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# 595. FOSSIL SPORES AND POLLEN GRAINS FROM THE NEOGENE DEPOSITS IN NOTO PENINSULA, CENTRAL JAPAN—IV

## A PALYNOLOGICAL STUDY OF THE LATE MIOCENE TSUKADA MEMBER*

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能登半島新第三系産化石胞子・花粉—IV；中新世後期塚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関する花粉学的研究のうち，今回は，その第 IV 報として，能登半島北端の輪島市に発達する中新世後期の塚田含珪藻泥岩層についての花粉学的研究の結果を報告する。

塚田層は輪島市の一本松公園付近と宅田付近に，局部的に発達する含珪藻泥岩を主体とする累層である。本層は硬質頁岩の薄層によって，上部層と下部層とに 2 分される。上部層は泥岩よりなり，下部層は砂岩薄層を夾在する泥岩よりなっている。

塚田層の 13 層準からの 16 試料と，他に，参考までに洪積世後期の稲舟段丘堆積物からの 1 試料，中新世中期の地層からの 2 試料（栗蔵層—1 試料，縄又層—1 試料）について分析し，各層準毎の化石群集の構成・変化の内容を明らかにし，これらの分析結果に基づいて，塚田層堆積時の古気候・古地理的条件・地質時代について考察した。

(1) 塚田層堆積時の古地理的条件： 本層からの花粉の構成は，upland 系の植物をいくらか含んではいるが，mixed-slope・riparian 要素を主体とする。本層に含まれている化石珪藻の構成内容や岩相などからの資料をも併せて判断すると，本層の堆積盆地は，入口の広い入江が直接外海に面しており，その入江の奥の，出入りの多い水域であった，と推定される。本層と同時代といわれる能登半島中央部の和倉層・聖川層からの花粉構成は，寒冷系の要素が塚田層のそれの 1/2～1/3 である。このことは，和倉層・聖川層の堆積域が半島中央部の，入江や湾奥で，北方からの風や海流の影響を直接うけないような環境であったのに対して，塚田層の堆積域では，比較的直接うけるような環境下であった，と推定される。

(2) 塚田層堆積時の古気候： 温暖系の植物の花粉の頻度は 10% で，和倉層の 30% や台島期の砂子坂層・山戸田層のそれらが 50～60% であるのに比較すると，かなり低率である。本層の主体をなすのは温帯系の要素で，60～70% を占めている。本層の下部と上部とを比較すると，下部に，温暖系要素が多い。本層では，寒冷・冷涼系要素は，温暖系要素に対してよりも，むしろ温帯系要素と正の相関々係を示す。

塚田層と同時代といわれる和倉層・聖川層の花粉構成に比較すると，細かな点では違いがあるが，大局的には同じである，と判断され，塚田層堆積当時の古気候は，現在の北陸地区の気候に殆んど同じか，若干冷涼か位であろう。

(3) 塚田層の地質時代： 本層からの花粉群集は，大局的には中新世後期の和倉層・聖川層，鮮新世前期の荻の谷層の花粉群集に酷似し，本層の地質時代もこれらの地層の時代に対比されよう。

藤 則 雄

### Introduction

Diatomaceous deposits occur at different stratigraphical horizons in the Neogene system of the Noto Peninsula, Ishikawa Prefecture, Central Japan. These diatomaceous deposits are classified into four horizons which range in age from the Middle to Late Miocene. The writer has been studying the fossil pollen grains and spores found from these diatomaceous deposits, and a part of the

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results appeared concerning the Late Miocece Wakura diatomaceous mudstone Member (the first report; FUJI, 1969a), the Middle Yamatoda diatomaceous mudstone Member (the second report; FUJI, 1969b), and the Late Miocene Hijirikawa diatomaceous mudstone Member (the third report; FUJI, 1970).

The present report, the fourth of the series, records the result of palynological analysis of the Late Miocene Tsukada diatomaceous mudstone Member, a unit which is distributed locally in Wajima City in the northern part of Noto Peninsula, Ishikawa Prefecture.

The scope of the study, based on the microfossils, is to make a systematic description of the microfossils, and to interpret the paleoclimatic condition and paleogeographical environment under which the Tsukada Member was deposited during the Otokawa stage of the Late Miocene age. Further, an attempt is made for correlation and comparison of the conditions and environment of the Tsukada Member with the Wakura, Hijirikawa and I'izuka diatomaceous members distributed in Noto Peninsula.

**Acknowledgements**

Here the writer wishes to record his sincere thanks to Professor Kotora HATAI of the Institute of Geology and Paleontology, Faculty of Science, Tohoku University for his kind advice during the course of the writer's palynological researches and for reading the manuscript. Thanks are due to Dr. Seiji SUGIURA, Professor of the Department of Earth Sciences, Faculty of Science, Kanazawa University, who kindly discussed with the writer a few problems on the clay minerals found from the Tsukada diatomaceous mudstone Member. Appreciation is expressed to Professor Yoshio KASENO of the Department of Earth Sciences, Faculty of Science, Kanazawa University, for his advice and information on the stratigraphy and paleogeography of the Wajima area during the Late Miocene age. Thanks are due to Mr. Nobuomi MATSU'URA of the Kanazawa Girl's Senior High School, Kanazawa, for his suggestions on sampling for palynological investigation and information on the stratigraphy of the Tsukada Member. Acknowledgements are also due to Dr. Wataru ICHIKAWA, Professor Emeritus of the Kanazawa University for information on the diatom assemblage found from the Tsukada Member and for its paleoecological implications. Finally, the writer expresses his appreciation to the Ministry of Education of the Japanese Government for support from the Science Expenditure Funds.

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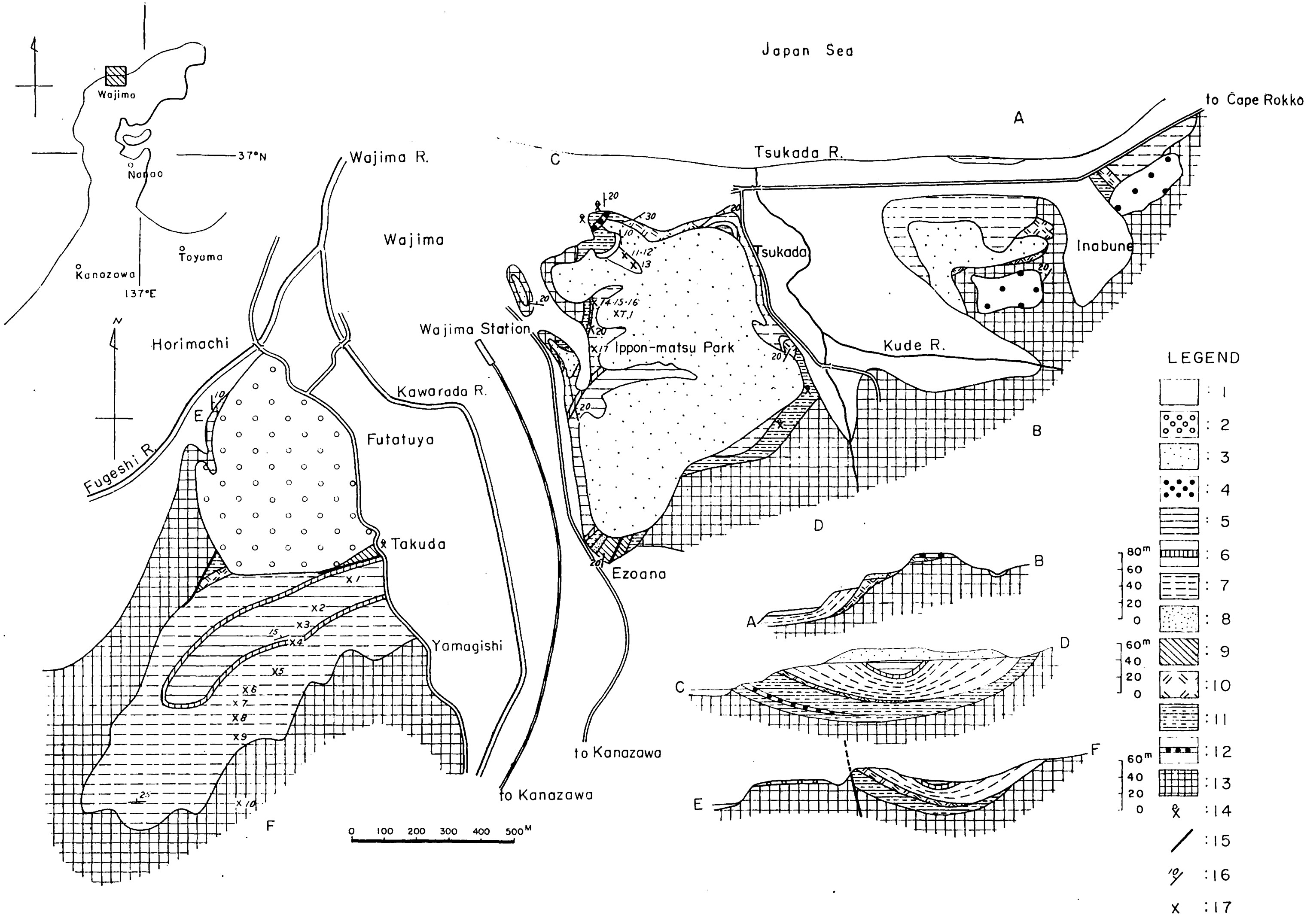
Text-fig. 1. Geological map of the Wajima area, central part of Noto Peninsula, Central Japan (Compiled by FUJI, 1969; after; N. MATSU'URA, 1955; N. FUJI, 1968) 1: Alluvial deposits, 2: Lower terrace deposits, 3: Middle terrace deposits, 4: Upper terrace deposits, 5: Upper mudstone part of the Tsukada Member, 6: Siliceous sandy tuff, 7: Lower mudstone part of the Tsukada Member, 8: Coarse-grained sandstone part of the Tsukada Member, 9: Wajima-zaki Member, 10: Awakura Member, 11: Wajima Member, 12: *Operculina* calcareous sandstone, 13: Nawamata Member, 14: animal fossils, 15: fault, 16: strike and dip, 17: plant fossils.


Japan Sea
to Cape Rokko
A
Wajima
Nanao
37°N
Toyama
Kanazawa
137°E
Wajima R.
C
Tsukada R.
Wajima
Tsukada
Inabune
Wajima Station
Ippon-matsu Park
Kude R.
Horimachi
Kawarada R.
B
Futatuya
Fugeshi R.
E
D
Takuda
Ezoana
Yamagishi
to Kanazawa
to Kanazawa
F
0 100 200 300 400 500M
LEGEND
: 1
: 2
: 3
: 4
: 5
: 6
: 7
: 8
: 9
: 10
: 11
: 12
: 13
: 14
: 15
: 16
: 17

## Outline of the geology

Many diatomaceous muddy deposits of Neogene age are distributed widely in the central and northern parts of the Noto Peninsula. They are mainly composed of homogeneous silty mudstone characterized with abundant fossil microorganisms, especially diatoms and silicoflagellates. In the Wajima area of the northwestern part of the peninsula, the diatomaceous deposits are distributed very locally, and their rock-facies are variable. In the Wajima area where the Late Miocene Tsukada Member is distributed the Neogene deposits are classified into two formations and five members in ascending order as follows; the Anamizu Formation, the Nawamata coarse-grained sandstone and mudstone Member, Wajima sandstone, sandy mudstone and tuffaceous mudstone alternation Member, Awakura sandy tuff Member, Wajima-zaki sandstone Member, Tsukada diatomaceous mudstone Member and the Late Pleistocene terrace deposits.

Some opinions about the stratigraphical succession of the Neogene deposits in the Wajima area were stated by many stratigraphers, namely, Yanosuke OTUKA (1946), Nobuomi MATSU'URA (1955, MS) and Yoshio KASENO (1963). The writer studied the stratigraphy of this area in the spring and summer seasons of 1967, and collected some samples for palynological investigation in the spring season of 1968. The other samples were obtained from a well drilled in this area for the research on the diatom earth distributed widely in the Noto Peninsula. The sampling localities and stratigraphical horizons of the materials from the Tsukada Member are shown in Text-figs. 1 and 2.

According to the writer's geological survey, these stratigraphical units are as mentioned below, in ascending order.

*The Anamizu Formation:* This formation is not only distributed in the Wajima area, but also widely in the northwestern and central parts of Noto Peninsula. It is generally classified in the northwestern part of Noto Peninsula into andesitic lava and andesitic pyroclastic rocks intercalated with dacitic pyroclastic rocks and thin basaltic lava. The stratigraphical succession of this formation is different in different localities, and also most of these rocks are disturbed by crustal movements such as faults and folds.

The fine-grained sandstone and siltstone intercalated in the pyroclastic rocks of this formation yielded many fragments of plants, namely, at Konogi, Ikuru and Soyama near Anamizu *Metasequoia occidentalis, Glyptostrobus europaeus, Acer* sp., *Lindera* sp., *Machilus* sp. and *Hemitrapa* sp., and also small foraminifers from the medium- or fine-grained sandstone. *Bunolophodon* was found from the tuffaceous sandstone exposed at Hosoya (SHIKAMA, T., 1936).

Dacite developed very locally at Okamoto, In'nai and Okazuka near Wajima is intercalated with a welded tuff bearing dacitic tuff, and is about 85 meters in thickness.

Basalt occurs very locally at Okazuka, Yokoji and Kirita, and lithologically is an olivine two pyroxene basalt. The lava is about 10 meters in thickness. The stratigraphical relationship between the dacite and basalt is uncertain.

Andesite, overlain with unconformity by the dacite and basalt above-mentioned, is generally classified into two pyroxene andesite, hypersthene andesite, augite andesite and their agglomerates. Two pyroxene andesite is distributed widely in the eastern and southern parts of Wajima City and is more extensive compared with the other volcanic rocks above-noted.

............................ unconformity ............................

*The Nawamata sandstone and mudstone alternation Member:* This member is distributed widely in the northwestern part of Noto Peninsula, namely, in the area from Wajima City to Monzen Town and the coastal area of western Noto Peninsula. The distribution of this member is about 7 km in breadth from north to south, and the principal geological structure in and around the surveyed area is the undulated folding structure of repeated anticlinal and synclinal structures which trend in ENE–WSW direction.

The member overlies with unconformity dacitic pyroclastic rocks intercalated with some welded tuff layers and basalts. These belong to the upper part of the Anamizu Formation in the area from the south of Wajima Station to Nawamata. On the other hand, in the area of Nawamata, the pyroclastic rocks and andesite of the Anamizu Formation are overlain by the member with unconformity.

The rock-facies of this member is composed generally of an alternation of dark brown or bluish green medium- or coarse-grained sandstone and dark grayish brown or bluish gray mudstone partly intercalated with thin conglomerate layers.

The member yielded many fossil plants as *Metasequoia japonica, Liquidambar formosana, Fagus* sp., *Platanus* sp., *Marles* sp., *Cedrela* sp., *Ficus* sp., *Benzoin umbellatum,* siliceous wood stumps. No marine fauna has been found from this member.

This member attains about 500 meters in maximum thickness.

——— conformity ———

*The Awakura sandy tuff Member:* This member is distributed very locally in the Wajima area, namely, Ippon-matsu Park, Ezoana, Koise and Wajima-zaki. The type locality of the member is an outcrop north of Ippon-matsu Park in Wajima City.

The upper part and lower part of the member are correlated respectively with the Awakura tuff Member and the upper part of the Wajima sandstone Member named by the late Y. ÔTUKA (1946).

The rock-facies of this member is composed of pumiceous tuff, pumice-bearing tuffaceous sandstone, sandy pumiceous tuff and medium- or fine-grained sandstone partly intercalated with thin hard coarse-grained sandstone. This member is composed of a pumiceous facies.

The Awakura Member overlies with conformity the Wajima-zaki Member. The member is variable in thickness, that is, measuring about 40 meters at the Ippon-matsu Park and about 10 meters at Wajima-zaki.

——— conformity ———

*The Wajima-zaki sandstone Member:* This member is distributed only at Wajima-zaki Cape in the north part of Wajima City, therefore, it was named as the Wajima-zaki sandstone Member by MATSU'URA (1955, MS).

The member is classified into three parts lithologically, namely, the lower part is composed mainly of hard calcareous sandstone intercalated with some nodule layers and attaining about 35 meters in thickness, the middle part is of homogeneous calcareous fine-grained sandstone of about 30 meters in thickness, and the upper part consists of glauconitic coarse-grained sandstone with dark colored pebbles and attains about 5 meters in thickness.

The member yielded fossil animals, especially pelecypods and brachiopods etc. These fossils are as follows:

Lower part: *Chlamys* sp., *Balanus* sp., *Gryphus* cfr. *davidsoni, G.* cfr. *hanzawai* HATAI, *G.* sp., *Laqueus* cfr. *rubellus* (SOWERBY), *L.* sp., and also plant fragments.

Middle part: *Linthia nipponica* YOSHIWARA, *Isurus hastalis* (AGASSIZ), *Dentalium* sp., *Balanus* sp., and plant fragments.

Upper part: *Chlamys crassivenia* (YOKOYAMA), *Lucinoma acutilineata* (CONRAD), *L.* sp., *Turbonilla* sp., and plant fragments.

Based on *Linthia nipponica* YOSHIWARA found from the middle part, the member is correlated with the Tsukada Member. This view is supported from rock-facies, which is similar to that of the Tsukada Member, and by that the upper part of the Wajima-zaki Member consists of glauconitic sandstone.

This member is stratigraphically equivalent to the lower part of the Tsukada Member.

— interfingering with the Tsukada Member —

*The Tsukada diatomaceous mudstone Member:* This member is distributed very locally at Ippon-matsu Park and Tsukada in the southeastern part of Wajima City. The type locality of the member is in the Tsukada area east of the Ippon-matsu Park.

The member is classified into two parts by the siliceous shale layer or thin sandy tuff layer.

The lower part is of coarse-grained sandstone and calcareous; it contains many nodules. It yielded some marine molluscan fossils as *Gryphus* sp., *Laqueus* sp., *Linthia nipponica* and *Isurus hastalis* etc., and is about 40 meters in thickness.

The upper part is light yellowish brown (weathered part) or dark greenish blue (fresh part), homogeneous, massive diatomaceous mudstone intercalated with some thin calcareous nodules and dark colored glauconitic fine-grained sandstone layers. The megafossils are rare in the upper part, but comprised such as, *Chlamys crassivenia* and *Lucinoma acutilineata* etc. Microfossils such as diatoms, sponge spicules, spores and pollen grains are common, that is, the homogeneous massive mudstone of the upper part yielded. *Actynoptychus undulata* A.S., *Coscinodiscus actinochilus* EHR., *C. centralis* EHR., *C. elegans* GREV., *C. gigas* EHR., *C. lineatus* EHR., *C. marginatus* EHR., *C. aculus* EHR., *C. perforatus* EHR., *C. radiatus* EHR., *Grammatophora aceanica* (EHR.) GRUN.

The thickness of the upper part is about 20 meters, and that of the lower part about 40 meters.

............................ unconformity ............................

*The Inabune terrace deposits:* The Inabune terrace deposits are composed of clay, and sand and gravel. The Inabune terrace is classified into three terrace levels according to height above sea level, namely, (1) high terrace, (2) middle terrace and (3) lower terrace. The high terrace is distributed locally in the areas west of Inabune and northwest of Nishi-ôno, and its height is about 80 meters above the present sea level.

The middle terrace is distributed in the areas west of Inabune and the Ippon-matsu Park, and is about 30 to 50 meters above the present sea level in height.

The lower terrace is distributed at Takuda and Futatsuya, and its height is about 20 meters above the present sea level. From the viewpoint of height of these terraces the lower and middle terrace deposits are correlated with the Late Pleistocene age, perhaps the Hiradoko transgression age in the Hokuriku district or the Shimosueyoshi age in the Kwanto district.

The Neogene deposits in the Wajima area show gently folded structure, and there are two synclinal basins and anticlinal structure, namely.

(1) Kônosu-Kekachi anticline which has NE-SW trend in the southern part of the Wajima area,
(2) Wajima-Warabino "buried" anticline,
(3) Tsukada syncline,
(4) Wajima-zaki syncline.

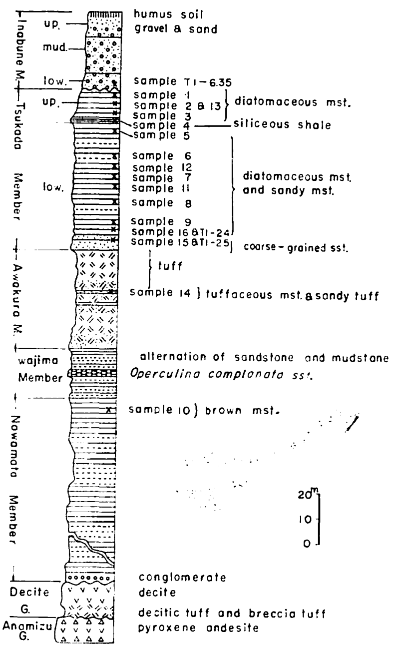
## Palynological research

(1) Foreword

The writer has been studying the Neogene system which occurs in Noto Peninsula, especially the diatomaceous deposits, and has already summarized on the fossil pollen and spore assemblage of the Late Miocene Wakura (FUJI, 1969a), Middle Miocene Yamatoda (FUJI, 1969b), and Pliocene Oginoya and Late Miocene Hijirikawa (FUJI, 1969c) members.

The present paper is the fourth report of the series.

The purpose of the present study is to interpret the significance of the pollen grains and spores found from the samples collected from the Late Miocene Tsukada Member, mainly in terms of paleoclimatic condition and paleogeographical environment.



Text-fig. 2. Columnar section showing the sampling horizons of the Tsukada, Awakura and Nawamata members and Inabune deposits.

(2) Sampling

The samples analysed in the present investigation were collected by the writer in the spring season of 1968. The other three samples (abbreviation: T-1) were obtained from a well drilled for the research of the diatom earth which is distributed locally in the Wajima area. The samples treated in connection with the present research are 19 samples in total. The localities and stratigraphical horizons in the Tsukada Member of these samples are shown in Text-figs. 1, 2 and 3.

Of the samples collected from some outcrops, one sample consisted of three to five pieces of rock ever collected at random along the length of one meter, measured parallel to the stratification of the member.

(3) Preparation of materials and method of study

The preparation of the materials and method of study for the palynological investigation are the same as described in the previous papers (FUJI, 1969a and 1969c).

All of the slides containing the specimens registered in the present research are deposited in the collection of the Institute of Earth Science, Faculty of Education, Kanazawa University (register abbreviation: EKZJ), Kanazawa, Ishikawa Prefecture, Central Japan.

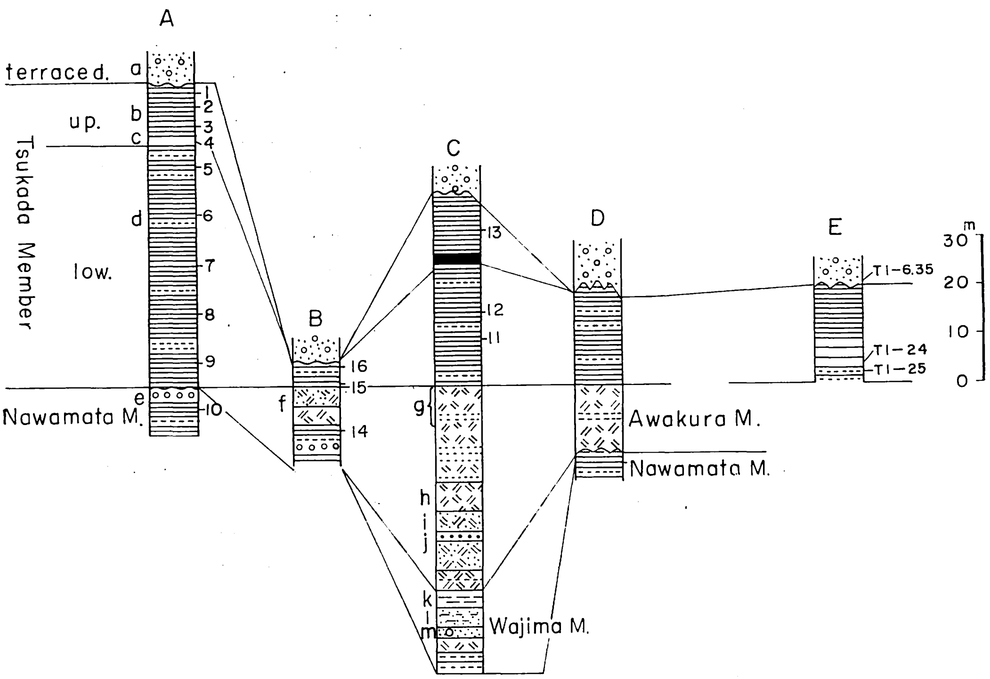
(4) Description of the assemblages

The assemblage of the fossil pollen grains and spores found from the analysed 19 samples is shown in Text-figs. 4 and 5, and is explained as follows in descending order.

*Sample T-1-6.35:*

This sample which belongs to the Inabune terrace deposits belongs to the lowermost horizon of the deposits. It was taken from the well drilled at Locality No. T-1 situated in Ippon-matsu Park about 500 meters east of Wajima Station of the Japanese National Railway Nanao Line, Wajima, Ishikawa Prefecture. Depth of the sample is 6.35 meters below the present ground surface. The sample is fairly weathered and is a light yellowish brown decomposed clayey mud. The lower part of the Inabune terrace deposits distributed in Ippon-matsu Park becomes the decomposed clayey mud at almost all part of the outcrop and these deposits are probably derived from the Tsukada diatomaceous mudstone Member. The decomposed mud has been used as " Jinoko " which is a kind of powder painted on the Japanese lacquer-ware named as " Wajima-nuri ".

The fossil pollen grains and spores




Text-fig. 3. Columnar sections showing the sampling horizons and the relationship between them. A : Takuda area, B : Wajima Hospital, C : Ippon-matsu Park, D : Inabune area, E : Locality No. T-1 (the well drilled) in Ippon-matsu Park, 1, 2, 3, .... 15, 16, T1-6.35, T1-24, T1-25 : sampling horizons (refer to Text-fig. 2) ; a : sand, mud and gravel of the Pleistocene terrace deposits, b : mudstone, c : hard siliceous shale, d : fine- and medium-grained sandstone, e : conglomerate, f : tuffaceous sandstone with nodules, g : alternation of sandstone and tuff, h : tuff, i : tuffaceous sandstone, j : hard coarse-grained sandstone, k : micaceous sandy mudstone, l : tuffaceous sandy mudstone, m : *Operculina* calcareous sandstone.

found from the sample are less than 200 specimens in total. The writer, therefore, can not carry out right statistical treatment in connection with the sample. This sample yielded; Gymnosperm-five genera; Dicotyledon-six genera and two subgenera; Monocotyledon-one family and one genus; Pteridophyta-two genera; two indeterminable grains. Among them, *Pinus*, Nympaeaceae, *Inapertipollenites* and *Inapertisporites* are abundant, and *Picea*, *Abies*, *Tsuga*, evergreen and deciduous *Quercus*, *Alnus*, *Zelkova* and *Nuphar* are common. The grains such as Taxodiaceae, *Fagus*, *Betula*, *Juglans*, *Acer*, *Myriophyllum*, *Tilia*, *Lycopodium* and *Osmunda* are rare in a relative frequency.

*Sample 1:*

The composite sample from Locality No. 1, situated at about 100 m west of Takuda, was examined for the present study. Locality No. 1 (Text-fig. 1) belongs to the uppermost horizon of the upper part of the Tsukada Member. The sample yielded, Gymnosperm-five genera (37%); Dicotyledon-11 genera and two subgenera (49%); Monocotyledon-two families (6%); spore-three genera (8%).

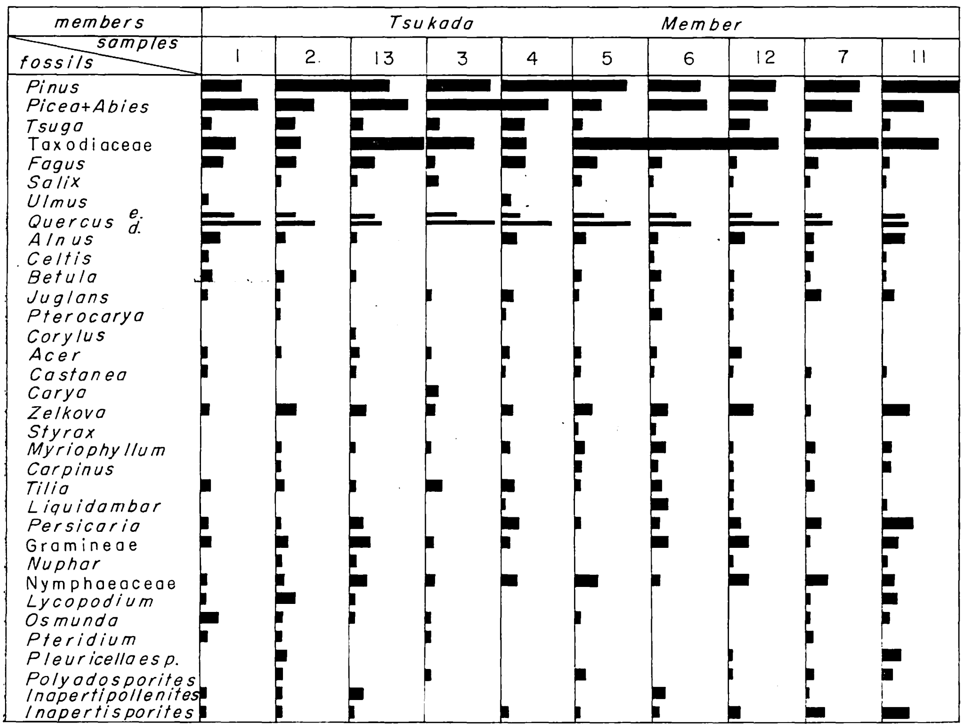
Among these groups, deciduous *Quercus*, *Picea*, *Abies* and *Pinus* are abundant and amount to 42% of the total frequency. The fossil pollen grain of deciduous *Quercus* totals 16%. Taxodiaceae and evergreen *Quercus* are common (ranging from 6 to 9%), both 9%. *Tsuga*, *Fagus*, *Ulmus*, *Alnus*, *Celtis*, *Betula*, *Juglans*, *Acer*, *Castanea*, *Zelkova*, *Tilia*, *Persicaria*, Gramineae, Nympaceae, *Lycopodium*, *Osmunda*, *Pteridium*, *Inapertipollenites* and *Inapertisporites* are rare.

As shown in some text-figures, plants having different habitats are distinguished among the treated composite sample. All of these genera which are representative plant of a warmer temperate and subtropical region, are denoted by the component "B", amounting to 11%. The cooler temperate plants denoted by "C" reach 58% of the total. Whereas the other elements denoted by "A" amount to 31%.

*Sample 2:*

The mixed sample was collected from an outcrop of Locality No. 2 (Text-fig. 1), where is situated at about 200 m just west of Takuda. It belongs to the middle horizon of the upper part of the Tsukada Member.

The sample yielded; Gymnosperm-five genera; Dicotyledon-12 genera and two subgenera; Monocotyledon-two families and one genus; spores-six genera. Among them, *Pinus* is very abundant, showing the highest concentration (20%) in this composite sample. The genus




Text-fig. 4. Pollen diagram (1) of the Tsukada Member.
Numbers refer to Text-figs. 1, 2 and 3.

*Quercus* is classified into two types, one is of large size and other of small size, based on the diameter of the pollen grain, and the latter belongs to the evergreen type. *Picea, Abies* and deciduous *Quercus* are abundant, ranging from 10 to 19%. Taxodiaceae is common, and the other pollen grains such as *Tsuga, Fagus*, evergreen *Quercus*, and *Zelkova* are rare. Gymnosperm, Dicotyledon, Monocotyledon and spore group are 41%, 41%, 6% and 12%, respectively.

The component "A", "B" and "C" are respectively 27, 6 and 67%.

*Sample 13:*

As shown in Text-fig. 1, the mixed sample was collected from Locality No. 13, at about 500 m northeast of the Wajima Station, Ippon-matsu Park. The horizon of the sample is similar to the horizon of Sample 2 above-mentioned. From the mixed sample, Taxodiaceae, *Picea* and *Abies* are very abundant, and the pollen grain of Taxodiaceae is the highest frequency in the sample. *Pinus* is common, amounting to 10%. The others are rare. Gymnosperm, Dicotyledon, Monocotyledon and spores contain respectively four genera and one family (49% in total), 11 genera and two subgenera (36%), one genus and two families (10%), and three genera (5%).

The component "A", "B" and "C" are respectively 31, 8 and 61%.

*Sample 3:*

The sample from Locality No. 3 situated at about 100 m just southwest of Locality No. 2, Takuda, occupies stratigraphically the lowermost horizon of the upper part of the Tsukada Member. In the sample, *Picea* and *Abies* are very abundant, its frequency being 28%. The deciduous *Quercus, Pinus* and Taxodiaceae are abundant, and evergreen *Quercus* is common. The other genera and families shown in Text-fig. 4 are rare.

Gymnosperm, Dicotyledon, Monocotyledon and spores are respectively 55% (four genera and one family), 38% (eight genera and two subgenera), 3% (two families) and 4% (three genera).

