro and Kakio Formations.

These evidences of distribution would present some questions about the specific separation and the range of morphological variations of these two forms. It is clearly observed that many of the specimens from the lower horizons have generally the characteristics of *G. tosaensis*, and that the higher the horizons in the Kazusa Group, the larger becomes the number of modernized *G. truncatulinoides* specimens. However, the above-mentioned features of *G. tosaensis* cannot serve as practical diagnoses of specific separation, because of the co-existence of the two extreme forms of different features.

The thickness of wall depends on the ecology as already pointed out by BOLLI (1964) and BOLLI and BERMÚDEZ (1965). Considering the results presented by BÉ (1964), some other characters and the general appearance of the so-called *G. tosaensis* seem to depend partly on this secondary thickening of the wall. The obliqueness of the dorsal sutures may be the only favorable criterion superficially recognized in my material for vertical two-fold division of the *G. tosaensis-truncatulinoides* lineage. The sutures of the specimens from the lower horizons are oblique and slightly more curved, whereas those from the upper are radial in general (PARKER, 1967).

The morphological changes from "*G. tosaensis*" to *G. truncatulinoides* occur progressively in Boso. Any abrupt change in morphology which may serve as a stratigraphic marker has never been detected in the thick sequence of the Kazusa Group. If the previous definition of these two species was followed, the evolutional changes from "*G. tosaensis*" to "*G. truncatulinoides*" cannot be recognized in the Boso material, and it seems to be probable that the two forms fall within the normal variation range of *G. truncatulinoides*. In that case, *G. tosaensis* is interpreted as the deep water variant of *G. truncatulinoides*. For instance, I believe that "*G. tosaensis*" and "*G. truncatulinoides*" illustrated from the Choshi area (MATOBA, 1967) would belong to the same species. It requires a more precise specific definition before further discussion is made on the morphological evolution of *G. tosaensis-truncatulinoides* group and a chronologic correlation is attempted. Owing to the insufficiency of adequate material, any more comment or specific emendation cannot been given on these two species.

In any case, it can be said that "*G. tosaensis*" and *G. truncatulinoides* may not be very useful index species for the zonation and correlation of the Upper Pliocene to Lower Pleistocene of central Japan. Moreover, the inital appearance of *G. truncatulinoides* (s. l.) is probably much influenced by the water temperature condition and depth of the basins (BOLLI, 1964; PARKER, 1967; HUANG, 1967).

Globorotalia crassaformis and *G. inflata*

Specimens of the *Globorotalia crassaformis-inflata* group are found throughout the whole sections. These are very rare or almost absent in the basal part of the *Gyroidina-Melonis* Zone where the planktonic foraminifera are scanty. The morphology is variable and the majority of specimens belongs to *G. crassaformis* or the transitional form to *G. inflata.*

Specimens of the more typical *G. inflata* appear in the middle part of the *Gyroidina-Melonis* Zone and the number of individuals gradually increases upwards. So, *G. inflata* is more common and is one of the important constituents of the planktonic foraminiferal faunas in every horizon of the *Bulimina-Bolivina* and the higher zones.

G. crassaformis and *G. inflata* are both constantly sinistrally coiled in the Kazusa Group, but the dextrally coiled specimens of *G. inflata* are occasionally found among the large number of the sinistral specimens.

Globorotalia hirsuta

Globorotalia hirsuta makes its initial appearance in the upper part of the *Bulimina striata* Zone and occurs sporadically in the Kazusa Group. The Boso specimen is smaller than the typical form and belongs to group 3 of PARKER (1962).

Sphaeroidinella species

Occurrence of *Sphaeroidinella* is also very rare in Boso. *Sphaeroidinella subdehiscens* and the morphologically transitional form between *S. subdehiscens* and *S. dehiscens* are rarely found below the middle horizon of the *Gyroidina-Melonis* Zone. In this horizon typical *S. dehiscens* occurs initially and ranges in occurrence upwards into higher horizons.

In Yokohama, *Sphaeroidinella* is seldom found in the Kazusa Group. *S. dehiscens* is found in the middle part of the Nojima Formation.

Globorotalia tumida

Globorotalia tumida (s. l.) is sporadical in occurrence, but is found in almost the whole range of the examined sections, excluding the basal part of the *Gyroidina-Melonis* Zone and some cold water horizons in the upper part of the Kazusa Group.

This species appears to be consistently sinistrally coiled throughout; however, dextrally coiled specimens were recognized in the samples from the following horizons:

(1) the middle part of the *Gyroidina-Melonis* Zone,
(2) the upper part of the *Cassidulina subcarinata* Zone, and
(3) the lower part of the Nojima Formation, Yokohama.

Remarks on the Boundaries

The *Gyroidina-Melonis* Zone and the the *Gyraidina* cf. *orbicularis* Zone in the lower part of the Kazusa Group are characterized by the following events in the planktonic foraminiferal faunas:

(1) the sinistral coiling of *Pulleniatina obliquiloculata*,
(2) the initial appearance of *Sphaeroidinella dehiscens*,
(3) the initial appearance of *Globorotalia tosaensis*,
(4) the increase in frequency of *Globorotalia inflata*, and
(5) the absence of the so-called Miocene zone index (except the basal part of this interval).

According to BANDY's scheme (1963a, 1964) of the planktonic foraminiferal zonation, these characters make this interval roughly correspond to the Lower Pliocene, and the *Sphaeroidinella dehiscens dehiscens datum* (=Miocene-Pliocene boundary of BANDY) can be expected in the lower part of the *Gyroidina-Melonis* Zone or in the horizon not far below it. Therefore, it would be better to place the boundary at the base of the Kazusa Group tentatively until further details become known.

According to another scheme proposed by BANNER and BLOW (1965) and PARKER (1967), the *Bulimina-Bolivina* zones in the lower and middle parts of the Kazusa Group are largely included in the Upper Pliocene. Up to the present there has been no useful zone index to determine the base of the Pliocene in Boso. *Globigerina nepenthes*, *Sphaeroidinella seminulina* and other planktonic species are found in the Kiyosumi Formation and the equivalent Zushi Formation of the Miura Group (SAITO, 1962-1963, and my observation). However, these species are no longer regarded as an index of the Upper Miocene. The morphological transition from *Sphaeroidinella subdehiscens* to *S. dehiscens* may be the only important criterion for decision of the Miocene-Pliocene boundary in Boso.

The Pliocene-Pleistocene boundary cannot be determined exactly in Boso by means of the morphological evolution of the *Globorotalia tosaensis-truncatulinoides* group (BANNER and BLOW, 1965; PARKER 1967). At present, the correlation with the planktonic foraminiferal zonation proposed in the tropical regions cannot be made for this horizon in Boso.

Acknowledgements—I wish to express my thanks to Prof. Wataru HASHIMOTO of the Tokyo University of Education for his encouragement and guidance,

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Choshi	銚子	Kiyosumi	清澄
Hayama	葉山	Nakazato	中里
Iimuro	飯室	Nobori	登
Iioka	飯岡	Nojima	野島
Isumi	夷隅	Ofuna	大船
Kakio	柿生	Yoro	養老
Kazusa	上総	Zushi	逗子

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554. LOWER PERMIAN BRACHIOPODS FROM NAKAKUBO, WEST-CENTRAL SHIKOKU, JAPAN*

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and

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四国西中央部中久保産早期ペルム紀腕足類： 西南日本外帯の愛媛県上浮穴郡柳谷村中久保付近の石灰岩より産出した腕足類を検討し，11属14種を識別しえた。これら腕足類化石群の構成要素の多くは，中国の下部ペルム系太原統および船山統の腕足類化石群のそれらと密接な関係をもち，またテチス地域の各地や南米西部の下部ペルム系産腕足類化石群中にも共通種ないし近縁種を見出しうる。さらにこの腕足類化石群に密接に伴われる4種のフズリナ化石が，いづれも九州矢山岳石灰岩の *Pseudoschwagerina minatoi* 帯石灰岩およびこれに対比される各地の下部ペルム系石灰岩を特徴づける種であることから，腕足類化石群の時代が後期サクマール世であることが明確となった。 柳田寿一・平田茂留

Introduction

Because of the rare occurrence of fossil brachiopods in the Lower Permian of Japan, a species assemblage herein described from the Outer zone of Southwest Japan is of special interest. No brachiopod fossils of the Early Permian age have as yet been described systematically from the Outer zone of Southwest Japan. The brachiopod fauna described in this paper was found from a fossiliferous limestone of the Permian Nakakubo Formation** at about 1 km west of Nakakubo, Yanadani-mura, Kamiukena-gun, Ehime Prefecture. The Nakakubo Formation is geologically located in the northern zone of the Chichibu terraine which consist mostly of the Carboniferous to Permian formations. There are two lenticular limestones in different horizons at Nakakubo, locating in a close distance of about 50 m with each other. Their general attitudes are N 80° W strike with nearly vertical dip. Each of them is a thin limestone in less than 10 m thick, extending about 30-50m from east to west. The western limestone, which is superficially lower, is larger than the other. They often intercalate thin pyroclastic rocks which generally merge into limestones. The limestones are whitish grey and massive,

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** The detailed stratigraphic descriptions of the Nakakubo and other formations in this area will be reported by HIRATA in near future.

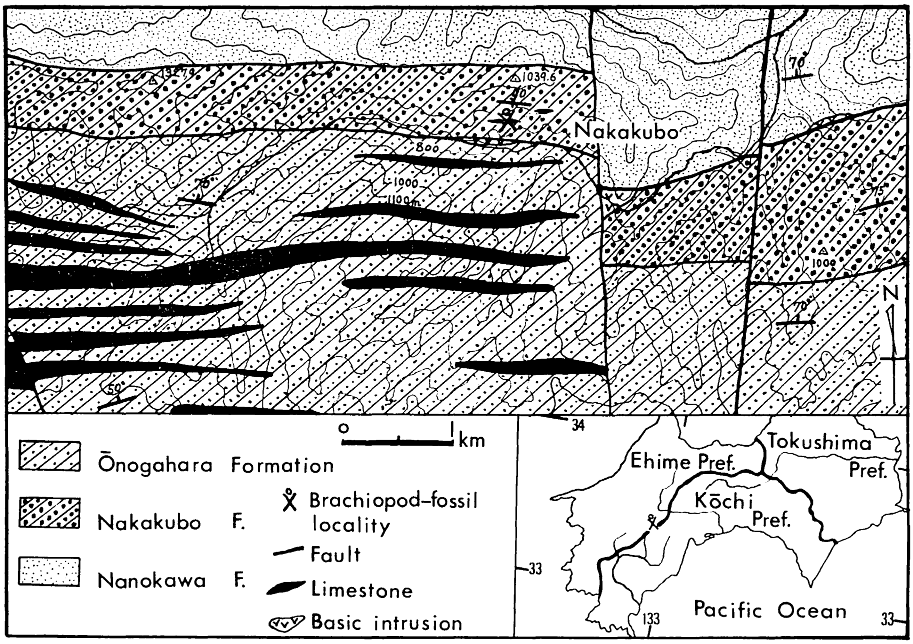

Fig. 1. Map showing the locality of brachiopods and the general outline of geology of the Nakakubo area (a part of the unpublished geological map of HIRATA).
Ōnogahara Formation: Lower to Middle Permian; mainly consists of sandstones, slates, pyroclastic rocks, limestones, and thin bedded cherts; limestones generally contain fusulinaceans.
Nakakubo Formation: Lower Permian: mainly consists of sandstones, slates, and pyroclastic rocks often intercalated with small lenticular limestones and dolomitic limestones; limestones partly contain fusulinaceans, brachiopods, corals, pelecypods, and gastropods.
Nanokawa Formation: ? Lower to ? Middle Permian; mainly consists of phyllites.

and consist of bioclastic calcarenite, including abundant fusulinaceans and brachiopods, and small amount of corals, crinoids, pelecypods, and gastropods. The brachiopods, however, are restricted in occurrence only in the western larger limestone. HIRATA (1958) once found the fusulinaceans from these limestones and recorded *Parafusulina* sp. from the eastern limestone and *Triticites* sp. from the western one. Later, HIRATA (1961) found a rich brachiopod fauna along with gastropods from the western limestone and recorded the followings: *Spirifer* sp., *Squamularia* sp., *Rhynchonella* spp., *Enteletes* ? sp., *Meekella* sp., *Leptaena* ? sp., *Pleurotomaria* ? sp.. The materials dealt with in this paper are based on HIRATA's former collections and our new collections.

The species assemblage herein described consists mainly of the Lower Permian elements. Most of the species have their equivalent species or close allies commonly found in the Lower Permian of Asian continent. Very few species are allied with species in the Lower Permian of South America.

Apart from brachiopods it is very important that the limestones contain abundant fusulinaceans in association with brachiopods. The following species are recognized: *Pseudoschwagerina minatoi* KANMERA, *Triticites* aff. *T. pusillus* (SCHELLWIEN), *Schwagerina stabilis* (RAUSER-CERNOUSSOVA), *Nankinella kawadai* (IGO). These fusulinaceans are all common to those of the *Pseudoschwagerina minatoi* zone of the Yayamadake limestone of the Kuma massif of central Kyushu.

Repository.—The specimens described in this paper under the designation of GK-D will be deposited in the Type Specimen Room, Department of Geology, Faculty of Science, Kyushu University, Fukuoka. Those designated MH will be kept in the Type Specimen Room of Kochi Prefectural Museum.

Acknowledgements.—We wish to express our sincere gratitudes to Professor Ryuzo TORIYAMA who kindly read the typescript of this paper. We are much indebted to Mr. Tomowo OZAWA who kindly gave valuable suggestions on identifying fusulinaceans and took pictures of them.

Systematic descriptions

Family Brachythyrididae FREDERICKS, 1919 (1924)

Genus *Tangshanella* CHAO, 1929

Type-species.—*Tangshanella kaipingensis* CHAO, 1929

Remarks. — The genus *Tangshanella* was orginally described by CHAO (1929, p. 57) with *Tangshanella kaipingensis* as the type-species. It has been hitherto known that the occurrence was restricted in the Tangshan limestone of the Upper Carboniferous Penchi Series of North China. In his definition of *Tangshanella* CHAO described the very fine radiating striae on the shell-surface and showed them by a figure (pl. 7, fig. 14). However, it is impossible to recognize the microornament in his figure, which only shows the dichotomous character of costae. Other figured specimens also show the same character. In Japanese materials we could not observe the character even in well preserved ones. CHAO's description on this character is very exceptional case and it may have no generic value. *Tangshanella* differs from *Purdonella* in having the denticular ridges on interarea and dental plates reduced to teeth ridges. *Tangshanella* is distinguished from *Choristites* by its characteristic internal structure of pedicle valve. The latter has long, stout, and parallel dental plates.

Tangshanella nakakuboensis, sp. nov.

Pl. 10, figs. 12–14; text-figs, 2

Materials.—Holotype, GK-D 30230 (Pl. 10, figs. 12a-c). Available materials consist of 39 specimens of which 29 are the pedicle valves and other 10 are the brachial ones. A pedicle valve, GK-D 30237, was serially sectioned to show the internal structures.

Descriptions.—Shell of medium size, transversely suboval in outline, greatest width at about mid length of shell; pedicle valve convex with largest convexity at umbo; beak pointed and slightly incurved; median sulcus well developed, broad and shallow at anterior margin, median deepest part very narrow and distinct along its all length; cardinal extremities rounded; interarea high and slightly concave with fine denticular ridges of 2 or 3 in distance of 1 mm and broad delthyrium, occupying about one third of hinge at its base; postero-lateral slopes slightly concave; brachial valve much wider than length, strongly convex, longitudinally uniformly convex; median fold broadly convex and highly elevated; lateral slopes slightly convex without clear boundaries between median fold. Pedicle valve ornamented by well rounded costae, increasing in number by bifurcation; first bifurcation occurs at about one third or one quarter length of shell from beak, costae often bifurcate again anteriorly; about 15 to 20 costae on each lateral slope and about 10 in sulcus of adult specimen; intercostal furrows sharp and their widths much narrower than costae; costae gradually decrease strength postero-laterally and shell-surface almost smooth near cardinal extremities; very fine, tightly arranged growth-striae with some stronger ones at intervals often observable at antero-lateral part of valve. Brachial valve similarly ornamented to opposite valve.

Pedicle valve interior with weak dental plates reduced to teeth ridges as shown in Fig. 2.

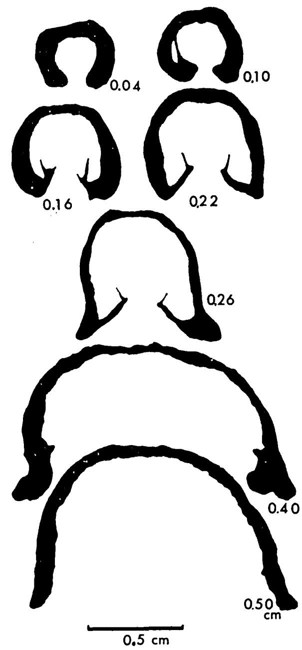

Fig. 2. Transverse serial sections of a pedicle valve, GK-D 30237.

Dimensions of the holotype and other 5 specimens in mm and degree.—	1 (Holotype)	2	3	4	5	6
(pedicle valve)						
length	21.5	29.0	44.0			
width	31.6	ca. 33	ca. 45			
thickness	9.0	12.0	18.0			
apical alnge	ca. 56°	ca. 65°	ca. 70°			
length along curvature	29.0	39.0	60.0			
height of interarea	5.0	6.0	7.0			
width of delthyrium	4.5	6.0	7.0			
delthyrial angle	ca. 55°	ca. 60°	ca. 60°			
greatest width of median sulcus	ca. 12	ca. 12	20.0			
(brachial valve)						
length				25.0	23.0	30.0
width				37.0	28	ca. 42
thickness				7.0	7.0	11.0
length along curvature				ca. 30	ca. 28	ca. 40
greatest width of median fold				ca. 14	ca. 14	ca. 16

Remarks.—Tangshanella nakakuboensis is superficially similar to *T. kaipingensis* CHAO from the Penchi Series of Kaiping coal basin, Chihli, North China, but in the former the umbonal region is more slender and umbonal slope is more concave than those of the latter. Costae on pedicle valve gradually taper the strength postero-laterally and become faint or completely disappear near the hinge in the Japanese species. While the specimens illustrated by CHAO have the distinct costae even near the hinge. Comparison of the brachial valves between Japanese and Chinese species shows that the former clearly differs from the latter in following features: the umbonal region of the Chinese species is highly convex and anteriorly the profile is nearly flat; the profile of the Japanese species shows the uniformly strong arch, and consequently the median portion is most inflated. The figured Chinese specimen (CHAO, 1929, Pl. 7, fig. 14) of brachial valve has a strong median fold, which is clearly distinguishable from each lateral part along its whole length. The Japanese species also has a strong median fold which is, however, only separable from each lateral part at anterior half of the valve.

Family Uncinulidae RZHONSNITSKAYA, 1956

Subfamily Hypothyridininae RZHONSNITSKAYA, 1956

Genus *Uncinunellina* GRABAU, 1932

Type-species.—Uncinulus theobaldi WAAGEN, 1884

Remarks. — *Uncinunellina* was incompletely defined by GRABAU (1932) with *Uncinulus theobaldi* WAAGEN (1884, p. 425-427) as the type-species. In his definition of the genus the external characters were only concerned. The internal characters of *Uncinulus theobaldi* was originally insufficiently described by WAAGEN. He only emphasized large, diverging dental plates recognized in the pedicle valve.

WANG, JING, and FANG (1964, p. 391-392) redescribed *Uncinunellina* and pointed out some distinguishing internal characters based on the Chinese materials such as posteriorly developed and distantly disposed dental plates in pedicle valve, and slender crura and long median septum without septalium and cardinal process in brachial valve, but gave no figures of them. It is rather difficult to compare in detail the internal characters of Chinese materials of *Uncinunellina* with those of the Japanese ones. Internal structures of seven Japanese specimens including two brachial valves were examined by their serial sections and it was confirmed that the dental plates are generally welding to wall or obsolete. In this point of view Japanese materials are more or less different from those of WAAGEN's *Uncinulus theobaldi* and some Chinese species referred to *Uncinunellina*. However, the dental plates treated as the generic character by WANG, JING, and FANG make a suggestion that the Chinese materials also have those very close to shell wall. The brachial valve interiors of the Japanese materials are characterized by completely separated hinge plate without making septalium same as in the Chinese materials. They are also characterized by very low obsolescent median ridges. They are often very obscure by burying in the strongly swollen valves. WANG et al. pointed out long median septum as one of the generic character of *Uncinunellina*. However, some variations are recognized in the internal structures among the Japanese materials. The Japanese materials also completely lack the cardinal process like the Chinese materials.

Taking these characteristics of the Japanese materials into consideration they clearly possess the generic characters of *Uncinunellina* diagnosed by WANG, JING, and FANG.

Uncinunellina shikokuensis, sp. nov.

Pl. 11, figs. 1; text-figs. 3-4

Materials.—Holotype, GK-D 30244 (Pl. 10, figs. 1a-d). A large number of specimens are available under the heading. Internal structures were examined and shown by the serial sections of two specimens, GK-D 30245 and GK-D 30246.

Descriptions.—Shell small to medium, transversely subpentagonal in outline with unequally convex valves; pedicle valve slightly convex with largest convexity at umbo; umbo small, weakly convex with erect beak; very shallow median sulcus at anterior half, rapidly becoming broad near anterior margin where it acutely bends with angles of nearly 90° and continues to large linguiform extension; length of linguiform extension often attains same with that of pedicle valve; lateral sides sharply truncated by short length; pedicle valve exterior ornamented by numerous subround costellae with rare bifurcation on posterior half of valve, 16–18 in 10 mm at about mid portion of valve and about 10 on median sulcus; narrow subangular grooves between costellae tend to become deep as costellae increase their widths anteriorly and at frontal margin grooves revealed as sharp incisions. Brachial valve transversely less convex than longitudinal with largest convexity at umbo; umbo strongly convex with beak completely concealed by ventral umbo; median fold low, broad, only distinguishable at anterior half of valve; anterior part of fold sharply bends toward linguiform extension showing acute margin of fold; ornament of brachial valve also consists of numerous costellae with quite similar characters to those of opposite valve; commissure on truncated part finely zigzag.

Interior of pedicle valve usually without dental plates, but rarely thin and short ones in umbonal part, reducing to teeth. Brachial valve interior with strong hinge plates lacking connecting plate between them; sockets deep with prominent inner socket ridges; median septum very short, only recognizable as a short ridge, but scarcely distinguishable or absent at all in swollen valve.