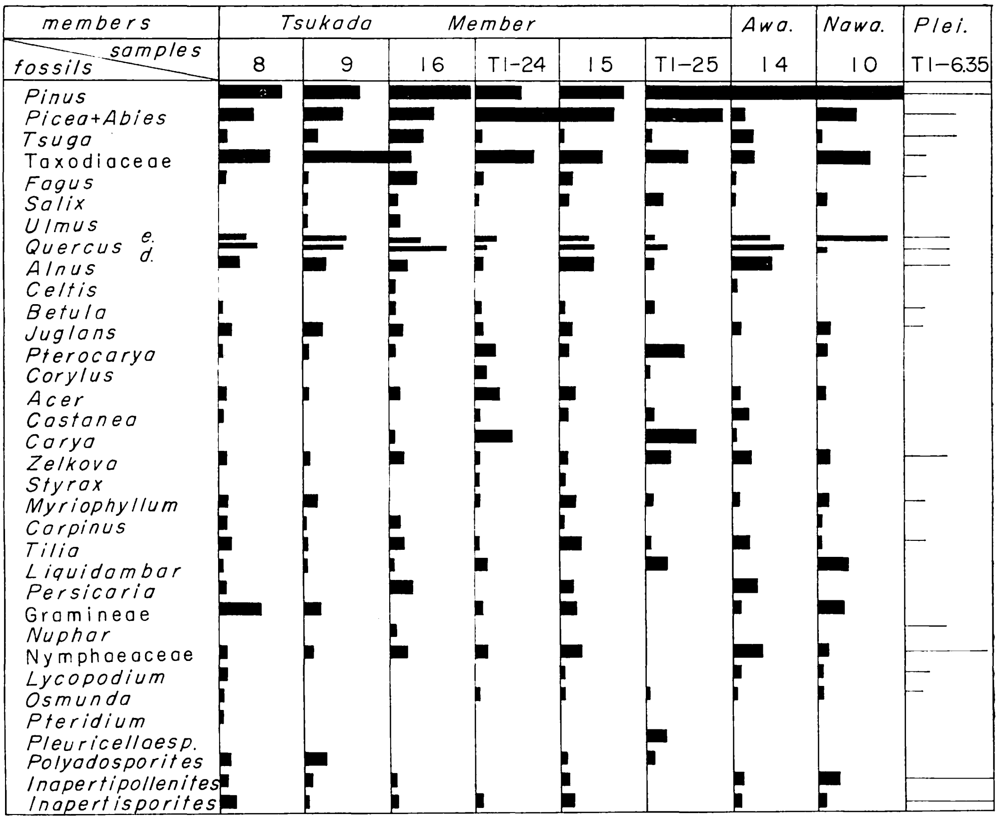
The element "A" amounts to 27%, element "B" to 9%, and element "C" to 64%. The non-arboreal pollen grains denoted by NA amounts only to 7% in total, and the arboreal pollen grains 93%.

*Sample 4:*

As shown in Text-fig. 1, the mixed sample, which was collected from Locality No. 4, at about 50 m southwest of Locality No. 3, Takuda, was treated for the present study. The horizon of Locality No. 4 belongs to the lowermost of the upper part of the Tsukada Member. The rockfacies of the sample is a siliceous shale lithologically and many field geologists classify the Tsukada Member into the upper and lower parts by the siliceous shale.

The composite sample yielded; Gymnosperm-four genera and one family (42%); Dicotyledon-12 genera and two subgenera (50%); Monocotyledon-two genera (6%). Among them, *Pinus* is very abundant and amounts to 20% of the total frequency, being the highest per centage in the composite sample. *Picea*; *Abies* and deciduous *Quercus* are abundant. *Tsuga*, Taxodiaceae, *Fagus* and *Persicaria* are common, and the other pollen grains such as *Ulmus*, evergreen *Quercus, Alnus, Juglans, Pterocarya, Acer, Castanea, Zelkova, Myriophyllum, Tilia, Liquidamber, Persicaria*, Gramineae and Nympaeaceae are frequent, amounting to about 40% in the total frequency.

The component "A", "B" and "C" are respectively 27, 7 and 66%.




Text-fig. 5. Pollen diagram (2) of the Tsukada, Nawamata and Awakura Members, and the Pleistocene Inabune deposits. Numbers refer to Text-figs. 1, 2 and 3.

*Sample 5:*

The mixed sample from Locality No. 5, situated at about 80 m southwest of Locality No. 4, Takuda, occupies stratigraphically the uppermost horizon of the lower part of the Tsukada Member.

The composite sample yielded; Gymnosperm-four genera and one family, amounting to 43%; Dicotyledon-13 genera and two subgenera, amounting to 49%; Monocotyledon-one family, being five per cent; spores-three genera, being three per cent. Among them, Taxodiaceae is very abundant and the highest per cent (20%) in the total frequency. Deciduous *Quercus* and *Pinus* are abundant, being respectively 14 and 13%. *Picea*, *Abies* and evergreen *Quercus* are common. *Tsuga*, *Salix*, *Alnus*, *Betula*, *Juglans*, *Acer*, *Castanea*, *Zelkova*, *Stylux*, *Myriophyllum*, *Carpinus*, *Tilia*, *Persicaria*, Nympaceae, *Osmunda*, *Polyadosporites* and *Inapertisporites* are rare, amounting to about 35% in the total frequency of these pollen grains and spores.

The element "A" amounts to 17%, element "B" to 8% and element "C" to 75%.

*Sample 6:*

This sample is from an outcrop of Locality No. 6 (Text-fig. 1), situated at about 1,300 m southwest of the Wajima Station of the National Railway Nanao

Line and about 50 m west of Locality No. 5, Takuda. From sample 6, which occupies stratigraphically the upper horizon of the lower part of the Tsukada Member. Taxodiaceae is very abundant and is found in 20% of the total frequency. *Picea*, *Abies*, *Pinus* and deciduous *Quercus* are abundant, ranging from 10 to 19%. This sample yielded, Gymnosperm-three genera and one family (45% of the total); Dicotyledon-16 genera and two subgenera (48%); Monocotyledon-two families (5%); spores-one genus (2%). Among them, it is noteworthy that the pollen grains of *Liquidambar* are found from this horizon of the Late Miocene.

On the other hand, the element " A " amounts to 23%, element " B " to 13%, and element " C " to 64%. And from the viewpoint of the palynological environment, the upland and mixed-slope elements are abundant.

*Sample 12:*

Sample 12 belongs stratigraphically to the middle horizon of the lower part of the Tsukada Member, and was collected from the highest level of an outcrop of Locality No. 12, situated at about 550 m nort east of the Wajima Station, and at northern side of Ippon-matsu Park. The horizon of Sample 11 mentioned below situates the lowermost level of this outcrop and the interval between these two horizons is about 20 m.

Taxodiaceae is abundant, being 13% of the total frequency. *Pinus*, deciduous *Quercus*, *Picea* and *Abies* are abundant, ranging from 10 to 13%. This sample yielded, Gymnosperm-four genera and one family, being about 40% in the total frequency; Dicotyledon-14 genera and two subgenera, amounting to 46%; Monocotyledon-one genus and two families, about 10%; spore-three genera and amounts to 5%.

On the other hand, the element " A " amounts to 22%, element " B " to 9% and element " C " to 69%. And also, the non-arboreal grains are about 20%, and the arboreal pollen grains about 80% of the total frequency.

*Sample 7:*

The composite sample from Locality No. 7, situated at about 100 m southwest of Locality No. 6, was examined for the present study. Locality No. 7 belongs to the middle horizon of the lower part of the Tsukada Member.

The composite sample yielded, Gymnosperm-four genera and one family (46%); Dicotyledon-12 genera and two subgenera (34%); Monocotyledon-two families (7%); spores-6 genera (13%).

The element " B " which is representative plants of a warmer temperate and subtropical region amounts to 5%. The cooler temperate plants denoted by " C " reach 73% of the total frequency. Whereas the other element " A " amounts to 22%.

Among them, Taxodiaceae, *Pinus*, *Picea* and *Abies* are abundant in the relative frequency, and Taxodiaceae amounts to 19% in the total frequency.

*Sample 11:*

As shown in Text-fig. 1, the mixed sample was collected from Locality No. 11 at about 1200 m northeast of Locality No. 1 and northern end of Tsukada-machi.

The horizon of the sample belongs to the middle horizon of the lower part of the Tsukada Member. From the composite sample, *Pinus*, Taxodiaceae, *Abies* and *Picea* are abundant in frequency, namely, *Pinus* is very abundant (20%) and the other pollen grains range from 11 to 15%. Both type of *Quercus*, *Alnus*, *Zelkova*, *Persicaria* and *Inapertisporites* are common, and *Tsuga*, *Fagus*, *Salix*, *Celtis*, *Betula*, *Juglans*, *Castanea*, *Myriophyllum*, *Carpinus*, *Liquidambar*, Gramineae (small type), *Nuphar*, Nymphaeceae, *Lycopodium*, *Osmunda*, *Pleuricellaesporites* and *Polyadosporites* are rare.

Among them, Gymnosperm-one family and four genera, being 43% in the total frequency; Dicotyledon-12 genera and two subgenera, amounting to 44%; Monocotyledon-two families and one genus, being 8%; spores-five genera, being 5% of the total frequency.

The elements "A", "B" and "C" are 25, 11 and 64% respectively.

*Sample 8:*

The sample is from an outcrop of Locality No. 8 (Text-fig. 1), where is situated at about 60 m southwest of Locality No. 7 of Takuda-machi. It belongs to the lower horizon of the lower part of the Tsukada Member. The rock-facies of the sample is dark bluish greenish gray homogeneous diatomaceous mudstone with very fine-grained sand and silt.

This sample yielded; Gymnosperm-one family and four genera, being 36% in the total frequency; Dicotyledon-13 genera and two subgenera, being 41%; Monocotyledon-two families, amounting to 12%; spores-six genera, being 12%. Among them, *Pinus*, Taxodiaceae and Gramineae (small grain type) are abundant, respectively 15, 12 and 10%. *Picea*, *Abies*, deciduous and evergreen *Quercus* are common, ranging from 6 to 9%.

The elements "A", "B" and "C" are 18, 11 and 71% of the total frequency.

*Sample 9:*

The sample was collected from Locality No. 9 situated at about 100 m southwest of Locality No. 8 of Takuda, and belongs to the lower horizon of the lower part of the Tsukada Member.

Among these pollen grains and spores, Taxodiaceae, *Pinus* and *Picea-Abies* are very abundant, being 20%, amount to 13 and 10% respectively. *Tsuga*, evergreen *Quercus* and deciduous *Quercus* are common.

The sample yielded; Gymnosperm-four genera and one family, being 45% of the total frequency; Dicotyledon-12 genera and two subgenera, being 41%; Monocotyledon-two families and amounting to 6%; spores-three genera, being 8%.

The elements "A", "B" and "C" are found 27, 13 and 60% respectively from the composite sample.

*Sample 16:*

This sample is from an outcrop of Locality No. 14 (Text-fig. 1) which is situated at about 50 m east of the Wajima Hospital and at western end of the Ippon-matsu Park.

From Sample 16, which occupies stratigraphically the lowermost horizon of the lower part of the Tsukada Member, *Pinus* is found in 19% of the total frequency. Deciduous *Quercus*, *Pinus* and *Abies* are abundant. *Tsuga*, *Fagus*, evergreen *Quercus* and *Persicaria* are common in relative frequency, ranging from 6 to 9%.

This sample yielded, Gymnosperm-one family and four genera, being 41%; Dicotyledon-15%; Monocotyledon-one genus and one family, being 4%; spores-two genera, amounting to 3%.

The elements "A", "B" and "C" are 29, 10 and 61% respectively.

*Sample T-1-24:*

This sample was taken from 24 m in depth of the well drilled at Locality No. T-1 situated at Ippon-matsu Park.

The sample from this boring-core is a light yellowish brown clayey siltstone, and the horizon of the sample belongs to the lowermost horizon of the lower part of the Tsukada Member.

This composite sample yielded, Gymnosperm-one family and four genera (47%); Dicotyledon-15 genera and two subgenera (45%); Monocotyledon-two families (5%) and spores-two genera (3%). Among them, Taxodiaceae, *Pinus* and *Abies* type pollen grains are abundant, *Acer* and *Carya* are common. The other grains such as *Tsuga, Fagus, Salix, Quercus, Betula* and *Corylus* etc. are rare in a relative frequency.

As shown in some text-figures plants having different habitats are distinguished among the treated composite sample. The element "A", "B" and "C" are respectively 27, 9 and 64%, and also the non arboreal pollen grains (NAP) and the arboreal pollen grains (AP) are 8 and 92%.

*Sample 15:*

This mixed sample is from an outcrop of Locality No. 14 (Text-fig. 1) which is same to the outcrop of the locality collecting Samples 14 and 16. Namely, Sample 16 was collected from the upper part (the lower horizon of the lower part of the Tsukada Member) of this large outcrop, Sample 15 from the middle part (the lowermost horizon of the lower part of the Tsukada Member) and also Sample 14 from the lower part (the middle horizon of the Awakura Member). The rock facies of this sample is a light brownish gray coarse-grained sandstone intercalated with thin dark bluish greenish gray mudstone layer.

The mixed sample yielded; Gymnosperm-one family and four genera (37% in the total); Dicotyledon-14 genera and two subgenera (48%); Monocotyledon-two families (9%); spores-five genera (6%). *Pinus* is abundant, being 15% of the total frequency. The element "A", "B" and "C" are 23, 9 and 68% respectively, and the arboreal pollen grain (AP) and non arboreal pollen grain are (NAP) 80 and 20%.

*Sample T-1-25:*

This sample was taken from 25 m in depth of the well drilled at Locality No. T-1 situated at Ippon-matsu Park.

The sample is a light brown siltstone, being correlated with a horizon between the horizon of Sample 15 and that of Sample 14. The horizon of Sample T-1-25 is the lowermost horizon of the lower part of the Tsukada Member.

The sample yielded; Gymnosperm-one family and four genera (49%); Dicotyledon-11 genera and two subgenera (52%); Monocotyledon-two families (9%) and spores-three genera (8%).

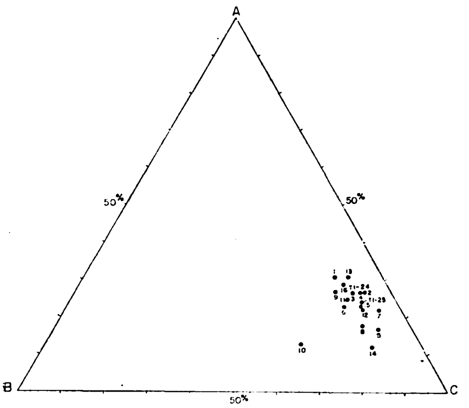
Among them, *Pinus, Abies* and *Picea* pollen grains are very abundant. Taxodiaceae and *Castanea* are abundant. Deciduous *Quercus, Juglans* and *Zelkova* are common, the other pollen grains and spores are rare in a relative frequency.

As shown in some text-figures the element "A", "B" and "C" are respectively 23, 9 and 68%, and the non arboreal pollen grains (NAP) and the arboreal pollen grains (AP) are 8 and 92% respectively.

*Sample 14:*

This mixed sample was collected from the outcrop of Locality No. 14 (Text-fig. 1) which is located at the back of the Wajima Hospital near the Wajima Station. The sample is belonging to the middle horizon of the Awakura Member.

The composite sample yielded; Gymnosperm-one family and four genera (33% in the total frequency); Dicotyledon-12 genera and two subgenera (50%); Monocotyledon-two families (9%); spores-four genera (8%). *Pinus* is ver, abundant,




Text-fig. 6. Pollen Diagram (3) : Triangular diagram showing the relationship between cold and cool, temperate and warm climate elements found from several samples of the Tsukada, Awakura, Nawamata Members and Inabune Deposits. Numbers refer to Text-figs. 1, 2 and 3.

being 20%.

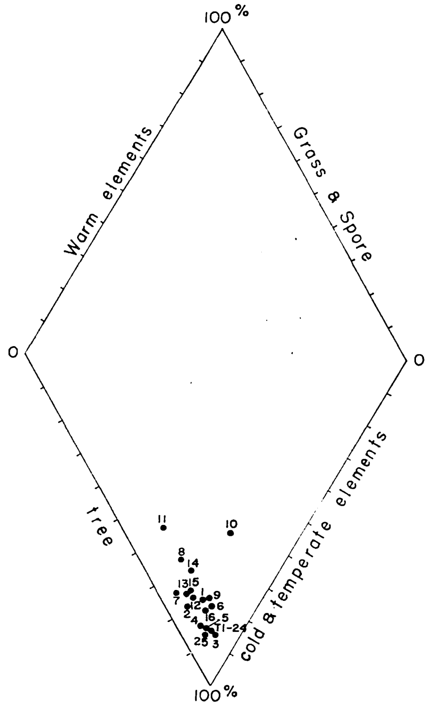
The component " A ", " B " and " C " are 12, 12 and 76% respectively and the arboreal pollen grains (AP) and non arboreal pollen grains (NAP) are 77 and 23% respectively.

*Sample 10:*

This sample was collected from Locality No. 10 at about 200 m south of Locality No. 9, Takuda. The mixed sample is belonging to the uppermost horizon of the Nawamata Member, being a dark brown mudstone.

The composite sample yielded; Gymnosperm-one family and four genera (42% in the total frequency); Dicotyledon-9 genera and two subgenera (42%); Monocotyledon-two families (8%) and spores-four genera (8%).

The element " A ", " B " and " C " are 13, 28 and 59% respectively, and non arboreal pollen grains (NAP) and arboreal pollen grains (AP) are respectively 17 and 83%.



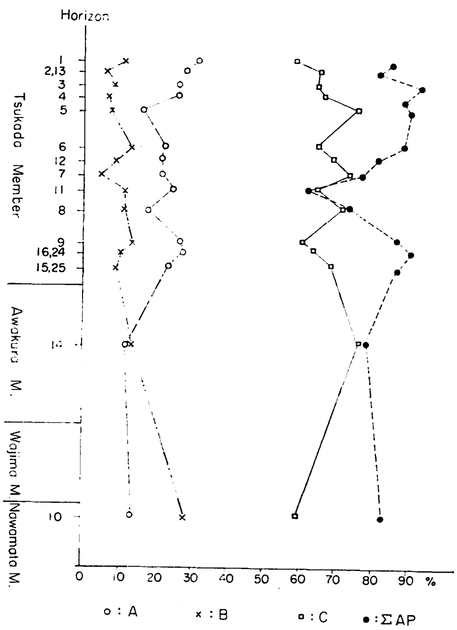

Text-fig. 7. Pollen diagram (4) : Quadrilateral diagram showing the paleoclimatic condition and paleoecological environment. Numbers refer to Text-figs. 1, 2 and 3.

(5) Discussion

A general interpretation is made of the physical conditions that prevailed during the growth of the sedimentary basin in which the flora was buried on the basis of an analysis of the fossil spores and pollen grains. In this section, the writer will give a discussion on the paleoclimatic condition, paleogeographical environment and geological age of the stratigraphical units based upon the palynological and field researches.

(a) Paleoclimatic condition

On the basis of the analysis of the pollen grain and spore assemblage the general characters of the paleoclimatic




Text-fig. 8. Pollen diagram (5) : Figure showing the relationship among cold and cool (A in Text-figs. 6 and 8), temperate (C) and warm (B) climate elements. Numbers refer to Text-figs. 1, 2, 3, 6 and 13. AP : arboreal pollen grains.

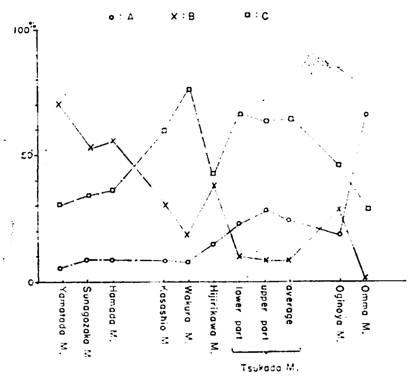
condition can be presented. The methods for analysing the assemblages for paleoclimatic interpretation have been proposed by some palynologists and paleobotanists. As shown in the triangular diagram (Text-fig. 6), quadrilateral diagram (Text-fig. 7) and pollen diagram (Text-fig. 8), the warm and subtropical plants denoted by " B " in some text-figures of this paper as *Liquidambar* and *Metasequoia* are yielded much less from the Tsukada Member than those from the Yamatoda and Sunagozaka members which are correlated with the Daijima age. That is to say, the Sunagozaka and Yamatoda members contain from 60 to 80% of the total frequency, and the Tsukada only 9%. This result is closely similar to those from the fossil pollen grain and spore assemblage from the Wakura diatomaceous mudstone Member (FUJI, 1969a) which is distributed in the central part of Noto Peninsula. As shown in Text-figs. 8 and 9, the warm climate elements from the lower part of the Tsukada Member show higher frequency than those from the upper part, namely, the lower part amounts to 10% whereas the upper part to only 8%. Throughout the member the change of the warm climate elements is a negative reciprocity to the cold and cool climate elements such as *Picea*, *Abies*, *Betula* and *Fagus* etc. That is to say, the warm climate elements are common a relative frequency mentioned above, the cold and cool climate elements 23 and 29% respectively. If we examine fully the relationship between the two climate elements denoted by A and B, the relationship is not always a negative reciprocity. For instance, in the change between Sample nos. 5 and 4, the cold and cool climate elements are found respectively to comprise 17% (Sample No. 5) and 27% (Sample No. 4), the warm climate elements B 8% (Sample No. 5) and 7% (Sample No. 4), and also the temperate climate elements C 75% (Sample No. 5) and 66% (Sample No. 4). Namely, the change of the cold and cool climate elements relates rather directly to the temperate climate elements than to the warm climate elements.

According to the writer's researches, as shown in the triangular and quadrilateral diagrams (Text-figs. 12 and 13), and pollen diagrams (Text-figs. 9 and 11), though the warm and subtropical plants found from the Tsukada Member show higher frequency than those from the Omma Member, they are numerically much less than those from the Hijirikawa, Wakura and Kasashio members which are correlated to the Tsukada

Member. The warm and tropical plants are found abundantly from the Middle Miocene Yamatoda, Sunagozaka and Hamada members. Though the Tsukada, Wakura, Kasashio and Hijirikawa members belong to the same age, the Late Miocene Epoch, the component of the pollen-floras from the other members is different from that of the Tsukada Member.

This result may be related closely to the paleoenvironment under which the Tsukada Member was deposited. That is to say, judging from the palynological results, litho-facies, poor contents of planktonic foraminifers, fossil diatom floras and diversity in the thickness of the deposits of the Hijirikawa and Wakura members, the paleogeographical environment under which the Tsukada Member was deposited was an open embayment facing the open sea. The sea under which the other members except the Tsukada Member were deposited seem to have been a closed embayment probably connected with the lagoon of that age. And as a consequence of the paleogeographical environment mentioned above those localities seem to have not been subjected to the influence of a cold current and/or north wind. As a natural course of the event, though the plants which are exotic conifers such as *Cunninghamia*, *Taiwania*, *Metasequoia* and *Glyptostrobus* and evergreen broad-leaved tree such as *Liquidambar* seem to have remained as a relict in the central part of Noto Peninsula where the Hijirikawa, Wakura and Kasashio members are locally distributed, those plants seem to have been affected by current and/or wind of the northern part (Tsukada area) of the peninsula.

Comparison between the fossil plants and the living equivalents whose climatic requirements are known is frequent-




Text-fig. 9. Pollen diagram (6) : Figure showing the cold and cool (A in Text-figs. 2, 3, 6 and 13), temperate (C) and warm (B) climate elements found from the Neogene System in the Hokuriku region.

ly used for climatic analysis of a fossil flora. Where the modern relationships are known definitely, this method is probably useful for acquring accurate information. The Neogene species are comparatively modernized in morphological features, so it is not difficult to compare them with their living equivalents with some exceptions. The genera composing 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. The exotic coniferous genera are found throughout the Neogene floras of the Japanese Islands, and they are now mostly living in China, and some of them are known in the western part of North America.

The Tsukada pollen-flora consists mainly of the temperate genera with some warm and cold—cool climate elements. The dominant genera among the temperate flora are *Alnus*, *Castanea*, *Quercus*, *Zelkova*, *Acer*, *Pterocarya* and *Juglans* etc. Their modern equivalent species are mostly distributed in the

Japanese Islands proper, especially in the northern part of Honshû and Hokkaido. Further, the pollen-flora from the Tsukada Member contains the exotic conifers such as *Metasequoia* and exotic broad-leaved Dicotyledons as *Liquidambar*, though they are not abundant in number of specimens and species and may be the relicts which survived from the previous Middle Miocene Epoch. Thus, according to the present writer's investigation, the pollen flora from the Tsukada Member is composed of a mixed, mainly temperate and some warm and cold climate elements in floristic composition as already described in the previous part of this paper.

From the viewpoint of leaf character analysis reported on the Late Miocene floras from various localities in the Japanese Islands, these pollen-floras are related to the present temperate or somewhat warm temperate forest now growing in the central and southern parts of the Japanese Islands, and they seem to have grown under a warm

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Explanation of Plate 35

Fig. 1. *Tilia*, polar view, 25μ; Locality No. 9, Takuda, Wajima City; the lowest horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20194.

Fig. 2. *Tilia*, polar view, 36μ; 24 m in depth of the well drilled in Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20195.

Fig. 3. *Tilia*, polar view, 32μ; Locality No. 9, Takuda, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20196.

Fig. 4. *Tilia*, polar view, 29μ; Locality No. 2, Takuda, Wajima City; the middle horizon of the upper part of the Tsukada Member; EKZJ coll. cat. no. 20197.

Fig. 5. *Tilia*, polar view, 24μ; Sample 13 from Locality No. 13, Ippon-matsu Park, Wajima City; the middle horizon of the upper part of the Tsukada Member; EKZJ coll. cat. no. 20198.

Fig. 6. Cf. *Fagus*, oblique equatorial view, 38μ; Locality No. 9, Takuda, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20199.

Fig. 7. *Juglans*, polar view, 37μ; Locality No. 9, Takuda, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20200.

Fig. 8. *Juglans*, polar view, 42μ; Locality No. 2, Takuda, Wajima City; the middle horizon of the upper part of the Tsukada Member; EKZJ coll. cat. no. 20201.

Fig. 9. *Juglans*, polar view, 40μ; 24 meters in depth of the well drilled in Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20202.

Fig. 10. *Inapertipollenites*, polar view, 45μ; Locality No. 6, Takuda, Wajima City; the upper horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20203.

Fig. 11. *Fagus*, oblique equatorial view, 43μ; Locality No. 1, Takuda, Wajima City; the uppermost horizon of the upper part of the Tsukada Member; EKZJ coll. cat. no. 20204.

Fig. 12. *Carya*, oblique polar view, 46μ; Locality No. 1, Takuda, Wajima City; the uppermost horizon of the upper part of the Tsukada Member; EKZJ coll. cat. no. 20205.

Fig. 13. Cf. *Fagus*, oblique equatorial view, 36μ; Locality No. 9, Takuda, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20206.

Fig. 14. *Fagus*, polar view, 30μ; Locality No. 2, Takuda, Wajima City; the middle horizon of the upper part of the Tsukada Member; EKZJ coll. cat. no. 20207.

Fig. 15. *Salix*, oblique polar view, 36μ; Locality No. 8, Takuda, Wajima City; the lower horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20208.


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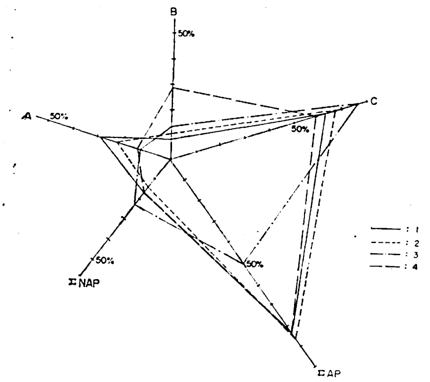
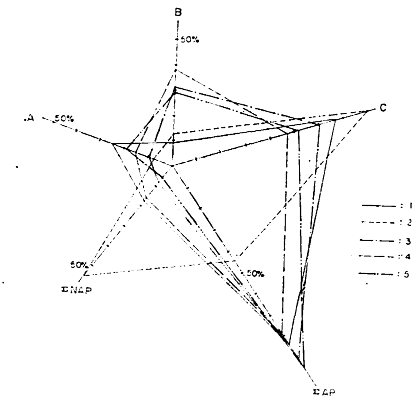



Text-fig. 10. Pollen diagram (7) : Pentagonal diagram showing the relationship among cold and cool (A), temperate (C) and warm (B) climate elements, NAP and AP found from the upper part of the Tsukada Member (1), the lower part of the Tsukada Member (2), Awakura (3) and Nawamata (4) members.



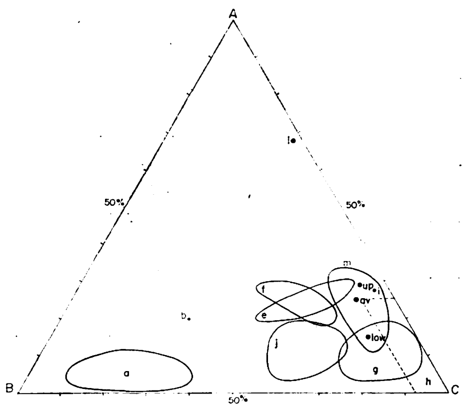

Text-fig. 11. Pollen diagram (8) : Pentagonal diagram showing the relationship among cold and cool (A), temperate (C) and warm (B) climate elements, arboreal pollen grains (AP) and non arboreal pollen grains found from the Tsukada (1), Wakura (2), Kasashio (3), Hijirikawa (4) and Oginoya (5) members.

temperate climatic condition. However, the reduction of warm and subtropical plants evidently indicates that the temperature had lowered in comparison with that of the Middle Miocene Yamatoda and Sunagozaka members (FUJI, 1969b).

The Tsukada pollen-flora somewhat resembles the forest now growing in the central or northern parts of the Japanese Islands. The floristic composition of the fossil floras of this stage, the Latest Miocene, varies with the localities, so that the climate at that time shows local difference. From the viewpoint of the result, the Tsukada pollen-flora seems to have differed from the other pollen-floras of the same time, such as Hijirikawa and Wakura floras.

(b) Paleogeographical environment

To facilitate the considerations on the probable paleogeographical environments under which the ancient plants grew, the modern equivalents of the fossil species can be grouped according to their




Text-fig. 12. Pollen diagram (9) : Triangular diagram showing the relationship among cold and cool (A), temperate (C) and warm (B) climate elements found from the Yamatoda (a), Sunagozaka (b), Hojuji (e), I'ida (f), Wakura (g), Nakayama-toge (i), Hijirikawa (j) and Omma (l) members, and the upper part (up), lower part (low) of the Tsukada Member, and average per cent (av) of the Tsukada Member.

habitats into four types of upland; mixed-slope, stream-side or riparian, and lake or marshy elements.

The Tsukada pollen-flora is composed mainly of mixed-slope or mixed-slope—riparian plants in the frequency of specimens, and contains upland—mixed-slope plants. That is to say, the Tsukada pollen-flora seems to represent a mixed-slope to riparian assemblage.

On the other hand, judging from the lithofacies, poor contents of the other microfossils such as diatoms and planktonic foraminifers and diversity in the thickness of the Tsukada Member, the basin in which the member was deposited seems to have been an open embayment with a wide mouth facing the open sea. The spread of the sedimentary basin and paleogeographical outline are shown in Text-figs. 14 and 15.

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Explanation of Plate 36

Fig. 1. Deciduous *Quercus*, equatorial view, 26μ; Locality No. 8, Takuda, Wajima City; the lower horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20209.

Fig. 2. Evergreen *Quercus*, equatorial view, 23μ; Locality No. 6, Takuda, Wajima City; the upper horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20210.

Fig. 3. Deciduous *Quercus*, equatorial view, 28μ; Sample 16 from Locality No. 14, Ippon-matsu Park, Wajima City; EKZJ coll. cat. no. 20211.

Fig. 4. Evergreen *Quercus*, equatorial view, 22μ; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20212.

Fig. 5. Deciduous *Quercus*, equatorial view, 27μ; 24 m in depth of the well drilled at Locality No. 1, Ippon-matsu Park, Wajima City; EKZJ coll. cat. no. 20213.

Fig. 6. Evergreen *Quercus*, equatorial view, 23μ; Sample 13 from Locality No. 13, Ippon-matsu Park, Wajima City; the middle horizon of the upper part of the Tsukada Member; EKZJ coll. cat. no. 20214.

Fig. 7. Deciduous *Quercus*, equatorial view, 29μ; Sample 15 from the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20215.

Fig. 8. Indeterminable pollen grain (?), 34μ; Locality No. 8, Tsukada, Wajima City; the lower horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20216.

Fig. 9. Cf. *Ilex*, oblique polar view, 26μ; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20217.

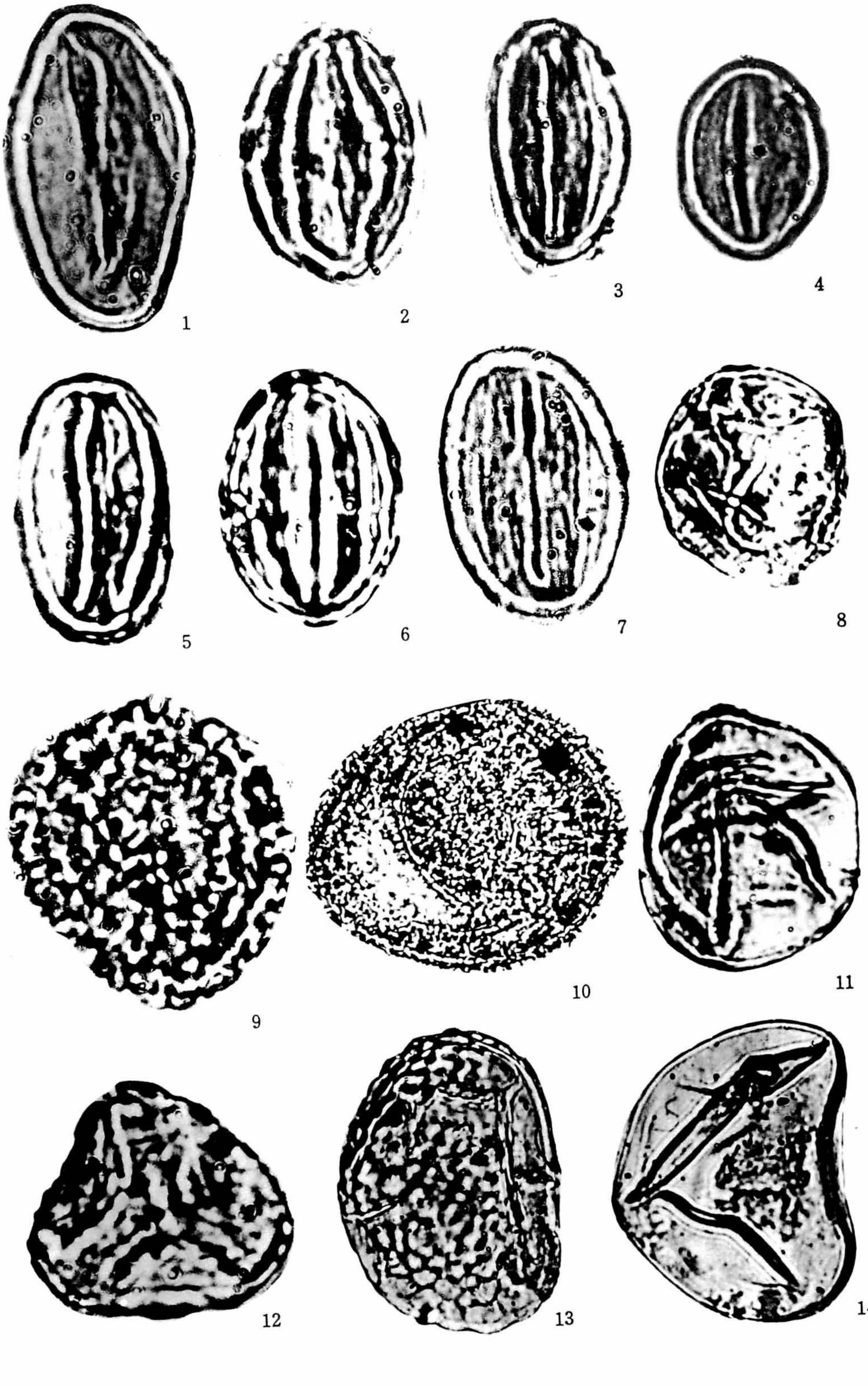
Fig. 10. *Nuphar* (?), equatorial view, 46μ; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20218.