Dimensions of the holotype and other 3 specimens in mm and degree.—	1 (Holotype)	2	3	4
length	13.5	14.2	13.1	13.2
width	17.5	15.0	15.5	18.5
thickness	13.2	9.4	11.0	11.0
cardinal angle	ca. 85°	ca. 85°	ca. 100°	ca. 85°
length along curvature of pedicle valve	25.0	20.0		ca. 20
length along curvature of brachial valve	16.0	15.0	16.0	
width of median sulcus and fold at anterior margin	12.3	9.5	9.5	13.5
number of costellae on sulcus and fold	11	10	10	12
length of linguiform extension of pedicle valve	10.0	ca. 5.5	9<	8<

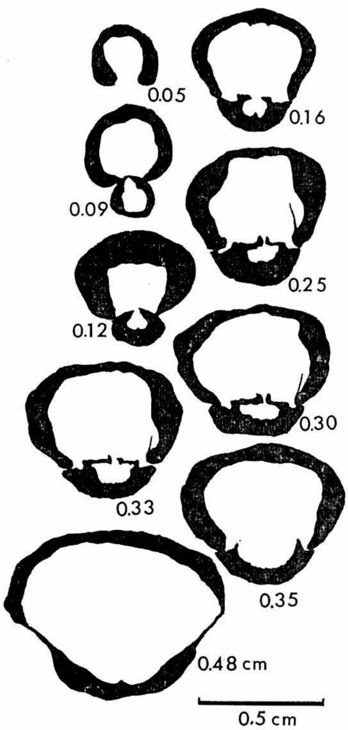

Fig. 3. Transverse serial sections of a complete specimen, GK-D 30245. Note the hinge plates lacking connecting plate between them and very low median septum in brachial valve.

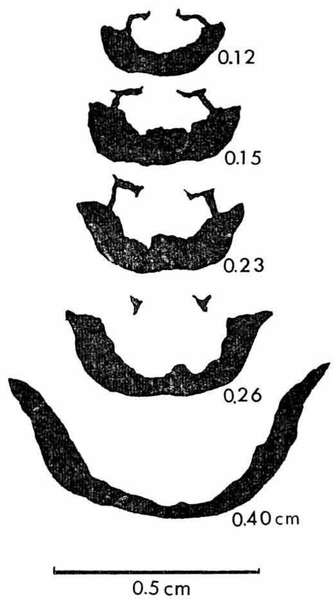

Fig. 4. Transverse serial sections of a brachial valve, GK-D 30246.

Remarks.—*Uncinunellina shikokuensis* superficially resembles *Uncinunellina wangenheimi* (PANDER) from the *Schwagerina* limestone of Ural by its pentagonal outline, strongly elongate linguiform extension, strongly vaulted frontal view of brachial valve, and subtriangular lateral profile. But the internal structures of the latter are unknown. *Uncinunellina wangenheimi*, however, is clearly distinguished from *Uncinunellina shikokuensis* by its much larger size, fewer and coarser costellae. In Asian continent *Uncinunellina wangenheimi* was described by GRABAU (1936) from the Lower Permian of Maping limestone of Kueichow. Externally the Chinese specimens also resemble the Japanese ones. But the formers are clearly distinguishable from the latters by their same external characters with the Russian specimens. In addition to them GRABAU described well developed dental plates which are generally absent or only obsoletely recognizable in the Japanese specimens.

Family Enteletidae WAAGEN, 1884

Subfamily Enteletinae WAAGEN, 1884

Genus *Enteletes* FISCHER DE WALDHEIM, 1825

Type-species.—Enteletes glabra FISCHER DE WALDHEIM, 1830

Enteletes gibbosus CHRONIC, 1949

Pl. 11, fig. 12

1953. *Enteletes gibbosus* CHRONIC, NEWELL' CHRONIC, and ROBERTS, *Geol. Soc. America*, Mem. 58, pp. 92-93, pl. 16, figs. 9a-14.

1966. *Enteletes gibbosus*, HAYASAKA and KATO, *Jour. Fac. Sci., Hokkaido Univ.*, vol. 13, no. 3, pp. 281-286, pl. 34, figs. 1-4, pl. 35, figs. 1-4.

Materials.— Internal structures were examined by the serial sections of a specimen, GK-D 30259. More than 20 specimens are available under the heading.

Descriptions.—Shell small, nearly equal in length and width, highly biconvex with brachial valve more convex and larger than pedicle valve and with short hinge line. Pedicle valve moderately convex, posterior half more strongly convex than anterior one with largest convexity at umbo; beak bluntly pointed and strongly incurved; interarea concave, very narrow, low, and obsolete; posterior lateral sides very steep, becoming flattened near commissure and highly concave along commissure; median sulcus broadly appears at about quarter of shell-length from beak, shallow and rounded posteriorly, increasing in width and depth toward anterior margin where sulcus deep, angular, and dorsally strongly projects. Brachial valve strongly convex with largest convexity at umbo; umbo broad and beak incurved, slightly projecting beyond hinge; lateral sides similar to opposite valve; median fold originates at about a sixth of valve-length from posterior margin, becoming wider and higher anteriorly and sharply elevated near anterior margin. Both valves ornamented by angular acute plicae, usually counting 3 on each side of sulcus and fold, decreasing strength toward lateral margins and outermost ones of each valve faintly visible or often undistinguishable; each furrow between plicae usually of similar width and sharpness with plicae at same growth-stage; anterior commissure characterized by sents very acute zigzag line; very fine striae on both valves, increasing in number by bifurcation, 7 to 8 in distance of 1 mm at about 3 mm from beak and about 5 in same distance near anterior margin; growth lines usually faint but sometimes 1 or 2 prominent ones at a distance near anterior margin.

Pedicle valve interior with long, slender, and parallel dental plates and median septum; brachial valve interior with curved crural plates and a low median septum.

Remarks:—The Nakakubo specimens are characterized by strongly inflated valves, ornamentation with prominent

Dimensions of 3 specimens in mm.—	1 (complete shell)	2 (ped. valve)	3 (br. valve)
length	13.5	14.1	14.3
width	13.0	14.5	14.9
thickness	14.6	9.4	7.9
length along curvature of pedicle valve	24.5	23+	
length along cuavature of brachial valve	22.0		
number of lateral plicae	3	3	3
length of hinge line	5.9	ca. 7	ca. 6.5

and very few plicae, high and acute fold, and anteriorly strongly incised median sulcus. Based on these characteristics the Nakakubo species is apparently referable to the South American species *Enteletes gibbosus* CHRONIC. Slight difference of the Nakakubo specimens from the South American ones is on their generally smaller size. In this point of view we first threw doubt on identifying the former to the latter. However, all of the external characteristics of the Nakakubo specimens are quite common with the others and moreover they also include few incomplete larger specimens. Their internal characters are also in harmony with the South American ones. Thereupon we concluded without doubt that the Nakakubo specimens and the South American ones belong to one and the same species.

Enteletes gibbosus was also recorded in Japan by HAYASAKA and KATO (1966) from the Lower Permian Miharanoro Formation, Hiroshima Prefecture, Inner zone of Southwest Japan in association with fusulinaceans. Although the majority of the Miharanoro specimens seems to be slightly larger than the Nakakubo ones, their external and internal characteristics are quite equivalent with each other.

Among the known species of *Enteletes* in the Tethyan province there are few which have globose shells. But all of them are clearly distinguished from *E. gibbosus* by the difference of shell outline, number and nature of lateral plicae, mode of growth of median sulcus and fold, and proportion between pedicle and brachial valves.

Family Elythidae FREDERIKS, 1919 (1924)

Genus *Phricodothyris* GEORGE, 1932

Type-species.—Phricodothyris lucerna GEORGE, 1932

Phricodothyris sp.

Pl. 10, figs. 6–8

Materials.—More than 40 specimens, including several fragmentary ones, are available. Internal structures of pedicle and brachial valves were respectively examined by serial sections of specimens, GK-D 30289 and GK-D 30296.

Descriptions.—Shell medium to large biconvex with pedicle valve more convex than opposite, transversely suboval with greatest width at about mid length of shell; pedicle valve highly convex in posterior portion with elevated umbo: beak highly incurved, slightly projecting over deltidium; hinge line short, about three fifth of shell-width; cardinal extremities rounded; width of interarea less than a half of shell-width with very narrow delthyrium at mid of it; median sulcus shallow and broad, originating at slightly anterior to umbo and becoming wider and deeper anteriorly. Brachial valve uniformly convex with largest inflation at mid length of it; umbo broadly pointed with beak slightly incurved beyond hinge; broad and very low median fold only distinguishable at about anterior third of valve; anterior commissure uniplicate. Both valves ornamented by closely arranged weak growth lines, about 10 to 12 in 5 mm in adults; very fine biramous spine bases anteriorly set on each growth line, 5 to 6 in 1 mm on mid valve. Pedicle valve interior without dental plates and median septum. None of distinguishable structures observed in brachial valve interior.

Dimensions of 2 specimens in mm and degree.—	1 (pedicle valve)	2 (brachial valve)
length	ca. 23	21
width	ca. 27	25
thickness	8.5	5
apical angle	85°	
length of hinge line	15	15
length along curvature	ca. 30	ca. 25

Remarks.—The Nakakubo specimens are all characterized by distinct median sulci and folds on pedicle and brachial valves respectively. In the Asian continent the specimens of *Phricodothyris toriyamai* YANAGIDA from the Lower Permian of Thumnammaholan, central Thailand, strongly resemble the Nakakubo specimens, especially in having distinct median sulci. But the Thailand specimens are clearly distinct from the latter in lacking median folds on anterior parts of brachial valves. In South China *Ph. extensa* (GRABAU) and *Ph. kwangsiensis* (WANG) from the Maping limestone are similar to the present species in their outlines and especially in having median depression and median sulcus respectively. The distinction between these two species and the present one is that the former two completely lack the median fold. Moreover, their both valves are ornamented by coarse, strong concentric bands of growth, while the Japanese species has fine and closely spaced ones. It is worthy of note that variations in outline are recognizable in the Nakakubo specimens. There exist some intermediate forms between transverse and less transverse ones.

Phricodothyris cf. *P. asiatica* (CHAO)

Pl. 10, figs. 9, 10

Compare.—

1929. *Squamularia asiatica* CHAO, *Palaeont. Sinica, ser. B*, vol. 11, fisc. 1, p. 91, pl. 11, figs. 12–14.
1936. *Squamularia asiatica*, GRABAU, *Ibid., ser. B*, vol. 8, fasc. 3, p. 71, pl. 5, figs. 3, 4.
1965. *Neophricodothyris asiatica*, CHAO, *Acta Palaeont. Sinica*, vol. 13, no. 3, p. 436, pl. 5, figs. 10, 11.
1967. *Phricodothyris asiatica*, YANAGIDA, *Geol. Palaeont. Southeast Asia*, vol. 3, pp. 75, 76, pl. 14, figs. 1, 2, 5, 7.

Materials.—Two small, umbonally broken pedicle valves, GK-D 30287 and GK-D 30288, are available with following dimensions respectively: length, 6 mm+, 7.1 mm+; width, 7.2 mm, 80 mm; thickness, 2.9 mm, 3.4 mm.

Descriptive remarks.—Shell small, suborbicular, nearly equal in length and width or slightly wider than long. Pedicle valve slightly convex with transverse profile more convex than longitudinal one; cardinal extremities remarkably rounded; posterior part highly elevated; hinge about a half length of greatest width; greatest width at about mid valve; interarea narrow, low, and highly concave; no distinct median sulcus, only revealed as narrow faint depression from umbo to anterior margin. Pedicle valve ornament with concentric growth bands, about 4 in 2 mm at mid valve, and very fine biramous spine bases along anterior margins of growth bands, about 8 to 10 in 1 mm at median anterior part.