Fig. 11. Aff. *Carya*, oblique polar view, 40μ; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower par of the Tsukada Member; EKZJ coll. cat. no. 20219.

Fig. 12. Gleicheniaceae, 38μ; Locality No. 5, Takuda, Wajima City; the uppermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20220.

Fig. 13. *Osmunda*, 48μ, lateral view; Locality No. 12, Ippon-matsu Park, Wajima City; the middle horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20221.

Fig. 14. Cf. Monolete type spore, 38μ, lateral view; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20222.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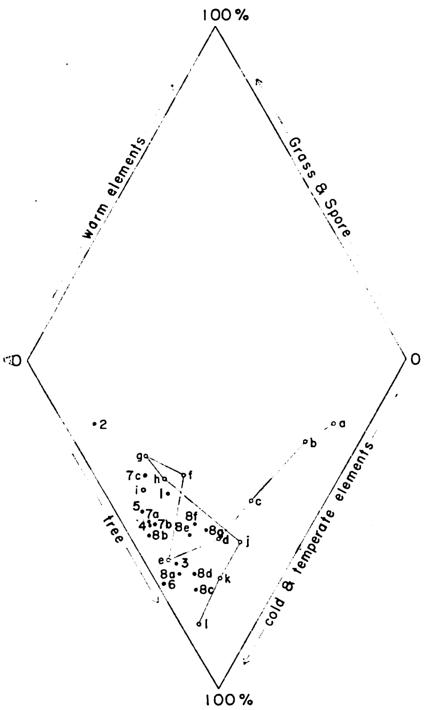
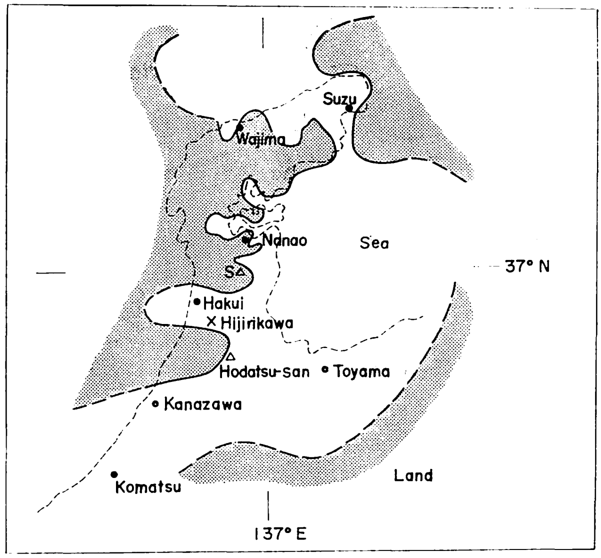



Text-fig. 13. Pollen diagram (10) : Quadrilateral diagram showing the paleoclimatic condition, paleoecological environment, tree pollen grains (AP) and grass pollen grains & spores (NAP) from the Yamatoda (a) ; Pollen grain from the Sunagozaka (b), Higashi-in'nai (c), Najimi (d), Hojuji (e), I'ida (f), Wakura (g), I'izuka (h), Nakayama-toge (i), Hijirikawa (j), Takakubo (k) and Omma (l) members. Numbers refer to Text-figs. 1 and 3 in the writer's previous paper (1969a).




Text-fig. 14. The paleogeographical map during the Otokawa Stage of the Late Miocene Epoch in the Hokuriku region (After Y. KASENO, 1963).

(c) Geological age

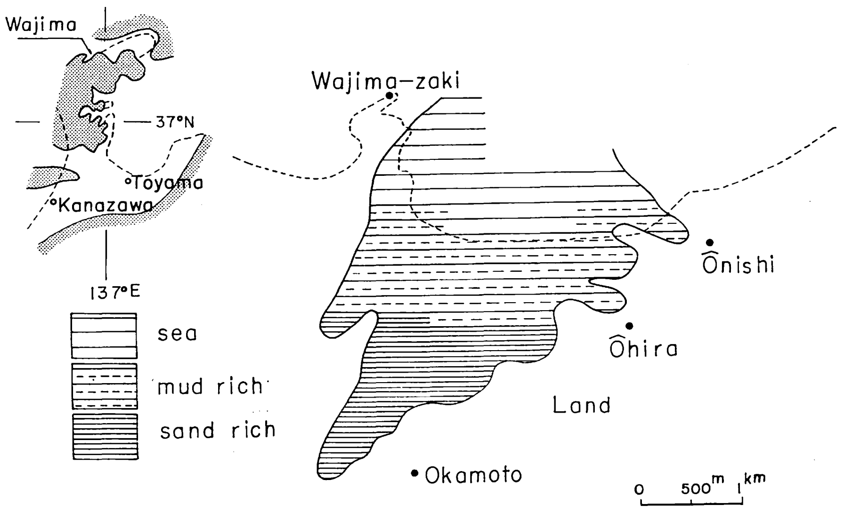
The correlation and age determination of the Neogene floras have been frequently done by use of some characteristic fossils and assemblages in the Japanese Islands. TANAI (1963) classified the Neogene floras of Japan into six types as described already in the writer's previous papers (FUJI, 1969a, b, c).

In generic composition the Tsukada pollen-flora is very similar to the Mitoku-type flora. The Mitoku-type flora contains a few exotic elements which are found abundantly in the Yamatoda and Noroshi floras. The exotic elements are commonly found in the Late Miocene floras of Europe and in the western region of the United States of America where the modernized plants of these exotic elements are abundant.

Thus, in comparison with various floras of the Tertiary in the Japanese Islands and from the viewpoint of stratigraphical evidences and paleontological data, the Tsukada pollen-flora is correlated with the Mitoku-type flora, and the member seems to be geochronologically of the Late Miocene or Earliest Pliocene epoch.

## References

COUPER, R.A. (1953) : Upper Mesozoic and Cainozoic spores and pollen grains from




Text-fig. 15. The paleogeographical map during the sedimentation of the Tsukada Member in the Otokawa Stage of the Late Miocene Epoch in the Wakura area of Noto Peninsula, Central Japan (after Y. KASENO, 1963).

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## Explanation of Plate 37

Fig. 1. *Picea*, lateral view, 70$\mu$; Locality No. 5, Takuda, Wajima City; the uppermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20223.

Fig. 2. *Picea*, lateral view, 82$\mu$; Locality No. 7, Takuda, Wajima City; the middle horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20224.

Fig. 3. *Picea*, lateral view, 67$\mu$; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20225.

Fig. 4. Taxodiaceae, Cf. *Metasequoia*, oblique lateral view, 22$\mu$; Sample 14 from the outcrop of Locality No. 14, Ippon-matsu Park, Wajima City; the middle horizon of the Awakura Member, Sample 14 was collected from the tuffaceous mudstone of the Awakura Member; EKZJ coll. cat. no. 20226.

Fig. 5. *Picea*, lateral view, 70$\mu$; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20227.

Fig. 6. *Abies*, lateral view, 82$\mu$; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20228.

Fig. 7. *Tricolpropollenites* type pollen grain, gen. indet, equatorial view, 46$\mu$; Locality No. 7, Takuda, Wajima City; the middle horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20229.

Fig. 8. Taxodiaceae, lateral view, 38$\mu$; Sample 15 from the lowermost horizon of the lower part of the Tsukada Member, Locality No. 14, Ippon-matsu Park, Wajima City; EKZJ coll. cat. no. 20230.

Fig. 9. *Abies*, oblique ventral view, 98$\mu$; 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; the lowermost horizon of the lower part of the Tsukada Member; EKZJ coll. cat. no. 20231.


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New Zealand. *New Zealand Geol. Surv. Paleont. Bull.* 22, 77pp., 3 text-figs., 3 tabs., 9 pls.

ERDTMAN, G. (1969) : Handbook of palynology. 486pp., 49 figs., 125 pls., *Munksgaard.*

FAEGRI, K. and IVERSEN, T. (1954) : Textbook of pollen analysis. 237pp., 23 text-figs., 8 pls., *Munksgaard.*

FUJI, N. (1964) : Palynological studies on the Late Tertiary and Quaternary Systems in Hokuriku District, Central Japan. *Quaternary Research,* vol. 4, 3,4, p. 138-190, 5 text-figs., 1 tab.

—— (1969a) : A palynological study of the Late Miocene Wakura Member. Fossil spores and pollen grains from the Neogene deposits in Noto Peninsula, Central Japan—I. *Trans. Proc. Palaeont. Soc. Japan,* N.S., No. 74, pp. 1-25, 2 pls., 2 tabs., 10 figs.

—— (1969b) : A palynological study of the Middle Miocene Yamatoda Member. Ditto —II. *Ibid.,* No. 75, pp. 51-80, 3 pls., 9 figs., 2 tabs.

—— (1969c) : A palynological study of the Pliocene Oginoya and Late Miocene Hijirikawa Members. Ditto—III. *Ibid.,* No. 76, pp. 185-204, 2 pls., 2 tabs., 7 figs.

KASENO, Y. (1963) : Geology of southern Noto Peninsula, Central Japan, with reference to the Cenozoic history. *Sci. Rept. Kanazawa Univ.,* vol. 8, No. 2, pp. 541-568, 11 text-figs., 1 tab., 4 pls.

—— (1965) : Geology of Noto Peninsula. *Scientific Survey of Noto Peninsula,* pp. 1-84, 4 pls., 20 figs., 11 tabs., 1 geol. map ; Ishikawa Prefecture.

MATSUURA, N. (1955) : Geology and landslide in the central area of the Wajima District, Ishikawa Prefecture (MS). *Graduation Thesis of the Kanazawa Univ.,* No. 15 in the Geological Institute, 76 pp., 3 maps, 13 figs., 13 tabs.

OTUKA, Y. (1946) : Geoscientific observation in the northern coast of Noto Peninsula. *Shizen-kenkyu,* pp. 12-17.

TANAI, T. (1961) : Neogene floral change in Japan. *Jour. Fac. Sci., Hokkaido Univ., Ser. 4,* vol. 11, no. 2, pp. 119-398, 32 pls., 15 tabs., 7 text-figs.

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| Anamizu | 穴 水 | Nanao | 七 尾 |
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| Daijima | 台 島 | Nishi-ôno | 西大野 |
| Ezoana | 蝦夷穴 | Noroshi | 狼 煙 |
| Hamada | 浜 田 | Noto | 能 登 |
| Hijirikawa | 聖 川 | Omma | 大 桑 |
| Hiradoko | 平 床 | Okamoto | 岡 本 |
| Hokuriku | 北 陸 | Okazuka | 岡 塚 |
| Ikuru | 伊久留 | Otokawa | 音 川 |
| Inabune | 稲 舟 | Soyama | 曽 山 |
| In'nai | 院 内 | Sunagozaka | 砂子坂 |
| Ippon-matsu | 一本松 | Takuda | 宅 田 |
| Ishikawa | 石 川 | Tsukada | 塚 田 |
| Jinoko | 地の粉 | Wajima | 輪 島 |
| Kanazawa | 金 沢 | Wajima-nuri | 輪島塗 |
| Kasashio | 笠師保 | Wajima-zaki | 輪島岬 |
| Kirita | 桐 田 | Wakura | 和 倉 |
| Ko-ise | 小伊勢 | Warabino | 蕨 野 |
| Konogi | 此 木 | Yamatoda | 山戸田 |
| Kwanto | 関 東 | Yokohama | 横 浜 |
| Mitoku | 三 徳 | Yokoji | 横 地 |

## Explanation of Plate 38

Fig. 1. Photograph showing contact of pollen grain body and bladders of *Picea* from Locality No. 9, Takuda, Wajima City; ×600; EKZJ coll. cat. no. 20232; A: bladder, B: pollen grain body, C: contact part.

Fig. 2. Photograph showing sporoderm pattern of pollen grain body of *Picea* from Locality No. 9; ×880; EKZJ coll. cat. no. 20233; A: bladder, B: pollen grain body.

Fig. 3. Microphotograph showing contact of pollen grain body and bladders of *Picea* from 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu Park, Wajima City; ×640; EKZJ coll. cat. no. 20234; C & D: bladder, E: pollen grain body; F: contact area.

Fig. 4. Photomicrograph showing sporoderm pattern, especially sexine, of bladder of *Abies* from 24 m in depth of the well drilled at Locality No. T-1; ×640; EKZJ coll. cat. no. 20235; D: bladder, E: body.

Fig. 5. Photomicrograph showing sporoderm pattern of pollen grain body and marginal ridge of *Abies* from horizon above mentioned; EKZJ coll. cat. no. 20236; ×640; E: pollen grain body, M: marginal ridge.

Fig. 6. Photomicrograph showing contact of bladders and pollen grain of *Abies* from horizon refered to Fig. 4; ×800; EKZJ coll. cat. no. 20237; C: bladders, D: contact area.

Fig. 7. Photograph showing colpus of the deciduous *Quercus* from Sample 15 of Locality No. 14, Ippon-matsu Park, Wajima City; ×1360; EKZJ coll. cat. no. 20238.

Fig. 8. Photomicrograph showing pollen aperture of *Tilia* from Locality No. 9, Takuda, Wajima City; EKZJ coll. cat. no. 20239; ×1200.

Fig. 9. Photomicrograph showing pollen aperture of *Tilia* from locality above mentioned; ×1200; EKZJ coll. cat. no. 20240.

Fig. 10. Photomicrograph showing pollen grain aperture of *Tilia* from Locality No. 9, Takuda, Wajima City; ×1040; EKZJ coll. cat. no. 20241.

Fig. 11. Photomicrograph showing pollen aperture of *Tilia* from Locality No. 9; ×1200; EKZJ coll. cat. no. 20242.

Fig. 12. Photomicrograph showing pollen grain aperture of *Tilia* from 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu, Wajima City; ×1200; EKZJ coll. cat. no. 20243.

Fig. 13. Photomicrograph showing pollen aperture of Cf. *Tilia* from 24 m in depth of the well drilled at Locality No. T-1; ×800; EKZJ coll. cat. no. 20244.

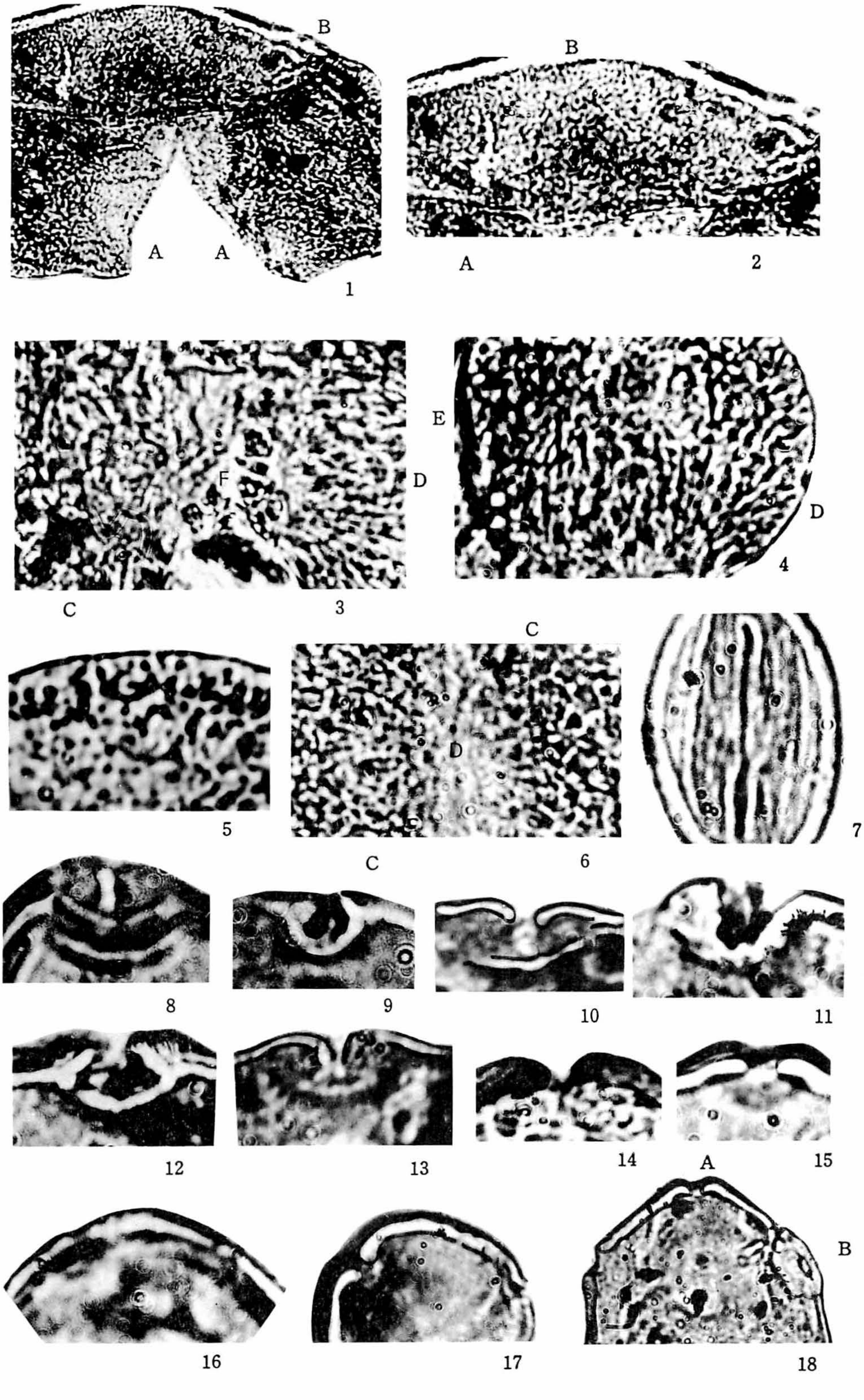
Fig. 14. Photomicrograph showing pollen aperture of *Carya* from Locality No. 1, Takuda, Wajima City; ×800; EKZJ coll. cat. no. 20245.

Fig. 15. Photomicrograph showing pollen aperture of *Carya* from Locality No. 1; ×800; EKZJ coll. cat. no. 20246.

Fig. 16. Photomicrograph showing pollen aperture of *Inapertipollenites* type pollen grain showing in Fig. 10, from Locality No. 6, Takuda, Wajima City; ×1040; EKZJ coll. cat. no. 20203.

Fig. 17. Photomicrograph showing pollen aperture of *Inapertipollenites* type pollen grain showing Fig. 10; ×480; EKZJ coll. cat. no. 20203.

Fig. 18. Photograph showing pollen aperture of *Juglans* from 24 m in depth of the well drilled at Locality No. T-1, Ippon-matsu, Wajima City; ×480; EKZJ coll. cat. no. 20247; A: profile of aperture, B: oblique view of aperture of *Tilia*.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Trans. Proc. Palaeont. Soc. Japan, N. S., No. 86, pp. 319-324, pl. 39, June 30, 1972

# 596. A PROBLEMATICA FROM THE MIZUHO-TO OF NIIGATA PREFECTURE*

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新潟県瑞穂統産 problematica について：新潟県西頸城郡能生町，能生川上流に発達する瑞穂統火打山層中部の黒色頁岩より産出した problematica を検討した。この problematica は長さ 24 cm，幅 4 cmで，表面に細かな鱗状彫刻を有し，5列の縦の溝が発達し，溝の断面は V 字形をなし両側面の傾き等は対称的である。

これらの特徴を，爬虫類，魚鱗，海藻その他の生物あるいは無機物の残し得そうな現象と検討した結果，あるエイの仲間の尾部化石で，Urolophidae 科の *Urolophus jamaicensis* の様に尾部に棘を有しないもので *Kubikichthys raris* なる従来知られていない新属，新種であると結論した。 畑井小虎・野田浩司

## Introduction and acknowledgments

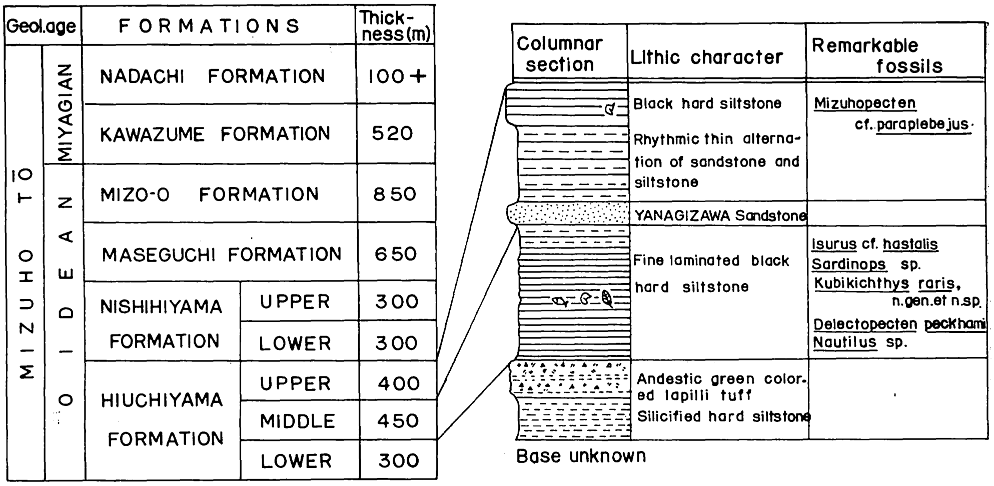
A fossil problematica impressed in a black, finely laminated, well consolidated mudstone was found in the debris below a cliff in the upper reaches of the Noo-River at Kurosawa, Noo-machi, Nishi-Kubiki-gun, Niigata Prefecture, by Mr. Hajime MURASAWA of the Department of Geology, Faculty of Science, Kanazawa University. The stratigraphic position of the problematica is said to be the middle part of the Hiuchiyama Formation, according to verbal information of the collector. As the specimen was found among the fallen rocks of the cliff, its being derived from the cliff seems to be without doubt, and its stratigraphic position is as indicated in Text-figure 1.

At this place the writers wish to thank Mr. Hajime MURASAWA of the Department of Geology, Faculty of Science, Kanazawa University for kindly donating the specimen for study, Mr. Shinichi SAKURAI of our Institute of Geology and Paleontology, Faculty of Science, Tohoku University, for his information on the geology of the area, and Messrs. Kimiji KUMAGAI and Shohei OTOMO and Mrs. Kimiko SHIBUYA of the Institute of Geology and Paleontology, for their kind assistance.

## The problematica

The problematica is an impression in a fine grained, black colored, finely laminated, hard mudstone. It consists of about five longitudinal grooves, each of different length, separated by triangular to flatly rounded interspaces, with numerous well sculptured scale-like impressions in the grooves and on the interspaces as well as scattered in different parts of the specimen; four

* Received May 6, 1971; read June 27, 1971 at Nara.




Text-fig. 1. Stratigraphic sequence of the formations in the area of Noo-machi, Nishi-Kubiki-gun, Niigata Prefecture (according to Shinichi SAKURAI, 1971 MS.).

parallel-sided rather, short, incomplete bands are preserved at the distal end. All the grooves and interspaces are gently curved longitudinally. The specimen measures about 24 cm in total length and about 4 cm in maximum width. The details of the features are described below.

The grooves, about five in number and of different lengths, the longest is about 22 cm in length, each groove is v-shaped in profile, with the sides of almost equal inclination though some are more or less steeper than others, each groove is provided with scaly sculpture consisting of 8-10 rows of tuberculated (positive) or pitted (negative) structures. These structures are squarely rounded slightly elevated (negative) or originally apparently depressed button-like structures, arranged in closely set rows extending outward in v-shaped grooves and terminating in threads, where the tubercular structures become obliterated. Each scale is about 5 mm in width and about 4-5 mm in length, being almost as wide as long. These scaly structures occur in each groove as well as in the spaces separating each groove from one another. The scaly structures and grooves are best preserved, probably in almost original form, on the left part of the specimen, whereas towards the right the grooves become less extensive, and are disturbed considerably, and at such places the scaly structures loose their (probable) orientation and are impressed in the rock at random, that is to say, some overlap others, many are oriented in different directions, and some singular ones are found situated away from the grooves or interspaces and without definite orientation. Most of the scaly structures appear v-shaped whereas some are found to be inverted v-shape with their axis pointing in different directions. The spaces between the grooves, especially in the area between the central to right lateral parts, are disturbed, being roughened by random scales, blurred as if by rubbing and in part cracked and partially overlapping as if subjected to pressure.

At the anterior-most part of the specimen there are about four parallel-sided, almost flat, somewhat deformed structures, two are sculptured with parallel grooves and ridges and the other two with tuberculations on their surfaces. The former sculpture consists of round-bottom grooves and roundly elevated ridges each of almost equal width, and the latter of apparently longitudinally arranged rows of rounded, slightly elevated tubercles. The structures seem to have been deformed by some pressure subsequent to burial and before consolidation.

**Interpretation**

It seems that various views can be expressed concerning the nature of the problematica at hand. One view is that the structure impressed in the black mudstone may be a part of some kind of a reptile as a lizard that had either drowned or drifted to sea after death, to be buried in soft black mud. The problematica may represent some kind of a plant that was drifted from land to be buried in the muddy sea bottom. The fossil impression may represent some kind of fish, possibly one that is now extinct in the present seas. The impression may possibly be the remains of two different kinds of organisms, one of the scales and the other of the two different kinds of blades. The two different kinds of blades may be parts of some kind of plant such as *Zostera* (the one with longitudinal furrows and ridges), or the detached broken bones of some kind of marine or terrestrial animal.

A remote guess may be the impression of the dorsal part of a shark-tail (Hexanchidae) or possibly the impression of part of the skin of some kind of shark.

From the description and illustration of the problematical fossil at hand it seems evident that its origin is organic and not inorganic. Among organisms able to make such peculiar features, several probably remote views were expressed above. However, from the features preserved as impressions in the black mudstone, any one of the possibilities of its origin mentioned above may be remote, here it should be added that the impression as preserved is most probably not in its original state and the described details strongly suggest that the organism that made the impression was subjected to certain agencies after death and before burial, such as turning over more than once, as indicated by the preserved features.

The writers after taking into consideration each of the possibilites mentioned above, have come to the conclusion that the present problematica represents a part of the tail of a ray, the body having either been decayed or devoured by some predaceous marine organism, and the detached tail subjected to turning-over by agencies subsequent to its detachment.

The longitudinal grooves are considered to represent the dorsal border of the tail which was covered on its surface and sides with numerous small scaly structures.

The longitudinal grooves mentioned already are thought to represent the dorsal and probably also lateral borders of the tail, which entire surface was covered with small scaly structures whose tubercular and thread-like structures were originally covered with the skin of the ray. The short, parallel-sides, blade-like structure situated at the distal end of the specimen is considered to be the spine of the ray, and the longitudinal furrows and ridges were probably covered with skin, and in the furrows may have been organs for poison. The blade-like structure with tubercular sculpture is thought to be not a blade-shaped spine but the body part of the original tail, and its appearance as a blade-like spine is due to that it is covered in part by the spine as the result of lateral pressure subsequent to its burial.

If the present specimen is to be considered to represent the tail of some kind of sting-ray, such as *Urolophus jamaicensis* CUVIER, (Urolophidae), an Atlantic species living on sandy and muddy sea bottoms (MCCORMICK, ALLEN and YOUNG, 1964, p. 271-272, fig. on p. 272), then it must be stated that rays with which the present fossil one can be identified are not known to the writers. The Atlantic sting-ray is a peculiar one in having scale-like covering body and tail and there is a spine situated near the distal end of the tail. For the reasons stated and for the taxonomic value of the fossil, a form genus and species becomes necessary in the light that the fossil cannot be identified with any living form. The initiation of a form genus and species name for the fossil at hand will aid in determining the taxonomic relation of it to living and other fossil forms, and also for the purpose of biostratigraphy should more specimens be found from different horizons and localities and also for aid in the interpretation of the paleoecological conditions of the sedimentary basin in which it once lived. For the reasons stated the form genus and species name of *Kubikichthys raris* n. gen. & n. sp. is proposed. The form genus is tentatively placed in the Family Urolophidae.

Among the sting-rays recorded from the Mizuho-Tō deposits of Japan (HATAI & KOTAKA, 1962; HATAI, MURATA and MASUDA, 1965; HATAI, 1966), none are known as to shape and characters of the tail, although their spines have been described and illustrated. Among the spines known of the sting-rays, *Dasybatus masudae* HATAI and KATAKA, 1962 shows a remote resemblance with the blade-like spine of *Kubikichthys raris*, although in the latter nothing is known of whether lateral denticles or spines are developed, whereas they are small but well developed in *Dasybatus masudae*. Further the shape and characters of the tail of *Dasybatus masudae* is unknown. No other recorded Japanese Mizuho-Tō sting-ray spines show resemblance with the spine of the present species.

Among the Recent species of sting rays known from the seas of the Japanese Islands, none seem to show such characteristic scale-like sculpture as the fossil ray under consideration. Many species of rays are illustrated and remarked upon by MCCORMICK, ALLEN and YOUNG (1964), and among them only *Urolophus jamaicensis* shows some resemblance with the present one, although differing in details. No other Recent species is known to the writers to be comparable with the present fossil in details of the spine and sculpture of the tail skin.

## Associated fossils and geological age

In association with and in the stratigraphic position in the Hiuchiyama Formation were found abundant discoid pyrite concretions measuring up to about 10 cm in diameter and occupying almost the same horizon, well preserved specimens of Gen-no-ishi (Pseudo-gaylussite, that is, calcite after gaylussite, according to HIKI, 1915), or hammer stones, fragmental remains of plant leaves, fish bones and fish scales, a sea-weed called *Hijikia* (verbal information from Dr. Hidekuni MATSUO of the Kanazawa University), and numerous more or less deformed cephalopod shells (*Nautilus*). No other kinds of fossils were found.

None of the fossils found in association with *Kubikichthys raris* serve for determination of the geological age, but from a slightly higher horizon such molluscs as *Delectopecten peckhami* (GABB) and *Mizuhopecten* cf. *paraplebejus* (NOMURA and HATAI) occur, and these point to the middle-upper part of the Early Mizuho, therefore the underlying *Kubikichthys* is slightly older.

## References

HATAI, K. (1966): Some fossil stingrays from Northeast Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 34, p. 15-18, 1 pl.

—— and KOTAKA, T. (1962): *Dasybatus* from the Japanese Miocene. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, no. 45, p. 201-205, pl. 30.

HATAI, K., MURATA, M. and MASUDA, K. (1965): A sting ray and eagle ray from the Tatsunokuchi Formation (Pliocene) in Sendai City, Miyagi Prefecture, Japan. *Ibid.*, no. 57, p. 34-37, 5 figs.

HIKI, T. (1915): On the Gennō-ishi. *Mem. Coll. Engineering, Kyoto Imp. Univ.*, vol. 1, no. 2, p. 55-58, 1 pl.

MCCORMICK, H. W., ALLEN, T. and YOUNG, W. (1964): Shadows in the sea. *Sidgwick & Jackson*, 415 pp., numerous illustrations.

OBRUCHEV, D. V. (1967): Fundamentals of paleontology, vol. 11, Agnatha, Pisces. *Acad. Sci. U. S. S. R.*, 825 pp., numerous illustrations.

Revised Edition of Illustrated Encyclopedia of the Fauna of Japan. *Hokuryu-kan Publ. Co.*, 107+1898 pp., 5213 figs.

SAKURAI, S. (1971 MS): Geology of the southern part of Nishi-Kubiki-gun, Niigata Prefecture, Graduate Thesis of the Insittute of Geology and Paleontology, Faculty of Science, Tohoku University.