The Nakakubo specimens are only represented by incomplete pedicle valves and their internal structures are unknown. But they are strongly comparable with those of the Chinese Lower Permian *Phricodothyris asiatica* (CHAO) in their characteristically rounded outlines, small sizes, and broad distinct concentric bands with fine spine bases.

Phricodothyris echinata (CHAO)

Pl. 10, figs. 4, 5

1929. *Squamularia echinata* CHAO, *Palaeont. Sinica, ser. B*, vol. 11, fasc. 1, pp. 86-89, pl. 8, figs. 17-19.

Materials.—Two small pedicle valves, GK-D 30289 and GK-D 30290, with following dimensions respectively: length, 9.5 mm, ca. 9 mm; width, 9.5 mm, ca. 9 mm; thickness, ca. 4 mm, ca. 4 mm.

Descriptive remarks.—Shell small, subcircular, nearly equal in length and width, transversely more convex than longitudinal. Pedicle valve highly convex with rounded cardinal extremities; umbo strongly convex with beak highly incurved over narrow delthyrium hinge slighly shorter than a half of shell-width; greatest width at about mid valve; interarea narrow and moderately concave; median sulcus completely absent. Pedicle valve ornamented by slender concentric bands of growth and very fine, rounded double-barreled spine bases on each growth-band, counting about 4 in 1 mm on anterior surface; growth-bands anteriorly more tightly arranged than mid valve.

The Nakakubo specimens have the following external characteristics which CHAO (1929) diagnosed as the specific characters of *Ph. echinata*: subround pedicle valve with nearly equidimensional or rather slightly elongate outline; weak, generally broad growth-bands which tend to become narrow toward anterior margin; large, loosely arranged, double-barreled spine bases on growth-bands. In these points of views the Nakakubo species is clearly identifiable with *Phricodothyris echinata* from the Upper Carboniferous Penchi and Lower Permian Taiyuan Series of North China.

Family Spiriferinidae DAVIDSON, 1884

Genus *Callispirina* COOPER and MUIR-WOOD, 1951

Type-species.—Spiriferina ornata WAAGEN, 1883

Callispirina aff. *C. ornata* (WAAGEN)

Pl. 10, figs. 11, 16

Compare.—

1883. *Spiriferina ornata* WAAGEN, *Palaeont. Indica*, ser. 13, vol. 1, fasc. 2, pp. 505-506, pl. 50, figs. 1-2.

Materials.—Available specimens are composed of 11 incompletely preserved ones, including 10 pedicle valves and a brachial valve.

Descriptions.—Shell small, strongly biconvex with pedicle valve more convex than opposite one, and subround in outline. Pedicle valve strongly inflated, highly convex with transverse profile more convex than longitudinal one and largest convexity at posterior half; cardinal extremities rounded; largest width at mid length of valve; length of hinge line about five seventh of shell-width; interarea highly concave with narrow high delthyrium at mid portion; surface of interarea longitudinally very finely striated; distinct edges of deltidial plates along lateral margins of delthyrium; median sulcus wide, smooth, making shallow depression with median deepest part slightly incised; each lateral

Dimensions of 4 specimens in mm and degree.—	1	2 (pedicle valves)	3	4 (brachial valve)
length	8.2	10.2+	7.5	7.8
width	10.4	ca. 12	8+	8.9
thickness	5.2	7.3	3.5	5.0
length along curvature	ca. 15	15+	10.0	ca. 11
length of hinge line	6.5	7.8	5.3	ca. 7
height of interarea	3.0	ca. 5	2.2	
width of delthyrium	ca. 1.3	2.9	0.9	
width of sulcus or fold at anterior margin	4.0	5.2	3.5	3.6
apical angle	ca. 85°		ca. 80°	ca. 150°
angle of cardinal extremities	ca. 110°	ca. 130°	ca. 120°	ca. 85°

slope ornamented by 3 or 4 subangular simple costae; microornaments on valve not recognizable because of poor state of preservation. Brachial valve moderately inflated with largest convexity at posterior half; umbo strongly incurved; median fold very strong, smooth, and subangular on posterior half, rapidly increasing width and strength toward anterior margin where it makes much rounded crest; each lateral slope ornamented by 4 subangular simple costae; microornaments not visible. Internal structure not preserved at all.

Remarks.—The Nakakubo specimens are characterized by nearly equidimensional outlines, strongly inflated valves, high and moderately concave interareas, broad, shallow and smooth median sulcus, high strong median fold, and few remarkable costae. In these points they resemble *Callispirina ornata* (WAAGEN) from the Middle Permian of Salt Range. *Callispirina ornata*, however, is distinguishable from the Nakakubo species by having more rounded cardinal extremities and the stronger costae. The median sulcus of *C. ornata* is sharply incised on the bottom. That of the Nakakubo species is less angulate and rather shallow.

The general outline and radial ornamentation of the Nakakubo species closely resemble those of some species of *Punctospirifer*. For example *P. inflatus* CHRONIC and *P. adstrictus* CHRONIC from the Lower Permian Copacabana Group of Peru are the highly similar species. The Peruvian specimens, however, are principally distinguishable from the Nakakubo ones by having the imbricate growth lamellae. Although the shell surface of the Nakakubo specimens are more or less exfoliated, it is impossible to recognize even the trace of growth lamellae on rather well preserved specimens. This means that the Nakakubo specimens fundamentally have no such imbricate structure and are ornamented only by very fine growth lines which were now completely lost by exfoliation.

Family Spiriferidae KING, 1846

Genus *Neospirifer* FREDERIKS, 1919 (1924)

Type-species.—Spirifer fasciger KEYSERLING, 1846

Neospirifer cf. *N. fasciger* (KEYSERLING)

Pl. 10, fig. 15

Compare.—

1846. *Spirifer fasciger* KEYSERLING, *Reise nach Petschora Land*, p. 231, pl. 8, figs. 3, 3a, 3b.
1902. *Spirifer fasciger* TSCHERNYSCHEW, *Mem. Com. Geol.*, pp. 141-143, pl. 38, figs. 3, 4; pl. 49, fig. 1.
1912. *Spirifer fasciger*, MANSUY. *Mem. Serv. Geol. Indochine*, vol. 1, fasc. 2, pp. 57-59, pl. 5, figs. 5a, b.
1929. *Spirifer fasciger*, CHAO, *Palaeont. Sinica, ser. B*, vol. 11, fasc. 1, pp. 8-11, pl. 1, figs. 8-9, pl. 2, figs. 1-7.
1965. *Neospirifer fasciger*, HAYASAKA, *Coll. Essays in Commem. Tenth Aniv. Shimane Univ.*, pp. 42-44, pl. 1, figs. 1-7, pl. 2, figs. 1, 2.
1963. *Neospirifer fasciger* YANAGIDA, *Mem. Fac. Sci., Kyushu Univ.*, vol. 14, no. 2, pp. 71, 72, pl. 8, figs. 1-7, pl. 9, figs. 1-3.

Descriptive remarks. — Only a single poorly preserved specimen of pedicle valve, GK-D 30274, with dimensions: width, 36.5 mm; length, 22.5 mm; thickness, 10.5 mm; height of interarea, ca. 27 mm, width of delthyrium, ca. 5 mm. Shell medium, uniformly convex with transverse convexity much larger than longitudinal one; hinge line straight, nearly equal to largest width, situating at about slightly posterior to mid length of valve; cardinal extremities subrectangular; umbo acutely elevated with slightly incurved beak; interarea low, weakly concave, and ornamented by very fine, closely arranged denticular ridges, about 5 in 1 mm; delthyrium large, suggesting its basal part about a quarter length of hinge line; median sulcus distinct, sharp at umbo, becoming broad, deep, and round bottomed anteriorly; median sulcus covered by costae, about 20 costae suggested at anterior margin on median sulcus; each lateral slope ornamented by numerous costae with strong fasciculation of 5 rounded fascicles, becoming weak toward cardinal extremity; each fascicle consists of about 3 or 4 costae near anterior margin; mode of increment of costae on median sulcus and lateral slopes unknown.

The Nakakubo specimen is unfortunately poor in preservation and detailed external characters are unknown. However, the outline of shell, shape of median sulcus, number and brief character of fasciculation of costae are closely suggestive of those of *Neospirifer fasciger* (KEYSERLING) of the Permian of the Tethyan province.

Family Notothyrididae LIKHAREV, 1960

Genus *Rostranteris* GEMMELLARO, 1898 (1899)

Type-species.—Dielasma adrianense GEMMELLARO, 1894

Subgenus *Rostranteris* s. st.

Rostranteris (*Rostranteris*) cf. *R.* (*R.*) *nucleolus* (KUTORGA)

Pl. 11, fig 8

Compare.—

1902. *Notothyris nucleouls*, TSCHERNYSCHEW. *Mém. Com. Géol.*, vol. 16, no. 2, pp. 464-466, pl. 42, figs. 9-12.
1931. *Notothyris nucleolus*, GRABAU. *Nat. Hist. Central Asia*, vol. 4, pp. 111-113, pl. 8, fig. 7.

Material. — A small relatively well preserved specimen, GK-D 30275, with following dimensions: length, 10.5 mm; width, 8.3 mm; thickness, 7.5 mm.

Descriptive remarks.—Shell small, uniformly biconvex, and elongate suboval in outline; hinge line much shorter than maximum width; anterior commissure intraplicate. Pedicle valve slightly more convex than brachial one with largest convexity on posterior half; umbo pointed with beak slightly incurved; median sulcus originates at about mid length of shell as a broad, shallow, and smooth depression, becoming slightly wider and deeper toward anterior margin; broad plica, on each side of sulcus occurring at mid length of shell; largest convexity of bracial valve at its mid portion; it characterized by very low fold near anterior margin, a couple of short low plicae on lateral slopes, and very fine growth lines near anterior margin; internal structures unknown.

Although a small specimen is available at the present and only the external characters are examined, the Nakakubo specimen is almost identifiable to those of Russian Lower Permian *Rostranteris* (*R.*) *nucleolus* (KUTORGA) redescribed in detail by TSCHERNYSCHEW (1902). Under the name of *Rostranteris* (*R.*) *nucleolus* (KUTORGA) many forms were recorded from several places of the Permian of Europe and Asia. Among them those which have strongly convex pedicle valves do not probably belong to *Rostranteris* (*R.*) *nucleolus*. Because the original specimen of KUTORGA shown by TSCHERNYSCHEW (pl. 42, fig. 9) clearly reveals the pedicle valve slightly more convex than or almost equal to the brachial valve. The variation in external and internal characters is not known. Such being the case we would like to restrict at present *R.* (*R.*) *nucleolus* (KUTORGA) to the species which is especially characterized by similarly convex both valves.

Rostranteris (*Rostranteris*) sp.

Pl. 11, fig. 7

Descriptive remarks.— An incomplete shell, GK-D 30276, with following dimensions: length, 12.1 mm; width, 9.2 mm; thickness, 5.4 mm. Shell small, weakly biconvex with pedicle valve slightly more convex than brachial one, and elongate oval in outline. Pedicle valve uniformly convex with posterior half relatively more convex than anterior one; umbonal region not preserved but posterior curvature suggests moderately incurved umbo; maximum width at mid length of valve; median sulcus broad and very shallow, originating at slightly posterior to mid length of valve as a faint depression; both sides of sulcus bordered by low rounded costae, subparallel with each other, occurring at posterior half of valve. Brachial valve transversely more convex than longitudinal; umbo pointed; very low fold on anterior third of valve; a pair of weak costae near anterior margin, making smooth shallow depressions between fold; anterior commissure weakly intraplicate; internal structures unknown.