TANAKA, S. and ABE, S. (1955): One thousand species of important fish. *Morihoku Publ. Co.*, 294 pp. +12, numerous illustrations.

| | |
|---|---|
| Hiuchiyama | 火打山 |
| Kawazume | 川結 |
| Kubiki | 頸城 |
| Maseguchi | 柵口 |
| Mizoo | 溝尾 |
| Miyagian | 宮城階 |
| Mizuho | 瑞穂 |
| Nadachi | 名立 |
| Nishihiyama | 西飛山 |
| Noo | 能生 |
| Oidean | 生出階 |

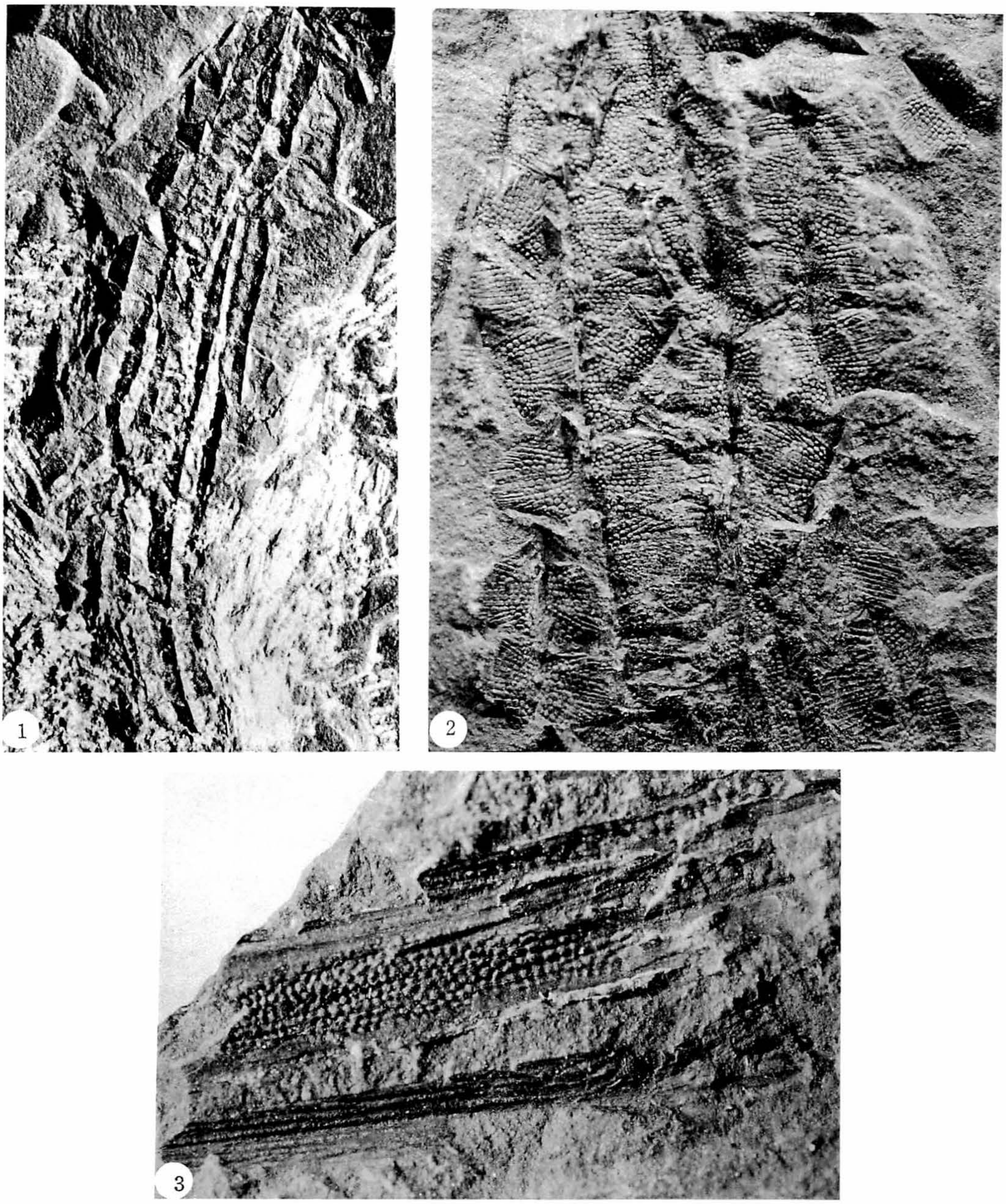
## Explanation of Plate 39

Fig. 1. Entire view of *Kubikichthys raris*, n. gen. & n. sp., in natural size. Note the different lengths of the grooves, the blurred condition and interspaces of the grooves.

Fig. 2. Scaly structure covering the body (?) and tail portions of *Kubikichthys raris*, ×5, Note the detail sculpture of the scales and the terminal parts. Also to be noticed is the position of the scales in the grooves and in the interspaces.

Fig. 3. Views of the blade-like spines with longitudinal grooves and ridges; shown at the lower and upper middle part of the photograph, ×5.

Figs. 2 & 3. Enlarged parts of Fig. 1. Impressed in black, finely laminated mudstone.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Trans. Proc. Palaeont. Soc. Japan, N. S., No. 86, pp. 325-339, pls. 40, 41, June 30, 1972

# 597. ON THE SURFACE ORNAMENTATION OF THE PENNATAE TRIGONIIDS, AND ON THREE NEW SPECIES OF THE TRIGONIIDS FROM THE HIMENOURA GROUP, KYUSHU, JAPAN

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Pennatae trigoniids の表面装飾の変化と姫浦層群産の3新種について：日本産の pennatae trigoniids の特に九州姫浦層群産の種を中心に，その表面装飾及び成長に伴う形態変化を細かく観察した結果，これらの3属 *Apiotrigonia, Heterotrigonia, Microtrigonia* は *Frenguelliella* に酷似した幼殻を持ち，disk のL型肋は各々成長初期に突発的に形成され，area の装飾は種により特徴ある形態を示す。*Heterotrigonia* 特有とされた area の放射状肋に似た細肋が *Apiotrigonia* や *Microtrigonia* の成長形にも弱いが出現することがある。又 *Heterotrigonia* の disk における定向的な装飾変化は *Apiotrigonia, Microtrigonia* と酷似する。したがって，これら3属間には互いに密接な関係があり，特に *Microtrigonia* は *Apiotrigonia* より分かれたことは明瞭である。この pennatae trigoniids の起源はおそらく *Frenguelliella* に端を発し，Trigoniinae に加うべき過程を経たと思われるが，成長後の形態は独特のL型肋を示すので，むしろこれらを一括して，新亜科を設定すべきかと思われる。これらの属に加えられる姫浦層群産の3新種 *Ap. utoensis, Het. himenourensis, M. imutensis* を記載した。また *Ap. minor* var. *nankoi* NAKANO と *Ap. obliquecostata* NAKANO は各々 *Ap. obsoleta* NAKANO と *Ap. minor* (YABE and NAGAO) の同種異名であろう。

田 代 正 之

## Introduction and acknowledgement

The Upper Cretaceous pennatae trigoniids in Japan are interesting bivalves. NAKANO (1957) classified them into three genera, i. e., *Apiotrigonia* COX, 1952, *Microtrigonia* NAKANO, 1957 and *Heterotrigonia* COX, 1952. *Apiotrigonia* was originally established by COX (1952) as a subgenus of *Megatrigonia* VAN HOEPEN, 1929. SAVELIEV (1958), LIWEROWSKAJA (1960) and JONES (1960) supported COX's classification of *Apiotrigonia*. KOBAYASHI (1954) promoted *Apiotrigonia* to the generic rank. NAKANO (1956) stated that *Apiotrigonia* should be a member of the subfamily Vaugoniinae KOBAYASHI, 1954, because the costae on the disk gradually change from concentric to L-shape through a V-stage like in *Vaugonia* CRICKMAY, 1930. SKAWARKO (1968) regarded *Apiotrigonia* as a genus of Vaugoniinae. On the other hand, KOBAYASHI (1954) suggested that *Heterotrigonia* was derived from the Trigoniinae LAMARCK, 1819, because it has distinct radial costellae on the area. NAKANO (1961) referred *Heterotrigonia* to the Trigoniinae on account of radial sculptures on the area. HAYAMI and NAKANO (1968), in their numerical tax-

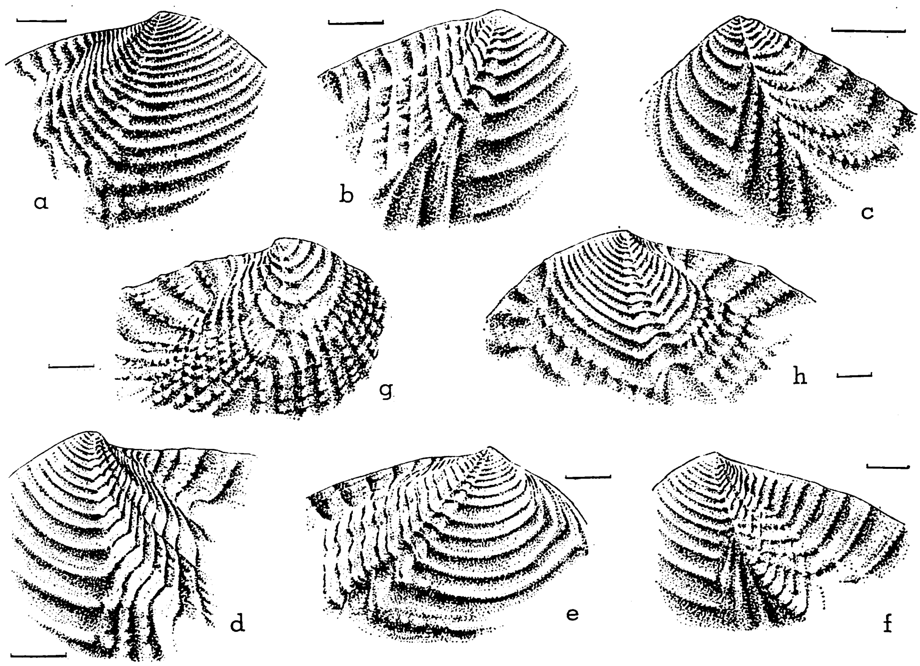
* Received May 12, 1971; read Sept. 12, 1970 at Tokyo.

onomic study on the Trigoniidae, suggested that *Apiotrigonia* should be related to *Heterotrigonia*. In Treatise on invertebrate paleontology, COX (1968) classified *Heterotrigonia* as a subgenus of *Apiotrigonia*, but NAKANO (1970) placed *Heterotrigonia* in the Nototrigoniinae SKAWARKO, 1963.

I have collected numerous pennatae trigoniid specimens from the Himenoura group in Kyushu as well as several trigoniid species from the Mikasa sandstone in Hokkaido, the Futaba group in Joban district and the Izumi group in Shikoku. Here, the relationship among three pennatae genera in Japan is discussed, and the following four species from the Himenoura group of Uto peninsula and Shimo-koshiki island are described.

*Apiotrigonia obsoleta* NAKANO
*Apiotrigonia utoensis* TASHIRO, new species
*Heterotrigonia himenourensis* TASHIRO, new species
*Microtrigonia imutensis* TASHIRO, new species

I wish to express my sincere thanks to Emeritus Prof. T. KOBAYASHI of the University of Tokyo for his kind reading the manuscript. I am also much indebted to Dr. M. TAMURA, Associate Prof. of Kumamoto University for his kind guidance. I thank Associate Prof. M. NAKANO of Hiroshima University for his continuous encouragement. I am




Text-fig. 1. Umbonal characters of Japanese pennatae trigoniids.
a. *Apiotrigonia undulosa* NAKANO, b. *Ap. minor* (YABE and NAGAO), c. *Ap. postonodosa* NAKANO, d. *Ap. obsoleta* NAKANO, e. *Ap. utoensis* TASHIRO, n. sp. f. *Ap.* cfr. *obsoleta* NAKANO, g. *Heterotrigonia himenourensis* TASHIRO, n. sp., h. *Microtrigonia amanoi* NAKANO. Scale: 1 mm.

also grateful to Mr. M. OTSUKA of Oyano Senior Highschool in Amakusa county for supplying me pennatae trigoniid specimens.

(The specimens (KE) in this study are kept in the Faculty of Education, Kumamoto University.)

## Umbonal characters of pennatae trigoniids

According to NAKANO (1957), the L costae on the disk of *Apiotrigonia* developed from concentric costae through a *Vaugonia*-like V-stage. He also observed *Frenguelliella*-like concentric costae on the surface of immature specimens of *Heterotrigonia subovalis* (JIMBO) (NAKANO, 1961).

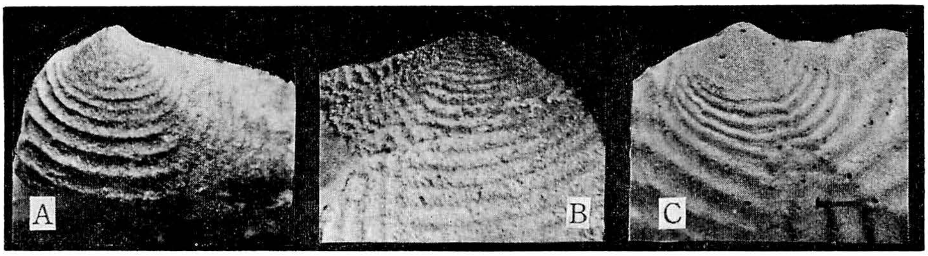
The umbonal traits of the Japanese pennatae trigoniids are shown in Text-fig. 1. Though the number of costae and costellae on the surface of their immature valves differs among these species, they have common traits as follows:

Shell resembles typical species of *Frenguelliella* LEANZA, 1942 or *Trigonia* in outline; marginal carina is well elevated and accompanied by a shallow marginal sulcus (carinal depression); dorsal carina low but distinct; area wide, triangular, ornamented with concentric plain costellae which extend into escutcheon; median groove on area shallow; escutcheon narrow, with concentric plain costellae; disk ornamented with plain and regular concentric costae; marginal sulcus has fine plain costellae, which are concentric near umbo but gradually become vertical, and each costella on the sulcus joins with a costa of disk on one side and a costella of area on the other (see Text-figs. 1 and 2).

The junction of the costae on the disk and the costellae on the sulcus are first concentric but gradually become V-shaped. It, however, can hardly be warranted that the V-shaped costation reveals "*Vaugonia* stage". The subradial costae called "posterior series" on the disk of these trigoniids represent themselves quite independently of V-shape. The costae are at first short and tuberculate, appear near the marginal carina and are later linked with the costellae of the sulcus. In the same stage, the concentric costae of the disk and costellae of escutcheon become stout rapidly and begin to show traits characteristic of respective species.

## Ornamentation of area

Japanese pennatae trigoniids can be




Text-fig. 2. *Frenguelliella*-like umbonal part.
A: *Apiotrigonia obsoleta* NAKANO, B: *Ap. undulosa* NAKANO, C: *Microtrigonia amanoi* NAKANO. (scale, 1 mm).

sorted into three group by the morphological characters of their area as follows:

I. Group with obliqe costellae

This group comprises *minor*, *postonodosa*, and *amanoi*. (Text-fig. 3-C, D and E).

*minor* subgroup: Costellae on the area, first concentric, gradually become oblique on the dorsal half of the area, the costellae on the other half of area being concentric as far as the point where they disappear. *Apiotrigonia minor*, *Ap. undulosa*, *Ap. hironoensis*, *Ap. orikiensis*, *Ap. futabaensis*, and *Ap. ashizawaensis* belong to this subgroup.

*postonodosa* subgroup: Costellae of the area are concentric in immature valve, but suddenly become oblique and continue through the mature stage; they are tuberculate. *Ap. postonodosa* belongs to this subgroup.

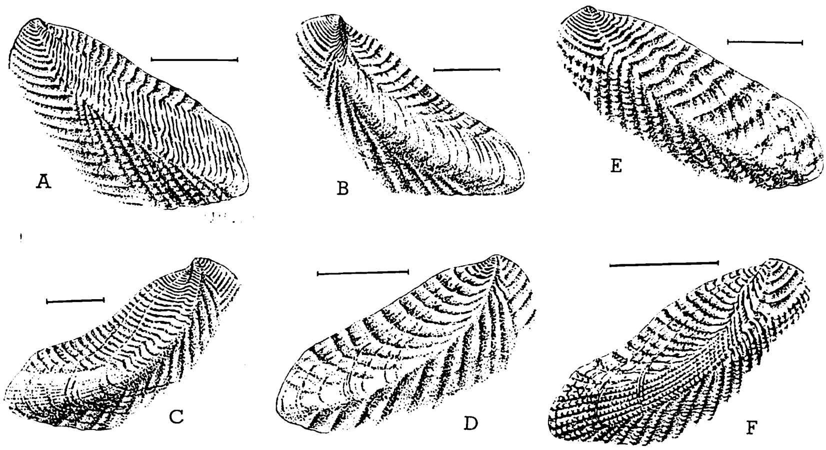
*amanoi* subgroup: The area is relatively wide for pennatae trigoniids; costellae of the area first concentric but gradually change oblique and tuberculate. *Microtrigonia amanoi*, *Micr. minima*, and *Micr. imutensis* n. sp. belong to this subgroup.

II. Group with concentric costellae

The area of *Ap. utoensis* n. sp. and *Ap. obsoleta* is ornamented with concentric or vertical costellae. The costellae in the former are no less distinct in the adult stage. Those in the latter are distinct in the younger stage but soon disappear in adult. *Ap. crassoradiata* may be a member of this group (see Text-fig. 3-A and B).

III. Group with radial costellae

*Heterotrigonia* species belong to this group. In *Het. subovalis* and *Het. himenourensis* n. sp., radial costellae on the area suddenly appear at the outskirts




Text-fig. 3. Ornamentation of area on Japanese pennatae trigoniids.

Concentric-group; A: *Apiotrigonia utoensis* TASHIRO, n. sp.
B: *Apiotrigonia obsoleta* NAKANO,
Oblique-group; C: *Apiotrigonia minor* (YABE & NAGAO),
D: *Apiotrigonia postonodosa* NAKANO,
E: *Microtrigonia amanoi* NAKANO.
Radial-group; F: *Heterotrigonia himenourensis* TASHIRO, n. sp.
Scale: 5 mm.

of the area in immature stage. In these species the radial costellae exist only on one side of the marginal half of the area. In the type-species of *Heterotrigonia* from British Columbia however, they exist on the whole area.

In several mature specimens of *Ap. minor* and *Micr. imutensis* n. sp. from the Himenoura group, the radial threads appear on the posterior parts of area (see, Pl. 40, Figs. 9b and 15, Text-figs. 3-c, and 9). Fine radial wrinkles appear often on the area of immature *Ap. minor* (Pl. 40, Fig. 14), *Ap. obsoleta* (Text-fig. 1-d), and *Micr. amanoi* (Text-fig. 1-h). *Apiotrigonia* and *Microtrigonia* appear to have a latent character to possess radial threads or wrinkles on the area.

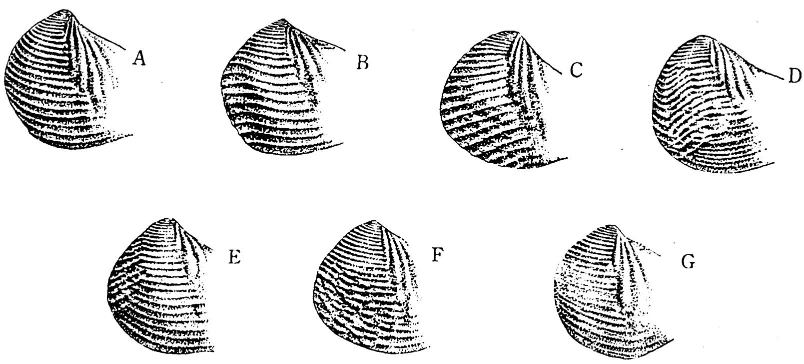
According to SKAWARKO (1970) in *Ap. calderoni* (AGUILERA) from the Upper Jurassic of Mexico no rib is present on the area except its proximal part, where a few radial riblets are visible. NAKANO (1961) observed radial riblets on the area of a mature specimen of *Ap. newcombei* (PACKARD) from the Haida formation of British Columbia in the collection of Kyoto University. Though NAKANO stated that the specimen might be a member of *Heterotrigonia* having radial costae on the area, it seems to me that the specimen represents a mature form of *Apiotrigonia* like the same stage of *Ap. minor* mentioned above.

This radial latent or visible character on the area of *Apiotrigonia* and *Microtrigonia* evidently shows an intimate relationship with the radial costellae on the area of *Heterotrigonia*.

## Ornaments on the disk

The anterior series of costae in *Ap. minor* from the Himenoura group is shown in Text-fig. 4: The concentric and horizontal shapes (A and B) are general shapes in *Ap. minor;* the undulated shape (F) is similar to the series of *Ap. undulosa; Ap. obliquecostata, Ap. orikiensis*, and *Ap. futabaensis* resemble those of the specimens of the oblique shape (C); V-shape (D) and chevron shape (E) are as yet unkown in Japan; obsolete shape (G) is akin to the series of *Ap. obsoleta*. As there are intermediate shapes between these 7 shapes in *Ap. minor*, their distinction is somewhat artificial.

*Ap. postonodosa* changes its shape




Text-fig. 4. Variation of anterior series in *Apiotrigonia minor* (YABE & NAGAO).
A: concentric shape. B: horizontal shape. C: oblique shape. D: V-shape.
E: chevron shape. F: undulate shape. G: obsolete shape.

of anterior series through growth, as shown in Text-fig. 5. A similar change is observable in *Heterotrigonia subovalis* from the Mikasa sandstone of Hokkaido.

In Late Cretaceous pennatae trigoniids such as *Microtrigonia amanoi, M. minima* and *M. imutensis* n. sp., the anterior series is almost effaced except for the umbonal part, and the disk is ornamented with subradial tuberculate costae which bifurcate near the antero-ventral margin. These species closely resemble *Heterotrigonia himenourensis* as regards the ornamentation of disk (see, Text-figs. 6–C, F and 8).

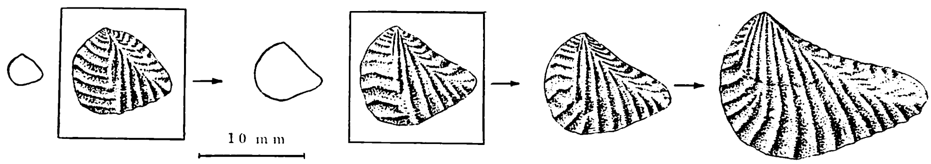
Text-fig. 6 shows such a morphological change occurred on the disk of pennatae trigoniids through geological ages. *Heterotrigonia* closely resembles *Apiotrigonia* (including *Microtrigonia*) as regards each morphological character in each series of the disk. These morphological changes on the disk of *Ap. postonodosa* and *Het. subovalis* represent an example of palingenesis.

**On the taxonomic position of pennatae trigoniids**

Though *Apiotrigonia* is closely related to *Heterotrigonia*, I am inclined to leave *Heterotrigonia* as a distinct genus, instead of regarding it as a subgenus of *Apiotrigonia*, because distinct difference in evolutional tempo exists between the trunks of *Apiotrigonia* and *Heterotrigonia* (see, Text-fig. 6). *Microtrigonia* is undoubtedly a derivative of *Apiotrigonia* as already suggested by NAKANO (1957).

In the immature stage of *Megatrigonia*, *Iotrigonia* VAN HOEPEN, 1929, and *Vaugonia*, concentric costae change gradually into sinuate or V-shaped ones as seen in *Meg. obesa* VAN HOEPEN, *I. crassitesta* VAN HOEPEN, and *V. v-costata* (LYCETT), but the costae on the disk of pennatae trigoniids develop into L-shape, without passing through the sinuate or V-shaped stage as already mentioned in detail. The immature stages of *Haidaia* CRICKMAY, em. KOBYASHI and TAMURA, 1955, and *Latitrigonia* KOBAYASHI, 1957 are similar to those of pennatae trigoniids in the concentric costae and costellae on the surface, but *Haidaia* differs from these trigoniids in the crenulated costae on the disk as in *Myophorella* (*Haidaia*) *pulex* TAMURA (TAMURA, 1959a). *Latitrigonia* is distinguishable from these trigoniids by the tuberculate costae on the disk as in *Lat. pyramidalis* KOBAYASHI and TAMURA. Immature pennatae trigoniids are very similar to *Frenguelliella tanourensis* TAMURA from the Carnic Tanoura formation of Kumamoto (TAMURA, 1959b) in shell-outline and concentric ribs.

On the other hand, mature pennatae trigoniids resemble the typical *Rutitrigonia* VAN HOEPEN, 1929 from the Albian of Zululand in the rostrated outline and subconcentric costae of the disk, but *Rutitrigonia* differs from pennatae trigoniids in the smooth escutcheon and absence of the posterior series on the disk. *Nototrigonia* COX, 1959 and *Cal-*




Text-fig. 5. Morphological change in the ontogeny of *Apiotrigonia postonodosa* NAKANO.

*Litrigonia* COX, 1964 fairly resemble *Heterotrigonia* in the radial costellae of the area and the rostrated outline. However, the marginal sulcus in the former extends as far as postero-ventral margin with increasing width, and the costae on the disk change from oblique to concentric.

Insofar as I can see the collection at hand, pennatae trigoniids may be a derivative from *Frenguelliella*, because *Frenguelliella*-like costae and costellae are present on the immature valve of pennatae trigoniids as mentioned above. If the radial costation on the area is one of the important traits in the taxonomy of Trigoniinae (KOBAYASHI, 1954, NAKANO, 1961, 1970), pennatae trigoniids are probably related to the Trigoniinae primarily, because the distinct radial costellae (*Heterotrigonia*) and the latent radial threads or wrinkles (*Apiotrigonia* and *Microtrigonia*) are recognizable on their areas as stated already. Adult pennatae trigoniids have an extraordinary shape for the Trigoniinae. In my opinion, pennatae trigoniids should be an independent subfamily.

## Systematic description

Family Trigoniidae LAMARCK, 1819

Genus *Apiotrigonia* COX, 1952

Type species: *Trigonia sulcataria* LAMARCK, 1819.

*Remarks:*—The area of this genus is of *minor* subgroup, *postonodosa* subgroup in oblique-group (I), or the shapes in concentric-group (II) (see Text-fig. 3). Radial threads or wrinkles frequently appear on the area. Species of this genus are fairly variable in the number of costae and costellae on the surface and in the shape of anterior series as seen in *Ap. minor* or *Ap. postonodosa* (see Text-figs. 4, 5). However, the outline of the shell and the shape of immature valve (or umbonal part of the shell) are rather uniform in this genus.

Many species of *Apiotrigonia* have hitherto been reported from several localities in Japan by many authors: JIMBO (1894), YEHARA (1915, 1923), HAYASAKA (1921), YABE and NAGAO (1925), YABE (1927), NAGAO and OTATUME (1938), AMANO (1957), NAKANO (1957), SAITO (1963) and MAEDA and KAWABE (1966), as listed below:

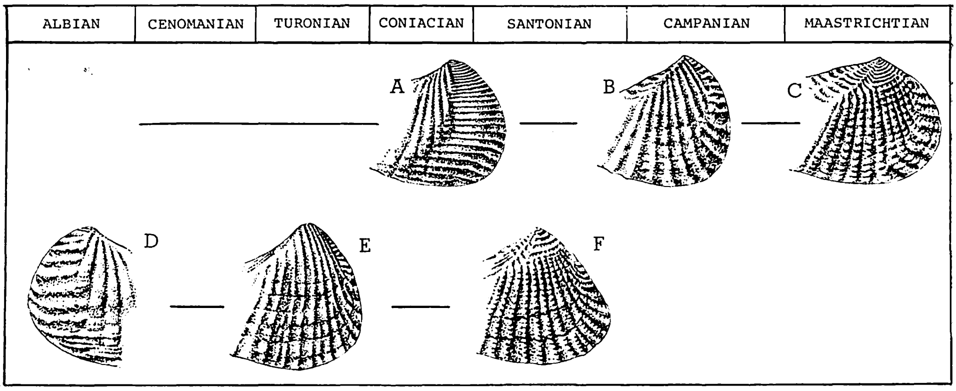
*Apiotrigonia minor* (YABE and NAGAO) (*Trigonia subovalis* var. *minor* Y. & N.),
*Apiotrigonia minor* var. *nankoi* NAKANO,
*Apiotrigonia undulosa* NAKANO,
*Apiotrigonia obliquecostata* NAKANO,
*Apiotrigonia crassoradiata* NAKANO,
*Apiotrigonia obsoleta* NAKANO,
*Apiotrigonia postonodosa* NAKANO,
*Apiotrigonia tuberculata* NAKANO,
*Apiotrigonia ashizawaensis* SAITO,
*Apiotrigonia futabaensis* MAEDA and KAWABE,
*Apiotrigonia hironoensis* MAEDA and KAWABE,
*Apiotrigonia orikiensis* MAEDA and KAWABE.

In my opinion, *Ap. minor* var. *nankoi* and *Ap. obliquecostata* are synonymous with *Ap. minor* and *Ap. obsoleta* respectively. *Ap. tuberculata* is a member of *Microtrigonia*. Several species from the Futaba group of Joban district such as *Ap. ashizawaensis*, *Ap. futabaensis*, *Ap. hironoensis*, and *Ap. orikiensis* are probably varieties of *Ap. minor*, and hence they are synonymus with *Ap. minor*.

### *Apiotrigonia obsoleta* NAKANO, 1957

Plate 41, Figs. 1–8, 12, 13.

1957. *Apiotrigonia obsoleta* NAKANO, *Japan Jour. Geol. Geogr.*, Vol. 28, Nos. 1–3, p. 114, pl. 9, figs. 5–7.




Text-fig. 6. Morphological changes of pennatae trigoniids through geological ages. A: *Apiotrigonia minor* (YABE and NAGAO), B: *Ap. postonodosa* NAKANO, C: *Microtrigonia amanoi* NAKANO, D: *Heterotrigonia diversicostata* (WHITEAVES) (after NAKANO, 1961), E: *Het. subovalis* (JIMBO), F: *Het. himenourensis* TASHIRO, n. sp.

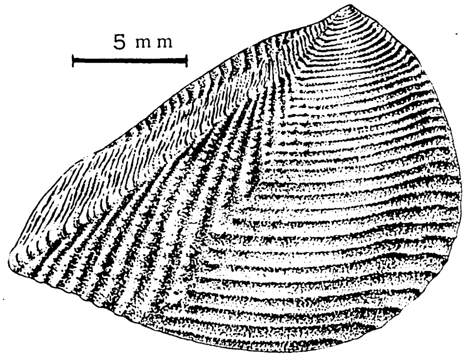
1957. *Apiotrigonia minor* (YABE and NAGAO) var. *nankoi* NAKANO, *Ibid.* pp. 113–114, pl. 9, figs. 1–4.

*Remarks:*—The area of this species is smooth except for the umbonal part with concentric costellae (see Text-fig. 3-B). The anterior series is gradually effaced through growth. On some specimens the series begins to disappear at about 3 mm height of the shell. On some other specimens the series is distinct as far as the shell about 15 mm high. The latter specimens are referable to *Ap. minor* var. *nankoi*, according to NAKANO's description (1957). As intermediate specimens are usually found in the collection from the same locality, *Ap. minor* var. *nankoi* is probably a variety of this species. The specimens from the Izumi group of Awaji island are smaller than my specimens. In the trigoniids from the Izumi group of Kii peninsula, which are referable to this species (Pl. 41, Figs. 13, 14, Text-fig. 1-f), about 3 oblique and tuberculate costellae

*Measurements:* (in mm)

| Specimen | Length | Height | Thickness | h. |
|---|---|---|---|---|
| KE 1890 right valve | 20.7 | 20.7 | 4.0 | 3.6 |
| KE 1891 left valve | 20.6 | 20.6 | 4.6 | 2.5 |
| KE 1892 left valve | 16.7 | 16.7 | 3.7 | 10.5 |
| KE 1893 left valve | 20.0 | 20.0 | 4.8 | 15.0 |
| KE 1894 left valve | 16.8 | 16.8 | 3.9 | 5.4 |
| KE 1895 right valve | 17.7 | 17.7 | 4.0 | 10.5 |
| KE 1896 right valve | 16.0 | 16.0 | 4.0 | 9.5 |
| KE 1897 left valve | 15.0 | 15.0 | 3.0 | 11.2 |
| KE 1898 left valve | 14.2 | 14.2 | 3.7 | 11.8 |
| KE 1899 right valve | 11.5 | 11.5 | 3.5 | 5.4 |

h.: Height of the shell where the anterior series begins to disappear.




Text-fig. 7. *Apiotrigonia utoensis* TASHIRO, new species.

appear near the outskirts of area in the umbonal shell (or immature valve). But the costellae soon vanish.

*Occurrence:*—Black siltstone of the Upper (?) formation of Himenoura group at Okoshiki and Hiraiwa, Ohda-machi, Uto city (Uto peninsula), Kumamoto pref. Black siltstone of the middle formation of the same group at Wadanohana, Takado, Ryugatake-machi Amakusa county, Kumamoto prefecture.

### *Apiotrigonia utoensis* TASHIRO, new species

Plate 41, Figs. 9-11, Text-fig. 7.

*Description:* — Shell small, trigonal-ovate, inequilateral, moderately inflated; anterior margin rounded, passing gradually into broadly arched ventral margin; dorsal margin fairly long and gently convex; siphonal margin weakly arched or nearly straight; umbo small, somewhat prominent, orthogyrous or slightly prosogyrous, situated at about a third to a fourth of the length from anterior; disk ornamented with two series of costae except for about 13 umbonal concentrics; anterior series consisting of 15 or more plain costae which are first concentric and straight in later stage and occasionally flexed near anterior margin; posterior series which occupies about a third of the area of disk, consisting of about 9 tuberculate subradial costae, of which about 4 anterior ones gradually fade towards venter; marginal and escutcheon carinae effaced except near umbo, and median groove observable only near umbo; area rather wide, ornamented with fine concentric or transverse costellae, generally wavy, about 15 of which lying in a distance of 5 mm; escutcheon narrow, with about 15 plain transverse costellae; a lunule-like narrow flat area exists under the antero-umbonal part, with fine concentric costellae.

*Observation and remarks:*—Umbonal features of this species are shown in Text-fig. 1-e. The ornamentation of the area is indicated in Text-fig. 3-A. The orthogyrous or rather prosogyrous umbo of this species is extremely unusual for the species of *Apiotrigonia* in Japan. However, *Ap. newcombei* (PACKARD) from the Queen Charlotte Island (PACKARD, 1921) is similar to this species in the orthogyrous umbo.

*Comparison:*—This species is similar to *Ap. sulcataria* (LAMARCK) from the Cenomanian of France and *Ap. pennata* (SOWERBY) from the Cenomanian of En-

*Measurements:*— (in mm)

| Specimen | Length | Height | Thickness |
|---|---|---|---|
| KE 1881 right valve (Holotype) | 14.9 | 11.2 | 4.0 |
| KE 1882 left valve (Paratype) | 22.0 | 16.9 | 6.8 |

gland (LYCETT, 1872-1879) in the tuberculate costae of the posterior series on the disk, but this species differs from the two foreign species by its concentric or transverse costellae on the area and the orthodetic or prosodetic umbo. *Ap. newcombei* differs from this species in respect to its smooth area and plain costae of the posterior series.

*Occurrence:*—Black siltstone of the Upper formation (?) of the Himenoura group at Okoshiki and Hiraiwa, Ohda-machi, Uto city, Kumamoto prefecture.

### Genus *Heterotrigonia* COX, 1952

Type species: *Trigonia diversicostata* WHITEAVES, 1876

*Remarks:*—This genus differs from *Apiotrigonia* and *Microtrigonia* in having radial costellae on the area. This genus was reinvestigated in detail by NAKANO (1957, 1961).

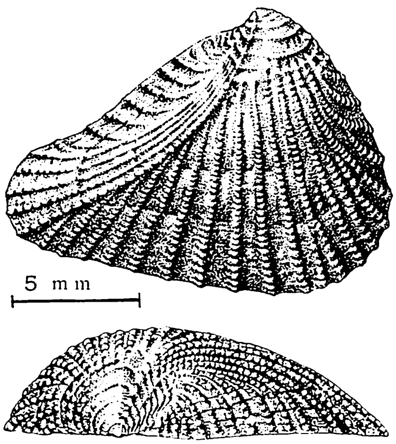
*List of the species:*—

*Trigonia diversicostata* WHITEAVES, 1876. Haida formation (Up. Albian?) of Queen Charlotte series; British Columbia.

*Trigonia subovalis* JIMBO, 1894. (*Trigonia sawatai* YEHARA, 1923.) Cenomanian to Santonian; Central Hokkaido, Japan.

*Heterotrigonia granosa* NAKANO, 1957. Santonian; Middle formation of Himenoura group; Amakusa, Kyushu, Japan.

*Heterotrigonia himenourensis* TASHIRO, new species. Upper (?) formation (Campanian?) of Himenoura group; Uto peninsula, Kyushu, Japan.




Text-fig. 8. *Heterotrigonia himenourensis* TASHIRO, new species.

### *Heterotrigonia himenourensis* TASHIRO, new species

Plate 41, Figs. 14-16, Text-fig. 8.

*Description:*—Shell small, trigonal-ovate, inequilateral, moderately inflated, greater in length than height; anterior margin convex, ventral margin weakly arched; dorsal margin nearly straight or weakly concave; siphonal margin rounded; umbo small, slightly prominent, opisthogyrous, situated at about a fourth of the length from anterior; marginal carina weak, with a tuberculate costella; dorsal carina and median groove obscure except near umbo; disk ornamented with tuberculate subradial costae, about 18 in number, 7 or so of which in the anterior half of disk are bi- or trifurcated in ventral part; area ornamented with 6 or so tuberculate radial costellae except near umbo; escutcheon rather wide, or-

*Measurements:*— (in mm)

| Specimen | Length | Height | Thickness |
|---|---|---|---|
| KE 1884 right valve (Holotype) | 14.9 | 10.9 | 4.1 |
| KE 1885 right valve (Paratype) | 11.2 | 8.7 | 3.5 |

namented with about 15 tuberculate costae of which the first 5 or so are concentric, the next 8 or so transverse, and the other 3 or so oblique.

*Observation and remarks:*—The radial costellae on the area appear at about 3 mm from the beak. This immature *Frenguelliella*-like stage is about 3 mm in height. The umbonal and dorsal ornamentations of this species are shown in Text-figs. 1-g, 3-F. The remarkable traits of this species are the absence of anterior series, bi- or trifurcated costae on the anterior half of the disk, and distinct and concentric riblets near the umbo. It seems that these traits discriminate this as a species of *Heterotrigonia.*

*Comparison:* — *Heterotrigonia granosa* NAKANO from the Middle formation of Himenoura group is closely similar to this species in respect of its tuberculate costae and costellae on the surface, its radial costellae of the area, and the smaller size of its shell. However, in *Het. granosa* the area occupied by umbonal concentrics is narrower than the corresponding area of this species, bi- or trifurcated costae of the disk are indistinct, the anterior series on the disk exists, and the radial costellae on the area are about 3 in number.

*Occurrence:*—Black siltstone of the Upper formation (?) of Himenoura group at Okoshiki and Hiraiwa, Ohda-machi, Uto city, Kumamoto prefecture.

Genus *Microtrigonia* NAKANO, 1957

Type species: *Microtrigonia amanoi* NAKANO, 1957.

*Remarks:*—The posterior series of *Microtrigonia* is tuberculate, and extends as far as the antero-ventral part of the disk. Costae of the series very often bifurcate on the anterior half of the disk. The anterior series of this genus is subdued, and exists only in umbonal region. *Microtirgonia* may be a derivative from *Ap. postonodosa* or some related species, as already suggested by NAKANO (1957).

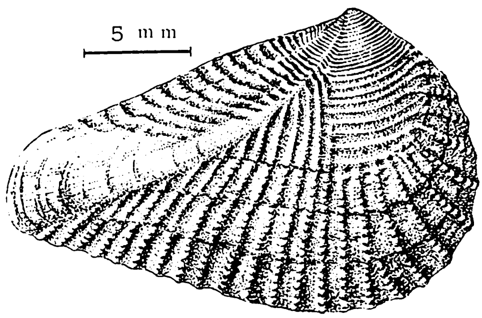
*List of the species:*—

*Microtrigonia amanoi* NAKANO, 1957. Maestrichtian; Upper formation of Himenoura group; Shimo-koshiki island, Kyushu, Japan.

*Microtrigonia minima* NAKANO, 1957. Maestrichtian; Shichi shale of Izumi group; Awaji island, Shikoku, Japan.

*Apiotrigonia tuberculata* NAKANO, 1957. Maestrichtian; Shichi shale of Izumi group; Awaji island, Shikoku, Japan.

*Microtrigonia imutensis* TASHIRO, new species. Maestrichtian; Upper formation of Himenoura group; Shimo-koshiki island, Kyushu, Japan.




Text-fig. 9. *Microtrigonia imutensis* TASHIRO, new species.

*Microtrigonia imutensis* TASHIRO, new species

Plate 40, Fig. 26, Text-fig. 9,

*Description:*—Shell medium to small, trigonal-ovate, greater in length than height; anterior margin rounded; ventral margin weakly arched; dorsal margin nearly straight or somewhat sinuate; siphonal margin well rounded; umbo improminent, orthogyrous or slightly opisthogyrous, situated about a fourth of the length from anterior; median groove, and marginal and dorsal carinae obscure except near umbo; umbonal

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## Explanation of Plate 40

*Apiotrigonia minor* (YABE and NAGAO)

Fig. 1. Lateral view of left valve (KE. 1904); Wadanohana, Ryugatake-machi, Amakusa county, Kumamoto pref.

Fig. 2. Ditto, (KE. 1905); Loc., Ditto.

Fig. 3. Ditto, (KE. 1906); Loc., Ditto.

Fig. 4. Lateral view of right valve (KE. 1907); Loc., Ditto.

Fig. 5. Ditto, (KE. 1908); Loc., Ditto.

Fig. 6. Ditto, (KE. 1909); Loc., Ditto.

Fig. 7. Ditto, (KE. 1910); Loc., Ditto.

Fig. 8. Ditto, (KE. 1911); ×1.5; Loc., Ditto.

Fig. 9a. Ditto, (KE. 1912); ×1.5; Loc., Ditto.

Fig. 9b. Postero-dorsal view of same specimen.

Fig. 10. Lateral view of right valve (KE. 1913); ×1.5; Loc., Ditto.

Fig. 11. Lateral view of imperfect left valve (KE. 1913); ×1.5; Loc., Ditto.

Fig. 12. Ditto, (KE. 1915); ×1.5; Loc., Ditto.

Fig. 13. Ditto, (KE. 1916); ×1.5; Loc., Ditto.

Fig. 14. Rubber external cast of immature right valve (KE. 1924); ×6; Loc., Ditto.

Fig. 15. Postero-dorsal view of right valve (KE. 1917); ×2; Loc., Ditto.

Fig. 16. Dorsal view of right valve (KE. 1918); ×2; Loc., Ditto.

Fig. 17. Ditto, (KE. 1919); ×1.5; Loc., Ditto.

*Apiotrigonia undulosa* NAKANO

Fig. 18. Rubber external cast of immature right valve (KE. 1925); ×2; Sakuradani, Hirono-machi, Futaba county, Fukushima pref.

Fig. 19. Rubber external cast of right valve, Postero-dorsal view (KE. 1926); ×2; Loc., Ditto.

*Apiotrigonia postonodosa* NAKANO

Fig. 20. Rubber external cast of right valve (KE. 1927); ×2; Kamihira, Kawaura-machi, Amakusa county, Kumamoto prefecture.

Fig. 21. Rubber external cast of left valve (KE. 1928); ×2; Loc., Ditto.

Fig. 22. Rubber external cast of immature left valve (KE. 1929); ×4; Loc., Ditto.

Figs. 23a, 23b. Rubber cast of immature left valve (KE. 1931); ×6; Loc., Ditto.

*Microtrigonia imutensis* TASHIRO, new species

Fig. 24. Rubber external cast of right valve, Holotype (KE. 1887); ×1.5; Ukimizu of Imuta, Kashima-mura (Shimokoshiki island), Satsuma county, Kagoshima prefecture.

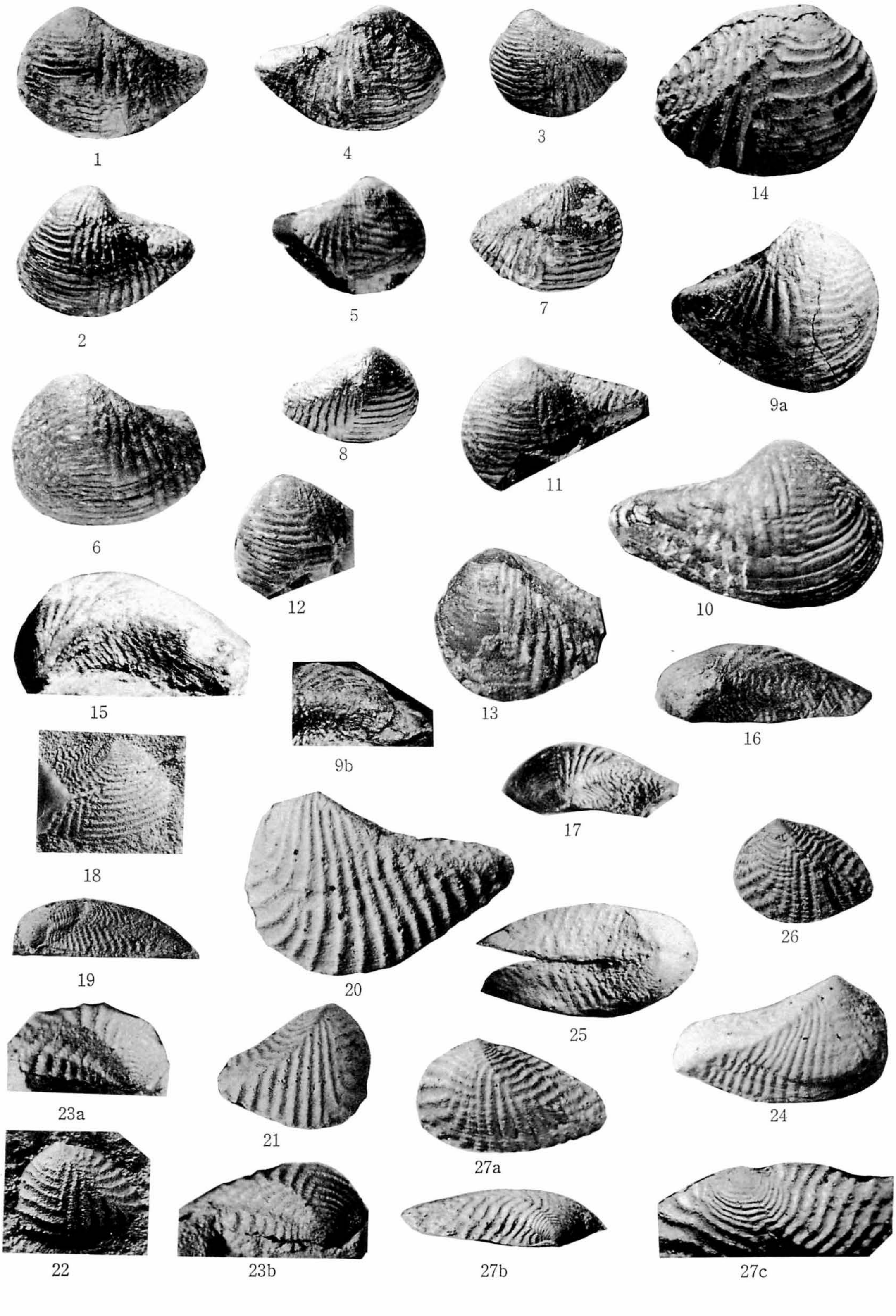
Fig. 25. Dorsal view of Holotype. ×1.5.

*Microtrigonia amanoi* NAKANO

Fig. 26. Rubber external cast of left valve (KE 1933); ×1.5; Ukimizu of Imuta, Kashima-mura, Satsuma county, Kagoshima prefecture.

Figs. 27a, 27b. Lateral and dorsal views of left valve, Rubber cast (KE. 1934); ×1.5; Loc., Ditto.

Fig. 27c. Umbonal view of the same specimen; ×3.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4
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14
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9a
6
8
11
12
10
15
13
9b
16
18
17
20
26
19
25
23a
21
24
27a
22
23b
27b
27c

*Measurements:—* (in mm)

| Specimen | Length | Height | Thickness |
|---|---|---|---|
| KE 1887 right valve (Holotype) | 22.2 | 14.3 | 5.0 |
| KE 1888 right valve (Paratype) | 15.0 | 10.3 | 3.2 |

part ornamented with fine crowded concentric costae and costellae, about 15 in number; disk with two series of costae; anterior series consisting of about 5 plain subhorizontal costae observable only near the umbonal concentrics; posterior series consisting of about 23 subradial tuberculate costae which extend as far as anterior ventral part, of which about 8 anterior ones are gradually bent towards anterior; area narrow for the genus, ornamented with about 18 tuberculate costellae, of which the first 5 or so are concentric, and the others gradually become oblique and weak; siphonal part of area nealy smooth; escutcheon with about 18 transverse tuberculate costellae, each of which joins with a costellae of area.

*Observation and remarks:—*This species resembles *Ap. utoensis* rather than the type species of *Microtrigonia*, in crowded costae and costellae near umbo. This immature *Frenguelliella*-like stage is about 6 mm in height. In several adult specimens, fine radial threads appear on the posterior part of area.

*Comparison:—*This species is different from *Micr. amanoi* from the same locality in more numerous subradial costae on the disk, smooth area of the posterior region, many crowded concentrics near the umbo, and a well rounded siphonal margin. Younger stage of this species (about 10 mm in height) is very similar to *Ap. minor* as regards the ornamentation of disk. The fine radial threads in the area as seen in this species are observable in the mature stage of *Ap. minor.*

*Occurrence:—*Black siltstone of the Upper formation of Himenoura group at Ukimizu of Imuta, Kashima-mura (Shimo-koshiki island), Satsuma county, Kagoshima prefecture.

## References

AMANO, M. (1957): Upper Cretaceous molluscan fossils from Shimokoshiki-jima, Kyushu. *Kumamoto Jour. Sci., Ser B, Sec. 1, Geol.*, Vol. 2, No. 2, pp. 51–67, 1 map, pls. 1, 2.

COX, L. R. (1952): Notes on the Trigoniidae, with outline of a classification of the family. *Proc. Malac. Soc. London*, Vol. 29, pts. 2, 3, pp. 45–70, 2 pls.

—— (1964): New genera and subgenera of Trigoniidae from Australia and Madagascar. *Ibid.*, Vol. 36, pt. 1, pp. 49–52, pl. 2.

—— (1969): Family Trigoniidae. in *Treaties on Invertebrate Paleontology*, MOORE edit., Pt. N, Mollusca 6, Vol. 1, Geol. Soc. Amer. & Univ. Kansas, pp. N476–N488, figs. D66–D75.

HAYAMI, I. and NAKANO, M. (1968): A consideration on the numerical taxonomy in palaeontology, taking the Trigoniidae as an example (in Japanese). *Sci. Rept., Fac. Sci., Kyushu Univ.*, Vol. 8, No. 4, pp. 191–236.

HAYASAKA, I. (1921): On a collection of the Cretaceous fauna from Russian Sachalin. *Rec. Geol. Comm. Russ. Far East*, No. 12, p. 4, pl. 1.

JIMBO, K. (1894): Beitrage zur Kentniss der Kreideformation von Hokkaido. *Palaeont. Abh., N.F.*, Bd. 2, Hft. 3, pp. 1–48, pls. 1–9.

JONES, L. D. (1960): Lower Cretaceous (Albian) fossils from southwestern Oregon and their paleontographic significance. *Jour. Paleont.*, Vol. 34, No. 1, pp. 152-160, pl. 29.

KOBAYASHI, T. (1954): Studies on the Jurassic trigonians in Japan. Part 1, Preliminary notes. *Japan. Jour. Geol. Geogr.*, Vol. 25, Nos. 1, 2, pp. 61-80.

—— and TAMURA, M. (1955): The Myophorellinae from North Japan. Studies on the Jurassic trigonians in Japan. *Ibid.*, Vol. 26, Nos. 1, 2, pp. 93-103, pls. 5, 6.

LIWEROWSKAJA, E. V. (1960): Stratigraphy and fauna of the Upper Cretaceous Formation in the east coast of Penshina Bay. *Palaeont. Bull.*, 2, Leningrad, pp. 231-261, pls. 1-6.

LYCETT, J. (1872-79): A monograph of the British fossil trigoniae. *Palaeontogr. Soc. London*, Vol. 245, 19 pp., 41+4 pls.

MAEDA, S. and KAWABE, T. (1967): *Apiotrigonia* from the Futaba group in the Joban District, North Japan. *Prof.* H. SHIBATA *Memorial Vol.*, pp. 420-430, pl. 1, tab. 1.

NAGAO, T. and OTATUME, K. (1938): Molluscan fossils of the Hakobuchi sandstone of Hokkaido. *Jour. Fac. Sci., Hokkaido Imp. Univ.*, Vol. 4, Nos. 1, 2, pp. 31-56, pls. 1-4.

NAKANO, M. (1957): On the Cretaceous pennatae trigonians in Japan. *Japan. Jour. Geol. Geogr.*, Vol. 28, Nos. 1-3, pp. 107-120, pls. 8, 9.

## Explanation of Plate 41

*Apiotrigonia obsoleta* NAKANO

Fig. 1. Lateral view of left valve (KE. 1891); ×1.5; Okoshiki, Ohda-machi, Uto city (Uto peninsula), Kumamoto prefecture.

Figs. 2a, 2b. Lateral and dorsal views of imperfect right valve (KE. 1890); ×1.5; Loc., Ditto.

Fig. 3. Lateral view of right valve (KE. 1899); ×1.5; Loc., Ditto.

Fig. 4. Lateral view of left valve (KE. 1893); ×1.5; Loc., Ditto.

Figs. 5a, 5b. Lateral and dorsal views of left valve (KE. 1892); ×2; Loc., Ditto.

Fig. 6. Umbonal view of left valve (KE. 1900); ×4; Loc., Ditto.

Fig. 7. Umbonal view of right valve (KE. 1901); ×4; Loc., Ditto.

Fig. 8. Postero-dorsal view of left valve (KE. 1903); ×4; Loc., Ditto.

*Apiotrigonia utoensis* TASHIRO, new species

Figs. 9a, 9b, 9c. Lateral, dorsal, and postero-dorsal views of left valve, Holotype (KE. 1881); ×2; Okoshiki, Ohda-machi, Uto city, Kumamoto prefecture.

Figs. 10a, 10b. Lateral and dorsal views of right valve, Paratype (KE. 1882); ×2; Loc., Ditto.

Fig. 11. Umbonal view of right valve, Paratype (KE. 1883); ×4; Loc., Ditto.

*Apiotrigonia* cfr. *obsoleta* NAKANO

Fig. 12. Rubber cast ef external left valve, Lateral view (KE. 1935); ×2.

Fig. 13a, 13b. Postero-dorsal views of left valve, Rubber external cast (KE. 1936).

Specimens of this species are collected by TAMURA from the Izumi group in Kii peninsula.

*Heterotrigonia himenourensis* TASHIRO, new species

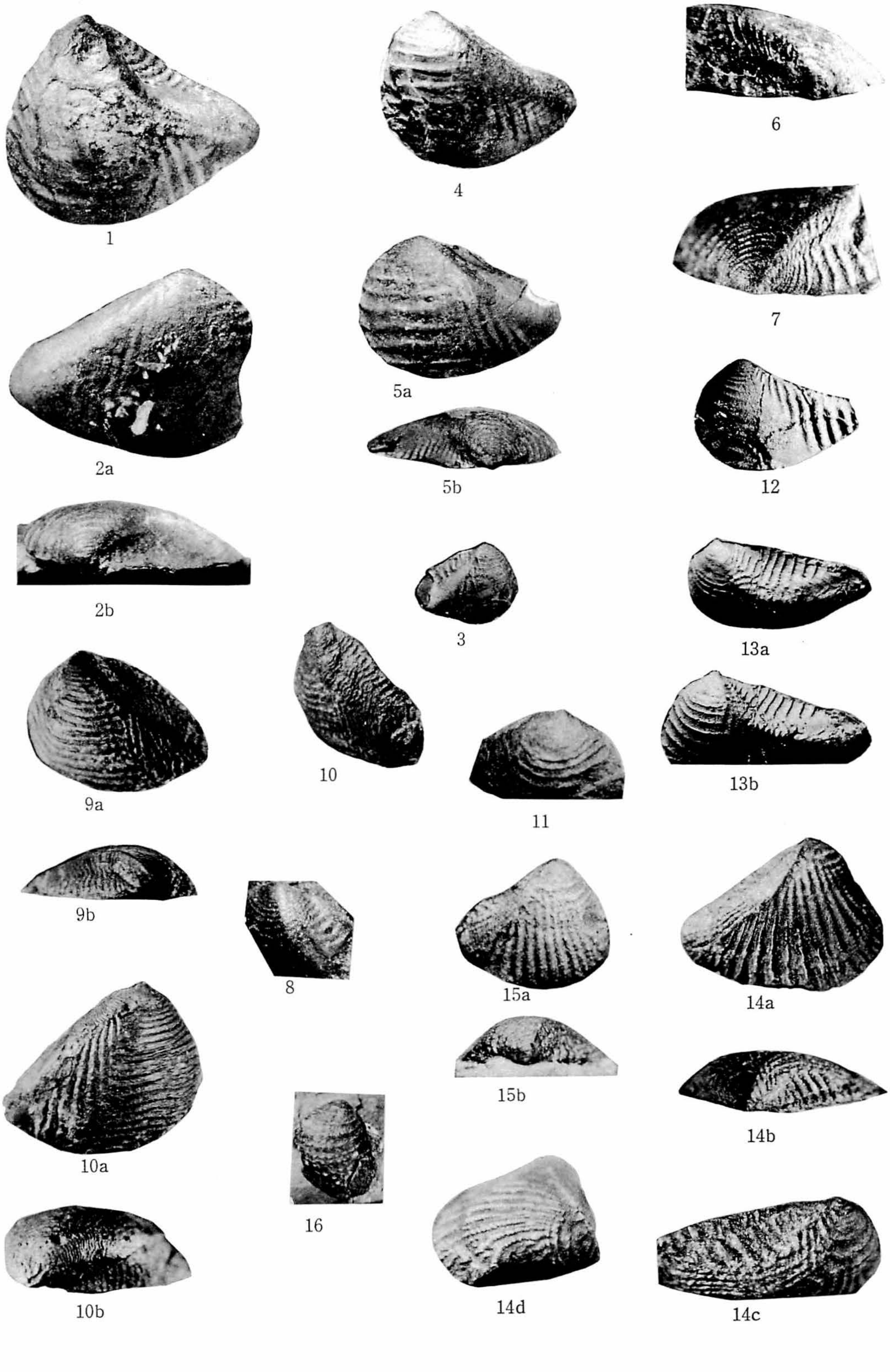
Figs. 14a, 14b. Lateral and dorsal views of right valve, Holotype (KE. 1884); ×2; Okoshiki, Ohda-machi, Uto city, Kumamoto prefecture.

Fig. 14c. Postero-dorsal view of Holotype; ×5.

Fig. 14d. Antero-marginal view of Holotype; ×2.

Figs. 15a, 15b. Lateral and dorsal views of right valve, Paratype (KE. 1885); ×2; Loc., Ditto.

Fig. 16. Antero-marginal view of imperfect right valve (KE. 1886); ×2; Loc., Ditto.



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10a
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13b
14a
14b
14c
14d
15a
15b
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—— (1961a): Note on *Heterotrigonia subovalis* (Jimbo). *Trans. Proc. Palaeont. Soc. Japan, N. S.*, No. 42, pp. 55-62, pl. 9.

—— (1961b): On the Trigoniinae. *Jour. Sci., Hiroshima Univ., Ser. C*, Vol. 4, No. 1, pp. 71-94, pl. 8.

—— (1970): Notes on the Trigoniinae and the Nototrigoniinae. *Res. Bull. Hiroshima Inst. Technol.*, Vol. 4, No. 1, pp. 91-108, tab. 1.

PACKARD, E. L. (1921): Trigoniae from the Pacific Coast of North America. *Univ. Oregon Publ.*, Vol. 1, No. 9, pp. 1-35, pls. 1-11.

SAITO, T. (1962): The Upper Cretaceous System of Ibaraki and Fukushima Pref., Japan. (Part 2), *Bull. Fac. Arts & Sci., Ibaraki Univ., Nat. Sci.* No. 13, pp. 51-87, pls. 1-8.

SAVELIEV, A. A. (1958): Lower Cretaceous trigoniids from Manghyschlack and Western Turkmenia. *Leningrad VNIGRI*, 125, pp. 1-386, pls. 1-58.

SKAWARKO, S. K. (1963): Australian Mesozoic trigoniids. *Bur. Miner. Resource, Geophys., Australia, Bull.* No. 67, pp. 1-42, pls. 1-6.

—— (1968): Aptian (Lower Cretaceous) '*Apiotrigonia*' from the Melligo quartzite, Dampier Peninsula, W. A. *Ibid.*, No. 108, pp. 227-233, pl. 33.

—— (1970): An Upper Jurassic *Apiotrigonia* from Mexico. *Bol. Soc. Geol. Mexicana*, Vol. 31, No. 2, pp. 75-78, pl. 1.

TAMURA, M. (1959a): Trigoniidae, Ostreidae, Bakevelliidae, Pteriidae, Cardiidae, and Astartidae from the Upper Jurassic Sakamoto Formation in Central Kyushu, Japan. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, No. 33, pp. 23-32, pl. 5.

—— (1959b): On *Kumatrigonia*, a new subgenus of *Frenguelliella*, and a *Tosapecten* from the Carnic Tanoura Formation in Kyushu, Japan. *Mem. Fac. Educ., Kumamoto Univ.*, Vol. 7, pp. 212-218, pl. 1.

VAN HOEPEN, E. C. N. (1929): Die Krytofauna van Soeloeland, 1. Trigoniidae. *Pal. Navorsing Nas. Bloemfontein*, Vol. 1, Pt. 1, pp. 1-38, pls. 1-7.

YABE, H. (1927): Cretaceous stratigraphy of the Japanese Islands. *Sci. Rept., Tohoku Imp. Univ., 2nd Ser.*, Vol. 11, No. 1, pp. 27-100, pls. 3-9.

—— and NAGAO, T. (1925): New of little-known Cretaceous fossils from North Sachalin (Lamellibranchiata and Gastropoda). *Ibid.*, Vol. 7, No. 4, pp. 111-124, pls. 28, 29.

YEHARA, S. (1915): The Cretaceous Trigoninae from Miyako and Hokkaido. *Jour.*, Vol. 2, No. 2, pp. 35-44, pls. 1, 2.

—— (1923a): Cretaceous trigoniae from Amakusa Island, Prov. Higo, Kyushu, Japan. *Jour. Geol. Soc. Tokyo*, Vol. 30, No. 356, pp. 1-12, pls. 4-7.

—— (1923b): Cretaceous trigoniae from South-Western Japan. *Japan. Jour. Geol. Geogr.*, Vol. 2, No. 3, pp. 59-84, pls. 8-13.

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|---|---|
| Amakusa | 天 草 |
| Hiraiwa | 平 岩 |
| Imuta | 藺 牟 田 |
| Mikasa | 三 笠 |
| Ohda | 網 田 |
| Okoshiki | 御 興 来 |
| Ryugatake | 竜 ケ 岳 |
| Satsuma | 薩 摩 |
| Shimo-koshiki-jima | 下 甑 島 |
| Takado | 高 戸 |
| Ukimizu | 浮 水 |
| Uto | 宇 土 |
| Wadanohana | 和 田 鼻 |

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 86, pp. 340-359, pls. 42, 43, June 30, 1972

# 598. MARINE DIATOM FLORA OF THE PLIOCENE TATSUNOKUCHI FORMATION IN FUKUSHIMA PREFECTURE*

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福島県，鮮新統・竜ノ口層中の海棲珪藻植物群： 阿武隈山地東縁の双葉断層以東， 海岸にいたるまでの丘陵地域に分布する竜ノ口層中の化石珪藻群集の解析と結果を述べる。

出現する珪藻種にもとづく統計的解析により， 類似性の強い4つの群に， 試料を大別し得た。試料の地理的， 層序的分布から，これらの各群は地域の南部と北部を， 北部では更に垂直的細分を代表するものであることが分る。

現生珪藻種の地理的分布から判断すると， これら各群の珪藻群集は主に環境要因によって規定されたものである。群集解析の結果， 竜ノ口層堆積当時は， 現在と同じように地域の南部ほど古黒潮の影響が強かったことが， そして堆積盆地は漸次浅海化していったことが分る。

これとは別に， 群集の大半を占める絶滅種は， これまで上部中新統ないし鮮新統， および鮮新統からしか報告されていない種のみである。

福島県，竜ノ口層中の各珪藻群（帯）の種組成，特徴，分布について述べ，2新種 *Stephanopyxis horridus* および *Rhaphoneis tatsunokuchiensis* を記載した。小　泉　格

## Introduction

The Tatsunokuchi Formation (IWAI, 1949), distributed along the Pacific side of northeast Japan, is characterized by its tuffaceous, blue, soft siltstone, intercalated with tuff, sandstone and conglomerate, and also by the yield of many kinds of fossil marine animals and plant remains (HATAI and NODA, 1968). There has been, however, no report on the diatom flora of the formation. Diatoms, because of their natural characteristics, are particularly useful in the field of biostratigraphy and paleogeography.

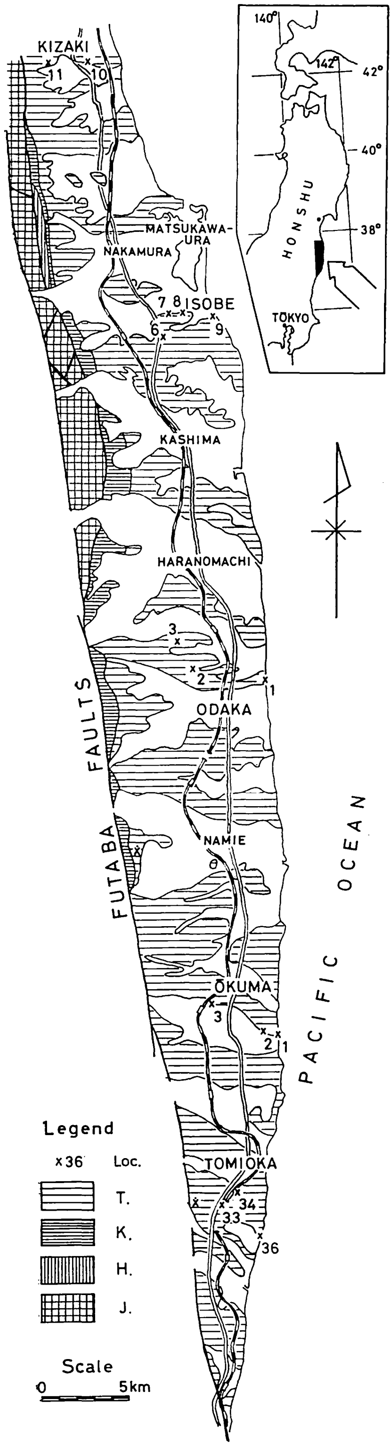
The first report on the Pliocene marine diatoms was by REINHOLD (1937) who described their stratigraphical distribution in the Miocene and Pliocene sequence of Java. Many important contributions have been added since then, and they are summarized as follows:

*North America:* The stratigraphical distribution in California of marine species of the genus *Denticula* in the Miocene and Pliocene was reported by SIMONSEN and KANAYA (1961). The uppermost Miocene and Pliocene diatoms were described by WORNARDT (1967).

*Alaska:* The Pliocene diatoms of the Pribilor Islands, Alaska, were reported by HANNA (1970).

*Soviet Far East:* Marine diatoms including 8 new species of the Miocene

* Received June 1, 1971; read June 27, 1970, at Mito.



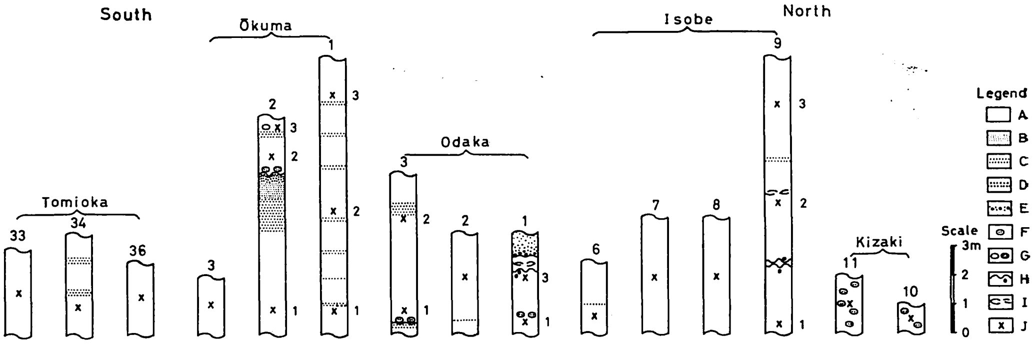

and Pliocene in Soviet Far East were reported by JOUSÉ (1961), and subsequently she (JOUSÉ, 1962) compiled a range chart of the more important species from the late Miocene to Recent. The zonal subdivisions of the Neogene of Sakhalin and Kamchatka by means of diatoms were described by SHESHUKOVA-PORENTZKAYA (1959, 1967).

*Japan:* The difference between the upper Miocene and Pliocene diatom assemblages in northern Japan was defined by KOIZUMI (1966). Seven diatom zones were recognized on the basis of four categories comprising 18 marine planktonic species in the Neogene sequence of northeast Japan by KOIZUMI (1968).

The progress and present status of the younger Cenozoic diatom biostratigraphy in the circum north Pacific region was described by KANAYA and KOIZUMI (1970).