Unfortunately it is impossible to recognize the variation on external characters of this species because only an incomplete specimen is now available. But as far as it is concerned it seems that there is no overseas form which has close similarity to the Nakakubo specimen. It is charactarized by rather weakly convex valves and slightly intraplicate anterior commissure with very low but distinct median sulcus and subparallel costae, and low fold on brachial valve. The Nakakubo species is comparable with *Rostranteris* (*Rostranteris*) *mediteranea* (GEMMELLARO) from the Permian of Sicily in having a distinct median sulcus and subparallel costae. But the Sicilian species is much convex than the Nakakubo one and is clearly distinguishable from the other. The Sicilian species *Rostranteris* (*R.*) *exilis* (GEMMELLARO) is also similar to the Nakakubo species in its outline and having less convex valves for the genus. The former, however, is distinguishable from the latter by its very short median sulcus and costae which are only recognizable at anterior margin.

Family Chonetidae BRONN, 1862

Subfamily Chonetinellinae MUIR-WOOD, 1962

Genus *Neochonetes* MUIR-WOOD, 1962

Type-species.—Chonetes dominus KING, 1938

Neochonetes sp.

Pl. 11, figs. 2, 3

Materials.— An incomplete brachial valve and its external mould, GK-D 30277 and GK-D 30278, respectively, and an incomplete pedicle valve, MH 502 F, are available. Dimensions of pedicle and brachial valves are respectively as follows: length, 6.1 mm, 8 mm; width, 10 mm, 15.5 mm; thickness, ca. 1.5 mm, ca. 1.5 mm.

Descriptive remarks.— Shell small, valves slightly concavo-convex with hinge equal to maximum width; ventral sulcus weakly developed, broadly originating near umbo and anteriorly making a faint depression; width of ventral sulcus at anterior margin about a half length of maximum width; pedicle valve slightly convex with largest convexity at umbo; ears well developed with cardinal extremities nearly to or slightly less than rectangle; pedicle valve exterior finely costellate, about 4 in 1 mm near anterior margin; brachial valve slightly concave without median fold; ears well demarcated; exfoliated surface with fine, radially arranged capillae, about 5 rows in 1 mm near anterior margin; internal structures unknown.

We first doubted whether the Nakakubo species clearly belongs to *Neochonetes* or not because only two incomplete specimens are available. The species of *Lisochonetes* also have the similar external characters to the present species. But we referred the Nakakubo specimens to a species of *Neochonetes* by the following reasons: They have the hinge line as the widest part of the shell but the transverse prolongation is only a little for the remainder; median sulcus of the pedicle valve is broad and appeared as a very weak depression; slightly concave brachial valve has no median fold; shell surfaces of the two valves are more or less exfoliated and clearly capillate but these capillae are principally distinguishable from those which are recognizable on species of *Lisochonetes* when they are decorticated.

The external characters of the Nakakubo species are almost equal to those of the north Chineses Upper Carboniferous Penchian and Lower Permian Taiyuan species described by CHAO (1928) under the name of *Chonetes carbonifera* KEYSERLING especially in having transversely subrectangular outline and indistinguishably weak median sulcus. It is highly possible that both Chinese and Japanese specimens belong to one and the same species.

Family Marginiferidae STEHLI, 1954

Subfamily Marginiferinae STEHLI, 1954

Genus *Marginifera* WAAGEN, 1884

Type-species.—Marginifera typica WAAGEN, 1884

? *Marginifera* sp.

Pl. 11, figs. 5, 6

Materials.—Two small incomplete pedicle valves, GK-D 30279 and GK-D 30280, with following dimensions respectively: length, 7.8 mm, 7.0 mm; width, 7.7 mm, 6.7 mm; thickness, ca. 3.5 mm, ca. 3.4 mm.

Descriptive remarks.—Shell small, strongly convex with suggestion of slight geniculation, and suboval to subround in outline; umbo pointed; beak slightly incurved over hinge; ears incompletely preserved, suggesting small ones; widest part of shell at about mid length of shell. Pedicle valve ornamented by quincuncially arranged erect spines, clear rugae on posterior surface, and weak costellae on anterior surface.

Since the present specimens are very incomplete, their generic position is rather doubtful. Their brief external characters are seemingly suggestive of genera of overtoniinae. The external characteristics of *Krotovia* and *Avonia* are respectively similar to those of the present forms in external configuration, especially in arrangement of spines. But clear rugae on visceral disc distinguish the Nakakubo specimens from those of *Krotovia* in which rugae are only distributed on ears and hinge slopes. Quincuncial distribution of spines on visceral disc and lack of concentric broad band also distinguish them from those of *Avonia*. *Avonia* has no rugae on visceral disc. Judging from these characteristics and anteriorly costellate charcter of the present specimens, it is highly possible to compare them with some species of *Marginifera* which have the similar external characters.

In external characters the Nakakubo species is similar to those Asian species, such as *Marginifera lopingensis* (KAYSER) and *M. jisuensis* CHAO respectively from the Middle and Upper Permian of China, *M. banphotensis* YANAGIDA from the Upper Permian of Thailand, and *M. spinoscostata* (ABICH) from the Permian of Armenia.

Family Linoproductidae STEHLI, 1954

Subfamily Linoproductinae STEHLI, 1954

Genus *Cancrinella* FREDERIKS, 1928

Type-species.—*Productus cancrini* DE VERNEUIL, 1845

Cancrinella sp.

Pl. 10, figs. 1-3

Materials.—A fragmentary and an exfoliated pedicle valves, GK-D 30282 and GK-D 30283 respectively, and an external mould of brachial valve, GK-D 30281. Dimensions of the latter two specimens are as follows, respectively: length, ca. 22.4 mm, 14.0 mm; width 21.5 mm, 14.3 mm; length of hinge line, 19.0 mm, 10.9 mm.

Descriptive remarks.—Shell medium. Pedicle valve subround and moderately convex; hinge line slightly shorter than widest part of valve; widest part at about mid valve; ear small; umbo moderately convex with beak slightly incurved beyond hinge; rugae numerous across visceral disc and venter, usually weak but rather prominent in umbonal region, flanks, and ears; flanks spreading; costellae rounded, increasing in number by bifurcation, 2 or 3 in 1 mm near anterior margin; bifurcation usually takes place at immediately anterior to spine; spines not numerous, suberect on anteriorly swollen costellae, and arranged in quincunx. Brachial valve slightly and uniformly concave without apparent geniculation; ears small and flat; valve-surface costellate and rugose, especially remarkable on visceral disc with small dimples.

Although they are too incomplete to determine the species, the Nakakubo specimens are characterized by the ornamentation of pedicle valve and the concavity of brachial valve. The fragmentary pedicle valve mainly consists of the majority of visceral disc and a part of venter and flanks. Rugae are remarkably developed on visceral disc and also they are clearly crossing venter. Costae always increase in number by bifurcation and the majority of bifurcation occur at immediately anterior of spines. It is very characteristic that no clear geniculation is found on the brachial valve and it is uniformly concave. The geniculation is only slightly suggestive near anterior margin. If we consider these characteristics above mentioned, it is suggestive that the Nakakubo specimens resemble those of American Pennsylvanian to Permian species, such as *Cancrinella boonensis* SHUMARD and *C. altissima* KING.

Linoproductidae gen. et sp. indet.

Pl. 11, fig. 4

Material.— A fragmentary pedicle valve, GK-D 30284, with following dimension: length, ca. 16 mm; width, ca. 18 mm.

Descriptive remarks.—Shell small, hemispherical, highly and uniformly convex, transversely more convex than longitudinal; hinge line may much shorter than greatest width of valve; widest part at about mid valve; umbo pointed, slightly incurved; ears not clearly ascertained and suggested very small; flanks convex. Pedicle valve ornaments of fine capillae, 5 to 6 in 1 mm on anterior surface, and numerous flexuous rugae, covering all over pedicle valve and becoming stronger anteriorly; spines not ascertained.

Although this pedicle valve is too poor to know its complete shape and external ornamentation, it may clearly be distinguishable from any other known forms by the following peculiar external characters: hemispherical outline and uniformly convex valve; very fine capillae and flexuous, numerous rugae across the whole pedicle valve. Among the linoproductids the similar forms to the Nakakubo specimen are those of Lower Carboniferous *Fluctuaria, Undaria,* and Permian *Compressoproductus.* The Nakakubo from is apparently distinguishable from those of *Fluctuaria* and *Undaria* by its hemispherical outline, highly and evenly convex valve, and very fine capillae. The latter two genera have elongate oval outline and ornamented by costellae. *Fluctuaria* is also characterized by its prominent rugae. *Undaria* is much less convex than the Nakakubo form. Permian cosmopolitan genus *Compressoproductus* resembles the Nakakubo form in its external ornamentation, but the former may be distinguished from the latter by having elongate trigonal outline and highly less convex pedicle valve.

Family Echinoconchidae STEHLI, 1954

Subfamily Echinoconchinae STEHLI, 1954

Genus *Echinaria* MUIR-WOOD and COOPER, 1960

Type-species. - *Productus semipunctatus* SHEPARD, 1838

Echinaria sp.

Pl. 11, figs. 9–11

Materials.— A fragmentary external

mould of brachial valve, GK-D 30285, an incomplete pedicle valve, MH 502 P, and a posterior part of immature specimen, GK-D 30286.

Descriptive remarks.—Shell medium. Pedicle valve broadly sulcate with tapering umbo. Pedicle valve exterior ornamented with broad, slightly raised concentric bands, originating near umbo; each band posteriorly smooth, anterior two thirds covered by numerous very fine spines. Brachial valve slightly concave with broad, low median fold on visceral disc, becoming broader and more prominent anteriorly. Brachial valve exterior ornamented by narrowly arranged concentric bands with fine spines in rows on them.

The three fragmentary specimens at present are undoubtedly identifiable as a species of *Echinaria*. They are more or less similar to those of *Calliprotonia* in external configuration. But the former may be distinguished from the latter by the following characteristics: Posteriorly preserved pedicle valve and the external mould of fragmentary brachial valve suggest that their complete shells are larger than average size of *Calliprotonia;* each concentric broad band on pedicle valve is slightly raised, that of *Calliprotonia* is flattened to the contrary; closely arranged concentric bands on brachial valve have the same character, those of *Calliprotonia* are anteriorly replaced by remarkable lamellae.

Among specimens described by CHAO (1927) under the name of *Echinoconchus punctatus* (MARTIN) from the Chinese Upper Carboniferous and Lower Permian, figured ones (Pl. 6, figs. 7, 8, 15, 16) from the Taiyuan Series are similar to the Nakakubo specimens. Pedicle valve of the former has ornamentation with raised remarkable bands of growth all over the surface. Brachial valve exterior of the Taiyuan specimens also ornamented by the closely similar concentric bands and spine rows just similar to the Nakakubo specimens. The only difference between Japanese and Chinese specimens is the median fold on brachial valve. According to CHAO, it is only observable on anterior surface in the Taiyuan specimens. That of the Nakakubo specimens is apparent, originating on posterior part of visceral disc. North Chinese and Japanese species, however, may be closely comparable with each other.

Correlation

The species assemblage of brachiopods described above is the Early Permian in age. As a whole the Nakakubo fauna has an affinity with the Early Permian faunas of the Tethyan province and, especially, the closest affinity with the Upper Carboniferous or the Lower Permian fauna of China. However, it is noteworthy that the Nakakubo fauna includes, at the same time, the Early Permian element of South American aspect.