The purpose of this paper is to describe the diatom assemblage of the Pliocene Tatsunokuchi Formation in Fukushima Prefecture to establish a local criteria with which other diatom assemblages can be compared. The assemblages are geographically and stratigraphically subdivided into four groups by statistical analysis based on the joint occurrences of the species. This is the first of the serial reports on the Pliocene marine diatoms of the Tatsunokuchi Formation.

Text-fig. 1. Geological map showing the locations of the samples of the Tatsunokuchi Formation, Fukushima Prefecture. x : Locality of the molluscan fauna, Loc. : Locality of samples studied and locality number, T : Tatsunokuchi Formation, K : Kuboma Formation, H : Hatsuno Formation, J : Jurassic strata.




Text-fig. 2. Columnar sections showing the stratigraphic position of the samples studied. A : siltstone, B : fine-grained sandstone, C : medium-grained sandstone, D : coarse-grained sandstone, E : conglomerate, F : pumiceous part, G : lithic marl and sandstone concretion, H : irregular surface and sand pipe, I : molluscan fossils, J : position of samples studied.

## Stratigraphic notes

The stratigraphy of the Soma-Futaba district, Fukushima Prefecture, situated on the east side of the Futaba Faults (TOKUNAGA, 1927), has been studied by many geologists (*e. g.* TOKUNAGA, 1948; MITA, 1951; HIRAYAMA, 1953; KITAMURA *et al.*, 1955; SUGAI *et al.*, 1957; SUZUKI, 1968; ISHIDA *et al.*, 1969). However, the opinions are diversed among them about stratigraphic classification of the Miocene and Pliocene strata in the present area, and the writer follows KITAMURA *et al.* (1955) and ISHIDA *et al.* (1969).

The samples examined in the present study are from the middle to upper parts of the Tatsunokuchi Formation distributed in the Soma-Futaba district. The stratigraphic positions of the samples are shown in Text-fig. 2, and their localities are plotted in the geological map (Text-fig. 1). Brief outlines of the Pliocene stratigraphy of the present area and the geologic age of the samples are given in the following.

***Stratigraphy*** (in ascending order)

Kuboma Formation (30-60 m): The type locality is the environment of Kayakura, Soma City (KITAMURA *et. al.*, 1955). The formation, distributed in a narrow belt along the east side of the Futaba Faults, consists of coarse grained sandstone, massive fine grained sandstone, bluish gray siltstone and light gray tuff intercalated with lignite layers. The top of the formation is defined by loose sand. The formation is in fault or unconformable contact with the older Hatsuno Formation or with Jurassic strata.

Tatsunokuchi Formation (80-150m): The type locality of the formation is the Tatsunokuchi gorge, a tributary of the Hirose River, in the western part of Sendai City located north of the present area. The main body of the formation extends from its type locality to the present area and can be traced in the field. The faunal similarity (HAYASAKA, 1956; SUGAI *et al.*, 1957; KAMADA and HAYASAKA, 1959; HAYASAKA and HANGAI, 1966), especially the occurrence of *Fortipecten takahashii*, endorses paleontologically the contemporaneity between the formation in the present area and that in the Sendai City area. The Tatsunokuchi Formation in the present area consists mainly of bluish gray, massive fine-grained sandstone and siltstone, intercalated with coarse-grained sandstone and pumiceous tuff layers (10-30 cm). The general geologic structure of the formation is monocline dipping at nearly 5° eastward, though with somewhat steep dip near the Futaba Faults. The formation rests on the Kuboma Formation with conformity.

***The geologic age of the samples studied***

As already mentioned, the diatom samples of the present study were collected from the Tatsunokuchi Formation distributed in the Soma-Futaba district, but traced continuously throughout its distribution. The geologic age of the Tatsunokuchi Formation in and around Sendai City based upon the different kinds of fossils is generally accepted to correspond to the Early Pliocene or to the lower part of the Miyagian (HATAI, 1962; HATAI and MASUDA, 1966).

The under mentioned fossils besides the stratigraphic evidences are useful in determining the geologic age of the formation in the present area. Namely, the occurrence of *Acila* (*Truncacila*) *insignis*, *Fortipecten takahashii*, *Glycymeris* cf. *nakamurai*, *Mercenaria chitaniana*, *Patinopecten ibaragiensis* and *Turritella* cf. *ikebei* in Namie-machi indicates the Pliocene age (HAYASAKA, *op. cit.;* HAYASAKA and HANGAI, *op. cit.*). The mollucan fauna containing such species as *Fusitriton oregonensis*, *Nemocardium* (*Keenaea*) *samarangae*, *Neverita* (*Glossaulax*) *didyma*, *Tectonatica janthostomoides* and *Venericardia* (*Cyclocardia*) *ferruginea* from Tomioka-machi is of Early Pliocene in age according to KAMADA and HAYASAKA (*op. cit.*).

## Method of study

The method of study once described by the writer (KOIZUMI, 1968) is followed in the present study, except for being improved by counting 400 diatom valves for each sample instead of 200 valves as done previously.

## Diatom flora of the Tatsunokuchi Formation

Among the 23 samples from the Tatsunokuchi Formation, the distribution of the 74 diatom taxa distinguished is shown in Chart 1. Of these 74 taxa, 25 are judged to be benthonic and tychopelagic species. Although no freshwater forms are given in the chart, such species as *Cocconeis disculus*, *C. placentula*, *Cyclotella chaetoceros*, *Cymbella sinuata* and *Epithemia zebra* occur rarely. Judging from the previous records of occurrences of the distinguished taxa, 24 are now extinct in the Pacific area.

Most of the taxa in the chart have been used in current works (*e. g.* SIMONSEN and KANAYA, *op. cit.*; JOUSÉ, *op. cit.*; MUCHINA, 1965; MERTZ, 1966; KOIZUMI, *op. cit.*; SHESHUKOVA-PORENTZKAYA, *op. cit.*) in characterizing the upper Miocene and Pliocene diatom assemblages of the Circum-Pacific regions. The chronologic range of each species will be mentioned in the chapter of floral reference. As indicated in the chart, the flora is largely dominated by *Denticula kamtschatica* and *D. seminae*. *D. kamtschatica* was found by SIMONSEN and KANAYA (*op. cit.*) only in the Pliocene samples from California, but its first appearance dates back to the Miocene (KOIZUMI, *op. cit.;* SHESHUKOVA-

| Areas / Samples / Species | Tomioka | | | Ōkuma | | | | | | | Odaka | | | | | Isobe | | | | | | Kizaki | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Samples | 36 | 34 | 33 | 3 | 2 | | | 1 | | | 3 | | 2 | 1 | | 6 | 7 | 8 | 9 | | | 11 | 10 |
| | | | | | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | | 1 | 3 | | | | 1 | 2 | 3 | | |
| Actinocyclus curvatulus | | | | | | 2 | 2 | | | 1 | | | | 1 | 2 | | | | 1 | | | | 2 |
| A. divisus | | | | | | | | | | 1 | | | | 2 | | | | | 1 | | 1 | | |
| A. ehrenbergi | 2 | 2 | 1 | 1 | | 1 | | | 1 | 2 | | | | 3 | | | | | | | | 2 | |
| A. ellipticus v. moronensis * | 1 | | | | | | | | | | | | | | | | | | | | | | |
| A. elongatus | 1 | | | | | | | | | | | | | | | | | | | | | | |
| Actinoptychus splendens | | | | | | | 2 | | | | | | | | | | | | | | | 1 | |
| A. undulatus | 19 | 13 | 2 | 3 | 1 | | 4 | 1 | 5 | | | | 1 | 3 | 3 | 2 | 1 | 1 | 2 | | | | 1 |
| A. undulatus v. minor | 5 | 6 | | 4 | 2 | | 5 | 1 | 1 | 2 | 1 | 1 | 2 | 3 | | | | | 4 | 1 | 4 | | |
| Amphora costata | | | | | | 1 | | | | 1 | | | | | | | | | | | | | |
| Arachnoidiscus ehrenbergi | | | | | | 1 | 1 | | | | | | | 1 | | | | | | | | | |
| Asteromphalus darwinii * | | | | | | | | | | | | 1 | | | | | | | 1 | | | | |
| A. robustus | | | 1 | | 1 | | | | | | | | | | | | | | | 1 | | | |
| Bacteriosira fragilis | | 1 | 1 | | 1 | 2 | | 1 | 1 | | | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | | 3 | 2 | 4 |
| Biddulphia aurita | 1 | 5 | | 2 | 1 | | | 1 | | | | | 1 | | | | | | | | | | |
| Cladogramma californica * | | 1 | | | | | | | | | | | | | | | | | | | | | 1 |
| Cocconeis californicum | | | 1 | | | 1 | | | | 1 | | | | 3 | | | | | | | | 1 | 2 |
| C. costata | | 1 | 3 | 1 | 1 | 2 | 1 | 3 | 1 | 2 | 3 | 3 | 4 | 4 | 3 | 1 | 2 | 1 | | | 2 | 1 | 2 |
| C. scutellum | | | | | | | | 1 | | 1 | | | | | 1 | | | | 1 | | | | 1 |
| Coscinodiscus excentricus | 7 | 4 | 9 | 2 | 2 | 4 | 3 | 3 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | | | | 1 | 1 | 2 | 2 | 1 |
| C. lacustris | | 1 | 3 | | | | 1 | 1 | 1 | 1 | | 1 | | 3 | 1 | | | 1 | | | | 6 | |
| C. lineatus | 6 | 3 | 3 | 1 | 1 | 2 | 2 | | 2 | | 1 | | | | | | | | | | | | |
| C. marginatus | 8 | 11 | 10 | | 28 | | 4 | 6 | 5 | 6 | 8 | 5 | 6 | 12 | 12 | 4 | 8 | 12 | 8 | 7 | 8 | 5 | 12 |
| C. nodulifer | 1 | | 1 | | | 1 | 1 | | 1 | | | | | | | | | | | | | | |
| C. oculus-iridis | 1 | | 1 | | 1 | 1 | | | | | | | | | | | | | | | | | |
| C. pustulatus * | | | | | | | | 1 | | | 2 | | 3 | 4 | 6 | | | | | | | | |
| C. stellaris | | | 1 | | 1 | 1 | 7 | | | 1 | 1 | | | | | | | 1 | | 1 | 1 | | |
| C. sublineatus | 3 | 3 | 5 | 2 | 2 | 2 | 3 | 6 | 4 | 2 | 1 | 4 | 4 | 5 | 4 | 4 | 1 | 2 | 2 | 3 | 4 | 5 | 4 |
| Denticula kamtschatica * | 37 | 110 | 67 | 96 | 73 | 57 | 17 | 52 | 6 | 8 | 54 | 53 | 61 | 4 | 36 | 70 | 45 | 60 | 38 | 33 | 57 | 35 | 40 |
| D. seminae | 12 | 3 | 58 | 15 | 27 | 46 | 29 | 88 | 76 | 108 | 131 | 107 | 130 | 38 | 72 | 192 | 201 | 235 | 128 | 215 | 112 | 105 | 129 |
| Diploneis sejuncta f. constricta | | | | | | | | | | | | | | | | | 1 | | | | | 1 | |
| D. smithi | 2 | | 1 | | | 1 | 1 | | 1 | 1 | | | | 1 | | | | | 1 | | 1 | 1 | |
| Fragilariopsis cylindrus | | 1 | | | 3 | 3 | | | | | | 1 | 2 | | 2 | 1 | 2 | 1 | 2 | | 1 | | 1 |
| Grammatophora angulosa | | | | | | | | | 1 | | | | | 1 | | | | | | | | | |
| G. robusta | | | | | | | | | | | | | | | | | | | | 1 | | | |
| Hemidiscus cuneiformis | 3 | | 3 | | 1 | 2 | 3 | | | | | | | | | | | | | | | | |
| H. weissflogi | | | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | |
| Hyalodiscus obsoletus * | 2 | | | | | | | 1 | 3 | 1 | 1 | | | | 2 | | | | 1 | | 1 | | 1 |
| Melosira albicans * | | | | 2 | 8 | 4 | 6 | 10 | | | 9 | 12 | 5 | | 1 | 1 | 1 | 2 | | | | 1 | 1 |
| M. sulcata | 10 | 3 | | 6 | 1 | | 7 | | 2 | 4 | 1 | 1 | 3 | 2 | | | 1 | | 2 | | 2 | 1 | 1 |
| M. sulcata v. biseriata | 1 | 1 | 6 | 1 | 1 | | 2 | 1 | 1 | 1 | 1 | 4 | | 1 | 2 | | 1 | 2 | 1 | 1 | 1 | 2 | 1 |
| Navicula jamalinensis v. simisevultus * | | | 1 | | | | | | | 1 | | | | | | | | | | | | | |
| Nitzschia extincta * | 1 | | | 3 | | 1 | 2 | 1 | 4 | 1 | 1 | 1 | 2 | 1 | 1 | | 1 | | 4 | ·2 | 3 | 2 | 1 |
| N. reinholdii * | 4 | 3 | 1 | 3 | | 2 | 3 | 2 | 1 | 1 | 1 | 1 | | 2 | 1 | | | | | | | 1 | 1 |
| N. sicula | | | 1 | | | | | | 1 | | | | | | | | | | 1 | | 1 | | |
| N. fossilis * | 4 | 3 | 1 | 1 | | 1 | 2 | | 9 | 1 | 1 | | | | | | | | | 1 | | | |
| Planktoniella sol | | | 1 | 1 | | 2 | | | 2 | 1 | | | | | 2 | | | | | | 1 | | |
| Porosira glacialis | 2 | | | | | | | 1 | | | | | | | 2 | | | | | | | | |
| Pseudopodosira elegans * | 1 | 1 | | 5 | 2 | 2 | | 2 | 9 | 6 | | | 1 | | 10 | 19 | 18 | 5 | 4 | 1 | 4 | 4 | 7 |
| Pyxidicula weyprechtii | | | | | | | | | | | | 1 | | | | | | | | | | | 1 |
| Rhabdonema arcuatum | | | | | | | | | | 1 | | | | | | | | | | | | | |
| Rhaphoneis amphiceros | 3 | 1 | 2 | | | 1 | 2 | | | 1 | 1 | | 2 | 3 | 2 | 1 | 2 | | | 1 | 3 | 6 | 7 |
| R. ischaboensis v. angusta * | 1 | 5 | 1 | 3 | | 1 | 24 | | | 1 | 1 | | | 3 | | | | | | | 1 | 1 | |
| R. ischaboensis v. linguiformis * | | | | | | | | | | 1 | 2 | | | | 3 | 1 | 1 | 1 | 1 | | 1 | 1 | |
| R. margaritalimbata * | 1 | | | | 1 | | | 2 | | | 1 | 1 | | 1 | 5 | | 1 | 2 | 2 | 1 | 1 | 1 | 1 |
| R. surirella | 2 | 4 | 2 | 23 | 2 | 3 | 3 | 1 | 37 | 45 | | 2 | 4 | 3 | 3 | 2 | 2 | 1 | 10 | 8 | 19 | 6 | 4 |
| R. tatsunokuchiensis (n. sp.) * | | 2 | | | | | 3 | | | | | | 1 | | | | | | | | | | |
| Rhizosolenia bergonii | | | | | | 1 | | | | | | | 1 | | | | | | 1 | | | | |
| Stephanopyxis schenckii * | 5 | | | | | | | | | | | | | | | | | | | | | | |
| S. turris | 13 | 20 | 14 | 1 | 3 | 2 | | 1 | 4 | | 6 | 11 | 9 | 30 | 15 | 2 | 2 | | 2 | 1 | 1 | 3 | 2 |
| S. horridus (n. sp.) * | | | | 2 | 2 | | | | 1 | 1 | 2 | 2 | 2 | 5 | 3 | | | 1 | 1 | 1 | | | |
| S. turris v. cylindrius | 63 | 68 | 38 | 42 | 83 | 75 | 42 | 46 | 27 | 29 | 10 | 18 | 17 | 68 | 29 | 14 | 18 | 7 | 20 | 14 | 31 | 34 | 34 |
| Thalassionema nitzschioides | 65 | 52 | 89 | 71 | 80 | 97 | 155 | 61 | 130 | 89 | 62 | 63 | 48 | 102 | 94 | 23 | 35 | 20 | 95 | 50 | 45 | 112 | 81 |
| T. nitzschioides vars. | 4 | 4 | 2 | 11 | 5 | 3 | 9 | 2 | 17 | 11 | 3 | 2 | 1 | 4 | 2 | 6 | 2 | 3 | 1 | 5 | 2 | 9 | 3 |
| Thalassiosira antiqua * | 44 | 19 | 20 | 31 | 9 | 19 | 10 | 39 | 17 | 30 | 56 | 58 | 48 | 19 | 21 | 24 | 20 | 20 | 33 | 29 | 47 | 20 | 21 |
| T. convexa * | 2 | 4 | 2 | | 1 | 3 | 3 | 1 | 2 | | 1 | 1 | 1 | 8 | 2 | | 1 | | | | | | |
| T. decipiens | 10 | 13 | 5 | 19 | 16 | 8 | 12 | 4 | 4 | 8 | 6 | 5 | 8 | 8 | 12 | 12 | 16 | 12 | 13 | 8 | 7 | 6 | 6 |
| T. gravida and f. fossilis * | 3 | 5 | 3 | 4 | 11 | 5 | 3 | 6 | 4 | 8 | 9 | 6 | 3 | 22 | 20 | 6 | 7 | 2 | 3 | 4 | 8 | 5 | 7 |
| T. hyalina | 6 | 9 | 5 | 4 | 3 | 1 | 4 | 3 | 2 | 2 | 5 | 7 | 2 | 3 | 4 | 2 | 2 | | 2 | 1 | 3 | 1 | 3 |
| T. kryophila | 3 | | 1 | 1 | | 1 | | 5 | 2 | 3 | | 1 | 2 | | 1 | | | | 1 | 1 | 1 | 1 | 1 |
| T. nidulus * | 5 | 2 | 6 | 2 | 4 | 7 | 4 | 13 | 6 | 3 | 5 | 7 | 4 | 10 | 6 | 2 | 3 | 2 | 2 | 2 | 4 | 6 | 3 |
| T. nordenskiöldi | 28 | 4 | 13 | 31 | 15 | 24 | 9 | 26 | 5 | 6 | 9 | 15 | 17 | 7 | 6 | 9 | 2 | 2 | 6 | 6 | 16 | 6 | 10 |
| T. oestrupi | 3 | 1 | 5 | 2 | 4 | 5 | 7 | 3 | 2 | 3 | 1 | 1 | 2 | 7 | | | 1 | 3 | 1 | | | 1 | 1 |
| T. pacifica | | | 2 | 2 | 1 | | | 1 | 1 | 1 | | | | | 1 | | 1 | | 2 | | 1 | 1 | |
| T. zabelinae * | 5 | 11 | 6 | 2 | 1 | 1 | 1 | 3 | | | 2 | 1 | | | 2 | | | | | | | 2 | 1 |
| Total valves | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 |
| Diatom numbers ($\times 10^6$) | 0.4 | 1.4 | 1.5 | 4.0 | 3.0 | 5.3 | 4.6 | 8.0 | 5.0 | 9.1 | 12.8 | 12.8 | 9.1 | 1.1 | 2.7 | 16.0 | 4.9 | 16.0 | 3.6 | 10.7 | 4.9 | 3.6 | 2.1 |

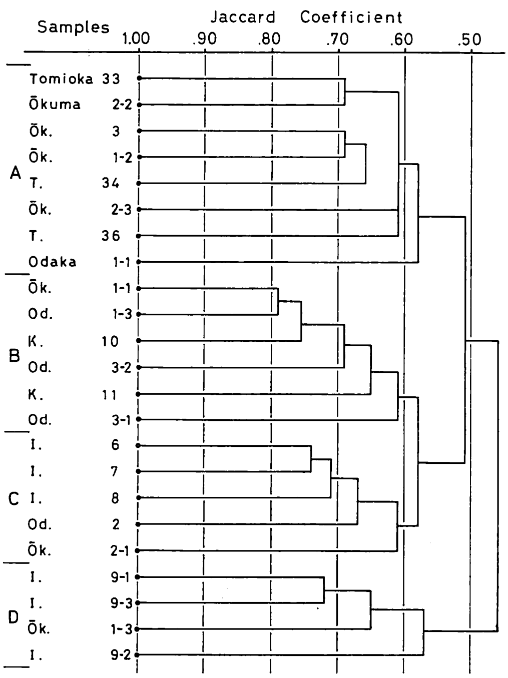
Chart 1. Chart showing the distribution of the marine diatoms of the Tatsunokuchi Formation. The asterisked species are now extinct in the Pacific.

PORENTZKAYA, *op. cit.*). *D. seminae*, a well known cold-water or boreal species of the north Pacific plankton flora, is the only living representative of the marine *Denticula*, and is considered a descendant of *D. kamtschatica* (JOUSÉ, *op. cit.*). The first appearance of *D. seminae* was reported by SHESHUKOVA-PORENTZKAYA (*op. cit.*) from Kamchatka to be in the Pliocene. The next frequent fossil species are of the genus *Thalassiosira*. Except for *T. convexa* that is a Pliocene guide fossil in cores from the equatorial Pacific, four *Thalassiosira* species, *T. antiqua*, *T. gravida* f. *fossilis*, *T. nidulus* and *T. zabelinae*, appear in the late Miocene and extend up to the Pliocene in northeast Japan (KOIZUMI, *op. cit.*) and in Sakhalin and Kamchatka (SHESHUKOVA-PORENTZKAYA, *op. cit.*). The first appearance of *T. hyalina*, *T. kryophila* and *T. nordenskioldi* is in the Pliocene.

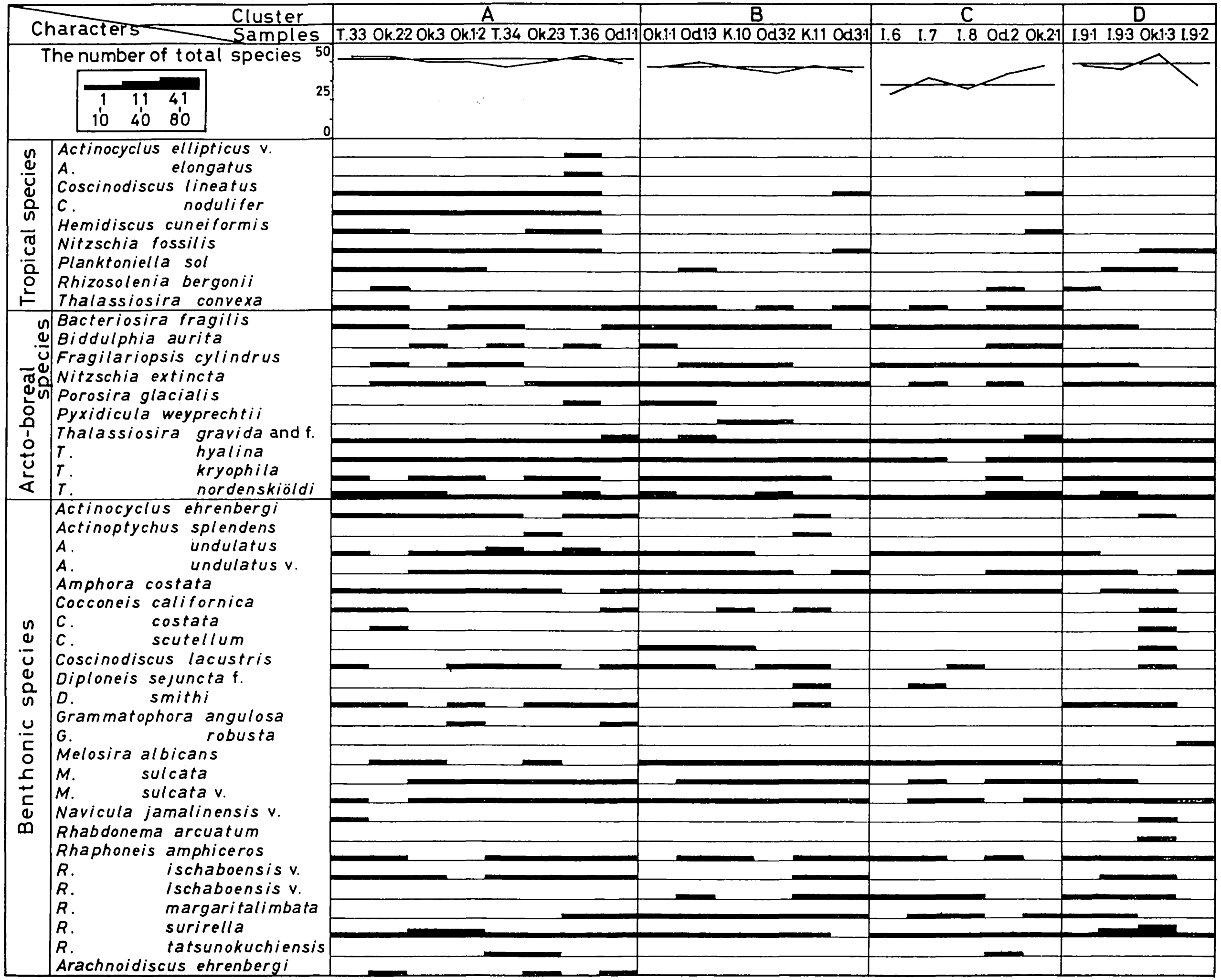
The sequential changes in the combinations of these extinct and marine planktonic species are not given in the distribution chart (Chart 1). The features of the diatom assemblage in the Tatsunokuchi Formation, therefore, are considered to be due to environmental changes throughout the depositional time, with evolutionary changes playing a minor role.

According to the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1961), a body of rock strata characterized by a certain assemblage of fossils, which are mainly controlled by variations of the environment in the present case, is called an assemblage zone. Within an assemblage zone, organisms which most frequently occur together are grouped into a fossil association, which in some cases can be interpreted as a fossil community. A fossil community is a fossil assemblage in which nearly all the specimens belong to the same ecological community according to FAGERSTROM (1964).

In the present study, the fosssil associations are defined by a statistical technique. There are several statistical techniques available for grouping the variables for forming fossil associations. The cluster analysis, developed in numerical taxonomy (MICHENER and SOKAL, 1957; SOKAL and SENATH, 1963; HAYAMI and NAKANO, 1968), is used here to establish the fossil associations. This method was first applied to ecological analysis by KAESLER (1966), and subsequently for analysis of the ecology of living and subfossil animals (*e. g.* MADDOCKS, 1966; MELLO and BUZAS, 1968;




Text-fig. 3. Dendrogram showing the similarities of the samples based upon the Jaccard Coefficient computed from the occurrence data for diatom species.




Text-fig. 4. Figure showing the number of total species and the occurrence records of characteristic species within each sample arranged in order of clusters. Bar thickness indicates frequency of occurrence within a sample.

ISHIZAKI, 1968, 1969; UJIIÉ and KUSUKAWA, 1969). In the paleoecological analysis, so far as the writer is aware, FOX (1968) used the same method to establish the fossil associations within each assemblage zone of the upper Ordovician Richmond Group.

In the present study, the Q-mode analysis (sample by sample comparison) is performed to group the aggregate of the samples having similar associations of species. Similarity coefficient between the pair of samples was calculated for the Jaccard Coefficient. The Jaccard Coefficient (Sj) is given by the equation

$$Sj = \frac{N_{JK}}{N_{JK} + N_{jK} + N_{Jk}}$$

where $N_{JK}$ is the entire number of species contained in the samples being compared, $N_{jK}$ and $N_{Jk}$ are the number of species either present or absent in the samples. Positive but not negative matches and mismatches of the species are taken into account in the coefficient. The clustering method used in computing the dendrogram is the unweighted pair group method with simple arithmetic averages, and this is finally modified by the short-circuit method described by HAYAMI and NAKANO (*op. cit.*).

The results of the analysis are shown in the dendrogram of Text-fig. 3. At the 0.60 level there are six clusters, two of which are composed of one sample respectively. The first of these single-sample "clusters" joins the first large cluster, and the second joins the fourth large cluster at a level lower than the chosen 0.60 phenon line. Consequently, four clusters, A, B, C and D, can be distinguished. As can be seen from Text-fig. 2, the clusters are discriminated reasonably in the view point of geography and also stratigraphy. Cluster A is geographically restricted to the southern region of the present area, consisting of samples which spread throughout the vertical level. The residuary clusters distribute in the northern region, in which cluster B is nearly restricted to the lower part, cluster C to the middle part and cluster D to the upper part of the stratigraphic column respectively.

The division mentioned above of the clusters (Text-fig. 3) appears to reflect the species association of the same environmental conditions (Text-fig. 4). Paleoecological interpretation of the fossil assemblages should be based on the closeness of the assemblages to the original assemblages that are composed of preservable organisms. The resemblance of the Pliocene assemblage to the modern community may be very close. A classification of the modern diatom thanatocoenoses in the Pacific and the areal distribution of the assemblages were reported by KANAYA and KOIZUMI (1966), and Russian students (*e. g.* JOUSÉ, 1962; BELYAEVA, 1963; JOUSÉ *et. al.*, 1969). The definition of the diatom assemblages at the present follows JOUSÉ *et. al.* (*op. cit.*) in that the cold-water elements can be classified under smaller categories.

Cluster A consists of species and varieties judged to be indigenous to the area of the Central and Equatorial water-masses, which are called the warm-water forms. Cluster B consists of species mainly indigenous to the arcto-boreal area, that is, the Bering Sea and the Sea of Okhotsk where the surface water is of lower salinity. Cluster C is characterized by the decrease in the number of total species, which appears to affect the number of benthonic elements. Cluster D is characterized by having many benthonic species.

## Summary

During the Early Pliocene marine transgression, the Tatsunokuchi Formation was deposited in a fairly wide embayment extending along the eastern margin of the Abukuma massif in Fukushima Prefecture (HANZAWA, 1950). The Tatsunokuchi sea deposited in the present area fine grained silts or sandy silts containing many diatom valves. After the deposition of these materials, a marine regression occurred and terrestrial sediments were deposited in the Sendai area.

The general interpretation of the environment when the Tatsunokuchi sediments were deposited had been based on the molluscan fossils. According to HAYASAKA (*op. cit.*), and KAMADA and HAYASAKA (*op. cit.*), the molluscan fauna in the present area is characterized by having such typical cold Oyashio elements as *Nucula tenuis*, *Spisula polynyma voyi* and *Peronidia venulosa*, but no species restricted to the warm-water of southwest Japan. It was also stated by those authors that the molluscan fauna was composed of pure marine or stenohaline species of rather wide bathymetrical range.

The present study reveals a distinct difference in the combinations of the diatom species. In the southern part of the present area the fossil diatom association consisted of warm-water elements which might be due to a warm paleo-Kuroshio Current during Tatsunokuchi time. In the northern part of the area the association of diatom species mainly consists of open-water elements that changed to shallow-water elements near at the end of Tatsunokuchi time.

The diatom assemblage of the Tatsunokuchi Formation is in response both to the environmental conditions and the general evolutionary trends of the diatoms. And they seem to be chronologically restricted to the lower Pliocene.


## Description of two new species

Family Discoideae SCHÜTT, 1896

Subfamily Coscinodiscoideae SCHÜTT, 1896

Tribe Melosirae SCHÜTT, 1896

Genus *Stephanopyxis* EHRENBERG, 1845

*Stephanopyxis horridus* KOIZUMI, n. sp.

Pl. 42, figs. 1a–2b

Syn. As *Stephanopyxis schenckii* KANAYA, 1959: SHESHUKOVA-PORENTZKAYA, 1967, pl. 1, fig. 1, pl. 7, figs. 4a, σ, pl. 13, figs. 2a, σ.

*Description:* Valve circular, 35–53 μ in diameter, arched as high as valve diameter. Areolae closed, coarse, hexagonal, covering the valve surface, attaining nearly equal-size, numbering about 2 in 10 μ, and arranged in three systems of straight tangential sculptures. On entire valve, short spines present at the corners of areolae. The marginal brim bears spines extending from the corners of marginal areolae, 3–4 in 10 μ, on the hyaline margin, 3–4 μ in width.

*Holotype:* The position of a specimen by the England Finder (RIEDEL and FOREMAN, 1961) is J48-ON, in slide no. 7145, 40 μ in diameter, from loc. no. Odaka 1-1.

*Paratype:* The position of a specimen by the England Finder, T44-OE; in slide no. 7123, 35 μ in diameter, from loc. no. Isobe 9-1.

*Remarks:* The new species resembles *Stephanopyxis schenckii* but differs from it in not having petal-shaped areolae on the brim and hyaline margin. SHESHUKOVA-PORENTZKAYA (*op. cit.*) states that the specimens that were identified with *Stephanopyxis schenckii* in the Pliocene samples from Etholonskaya suit, Rekinnikskaya Bay, Kamchatka, lack the petal-shaped areolae on the brim and the hyaline. The new species is distinguished from *Stephanopyxis ferox* (GREV.) RALFS, 1861: *in* SCHMIDT, 1888, Atlas, pl. 130, fig. 15, by the coarser areolae.

*Occurrences in the present materials:* Rare in many samples. The new species may be one of the marker taxa of the Pliocene age.

Family Fragilarioideae SCHÜTT, 1896

Subfamily Fragilarieae SCHÜTT, 1896

Tribe Fragilariinae SCHÜTT, 1896

Genus *Rhaphoneis* EHRENBERG, 1844

*Rhaphoneis tatsunokuchiensis* KOIZUMI, n. sp.

Pl. 42, figs. 3, 4

*Description:* Valve lanceolate-rhombic or lanceolate, with produced apices. The length of the apical axis 20-36 $\mu$, transapical axis 5-10 $\mu$. Valve surface flat, covered with large sub-rectangular puncta, 6-8 in 10 $\mu$. Puncta in weakly radiating curved lines on both sides of a narrowed linear pseudoraphe, and are interrupted by the sub-marginal hyaline line extending parallel to the valve margin. The number of longitudinal parallel rows of puncta is about 6.

*Holotype:* The position of a specimen by the England Finder, T44-4; in slide no. 6717, 22 $\mu$ in length, from loc. no. Tomioka 36.

*Paratype:* The position of a specimen by the England Finder, U33-OW; in slide no. 7107, 28 $\mu$ in length, from loc. no. Okuma 2-3.

*Remarks:* The new species resembles *Rhaphoneis mediopunctata* MARTA, 1968: p. 143, pl. 41, figs. 16-27, and its variety *matraensis* MARTA, p. 144, pl. 42, figs. 1-5, from which it differs by the small size of the valve.

*Occurrences in the present materials:* Very rare in the three samples studied. The species are found commonly throughout the Pliocene of northeast Japan.

*Acknowledgments*

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**Floral references**

The references are given for those taxa of the Tatsunokuchi Formation that are judged to be marine planktonic tropical and arcto-boreal forms, and extinct forms in the Pacific. They are arranged alphabetically. The taxa which are treated in HUSTEDT (1927-) are referred directly to HUSTEDT (*op. cit.*). As for the taxa which are not treated in HUSTEDT (*op. cit.*), the references to the original descriptions as far as possible are made. Additional references are selected from the descriptions and illustrations which were particularly helpful for the present identifications. Synonyms are mentioned only in the case that they are not cited in the previous works.

Most of the species are illustrated as indicated in brackets.

*Actinocyclus ellipticus* GRUN. v. *moronensis* (DEBY) KOLBE, 1954: p. 21, pl. 3, figs. 29, 30. Remarks: A broken specimen from the sample of Tomioka 36 fully agrees with the figures of KOLBE (*l. c.*) as well as with the individuals from the original material from Moron (as *Actinocyclus* (*Cestodiscus*) *moroniensis* BRUN, 1891: p. 6, pl. 19, fig. 2). As far as known today, the geologic range of the varity is middle-upper Miocene.

*Actinocyclus elongatus* GRUN. *in* VAN HEURCK, 1880: pl. 125, fig. 15; KOLBE, 1955, p. 164, pl. 2, fig. 20.

*Asteromphalus darwinii* EHR., 1844: *in* SCHMIDT, 1876, Atlas, pl. 38, fig. 16; KOIZUMI, 1968, pl. 32, fig. 7; HANNA, 1970, p. 180, fig. 90. Remarks: The observed specimens seem to be close to *A. darwinii* as described and illustrated by GREVILLE (1860, p. 116, pl. 4, figs. 12, 13). The outline of the hyaline area is slightly concave. The species has been previously reported only from the upper Miocene-Pliocene. [Pl. 43, fig. 5]

*Bacteriosira fragilis* GRAN, 1900: *in* HUSTEDT, 1929, Kieselalg. I, p. 544, fig. 310; SHESHUKOVA-PORENTZKAYA, 1967, p. 202, pl. 33, figs. 3a, b. Remarks: The species appears in the Far East during the Pliocene, and becomes an imporiant member of the flora of the neritic zone of the arcto-boreal region since the Pleistocene.

*Biedulphia aurita* (LYNG.) BREB. and GOD., 1838: *in* HUSTEDT, 1930, Kieselalg. I, p. 846, fig. 501.

*Cladogramma californica* EHR., 1854: *in* VAN HEURCK, 1881, pl. 83, figs. 8, 9; KANAYA, 1959, p. 87, pl. 6, fig. 1; WORNARDT, 1967, p. 42, fig. 64; KOIZUMI, 1968, pl. 32, fig. 19. Remarks: The known geological age of the species is upper Miocene.

*Coscinodiscus lineatus* EHR., 1938: *in* HUSTEDT, 1928, Kieselalg. I, p. 392, fig. 204; REINHOLD, 1937, p. 97, pl. 11, fig. 7; LOHMAN, 1941, p. 68, pl. 12, fig. 10; CUPP, 1943, p. 53, figs. 15a-c; KOIZUMI, 1968, pl. 32, fig. 26 (not fig. 27). Remarks: Diameter of valve 30-60 $\mu$. The rows of polygonal areolae in straight lines are arranged on three regular tangential systems, so that all the lines of the areolae appear to be parallel to the diameter. Areolae slightly smaller at the margin than in the central area of the valve, 3-6 in 10 $\mu$ at center and 7 at margin. Valve margin strong, radially striated and with distinct spinulae.

*Coscinodiscus nodulifer* SCHMIDT, 1878: *in* HUSTEDT, 1928, Kieselalg. I, p. 426, fig. 229; KOLBE, 1954, p. 33, pl. 3, figs. 35–37; HENDEY, 1964; p. 77, pl. 22, fig. 10.

*Coscinodiscus pustulatus* MANN, 1907: p. 257, pl. 48, fig. 3; HANNA, 1970, p. 185, figs. 12, 19–24. Remarks: The species was originally described from 1866 fathoms in the Bering Sea. HANNA (*l. c.*) states, however, that "it is entirely possible that it came from an exposed subsurface outcrop of strata of Pliocene age and nothing like it has been in any of the collections of living marine diatoms I have made in the Arctic and sub-Arctic". [Pl. 43, fig. 12]

*Denticula kamtschatica* ZABELINA, 1934: *in* SIMONSEN and KANAYA, 1961, p. 503, pl. 1, figs. 14–18; SHESHUKOVA-PORENTZKAYA, 1967, p. 300, pl. 47, figs. 9a, b, pl. 48, figs. 4a- ; KOIZUMI, 1968, pl. 34, figs. 7–10. Remarks: The species is found quite frequently in the samples of the upper Miocene and Pliocene age, and also from the upper part of the middle Miocene Onnagawa Formation and its correlative formations in northeast Japan. [Pl. 42, figs. 12, 13]

*Denticula seminae* SIMONSEN and KANAYA, 1961: p. 503, pl. 1, figs. 26–30; SHESHUKOVA-PORENTZKAYA, 1967, p. 301, pl. 47, figs. 11a- , pl. 48, figs. 6a-Г. Remarks: The species is frequently present also in the Pliocene strata of the Usti-Kamchatka, according to SHESHUKOVA-PORENTZKAYA (*l. c.*). [Pl. 42, figs. 5a, 5b, 6]

*Fragilariopsis cyclindrus* (GRUN.) KRIEGER, 1954: *in* HUSTEDT, 1958, p. 162, pl. 11, figs. 145, 146; HASLE, 1965, p. 34, pl. 12, figs. 6–12, pl. 14, figs. 1–10, pl. 17, figs. 2–4. Remarks: The observed specimens were 10–35 μ long, 3–6 μ wide and had 12–13 costae in 10 μ. The keel puncta were seen as coarsened continuations of the costae. The straight and parallel margins of the valve, the broadly rounded apices, the apical axis isopole, the straight transapical costae confined to the rectangular part of the valve and the more weakly silicified, oblique costae of the semicircular part characterize the species as stated by HASLE (*l. c.*). [Pl. 42, figs. 8, 9]

*Hemidiscus cuneiformis* WALL., 1860: *in* HUSTEDT, 1930, Kieselalg. I, p. 904, fig. 542.

*Hemidiscus weissflogi* (GRUN.) HUST., 1955: HUSTEDT, p. 11, pl. 1, figs. 6, 7. Remarks: The specimens in the present materials have all the appearance of HUSTEDT's original description and figures. Broad ellipsoidal valve, 16–32 μ in apical axis and 14–24 μ in transapical axis, with tangential undulation. Radially arranged areolae, 10–14 in 10 μ, which form a closed net of polygonal meshes. On one side of the valve, the areolae are distinctly smaller, and before the median ventral striae, 16–20 in 10μ, there is a small and shallow hyaline area with a faint pseudonodule. Marginal spines distinct, with interspaces of about 3 μ. [Pl. 43, fig. 14]

*Hyalodiscus obsoletus* SHESHUK., 1964: SHESHUKOVA-PORENTZKAYA, p. 71, pl. 1, fig. 1, SHESHUKOVA-PORENTZKAYA, 1967, p. 71, pl. 1, fig. 1, SHESHUKOVA-PORENTZKAYA, 1967, p. 131, pl. 12, fig. 2. Remarks: Valve circular, 25–30 μ in diameter, strongly concave, and depressed in center, 10 μ in diameter. Areolae and structure absent over valve surface, except distinct the marginal zone. The brim consists of a marginal zone of small areolae, 16–20 in 10 μ, and small dotted, about 25 in 10 μ, margin 1 μ in width. According to SHESHUKOVA-PORENTZKAYA (*l. c.*), this species has a long geologic range of middle Miocene-Pliocene, in the Sakhalin and Kamchatka regions. [Pl. 43, fig. 13]

*Melosira albicans* SHESHUK., 1964; SHESHUKOVA-PORENTZKAYA, p. 69, figs. 1, 2, pl. 1, fig. 3; SHESHUKOVA-PORENTZKAYA, 1967, p. 124, pl. 10, figs. 2a, σ, pl. 11, figs. 1a, σ. Remarks: Valve small circular, 10–18 μ in diameter, surface flat with raised margin. Valve surface punctate, puncta usually in radiating lines, often somewhat irregularly scattered in the center, 14–16 puncta in 10 μ. Valve margin well defined, with short striae, 14–18 in 10 μ, and among them strong spinules are conspinules, 6–8 in 10 μ. Known previously only from the type material of the Pliocene age in Ust-Kamchatka. [Pl. 43, figs. 1, 2]

*Navicula jamalinensis* CL. v. *simisevultus* (BRUN) CL., 1895; *in* SHESHUKOVA-PORENTZKAYA, 1967, p. 238, pl. 45, fig. 5. Remarks: Geologic age and locality of the type material, stated to be Sendai, but precisely unknown. SHESHUKOVA-PORENTZKAYA (*l. c.*) rarely found this species in the Pliocene Etholonskaya Formation, Penjnskaya Bay, Kamchatka.

*Nitzschia* cfr. *extincta* KOZ. and SHESHUK., 1967: *in* SHESHUKOVA-PORENTZKAYA, p. 303, pl. 47, fig. 12. Syn., *Nitzschia pliocena* (BRUN) MERTZ, 1966: p. 30, pl. 6, figs. 14–20. Remarks: Valve elliptical to lanceolate, with acutely rounded nonrostrate ends, 18–36 μ long, 4–7 μ wide. Canal raphe eccentric, keel puncta regularly spaced, 13–16 in 10 μ. Pseudonodulu present between the two keel puncta in the middle. Transapical costae present in number equal to keel puncta. By means of dark field illumination, the rows of poroids 2, poroids 3–4 in 10 μ. The species has been reported to have a long geologic range of middle Miocene-Pliocene. [Pl. 42, figs. 10a–11b]

*Nitzschia reinholdii* KANAYA (MS): *in* KANAYA and KOIZUMI, 1970, p. 58. Syn., *Fragilaria pliocena* BRUN, 1891: p. 28, pl. 14, fig. 7, pl. 17, fig. 7; REINHOLD, 1937, p. 104, pl. 12, fig. 18. *Nitzschia plio-*

*cena* (BRUN) WORNARDT, 1967: p. 88, figs. 212, 213. *Fragilariopsis pliocena* (BRUN) SHESHUK., 1967: SHESHUKOVA-PORENTZKAYA, p. 305, pl. 47, fig. 13, pl. 48, fig. 7; KOIZUMI, 1968, pl. 34, figs. 13–15; KANAYA, 1970, pl. 40, figs. 7, 8. Remarks: The observed valves are lanceolate, with more or less bluntly rounded ends, 60–85 μ in the length and 10–14 μ in width. The keel puncta and the transapical costae are present in equal number, 11–13 in 10 μ. The puncta in the transapical costae, 20–24 in 10 μ arranged in double rows. The species is closely related to *Nitzschia marina* GRUN., *in* VAN HEURCK, 1880: pl. 57, figs. 26, 27; KOLBE, 1954, p. 40, pl. 3, figs. 38–40, from which differs in the outline of the valves and the finer transapical costae. The species has been reported previously from the upper Miocene-Pliocene age. [Pl. 42, figs. 14a–15c]

*Nitzschia fossilis* KANAYA (MS): *in* KANAYA and KOIZUMI, 1970, p. 59. Remarks: The species shows a resemblance with *Pseudoeunhtia doliolus* (WALL.) GRUN., 1880: HUSTEDT, 1932, Kieselalg. II, p. 258, fig. 737: KOLBE, 1954, p. 43, pl. 3, fig. 41, from which it differs by the transapical axis isopole. In the present samples, the valves are identified with those of the species lanceolae with subacute apices. Length of valve 40–60 μ. width 7–10 μ, 11–14 keel puncta and transapical costae in 10 μ. Pseudonodulu present between the two keel puncta in the middle. The keel puncta are perceptible in dark field illumination as coarsened continuations of the transapical costae. Under the same condition, the puncta in the transapical costae are of two alternating rows, 20–24 in 10 μ. The species has been recoorded so far only from the Pliocene. [Pl. 42, figs. 14a–15c]

*Planktoniella sol* (WALL.) SCHUTT, 1893: *in* HUSTEDT, 1928, Kieselalg. I, p. 465, fig. 295; HASLE, 1960, p. 1, pl. 3, figs. 19, 20; BELYAEVA, 1968, p. 111, pl. 5, figs. 1, 2. Remarks: In the present study, the peripheral wing-like extension was not seen on any specimens identified with the species. The species was distinguished from *Coscinodiscus excentricus* EHR., 1839: *in* HUSTEDT, 1928, Kieselalg. I, p. 388, fig. 201, by having indistinct internal memberance opening and by lacking a ring of marginal spines.

*Porosira glacialis* (GRUN.) JφRG., 1905: *in* HUSEDT, 1928, Kieselalg. I, p. 315, fig. 153; JOUSÉ, 1957, pl. 3, figs. 4a, σ; JOUSÉ, 1962, pl. 2, fig. 1, pl. 79, fig. 11. Remarks: The valves are broadly concave, 20–30 μ in diameter. Areolae, 12–14 in 10 μ, arranged in indistinct fasciculae whose radial rows are somewhat sinuous and parallel to middle rows.

*Pseudopodosira elegans* SHESHUK., 1964: SHESHUKOVA-PORENTZKAYA, p. 75, pl. 1, fig. 3, pl. 2, figs. 4, 5; SHESHUKOVA-PORENTZKAYA, 1967, p. 178, pl. 24, fig. 3, pl. 25, fig. 4. Remarks: Valves are circular, 15–20 μ in diameter, flat, and with slightly swollen sharply defined narrow brim; valve surface hyaline but the central part of the valve bears a few distinct small papilleas. The brim consists of jagged margin and the same size marginal spinulae, 5–7 in 10 μ, in front of each projecting part of jagged margin. According to SHESHUKOVA-PORENTZKAYA (*l. c.*), the known geological occurrence of the species in the Sakhalin and Kamchatka is in Miocene and Pliocene. [Pl. 43, figs. 3, 4]

*Pyxidicula weyprechtii* GRUN., 1884: *in* HUSTEDT, 1927, Kieselalg. I, p. 300, fig. 138. Remarks: The species is known only from the Arctic Sea near the Franz Josef Land according to HUSTEDT (*l. c.*).

*Rhaphoneis ischaboensis* (GRUN.) MERTZ v. *angusta* MERTZ, 1966: p. 26, pl. 5, figs. 49–51. Remarks: Found so far only from the type material, Pisco Formation, upper Miocene, Peru, South America.

*Rhaphoneis ischaboensis* (GRUN.) MERTZ v. *linguiformis* MERTZ, 1966: p. 27, pl. 5, figs. 54–56. Remarks: Previously found only from its type locality.

*Rhaphoneis margaritalimbata* MERTZ, 1966:

p. 27, pl. 6, figs. 1–3. Remarks: The species has been reported previously only from the Pisco Formation, upper Miocene South America.

*Rhizosolenia bergonii* PERAG., 1892: *in* HUSTEDT, 1929, Kieselalg. I, p. 575, fig. 327; JOUSÉ, MUKHINA and KOZLOVA, 1969, p. 31, pl. 13, fig. 7; MUKHINA, 1969, p. 54, pl. 2, fig. 5. Remarks: In the present study, the species is distinguished from *Rhizosolenia praebergonii* MUCH., 1965: MUKHINA, p. 24, pl. 2, figs. 3, 4; KOIZUMI, 1968, p. 217, pl. 34, figs. 20, 21, by the very finely striate cylindrical valve, striae 18–20 rows in 10 μ and 18 puncta in 10 μ, and a spine which is long, slender and usually straight. [Pl. 42, fig. 7]

*Stephanopyxis schenckii* KANAYA, 1959: p. 67, pl. 2, figs. 2–4; SHESHUKOVA-PORENTZKAYA, 1967, p. 136, pl. 3, fig. 2, pl. 13, figs. 2B, Γ. Hom., *Stephanopyxis schenckii* KANAYA, *in part*, SHESHUKOVA-PORENTZKAYA, 1967, pl. 1, fig. 1, pl. 7, figs. 4a, σ, pl. 13, figs. 2a, σ. Remarks: Valves were found in the sample of Tomioka 36. The species is characterized by the brim bearing petal-shaped areolae, short spines at the corners of the areolae, and the hyaline margin. The species is a characteristic one in the middle Miocene. In the present study, the observed specimens may be ones intermixed.

*Thalassiosira antiqua* (GRUN.) CL., *in* SHESHUKOVA-PORENTZKAYA, 1967: p. 143, pl. 14, figs. 3a, σ; KOIZUMI, 1968, pl. 35, fig. 11. Syn., *Coscinodiscus antiuus* (GRUN.) RAT., 1889: WORNARDT, 1967, p. 20, fig. 23. Remarks: The valves resemble *Coscinodiscus excentricus* EHR., from which they are distinguished by that the central part of the valve bears many papilleae, which are distinct but smaller than ordinary areolae, and by the distinct border. The species has been reported previously from the middle Miocene-Pliocene.

*Thalassiosira convexa* MUCH., 1965: MUKHINA, p. 22, pl. 11, figs. 1, 2. Remarks: Valve circular, 30–40 μ in diameter, convex and with narrow margin, 2–3 μ in width. Areolae almost of same size throughout the valve surface, 8–12 in 10 μ except in center where they are rare, and irregularly arranged. Areolae fascicularly arranged, subdividing the valve surface into undulated sectors, the areolae running parallel to the lateral longest row of each sector. Margin distinct with striae, 10–12 in 10 μ and strong one almost alternately arranged, 5–7 in 10 μ. The species has been found so far only from the Pliocene. [Pl. 43, figs. 15a–16b]

*Thalassiosira gravida* CL., 1896: *in* HUSSEDT, 1928, Kieselalg. I, p. 325, fig. 161; CUPP, 1943, p. 48, fig. 11; HENDEY, 1964, p. 86, pl. 1, fig. 7; HASLE, 1968, p. 196, figs. 3, 4. Remarks: In the present study, unequally arched valves with coarser areolae are frequently observed, these may be the resting spores of the species. Diameter of valve 25–40μ. Polygonal areolae about 5 in 10 μ, arranged in irregularly radial rows. Central area bears many clustered papilleae. Marginal spines, 8–10 in 10 μ, conspicuous with one larger spine. [Pl. 43, figs. 11a, 11b]

*Thalassiosira gravida* CL. f. *fossilis* JOUSÉ, 1959: *in* JOUSÉ, 1961, p. 63, pl. 1, fig. 9; SHESHUKOVA-PORENTZKAYA, 1967, p. 147, pl. 15, figs. 1a–B. Remarks: Valve circular, 25–35 μ in diameter, swollen, as high as 2/3 to 1/2 of valve diameter, and with a hyaline brim at the base of valve mantle. Areolae penta to hexagonal with close and ordered mesh, sometimes elongated to radial in midway. Arranged radially, 5–6 areolae in 10 μ and with secondary concentric structure. The brim at the base of the valve mantle consists of a slope extending from the mantle, and a hyaline margin. Marginal minute puncta, 8–10 in 10 μ, 3 in 10 μ visible at inside, at the edge of the slope, no stronger spines. The range of the species is from the upper Miocene to Pliocene. [Pl. 43, fig. 10]

*Thalassiosira hyalina* (GRUN.) GRUN., 1897: *in* HUSTEDT, 1928, Kieselalg. I, p. 323, fig. 159; JOUSÉ, 1962, pl. 2, fig. 4. Remarks: The individuals have, as shown on JOUSÉ's illustration (*l. c.*), coarser areolae, 13–15 in 10 μ, than in the description given by HUSTEDT (*l. c.*), 25 in 10 μ. It has not been found in rocks older than the Pliocene. [Pl. 43, fig. 7]

*Thalassiosira kryophila* (GRUN.) JRG., 1905: *in* HUSTEDT, 1928, Kieselalg. I, p. 324, fig. 160; SHESHUKOVA-PORENTZKAYA, 1967, p. 146, pl. 14, fig. 6; KOIZUMI, 1968, p. 218, pl. 35, figs. 14, 15. Remarks: The known geologic range of the species is from the Pliocene to Recent. [Pl. 43, fig. 9]

*Thalassiosira nidulus* (TEMP. and BRUN) JOUSÉ, 1961: p. 63, pl. 3, figs. 4, 5; SHESHUKOVA-PORENTZKAYA, 1967, p. 140, pl. 11, figs. 8a, σ, pl. 14, figs. 1a, σ; KOIZUMI, 1968, pl. 35, figs. 21, 23. Remarks: Individuals, 20–30 μ in diameter are slightly convex and circular. The valve consists of three parts; central part of the valve, 10–17 μ in diameter, round to polygonal areolae arranged radially with secondary concentric rows, 6–8 in 10 μ; distinct marginal edge, flat, hyaline, 3–5 μ in width; and on the hyaline marginal edge, coronal ring with long thorn, 3–4 in 10 μ, which characterizes this species. The previous records of occurrences are only from the upper Miocene-Pliocene. [Pl. 43, fig. 6]

*Thalassiosira nordenskioldi* CL., 1875: *in* HUSTEDT, 1928, Kieselalg. I, p. 321, fig. 157; JOUSÉ, 1962, pl. 2, fig. 6, pl. 62, fig. 2, pl. 79, figs. 3–5; HASLE, 1968 p. 196, figs. 2, 4, 8. Remarks: The species is characterized by a mucous thread at the central depression of the valve and the distinct sub-marginal circlet of spinulae. The species has not been found in rocks older than the Pliocene. [Pl. 43, fig. 8]

*Thalassiosira zabelinae* JOUSÉ, 1961: p. 66, pl. 2, figs. 1–7; SHESHUKOVA-PORENTZKAYA, 1967, p. 149, pl. 16, figs. 2a-Γ; KOIZUMI, 1968, p. 219, pl. 35, figs. 27, 28. Remarks: The species has been reported previouly only from the upper Miocene-Pliocene. [Pl. 43, figs. 17a, 17b]

## References

AMERICAN COMMISSION ON STRATIGRAPHIC NOMENCLATURE (1961): Code of stratigraphic nomenclature. *Amer. Assoc. Petrol. Geol., Bull.*, vol. 45, no. 5, p. 645–665.

BELYAEVA, T. V. (1963): Composition and distribution of diatoms in the surface layer of the sediments in the Pacific Ocean. *Okeanologiya, Akad. Nauk S. S. S. R.*, vd. 3, no. 4, p. 684–696, 4 figs., 2 tabs. (in Russian)

—— (1968): Diatom flora of the equatorial Pacific (Along 140°W). *in* Plankton in the Pacific Ocean. *Izd. Akad. Nauk S. S. S. R.*, p. 103–124, pls. 5. Moscow. (in Russian with English summary)

BRUN, J. (1891): Diatomees especes nouvelles marines, fossiles ou pelagiques. *Mem. Soc. Phys. d'Hist. Nat. Geneve*, vol. 31, no. 1, p. 1–47, pls. 11–22.

CUPS, E. E. (1943): marine plankton diatoms of the west coast of North America. *Scripps Inst. Oceanogr., Univ. Calif., Bull.*, vol. 5, no. 1, p. 1–238, 168 figs., pls. 5.

FAGERSTROM, J. A. (1964): Fossil communities in paleoecology: Their recognition and significance. *Geol. Soc. Amer., Bull.*, vol. 75, no. 12, p. 1197–1216, 4 figs., pls. 5.

FOX, W. T. (1968): Quantitative paleoecologic analysis of fossil communities in the Richmond Group. *Jour. Geol.*, vol. 76, no. 6, p. 613–640, 12 figs., 6 tabs.

GREVILLE, R. K. (1860): A monograph of the genus *Asterolampra* including *Asteromphalus* and *Spatangidium*. *Trans. Micr. Soc. London, n. ser.*, vol. 8, p. 102–124, pls. 3–4.

HANNA, G. D. (1970): Fossil diatoms from the Pribilor Islands, Bering Sea, Alaska. *Calif. Acad. Sci., Proc., 4th ser.*, vol. 37, no. 5, p. 167–234, 105 figs., 2 maps.

HANZAWA, S. (1950): Tertiary paleogeography of North Japan. *Short Papers IGPS*, no. 2, p. 74–98, 4 maps.

HASLE, G. R. (1960): Phytoplankton and

cilate species from the tropical Pacific. *Skr. Norske Vidensk.-Akad. I. Mat.-Nat. Kl.*, no. 2, p. 1-50, 44 figs., 3 tabs., pls. 1-9.

—— (1965) : *Nitzschia* and *Fragilariopsis* species studied in the light and electron microscopes. III. The genus *Fragilariopsis*. *Skr. Norske Vidensk.-Akad. I. Mat.-Nat. Kl., n. ser.*, no. 21, p. 1-49, 1 fig., 1 tab., pls. 1-17.

—— (1968) : The valve processes of the centric diatom genus *Thalassiosira*. *Nytt Mag. Bot.*, vol. 15, no. 3, p. 193-201, 16 figs., 1 tab.

HATAI, K. (1962) : Mizuho-Tō. *Sci. Rep. Tohoku Univ., 2nd ser. (Geol.)*, spec. vol., no. 5, p. 329-348.

—— and MASUDA, K. (1966) : The stratigraphic position of *Trilophodon Sendaicus* MATSUMOTO in the Mizuho-Tō of Sendai City, Miyagi Prefecture. *Saito Ho-on Kai Mus., Res. Bull.*, no. 35, p. 1-10, 1 tab., pl. 1.

—— and NODA, H. (1968) : Cylindrical structures from the Tatsunokuchi Formation (Early Miyagian) in Sendai City, Miyagi Prefecture. *Trans. Proc. Palaeont. Soc. Japan, n. ser.*, no. 72, p. 345-350, 1 fig., pl. 1.

HAYAMI, I. and NAKANO, M. (1968) : A consideration on the numerical taxonomy in palaeontology, taking the Trigoniidae as an example. *Sci. Rep. Fac. Kyushu Univ.*, vol. 8, no. 4, p. 191-236, 10 figs., 9 tabs. (in Japanese with English abstract)

HAYASAKA, S. (1956) : Pliocene mollusca from the Futaba district, Fukushima Prefcture, Japan. *Saito Ho-on Kai Mus., Res. Bull.*, no. 25, p. 13-20, pl. 1-2.

—— and HANGAI, T. (1966) : A new locality of *Fortipecten takahashii* (YOKOYAMA) in Fukushima Prefcture, with reference to its associated fauna. *Saito Ho-on Kai Mus., Res. Bull.*, no. 34, 34, p. 29-37.

HENDEY, N. I. (1964) : An introductory account of the smaller algae of British coastal waters. Fishery Investigations. Ser. 4, part 5, Bacillariophyceae (Diatoms), 317, p., 9 figs., 8 tabs. 45, London.

HIRAYAMA, K. (1953) : "Taga Group" in northern region of the Joban coal-field. *Geol. and Mine. Inst. Tokyo Univ. Educ., Res. Bull.*, no. 2, p. 25-30, 3 figs., 1 tab. (in Japanese with English abstract)

HUSTEDT, F. (1927-) : Die Kieselalgen Deutschlands, Oesterreichs und der Schweiz mit Berücksichtigung der über Länden Europas sowie der andrenzen den Meeresgebiet : *in* Dr. Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreichs und der Schweiz. vol. 7, Teil I, sec. 1-5, 920 p., 542 figs., 1927-1930 ; Teil II, sec. 1-5, 736 p., 1105 figs., 1931-1937 ; sec. 6, 108 p., 73 figs., 1959 ; Teil III, sec. 1-3, 556 p., 411 figs., 1961-1964, not yet completed, Leipzig.

—— (1955) : Marine littoral diatoms of Beaufort, North Carolina. *Duke Univ. Marine St., Bull.*, no. 6, p. 1-66, pls. 1-16.

—— (1958) : Diatomeen aus der Antarktis und dem Südatlantik. *Deut. Antark. Exp. 1938-1939*. Bd. 2, sec. 3d., p. 103-188, pls. 3-13.

ISHIDA, T., OIKE, S., ONODERA, S., TAKEUTI, S., NAKAGAWA, H., NANASAKA, O. and MATSUYAMA, T. (1969) : Quaternary changes in the sea level in the Tohoku region, Japan. *in* Quaternary system of Japan. *Monogr. 15*, p. 37-83, 23 figs., 6 tabs., Tokyo. (in Japanese with English abstract)

ISHIZAKI, K. (1968) : Ostracodes from Uranouchi bay, Kochi Prefecture, Japan. *Sci. Rep. Tohoku Univ., 2nd ser. (geol.)*, vol. 40, no. 1, p. 1-45, 17 figs. 1 tab., pls. 1-9.

—— (1969) : Ostracods from Shinjiko and Nakanoumi, Shimane Prefecture, Western Honshu, Japan. *Ibid.*, vol. 41, no. 2, p. 197-224, 16 figs., no. 2, p. 197-224, 16 figs., 2 tabs., pls. 24-26.

IWAI, J. (1949) : Stratigraphy of the Cenozoic formations of Sendai and the environs. *Chikyu Kagaku (Earth Science)*, no. 1, p. 1-5, 1 tab. (in Japanese)

JOUSÉ, A. P. (1957) : Diatoms in the surface layer of the sediments in the Sea of Okhotsk. *Tr. Inst. Okeanol., Akad. Nauk S. S. S. R.*, vol. 22, p. 164-220, 13 figs., 2

tabs., pls. 3. (in Russian)
—— (1961) : Marine diatoms of the Miocene and Pliocene in Soviet Far East. *Bot. Mater. Spor. Rast., Bot. Inst., Akad. Nauk S. S. S. R.*, vol. 16, p. 59-70, 3 tabs. (in Russian)
—— (1962) : Stratigraphic and paleogeographic studies in the northwestern part of the Pacific Ocean. *Izd. Akad. Nauk S. S. S. R.*, 258, p., 69 figs., 31 tabs., pls. 1-5. Moscow. (in Russian with English abstract)
——, MUCHINA, V. V. and KOZLOVA, O. G. (1969) : Diatoms and silicoflagellates in the surface layer of sediments. *in* The Pacific Ocean, microflora and microfauna in the Recent sediments of Pacific Ocean. Akad. Nauk S. S. S. R., p. 7-47, 19 figs.,

## Explanation of Plate 42

(All figures ×1000)

Figs. 1a, 1b. *Stephanopyxis horridus* KOIZUMI, slide no. 7123, T44-OE,* 35 μ in diameter, from Isobe 9-1. 1b, with the focus lower than 1a.

Figs. 2a, 2b. *Stephanopyxis horridus* KOIZUMI, slide no. 7145, J48-ON, 40 μ in diameter, from Odaka 1-1. 2b, with the focus lower than 2a.

Fig. 3. *Rhaphoneis tatsunokuchiensis* KOIZUMI, slide no. 7107, U33-OW, 28 μ in length, from Okuma 2-3.

Fig. 4. *Rhaphoneis tatsunokuchiensis* KOIZUMI, slide no. 6717, T44-4, 22 μ in length, from Tomioka 36.

Figs. 5a, 5b. *Denticula seminae* SIMONSEN and KANAYA, slide no. 7113, F41-4, 22 μ in length, from Okuma 1-3.

Fig. 6. *Denticula seminae* SIMONSEN and KANAYA, slide no. 7128, G45-3N, 30 μ in length, from Odaka 1-3.

Fig. 7. *Rhizosolenia bergonii* PERAG., slide no. 7145, N38-OS, 67 μ in length, from Isobe 9-1.

Fig. 8. *Fragilariopsis cyclindrus* (GRUN.) KRIEGER, slide no. 6703, J42-4N, 36 μ in length, from Tomioka 34.

Fig. 9. *Fragilariopsis cyclindrus* (GRUN.) KRIEGER, slide no. 7133, W48-4N, 10 μ in length, from Isobe 6.

Figs. 10a, 10b. *Nitzschia* cfr. *extincta* KOZ. and SHESHUK., slide no. 7149, 045-3S, 35 μ in length, from Isobe 9-3. 10b, by means of the dark field illumination.

Figs. 11a, 11b. *Nitzschia* cfr. *extincta* KOZ. and SHESHUK., slide no. 7127, H47-4N, 19 μ in length, from Odaka 1-3. 11b, by means of the dark field illumination.

Fig. 12. *Denticula kamtschatica* ZABELINA, slide no. 7127, H47-4N, 195 in length, from Odaka 1-3.