Tangshanella nakakuboensis, sp. nov., is closely related with *T. kaipingensis* CHAO from the Upper Carboniferous Penchi Series of North China. *T. nakakuboensis* is the only species of this genus which is known outside China. *Uncinunellina shikokuensis*, sp. nov., is nearest to *Uncinunellina wangenheimi* (PANDER) from the Lower Permian *Schwagerina* limestone of Ural. The same species was also described by GRABAU from the Lower Permian Maping limestone of Kweichow, South China. *Enteletes gibbosus* CHRONIC is the element of the Peruvian Lower Permian fauna. It is important that this species occurs in two distant localities of Southwest Japan. One is from the Lower Permian Miharanoro Formation, Inner zone, and other is from Nakakubo. *Phricodothyris* cf. *P. asiatica* (CHAO) is closely referable to *P. asiatica* which is common in the Penchi Series of North China and the Lower Permian Wangchiapa limestone of Kweichow, South China. *Phricodothyris echinata* (CHAO) is the representative species of both Penchi and Taiyuan Series of North China. *Callispirina* aff. *C. ornata* (WAAGEN) is closely related with *Callispirina ornata* from the Middle Permian of Salt Range. *Neospirifer* cf. *N. fasciger* (KEYSERLING) closely resembles *Neospirifer fasciger* which ranges from Upper Carboniferous to Upper Permian in the Tethyan province and is very common in the Penchi and Taiyuan Series of North China. *Rostranteris* (*R.*) cf. *R.* (*R.*) *nucleolus* (KUTORGA) is very similar to *Rostranteris* (*R.*) *nucleolus* redescribed by TSCHER-

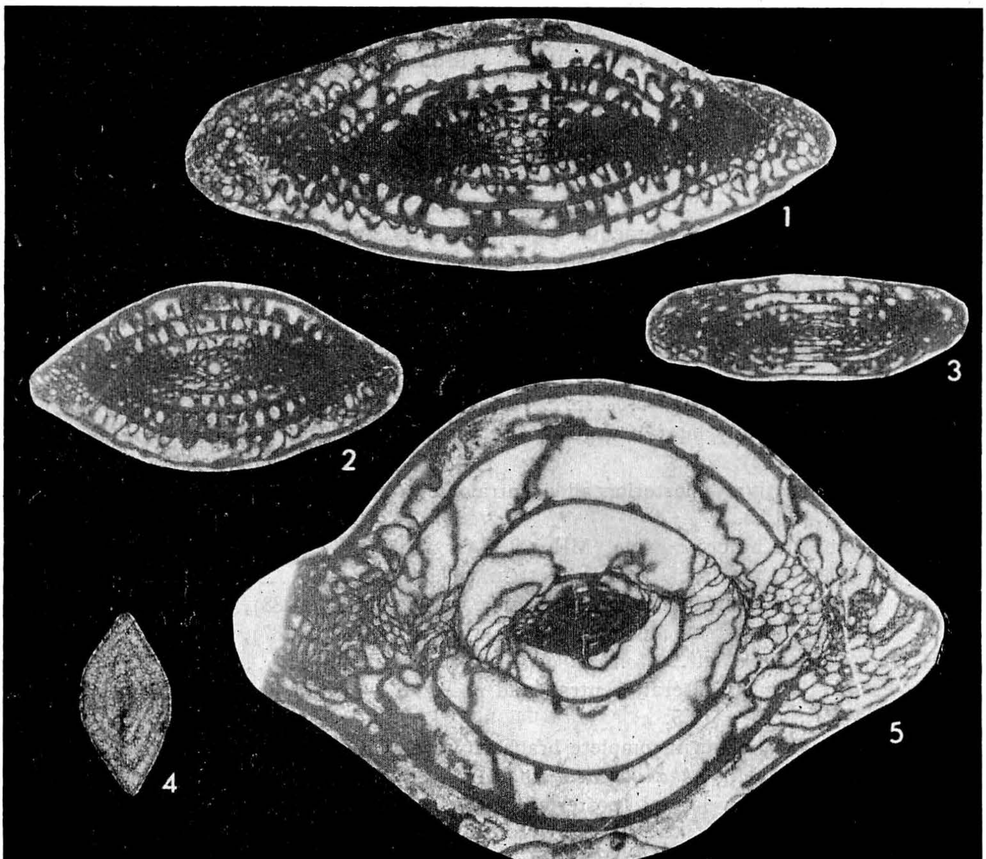

Fig. 5. Fusulinacean species associating with brachiopods. All figures are ×10.
1, 2. *Schwagerina stabilis* (RAUSER-CERNOUSSOVA) (common)
3. *Triticites* aff. *T. pusillus* (SCHELWIEN) (less common)
4. *Nankinella kawadai* (IGO) (rare)
5. *Pseudoschwagerina minatoi* KANMERA (common)

NYSCHEW from the Lower Permian of Ural.

Outside brachiopods, it is very characteristic that abundant fusulinaceans always associate with them. These fusulinaceans are quite common in specific assemblage to those of the *Pseudoschwagerina* zone of the Yayamadake limestone of southern Kyushu (KANMERA, 1958). The following four species are common to the Nakakubo and Yayamadake faunas: *Pseudoschwagerina minatoi* KANMERA, *Triticites* aff. T. *pusillus* (SCHELLWIEN), *Schwagerina stabilis* (RAUSER - CERNOUSSOVA), *Nankinella kawadai* (IGO). Among them *Pseudoschwagerina minatoi* and *Schwagerina stabilis* are most abundant species. They are very characteristic to the *Pseudoschwagerina minatoi* zone, the upper half of the *Pseudoschwagerina* zone, of the Yayamadake limestone.

In summarizing, the specific assemblages of brachiopods and fusulinaceans of the Nakakubo limestone are strongly similar to those of the Taiyuan Series of North China and the Maping Series of South China. Both are the Early Permian in age. The Nakakubo limestone is certainly correlted with the

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Explanation of Plate 10

Figs. 1–3. *Cancrinella* sp. .... p. 104
1. External mould of a brachial valve (GK-D 30281), ×2.
2. Ventral view of an incomplete pedicle valve (GK-D 30283), ×1.
3. Ventral view of an incomplete pedicle valve (GK-D 30282), ×1.

Figs. 4, 5, *Phricodothyris echinata* (CHAO) .... p. 99
4a, b. Respectively ventral and posterior views of an incomplete pedicle valve (GK-D 30290), ×3.

Figs. 6– 8. *Phricodothyris* sp. .... p. 97
6a–c. Respectively lateral, ventral, and posterior views of an incomplete pedicle valve (GK-D 30292), ×1.5.
7a, b. Respectively posterior and ventral views of an incomplete pedicle valve (GK-D 30291), ×1.25.
8. Incomplete brachial valve (MH 502 G_1), ×1.25.

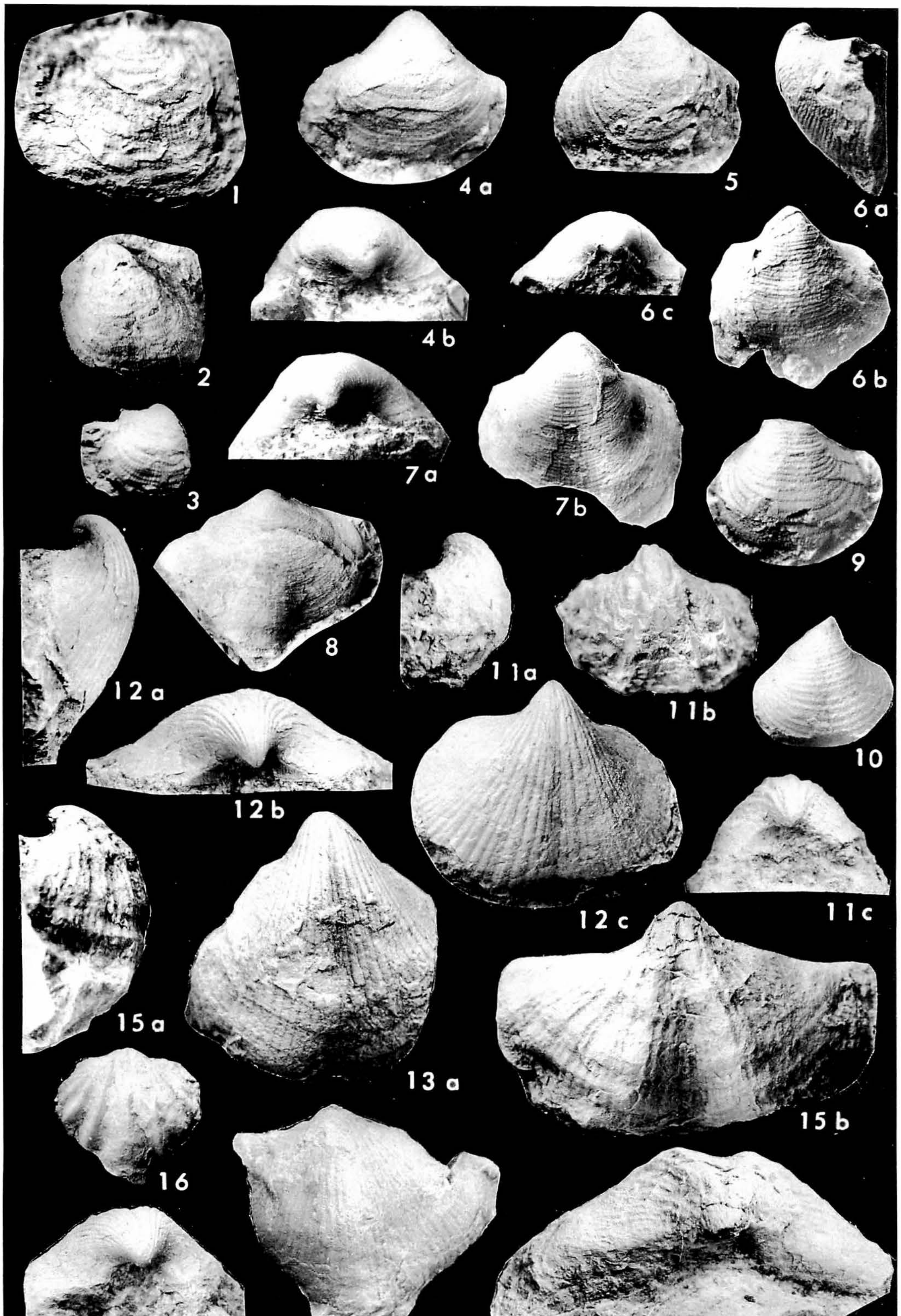
Figs. 9, 10. *Phricodothyris* cf. *P. asiatica* (CHAO) .... p. 98
9. Ventral view of an incomplete pedicle valve (GK-D 30288), ×3.
10. Ventral view of an incomplete pedicle valve (GK-D 30287), ×3.

Figs. 11, 16. *Callispirina* aff. *C. ornata* (WAAGEN) .... p. 99
11a–c. Respectively lateral, ventral, and posterior views of an incomplete pedicle valve (GK-D 30263), ×2.5.
16. Dorsal view of an incomplete brachial valve (GK-D 30269), ×2.5.

Figs. 12–14. *Tangshanella nakakuboensis*, sp. nov. .... p. 91
12a–c. Respectively lateral, posterior, and ventral views of the holotype (GK-D 30230), ×1.5.
13a, b. Respectively ventral and posterior views of an incomplete pedicle valve (GK-D 30233, ×1.5.
14. Dorsal view of an incomplete brachial valve (GK-D 30234), ×1.25.

Fig. 15. *Neospirifer* cf. *N. fasciger* (KEYSERLING) .... p. 100
15a–c. Respectively lateral, ventral, and posterior views of a pedicle valve (GK-D 30274), ×1.5.

Photos by YANAGIDA, with whitening.


1
4a
5
6a
2
4b
6c
6b
3
7a
7b
9
12a
8
11a
11b
10
12b
12c
11c
15a
13a
15b
16
14
13b
15c

Pseudoschwagerina minatoi zone of the Yayamadake limestone and with the upper part of the *Pseudoschwagerina* zone (upper Sakmarian) in the international correlation.

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Explanation of Plate 11

Fig. 1. *Uncinunellina shikokuensis*, sp. nov. .... p. 93
 1a–d. Respectively dorsal, anterior, ventral, and lateral views of the holotype (GK-D 30244), ×2.

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 3. An incomplete pedicle valve (MH 502 F), ×3.

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 11. Rubber replica of an incomplete brachial valve (GK-D 30285), ×1.5.

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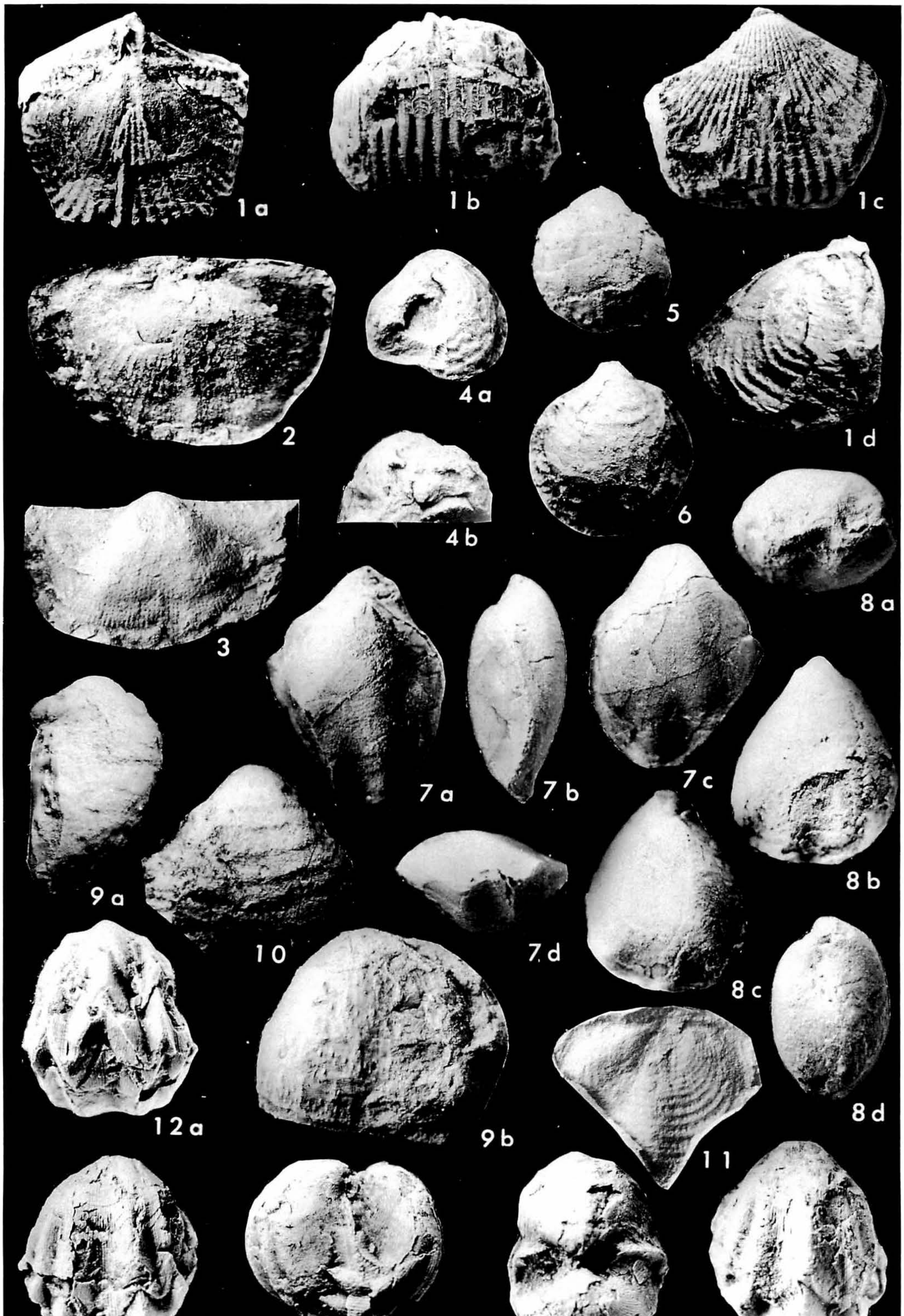
Photos by YANAGIDA, with whitening.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Yanadani-mura	柳谷村
Kamiukena-gun	上浮穴郡
Ōnogahara	大野ヶ原
Nakakubo	中久保
Nanokawa	名野川

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 74, pp. 112-115, June 30, 1969

SHORT NOTE

15. TWO INTERESTING FOSSIL SPECIMENS FROM THE UPPER PALEOZOIC SYSTEM IN JAPAN*

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Introduction

Last summer (1968) we received two interesting fossil specimens from the Upper Paleozoic system in Japan. One of them belongs to the Orthoceracoid cephalopod which was collected by Kazuo OUCHI on the eastern slope of Takakura-yama, about 7 km northwest of Yotsu-kura, Fukushima Prefecture. OUCHI kindly forwarded it to us for study.

Another specimen is *Calamites* sp. collected by members of the Earth Science Researching Party of the Tokyo College of Domestic Science, from the Lower Carboniferous Onimaru series at the Yukisawa valley, Rikuzen-Takata City, Iwate Prefecture.

Discoveries of these two fossil specimens are very notable, because the yield of Orthoceracoid specimen is the first record in Japan, and the collection of *Calamites* specimen from the Japanese Carboniferous formations is also for the first time so for as known up to now.

Therefore, we wish to present some descriptions in this short paper.

Descriptions

Class CEPHALOPODA

Order NAUTILOIDEA ZITTEL

Genus *Pseudorthoceras* GIRTY, 1911

Pseudorthoceras ouchii, new species

Fig. 1

Description:—The holotype is 125 mm long, 15 mm in diameter near the top, and 3 mm near the base, thus the apical angle being 6°. The tip of the initial stage and living chamber are not known. The cross section of the conch, apparently, was somewhat dorso-ventrally depressed, but a comparatively large part of the ventral side of the upper portion has weathered away. The surface of conch apparently unmarked. The location of the siphuncle is rather eccentric, its distance from the ventral wall of the conch being rather small. The number of camerae in a length equal to the diameter of the conch is 2.5. Where the diameter of specimen is 9 mm and where the septa are 4 mm apart, one of the siphuncle segment has a maximum diameter of 4.2 mm at mid height, constrictting to 2.5 mm at its passage through the septum. The resultant form of the siphuncle segments is globular. The septa and siphuncle are thickened very

* Received Dec. 26, 1968.

slightly with the deposition of calcareous matrix.

The present specimen is found in association with *Paradin yanagisawai* ENDO and MATSUMOTO. The specific name is given in honor of Kazuo OUCHI, collector of the present fossil specimen.

Comparison:—This species may be referable to *Pseudorthoceras splendens* CLIFTON from the Permian Leonard series in U. S. A., but it is distinguished by the much slender conch with rather acute apical angle. Moreover, in the Japanese specimen, 2.5 camerae occur in a length equal to the diameter of the conch, while in *P. splendens* the number is four or six.

Formation and locality:—Locality No. T7, Kashiwadaira formation of Takakura-yama group, Upper Permian; G2 valley on the eastern slope of Takakurayama hill, 7 km northwest of Yotsukura-cho, Iwaki City, Fukushima Pref.

Holotype:—GI., Tokyo Col. Domest. Sci. No. 585.

Class Articulatae

Order Equisetales

Genus *Calamite* SUCKOW

Calamites sp., Undet.

Figs. 2, 3

Even though the present specimen is too fragmentary to deserve a specific name, we shall describe it as for as possible considering it important from the paleogeographical standpoint.

Description:—The specimen on hand is 55 mm long, 42 mm in diameter at the middle. The surface of the specimen is characterized by the presence of longitudinally striated fine ridges which are somewhat rounded; these ridges are counted 14-15 in a transversal space of 1 cm. Because of rather poor preservation, articulated nodes and leaf scars are very indistinct. However, by making a very careful observation one may be able to ascertain their presence, as will be seen in the illustration of fig. 3.

Formation and Locality: — Onimaru series, Lower Carboniferous; Yukisawa valley, Rikuzen-Takata City, Iwate Prefecture.

Figured specimen:—GI., Tokyo Col. Domest. Sci., No. 586.

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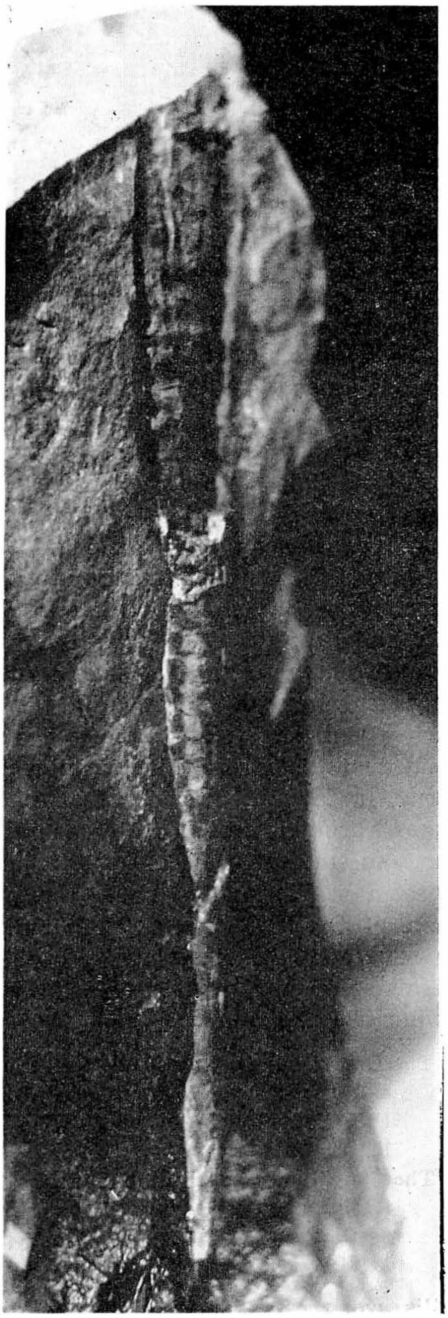
Fig. 1. *Pseudorthoceras ouchii*, new species, ×1.2. A weathered natural vertical section, showing parts of the siphuncle. Upper part of the specimen cut vertically through the center of the siphuncle. Locality No. T7, Kashiwadaira formation of the Takakurayama group, Up. Permian; G2 valley on the eastern slope of Takakurayama hill, 7km north-west of Yotsukura-cho, Iwaki-City, Fukushima Pref. GI., Tokyo Col. Domest. Sci., No. 585.

Figs. 2, 3. *Calamites* sp., ×1.2.

2. A specimen fragmentary preserved, shows very fine edges and furrows.

3. A brocken cast of the preceding specimen, showing the articulated nodes and leaf scarls at its lowest part. Onimaru series, Lower Carboniferous; Yukisawa valley, Riku-zen-Takata City, Iwate Pref., GI., Tokyo Col. Domest. Sci., No. 586.



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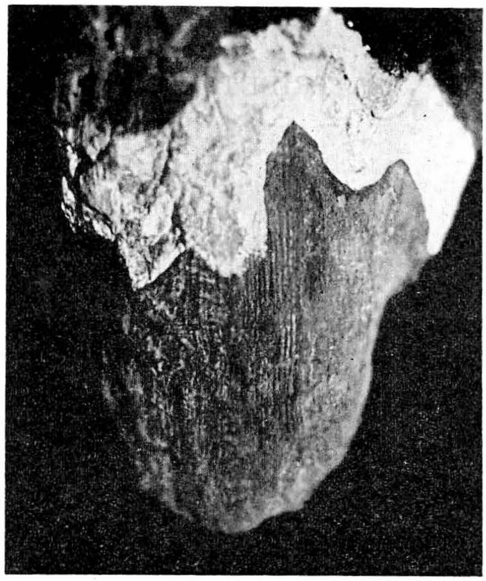

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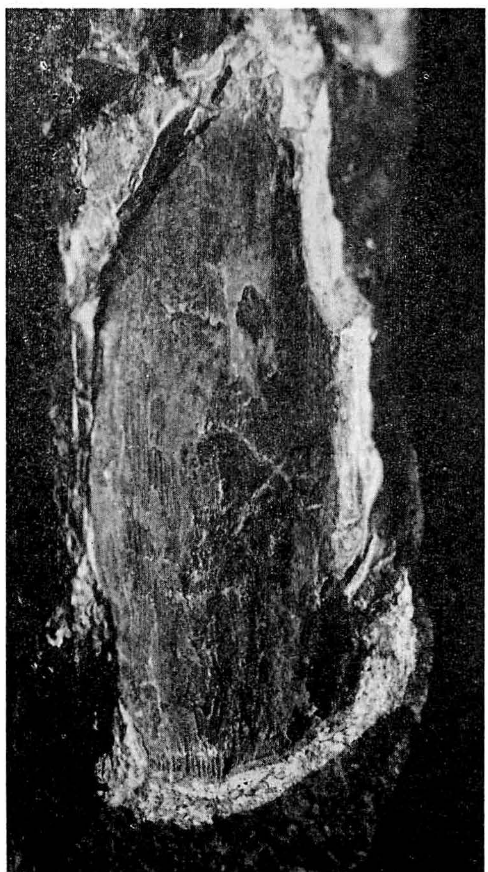

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Trans. Proc. Palaeont. Soc. Japan, N. S., No. 74, pp. 116-118, June 30, 1969

A TRIBUTE TO THE MEMORY OF DR. RIUJI ENDO

HARUYOSHI FUJIMOTO

Emeritus Professor, Tokyo University of Education

Dr. Riuji ENDO, my respected friend, used to boast of his fine health, until early February this year when he was afflicted with pneumonia and was sent to the Cancer Center at Otsuka. Under the treatment of Dr. KUROKAWA, he was on the road to recovery and we all felt relieved, but his condition took a bad turn suddenly, and on April the 1st he passed away at the age of seventy-seven. The news of his death filled me with deepest grief. I don't know how to express my condolences.

In 1923, Dr. ENDO was graduated from the Institute of Geology and Paleontology, Faculty of Science, Tohoku University. As a student he was engaged in the study of the Paleozoic system in the Kitakami Mountains under the guidance of Prof. Hisakatsu YABE, and disclosed the presence of the Lower Carboniferous coral limestone beneath the *Fusulina*-limestone.

Upon graduation, he entered the South Manchuria Railway Company. Later he served at the Bujun (Fushun) Middle School for a short period, but in 1927 he assumed the professorship at the Manchurian College of Education in Hoten (Mukden). In the meanwhile, he devoted himself to the geological study of Manchuria, with special reference to Early Paleozoic fossils, and collected great quantities of valuable fossil specimens. In 1929 he went to the United States, bringing these materials with him, and studied at the U. S. National Museum in Washington under the guidance of Drs. E. D. ULRICH, Ray Smith BASSLER and C. E. RESSER. The results of this study were published in the following two papers:

The Ozarkian and Ordovician formations and fossils of South Manchuria, *Bull. U.S. Nat. Mus.*, 1932, No. 164, pp. 1-152, 35 pls., 5 maps.

The Sinian and Cambrian formations and fossils of South Manchuria, *Bull. Educ. Inst., S.M. Ry. Co.*, 1937, No. 1, pp. 1-474, 73 pls.

His work established the foundation of the Paleozoic stratigraphy and paleontology of Manchuria, and won admiration from the academic world. For his accomplishments, he was granted the degree of Doctor of Science from Tohoku University in 1933.

In 1931 he traveled to European countries and visited institutes and laboratories in various parts of Europe. Through these trips he obtained casts of type specimens of Early Paleozoic fossils that had been collected in Eastern Asia by KOKEN, GOTTSCHE, MONKE and BERGERON. He thus prepared himself well for the future study.

The Manchurian College of Education was closed in 1933, but by that time the foundation of Manchoukuo was solidified and the construction of the Central Museum in Shinkyo (Hsinkin) was in progress. In 1939 Dr. ENDO was placed in this museum as the head curator of the Department of Natural History, which enabled him to resume his researches as well as to supervise the museum activities. During this period, he wrote a large number of excellent papers on the Paleozoic system in Manchuria and Shantung Province. Of these papers, the one entitled "On a correlation of the upper Cambrian formations between Manchuria and Shantung", published in Vol. 13 of the Report of the Japan Science Association, was especially remarkable, and won a prize from the Association in 1940.

When World War II came to an end in 1945 the Central Museum, to which Dr. ENDO dedicated a long time of his life, had been severely demolished. In 1947 Dr. ENDO became a professor at the Northeastern University, Republic of China, but he had to fight his way through the bitters of life all the time. Nevertheless, his unyielding spirit urged him to keep on studying. In Honkeiko (Penchifu) he made a discovery of *Pecopteris samaropsis* OGURA, a plant fossil valuable to science.

In June 1948, he returned to Japan penniless, and he worked temporarily at the U. S. Geological Survey Tokyo Office. Then in June 1949, he was engaged by Saitama University as a professor at the Faculty of Science and Literature, which gave him the opportunity to pursue the life of researcher and teacher again. Here the second period of his research activities began. The theme of his study was Paleozoic to Mesozoic calcareous algae, which had never been studied by anybody else till then. He continued this study for the last twenty years and obtained good results, which were reported in nineteen papers and four of them were published later in a volume in commemoration of his retirement from Saitama University.

Dr. ENDO's life as a scientific researcher in Manchuria and at Saitama University was as if he was reclaiming waste land to pave the way for the successors. This can be accomplished only by a man of ability and strong will, just like Dr. ENDO himself. Dr. ENDO was also an excellent educational administrator. In 1953 he was the dean of the Faculty of Science and Literature, Saitama University, and in 1954 he became the Universty's president. In 1959 he was elected to the membership of the 5th term of the Science Council of Japan. Also, in the Geological Society of Japan and the Palaeontological Society of Japan he successively filled various posts such as the councilor and the executive committee chairman. In 1960 Dr. ENDO retired from the presidency of Saitama University at the expiration of his term, and accepted the offer of a position as a professor at the Tokyo College of Domestic Science. Since then, he has been enjoying his life as an educator of girls and a researcher of calcareous algae.

Reviewing Dr. ENDO's life in retrospect, we realize that his surpassing ability and tireless efforts led him to attain the expected goal. His scientific achievements are brilliant, and his disciples, benefited by his learning and virtue, are amounting to a great number and they will proceed with their studies to prove themselves to be good successors to Dr. ENDO.

I am convinced that Dr. ENDO was a happy man, having been successful in his career as scholar and educator.

May his eternal sleep be peaceful.

日本古生物学会特別号の原稿募集

PALAEONTOLOGICAL SOCIETY OF JAPAN, SPECIAL PAPERS NUMBER 15 を 1970 年度に刊行したく，その原稿を公募します。適当な原稿をお持ちの方は，次の事項に合わせて申込書を作成し，福岡市箱崎町　九州大学理学部地質学教室気付，日本古生物学会特別号編集委員会（代表者　松本達郎）宛に申し込んで下さい。

(1) 古生物学に関する論文で，欧文の特別出版にふさわしい内容のもの。同一の大題目の下に数篇の論文を集めたもの（例えばシンポジュウムの欧文論文集）でもよい。分量は従来発行の特別号に経費上ほぼ匹敵すること。学会から支出できる経費は 35 万円程度です。学会以外からも経費が支出される見込のある場合には，その金額に応じて上記よりも分量が多くてよい。

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(3) 申込用紙は自由ですが，次の事項を明記し，〔　〕内の注意を守って下さい。

 (a) 申込者氏名；所属機関または連絡住所・電話番号。〔本会会員であること〕。
 (b) 著者名；論文題目。〔和訳を付記すること〕。
 (c) 研究内容の要旨。〔800～1,200 字程度〕。
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(4) 申込締切 1969 年 12 月 15 日（消印有効）。採否は 1970 年 1 月の評議員会で審議決定の上申込者に回答の予定です。ただしその前または後に，申込者との細部の交渉を，編集委員から求めることがあるかもしれません。

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(6) 特別号の投稿規定はとくにありません。会誌に準じ，前例を参考とし，不明の点は編集委員会に問い合わせて下さい。経費がかかるので，特別な場合を除き，別刷は作成せず，本刷 25 部を著者に無料進呈します。それ以上は購入（但し著者には割引）ということになります。いくつかの論文を集めて 1 冊にするときには，世話人の方から指示して，体裁上の不統一のないようにして下さい。印刷上の指示事項が記入できるよう，原稿の左右両側・上下に十分空白をとって，タイプを浄書して下さい。

例　会　通　知

	開　催　地	開　催　日	講演申込締切日
103回　例　会	鹿児島大学	1969年11月29,30日	1969年10月25日
1970年総会，年会	東北大学	1970年1月下旬	1969年12月1日

103回例会（鹿児島大）：日本地質学会西日本支部例会と合同。シンポジウム，九州の第四系—九州近海海底ならびに南西諸島地域を含む（世話人：首藤次男，早坂祥三），

学　会　記　事

◎ 1968年度中に会員古田保君が逝去された。(No. 73 の追補)

◎ 1969年6月14日神奈川県立博物館で開催された評議員会で次の方々の入会が承認された。
(申込順・敬称略)
古川隆治，林　徳衛，平　朝彦，田宮良一，SAMANIEGO, R. M. (Philippine)，REYES, M. V. (Philippine)，速水倶子，松隈明彦，両角芳郎

NEWS

◎ 会員松本達郎君は「環太平洋地域の白亜紀アンモナイトの研究」により学士院賞を受賞した。

◎ 会員小林貞一君は「アジア太平洋地域・特に東アジアの古期古生界の地史学的古生物学的研究」により藤原賞を受賞した。

◎「化石」第17号が発行された。内容は「新生代貝類化石群の時空分布」特集その他である。

◎ 地学用語委員会の古生物学関係の委員に鹿間時夫君が就任した。

◎ 日本古生物学会々員名簿（和文）が発行された。誤り変更については係まで。

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