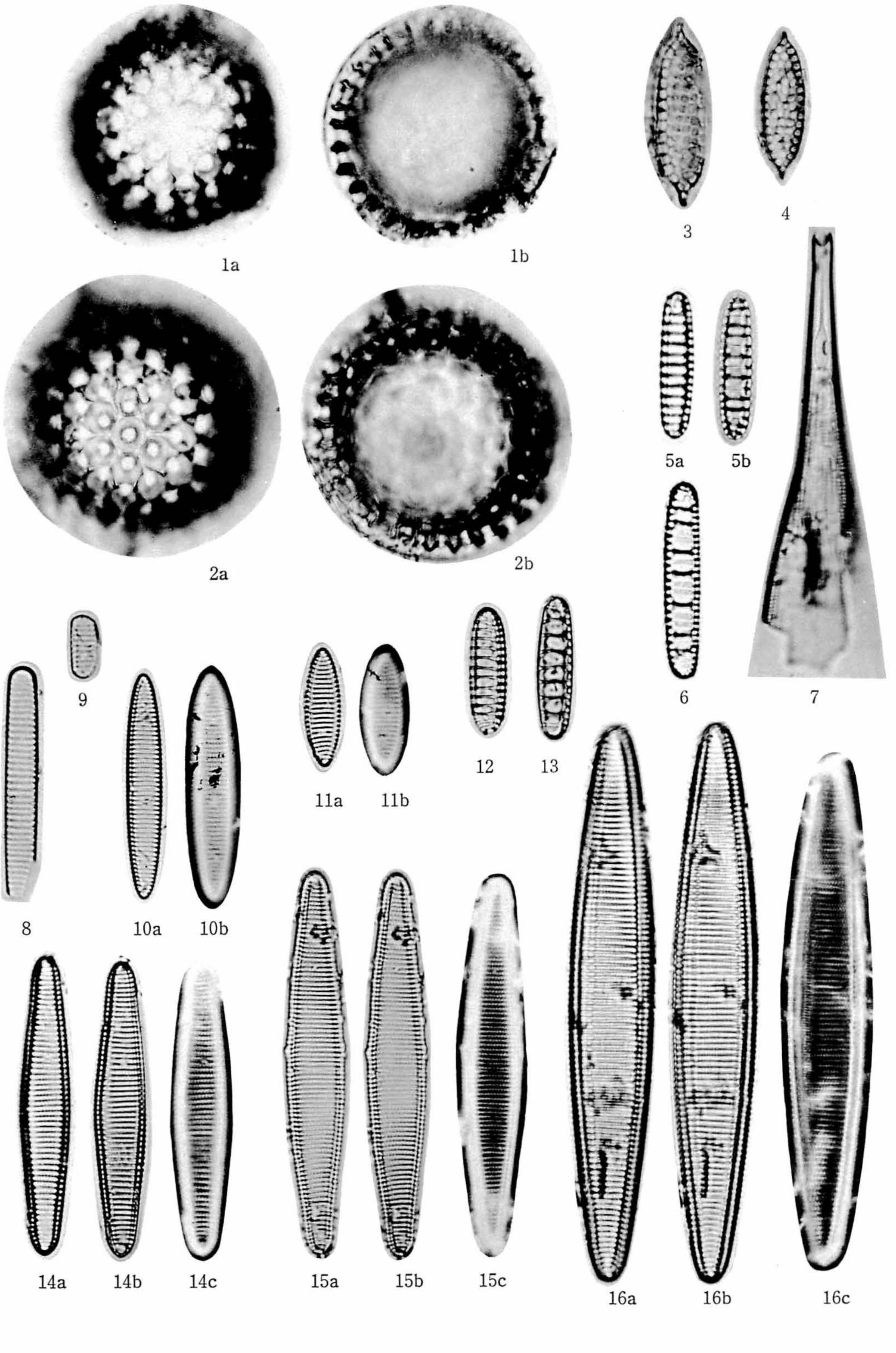
Fig. 13. *Denticula kamtschatica* ZABELINA, slide no. 7111, J41-2S, 21 μ in length, from Okuma 1-1.

Figs. 14a-14c. *Nitzschia fossilis* KANAYA (MS), slide no. 7113, 041-OS, 45 μ in length, from Okuma 1-3. 14b, with the focus lower than 14a. 14c, by means of the dark field illumination.

Figs. 15a-15c. *Nitzschia fossilis* KANAYA (MS), slide no. 7113, H40-3, 58 μ in length, from Okuma 1-3. 15b, with the focus lower than 15a. 15c, by means of dark field illumination.

Figs. 16a-16c. *Nitzschia reinholdii* KANAYA (MS), slide no. 7111, K42-1, 85 μ in length, from Okuma 1-1. 16b, with the focus lower than 16a. 16c, by means of the dark field illumination.

*: The position of a specimen in a strewn slide read by the England Finder (RIEDEL and FOREMAN, 1961).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Moscow. (in Russian with English abstract)

KAESLER, R. L. (1966) : Quantitative reevaluation of ecology and distribution of Recent Foraminifera and Ostracoda of Todos Santos bay, Baja California, Mexico. *Kansas Univ., Paleont. Contr.* paper 10, p. 1–50, 23 figs., 14 tabs.

KAMADA, Y. and HAYASAKA, S. (1959) : Remarks on a fossil marine fauna from Tateishi, Fukushima Prefecture. *Paper, Saito Ho-on Kai Mus., Res. Bull.*, no. 28, p. 17–28, pl. 1–2.

KANAYA, T. (1959) : Miocene diatom assemblages from the Onnagawa Formation and their distribution in the correlative formations in northeast Japan. *Sci. Rep. Tohoku Univ., 2nd ser.* (*Geol.*), vol. 30, p. 1–130, 2 figs., 7 charts, 1 tab., pls. 11.

—— (1970) : Some aspects of pre-Quaternary diatoms in the Oceans. In FUNNELL, B. M. & RIEDEL, W. R. edit. *Micropaleontology of the Oceans*, Cambridge Univ. Press, p. 545–565, 5 figs., pls. 6.

—— and KOIZUMI, I. (1966) : Interpretation of diatom thanatocoenoses from the north Pacific applied to a study of core V20-130 (Studies of a deep-sea core V20-130. part 4). *Sci. Rep. Tohoku Univ., 2nd ser.* (*Geol.*), vol. 37, no. 2, p. 89–130, 6 figs., 1 chart, 4 tabs.

—— and —— (1970) : The progress in the younger Cenozoic diatom biostratigraphy in the circum north Pacific region. *Jour. Mar. Geol.*, vol. 6, no. 2, p. 47–66.

KITAMURA, N., SHIBATA, T. and UEDA, A. (1955) : Geology of the neighbouring area of Matsukawa-Ura. *in* Studies on the ecology and sedimentation of Matsukawa-Ura, Soma city, Fukushima Prefecture. *Inst. Geol Paleont., Tohoku Univ., Contr.*, no. 45 p. 84–96, 6 figs. (in Japanese with English abstract)

KOIZUMI, I. (1966) : Tertiary stratigraphy and diatom flora of the Ajigasawa district, Aomori Prefecture, northeast Japan. *Inst. Geol. Paleont., Tohoku Univ., Contr.*, no. 62, p. 1–34, 10 figs., pls. 1–8. (in Japanese with English summary)

—— (1968) : Tertiary diatom flora of Oga peninsula, Akita Prefecture, northeast Japan. *Sci. Rep. Tohoku Univ., 2nd ser.* (*Geol.*), vol. 40, no. 3, p. 171–240, 15 figs., 2 chart, 2 tabs., pls. 32–35.

KOLBE, R. W. (1954) : Diatoms from equatorial Pacific cores. *Sew. Deep-Sea Exp., Rep., Sew. Deep-Sea Exp., Rep.*, vol. 6, no. 1, p. 1–49, 7 figs., 4 tabs., pls. 4.

—— (1955) : Diatoms from equatorial Atlantic cores. *Sew. Deep-Sea Exp., Rep.*, vol. 7, no. 3, p. 151–184, 6 figs., 2 tabs., pls. 1–2.

LOHMAN, K. E. (1941) : Diatomaceae, part 3. *in* Geology and biology of north Atlantic deep-sea cores, between Newfoundland and Ireland. *U. S. Geol. Surv., Prof. Papers*, 196–B, p. 5–14, 55–86, pls. 1–2, 11–17.

MADDOCKS, R. F. (1966) : Distribution patterns of living and sub-fossil podocopid ostracodes in the Nosy Be area, northeastern Madagascar. *Kansas Univ., Paleont. Contr. Papers*, paper 12, p. 1–72, 63 figs., 12 tabs.

MANN, A. (1907) : Report on the diatoms of the "Albatross" voyage in the Pacific Ocean, 1888–1904. *U. S. Natl. Herb., Contr.*, vol. 10, part 5, p. 221–442.

MELLO, J. F. and BUZAS, M. A. (1968) : An application of cluster analysis as a method of determining biofacies. *Jour. Paleont.*, vol. 32, no. 3, p. 747–758, 6 figs., 4 tabs.

MERTZ, D. (1966) : Mikropaläontologische und Sedimentologische Untersuchung der Pisco Formation Südperus. *Palaeontograpnica*, Bd. 118, Abt. B, p. 1–51, 2 figs., 7 tabs., pls. 1–7.

MICHENER, C. D. and SOKAL, R. R. (1957) : A quantitative approach to a problem in classification. *Evolution*, no. 11, p. 130–162.

MITA, M. (1951) : Report on the geology of north-Futaba district in Joban coal-field, Fukushima Prefecture. *Geol. Surv. Japan, Rep.*, no. 140, p. 1–43, 10 figs., 17 tabs. (in Japanese with English abstract)

MUCHINA, V. V. (1965) : New species of diatoms from the bottom sediments of the equatorial region of the Pacific *Nov. Sys. Plant. non Vas. Bot. Inst. Akad. Nauk S. S. S. R.*, p. 22-25, pls. 1-2. (in Russian)

—— (1969) : Biostratigraphy of sediments and questions of paleogeography of the tropical region of the Pacific and Indian Oceans. *in* Micropaleontology and organogenous sedimentation in the Oceans. *INQUA (VIII)*. p. 52-84, 8 figs., pls. 2. *Izd. Akad. Nauk S. S. S. R.* Moscow. (in Russian with English abstract)

REINHOLD, TH. (1937) : Fossil diatoms of the Neogene of Java and their zonal distribution. *Nederland en Kolonien Geol. Mijnb. Genoot., Verh., Geol. ser.*, vol. 12, p. 43-132, pls. 21.

RIEDEL, W. R. and FOREMAN, H. P. (1961) : Type specimens of North American Paleozoic Radiolaria. *Jour. Paleont.*, vol. 35, no. 3, p. 628-632, 8 figs.

SCHMIDT, A. (1874-1959) : Atlas der Diatomaceen-Kunde. vol. 1-120, pls. 480.

SHESHUKOVA-PORENTZKAYA, B. C. (1959) : Fossil diatom flora of south Sakhalin. *Leningr Univ., Biol. ser.*, no. 15, part 3, p. 36-55, pls. 4. (in Russian)

—— (1967) : Neogene marine diatoms of Sakhhalin and Kamchatka. Izd. Leningr. Univ., 327 p., 8 figs., 19 tabs., pls. 50,

## Explanation of Plate 43

(All figures ×1000)

Fig. 1. *Melosira albicans* SHESHUK., slide no. 7111, M39-1E, 10 μ in diameter, from Okuma 1-1.

Fig. 2. *Melosira albicans* SHESHUK., slide no. 7111, T39-3E, 13 μ in diameter, from Okuma 1-1.

Fig. 3. *Pseudopodosira elegans* SHESHUK., slide no. 7114, T42-3N, 18 μ in diameter, from Okuma, 1-3.

Fig. 4. *Pseudopodosira elegans* SHESHUK., slide no. 7137, G47-3, 19 μ in diameter, from Isobe 7.

Fig. 5. *Asteromphalus darwinii* EHR., slide no. 7145, J43-OE, 25 μ in diameter, from Isobe 9-1.

Fig. 6. *Thalassiosira nidulus* (TEMP. and BRUN) JOUSÉ, slide no. 7107, H41-ONE, 20 μ in diameter, from Okuma 2-3.

Fig. 7. *Thalassiosira hyalina* (GRUN.) GRUN., slide no. 7153, Q45-1, 27 μ in diameter, from Isobe 10.

Fig. 8. *Thalassiosira nordenskioldi* CL., slide no. 7107, M41-2, 21 μ in diameter, from Okuma 2-3.

Fig. 9. *Thalassiosira kryophila* (GRUN.) JRG., slide no. 7119, E40-OS, 23 μ in diameter, from Odaka 3-2.

Fig. 10. *Thalassiosira gravida* CL. f. *fossilis* JOUSÉ, slide no. 7115, F41-OE, 27 μ in diameter, from Okuma 1-2.

Figs. 11a, 11b. *Thalassiosira gravida* CL., slide no. 7128, M37-1S, 34 μ in diameter, from Odaka 1-3. 11b, with the focus lower than 11a.

Fig. 12. *Coscinodisus pustulatus* MANN, slide no. 7124, L40-2S, 37 μ in diameter, from Odaka 1-1.

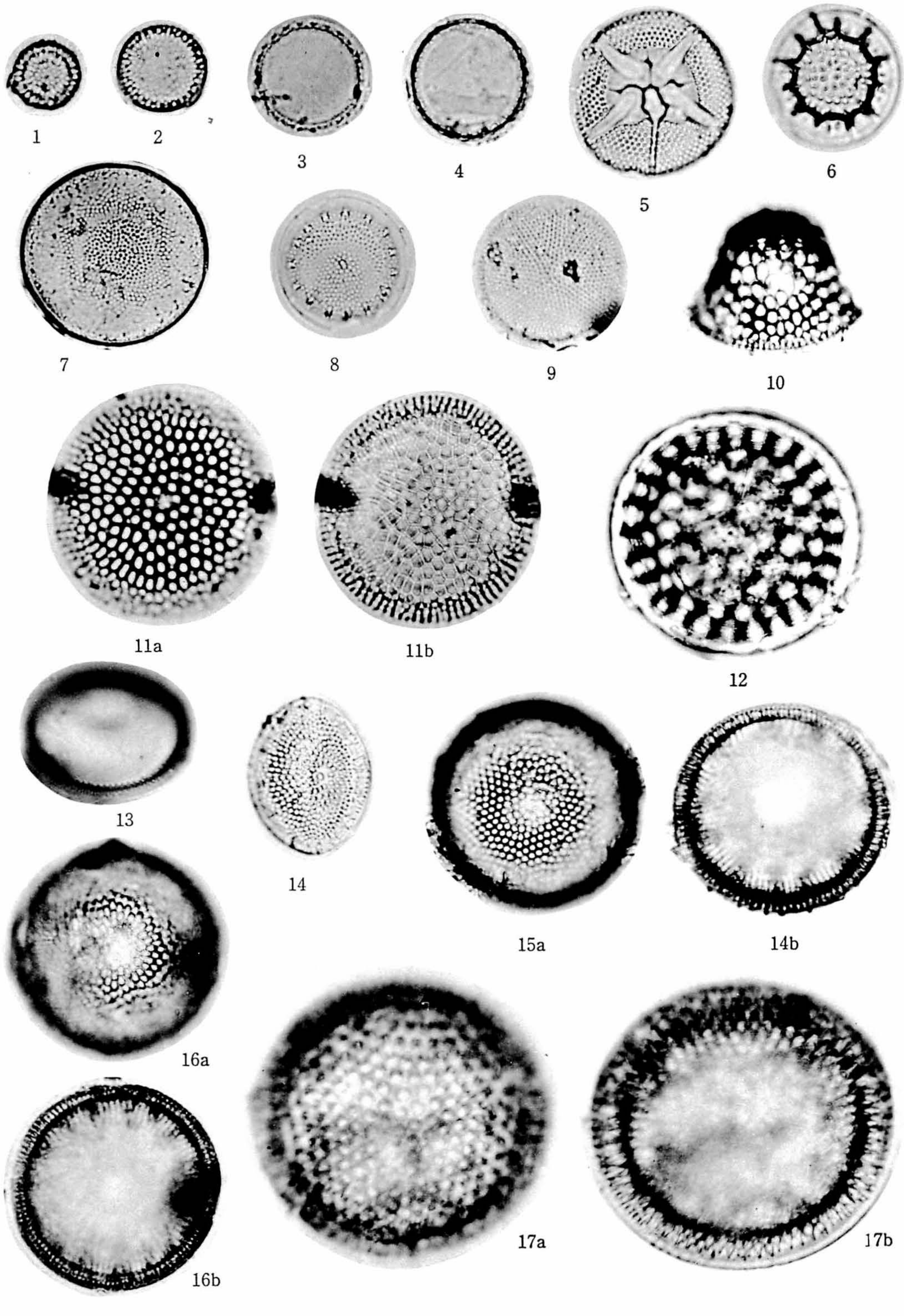
Fig. 13. *Hyalodiscus obsoletus* SHESHUK., slide no. 7111, O38-4, 26 μ in diameter, from Okuma 2-3.

Fig. 14. *Hemidiscus weissflogi* (GRUN.) HUST., slide no. 7107, S35-OW, 23 μ in length, from Okuma 2-3.

Figs. 15a, 15b. *Thalassiosira convexa* MUCH., slide no. 7113, R38-3, 33 μ in diameter, from Okuma 1-3. 15b, with the focus lower than 15a.

Figs. 16a, 16b. *Thalassiosira convexa* MUCH., slide no. 7117, E46-OW, 30 μ in diameter, from Odaka 3-1. 16b, with the focus lower than 16a.

Figs. 17a, 17b. *Thalassiosira zabelinae* JOUZÉ, slide no. 7104, J32-OSE, 46 μ in diameter, from Okuma 2-1. 17b, with the focus lower than 17a.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Leningrad (in Russian with English abstract)

SIMONSEN, R. and KANAYA, T. (1961) : Notes on the marine species of the diatom geaus *Denticula* Kütz. *Int. Revue ges. Hydrobiol.*, vol. 46, no. 4, p. 498-513, 1 fig., 2 tabs., 2 maps, pl. 1.

SOKAL, R.R. and SNEATH, P.H.A. (1963) : Principles of numerical taxonomy. 359 p. San Francisco

SUGAI, K., MATSUI, H., SATO, S., KITAGAWA, Y., SASAKI, M., and KAWACHI, H. (1957) : Explanatory text of the Joban coal field. *Geological maps of the coal fields of Japan I. Geol. Surv. Japan.* 154 p., 58 figs., 59 tabs., pls. 7. (in Japanese with English abstract)

SUZUKI, K. (1968) : Explanatory text of the Fukushima Prefecture. 34 p., 3 tabs. Fukushima Prefecture. (in Japanese)

TOKUNAGA, J. (1948) : Taga Group in the neighbouring area of Tomioka-machi, Joban coal-field. *Res. Inst. Nat. Resour., Misc. Rep.*, vol. 12. (in Japanese)

TOKUNAGA, S. (1927) : Geology of the Joban coal-field. *Mem. Fac. Sci. Eng., Waseda Univ.*, no. 5, p. 1-316, pls. 10. (in Japanese)

UJIIÉ, H. and KUSUKAWA, T. (1969) : Analysis of foraminiferal assemblages from Miyako and Yamada bays, northeastern Japan. *Natl. Sci. Mus. Tokyo, Bull.*, vol. 12, no. 3, p. 735-772, 11 figs., 4 tabs., pls. 5.

VAN HEURCK, H. (1880-1885) : Synopsis des diatomees de Belgique. Anvers. Atlas, 3 p., pls. 132, 1880-1881; text, 235 p., 1885.

WORNARDT, W.W. (1967) : Miocene and Pliocene marine diatoms from California. *Calif. Acad. Sci., Occasional Papers*, no. 63, p. 1-108, 217 figs.

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| Fukushima | 福島 | Onnagawa | 女川 |
| Futaba | 双葉 | Oyashio | 親潮 |
| Hatsuno | 初野 | Sendai | 仙台 |
| Hirose | 広瀬 | Soma-Futaba | 相馬—双葉 |
| Kayakura | 萱倉 | Tatsunokuchi | 竜ノ口 |
| Kuboma | 久保間 | Tomioka-machi | 富岡町 |
| Kuroshio | 黒潮 | | |

Trans. Proc. Palaeont, Soc. Japan, N. S., No. 86, pp. 360-368, pls. 44, 45, June 30, 1972

# 599. *CTENIS* SPECIES FROM THE ITOSHIRO SUB-GROUP (LOWER CRETACEOUS), THE TETORI GROUP, CENTRAL HONSHU, JAPAN*

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Mejiro Gakuen Woman's Junior College

and

SHINJI SEKIDO

Science Education Centre, Ishikawa Prefecture

手取層群石徹白亜層群の *Ctenis* 種： 石川県石川郡尾口村尾添，手取川支流の目付谷上流に分布する石徹白亜層群桑島砂岩・頁岩互層相当層から新種 *Ctenis nipponica* を発見したので記載報告するとともに，あわせて *Ctenis kaneharai* を再記載し，また別の新種とみられる *C.* sp. (n. sp.?) を記載した。新種とした標本の一部は 1961 年，木村によって，若干の疑問はあったが *C. kaneharai* YOKOYAMA として記載報告したものである。その後の採集によって，羽片の先端部の明瞭な標本多数が得られ，これら羽片の外形から判断して，筆者らの標本は，すでに世界各地から記載報告されている 50 有余の *Ctenis* 種のいずれとも一致しないことが明らかとなった。本属は *Anthrophyopsis, Quervainia* などとともに網状脈を示す Cycadales の一属で，Cycadales 以外の属で網状脈を示す *Dictyozamites, Senia, Sagenopteris, Glossopteris, Yabeiella* などとともに，分布に特長があるように認められる。

木村達明・関戸信次

In 1961, the senior writer KIMURA described two *Ctenis* fronds which were different in external appearance from each other, under the name of *Ctenis kaneharai* YOKOYAMA. Many good *Ctenis* fronds since then collected have led us into the result that most of them apparently belong to a new species, *Ctenis nipponica* here described, though depending only on their external morphology.

All specimens here described were derived from the upper course of the Mekkodani, Ozo, Oguchi-mura, Ishikawa-gun, Ishikawa prefecture, the equivalent of the Kuwashima formation (Lowest of Lower Cretaceous), the Itoshiro Sub-Group, the Tetori Group.

We thank the members of the Komatsu City Museum, Ishikawa prefecture for their kind help in collecting fossil material.

* Received Dec. 22, 1971; read June 3, 1972 at Utsunomiya.

## Description of the species

### Cycadales

### Genus *Ctenis* LINDLEY & HUTTON, 1834

Besides the most part of angiosperms

and some of pteridophytes, *Anthrophyopsis* NATHORST, 1879, *Ctenis* LINDLEY & HUTTON, 1834, *Dictyozamites* (OLDHAM) MEDLICOTT & BLANFORD, 1879, *Furcula* HARRIS, 1932, *Glossopteris* BRONGNIART, 1828, *Quervainia* HARRIS, 1932, *Sagenopteris* PRESL, 1838, *Senia* KHAN, 1969 and *Yabeiella* OISHI, 1931, are fossil genera known to have leaves representing networked nervation with various extent. Their palaeogeographical distribution, especially in *Ctenis*, *Dictyozamites*, *Glossopteris* and *Yabeiella* seems to be significant.

Among them, *Anthrophyopsis*, *Ctenis* and *Quervainia* are now believed to be cycadean frond, *Dictyozamites* to be bennettitalean, some of *Glossopteris* and most of *Sagenopteris* to be pteridospermous, and *Furcula* (some authors believe it to be some dicotyledon leaflet), *Senia* (from the Upper Permian of India) and *Yabeiella* are still problematical in their taxonomic position.

Regarding the *Ctenis*, though we have not taken an opportunity to see the original description by LINDLEY & HUTTON, our specimens agree well with the definition stated since by SEWARD (1917), HARRIS (1932, 1964) and FLORIN (1933) as follows; "Leaf once pinnate, pinna usually with entire margins, inserted laterally on the rachis; pinnae with no midrib but with several more or less parallel veins which anastomose and which reach the margins of the pinnae."

From the Mesozoic so far as we know, more than 50 *Ctenis* species have hitherto been described and most of them have been able to be referred here for the comparison with ours. Among the following, asterisked species have been distinguished with support by their cuticular character.

The following species have large fronds and have long and narrow, ribbon-like large pinnae, generally more than 3.5 cm in maximum width:

*Ctenis approximatus* JACOB & SHUKLA (Middle Jurassic ? of Afghanistan)
*C. asplenioides* (ETTINGSHAUSEN) SCHENK, 1868 (in SEWARD, 1917, Lower Jurassic of Hungary)
*C. grandifolia* FONTAINE, 1896 (in WARD, 1905, Middle Jurassic ? of Oregon and California)
*C. hungarica* STAUB, 1896 (in SEWARD, 1917, Lower Jurassic of Hungary)
**C. latepinnata* FLORIN, 1933 (Upper Triassic of Sweden)
**C. laxa* FLORIN, 1933 (Upper Triassic of Sweden)
**C. stewartiana* HARRIS, 1932 (Lower Jurassic of Greenland and Sweden)
**C.* cfr. *stewartiana* HARRIS, 1964 (Middle Jurassic of Yorkshire)

The following three species have toothed, deeply dissected margin around and deeply serrated only on the lower side respectively:

**Ctenis exilis* HARRIS, 1964 (Middle Jurassic of Yorkshire)
*C. harrisii* VAKHRAMEEV, 1971 (Lower Cretaceous of Stanovoy Range)
*C. stanovensis* VAKHRAMEEV, 1971 (Lower Cretaceous of Stanovoy Range)

Such pinnae as having toothed or deeply serrated margin appear to deviate from the generic definition of *Ctenis*, but according to HARRIS (1964), in cuticular nature, *C. exilis* resembles certain other *Ctenis* species, being intermediate between *C. kaneharai* and *C. stewartiana*.

The following nine species are respectively characteristic in their pinna form:

**Ctenis nathorsti* MÖLLER, 1902 (in FLORIN, 1933, Rhaeto-Liassic of Sweden) *C. nana* SAMYLINA, 1963 (Lower Cretaceous of Eastern Siberia) are both smaller in size and rectangular and ovate in pinna form respectively.

C. *gracilis* TSAO, 1965 (Upper Triassic of Kwangtung, China) and C. *takamiana* OISHI & HUZIOKA, 1938 (Upper Triassic of Nariwa, Japan and Llantenes, Argentina) have *Anomozamites*-type pinnae.

C. *remoitinervis* RACIBORSKI, 1894 (in SEWARD, 1917, Lower Jurassic of Poland) has pinnae attached to the upper surface of rachis as in *Nilssonia*.

C. *imbricata* FONTAINE, 1889 (Lower Cretaceous Potomac) represents the pinna bases imbricated on the rachis.

C. *yabei* OISHI, 1932 (Upper Triassic of Nariwa) has characteristic ovate pinnae.

C. *formosa* VAKHRAMEEV, 1961 (Lower Cretaceous of Bureja basin) and C. *latiloba* KRYSHTOFOVICH & PRYNADA, 1932 (Lower Cretaceous of Eastern Siberia and Ussuriland) are moderate in size but have also characteristic ear-like lobed pinnae.

The following species have characteristic triangular pinnae respectively:

*Ctenis auriculata* FONTAINE, 1896 (Middle Jurassic ? of Oregon)

C. *burejensis* PRYNADA, 1934 (in VAKHRAMEEV & DOLUDENKO, 1961, Jurasso-Cretaceous of Bureja basin)

C. *burejensis* PRYNADA f. *typica* PRYNADA, 1945 (in SAMYLINA, 1963, Lower Cretaceous of Eastern Siberia)

C. *latifolia* (BRONGNIART) SEWARD, 1904 (in BRONGNIART, 1828, Middle Jurassic of Yorkshire)

C. *uwatokoi* TOYAMA & OISHI, 1935 (Upper Jurassic of Northeastern China and Mongolia).

The following four also have characteristically rectangular pinnae which are truncated in the latter two:

*Ctenis chaoi* SZE, 1933 (Lower Jurassic of China)

C. *constrictus* JACOB & SHKULA, 1955 (Middle Jurassic ? of Afghanistan)

C. *pleschkovii* GENKINA, 1963 (Middle Jurassic of Eastern Ural)

C. *uralensis* GENKINA, 1963 (Middle Jurassic of Eastern Ural).

The following species have long and narrow, generally parallel-sided, ribbon-like pinnae, mostly with expanded or decurrent bases with various extent except C. *kaneharai* which sometimes have pinnae with contracted both basal margins. Pinnae are more or less falcate in some species:

**Ctenis sulcicaulis* (PHILLIPS) WARD, 1905 (Type species) (Middle Jurassic of Yorkshire; Middle Jurassic ? of Oregon; Lower Jurassic ? of Afghanistan; Lower Cretaceous of Eastern Siberia). C. *falcata* has been included in this type species as synonym on account of its priority.

C. *afghanensis* JACOB & SHKULA, 1955 (Middle Jurassic ? of Afghanistan)

C. *borealis* (DAWSON) BELL, 1956 (Lower Cretaceous of Western Canada)

C. *chinensis* HSU, 1954 (Middle Jurassic ? of China)

*C. *fallax* NATHORST, 1879 (in HARRIS, 1932, Upper Triassic of Sweden and Greenland) (FLORIN made HARRIS' Greenland specimen synonymous with his new species C. *minuta*)

C. *intermedia* (KRYSHTOFOVICH & PRYNADA) PRYNADA, 1937 (in SAMYLINA, 1963, Lower Cretaceous of Eastern Siberia)

C. *japonica* OISHI, 1932 (Upper Triassic of Nariwa)

*C. *kaneharai* YOKOYAMA (Middle Jurassic of Yorkshire; Upper Jurassic of Northeastern China; Lower Cretaceous Itoshiro)

*C. *minuta* FLORIN, 1933 (Upper Triassic of Sweden and Greenland)

*C. *nilssoni* (NATHORST) HARRIS, 1932 (Upper Triassic of Greenland and Sweden)

C. *orovillensis* FONTAINE 1896 (in WARD, 1905, Middle Jurassic? of Oregon; in 1961, VAKHRAMEEV & DOLUDENKO described C. cfr. *orovillensis* from the Jurasso-Cretaceous of Bureja basin)

C. *pontica* DELLE, 1967 (Middle Jurassic of Transcaucasia)

*C. *reedi* HARRIS, 1947 (Middle Jurassic of Yorkshire)

C. *yamanarii* KAWASAKI, 1926 (Lower Jurassic of Korea)

*C. yokoyamai* KRYSHTOFOVICH & PRYNADA, 1932 (Jurasso-Cretaceous of Siberia and Ussuriland).

Besides the above, we knew the following *Ctenis* species had been described by various authors, but unfortunately we could not give any comment on them for we had no more detailed information about them:

*Ctenis abbreviata* BRAUN, 1843, *C. angusta* BRAUN, 1843, *C. angustissima* PRYNADA (in VAKHRAMEEV & DOLUDENKO, 1961), *C. anomozamioides* LEE, 1964, *C. cracoviensis* RACIBORSKI, 1894, *C. grandis* SAPORTA, 1879, *C. inconstans* BRAUN, 1843, *C. lunzensis* STUR, 1885, *C. marginata* BRAUN, 1843, *C. neuropteroides* DAUGHERTY, 1941, *C. patagonica* CAZAUBON, 1947 (in HERBST, 1965), *C. permiana* HOWSE, 1890, *C. potockii* STUR, 1888 and its varieties, *C. renaulti* ZALLESKY, 1928 and *C. wardii* FONTAINE, 1896.

We could also refer the specimens described as *Ctenis* sp. or *Ctenis* ? sp. by BELL (1956), GENKINA (1963), HARRIS (1932), JONES & JERSEY (1947), KAWASAKI (1925), OISHI (1932), OISHI & TAKAHASHI (1936), SRIVASTAVA (1954), SZE (1931), TESLENKO (1970) and YOKOYAMA (1906) to the present study. *Ctenis* sp. derived from Raniganj coal-field, the Lower Gondwana, India by SRIVASTAVA is an imperfect impression but is of special interest in its oldest representative of *Ctenis*-type leaflet so far as we know.

### *Ctenis nipponica* KIMURA & SEKIDO, sp. nov.

Pl. 44, figs. 1, 2; Pl. 45, figs. 1, 2; Text-fig. 1

1961. *Ctenis kaneharai*: KIMURA, p. 29, Pl. 6, fig. 2 (non fig. 1)

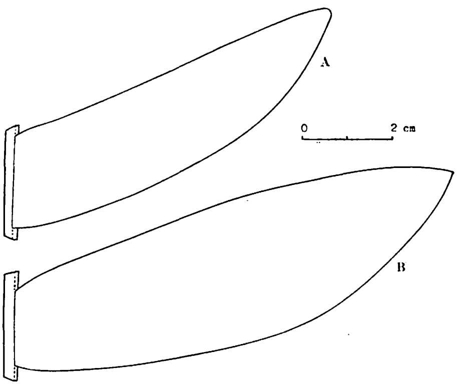
*Diagnosis:* Frond fairly large, 14 cm in width, unknown in length, pinnate. Rachis slender 1-6 mm across measured on impression, the ornamentation or striation of its surface not clear. Pinnae apparently subopposite or opposite, attached to the lateral sides of the rachis with wide angle, nearly perpendicular to 60 degrees, set closely or narrowly spaced, parallel-sided but increasing their width gradually to the apical portion and narrow quickly to meet at an angle of about 50-60 degrees instead of gradual tapering, pinna base mostly contracted; 8 cm in length and 2-3 cm wide at the widest portion. Nerves are numerous, parallel except near the base where they are somewhat divergent and often conspicuously decurrent, and ending at the margin, about 8 in number per cm at the base, often forking and are reticulate forming elongate meshes.

Description of specimens: Many fragments of fronds have been collected from the same locality. Unfortunately they are all impressions of the frond, so no organic substance has preserved.

Pl. 44, fig. 1 shows probably middle portion of a frond with slender rachis sending off the pinnae nearly perpendicularly, with somewhat contracted both basal margins and with conspicuously decurrent nerves at the base.

Pl. 45, fig. 1 shows a similar specimen to the above but having pinnae directed a little forwards and recurving backwards. Pl. 45, fig. 2 clearly shows the characteristic apical portion of pinnae enlarged and Pl. 44, fig. 2 shows enlarged basal part of nerves. Text-fig. 1 shows two typical pinna forms of this new species.

*Comparison and discussion:* This species is characterised in the pinna form which is parallel-sided or increasing gradually in width towards the abruptly




Text-fig. 1. Pinna outline of *Ctenis nipponica* KIMURA & SEKIDO sp. nov., A; copied from the paratype KM-61328, B; from the holotype KM-57101.

tapering apex, with more or less contracted both bases and in the conspicuously decurrent nerves at the base.

Among the species formerly described, as stated above, the species which should be compared with ours would be both *C. kaneharai* and *C. yokoyamai*. In 1906, YOKOYAMA originally described *C. kaneharai* based on single imperfect specimen without pinna apices from Northeastern China. He compared his new species witn *C. zeyshneri* RACIBORSKI, 1892 (Lower Jurassic of Poland) to which we have not been referred yet. YOKOYAMA's specimen is similar in form to a specimen described by the senior author (KIMURA, 1961, Pl. 6, fig. 1). In 1933 OISHI mentioned that YOKOYAMA's species was also comparable with *C. orovillensis* and in 1940 he described similar specimen without pinna apices as *C. kaneharai* from Kuwashima, a classical fossil-plant locality of the Itoshiro Sub-Group. In 1950 and 1964, HARRIS gave *C. kaneharai* an emended diagnosis based upon well-preserved specimens derived mainly from Yorkshire. They are as large as the original specimen in size, frond reaching 30-40 cm in width. In contracted pinna bases, our specimens agree with the above mentioned *C. kaneharai*, but as formerly pointed out by HARRIS (1964), our species is quite different from *C. kaneharai*, for the margins narrow quickly to meet at an angle of about 50-60 degrees instead of gradually tapering and meeting at 15-20 degrees in *C. kaneharai*.

Original specimen of *C. yokoyamai* is imperfect, without apical portions of pinnae. A specimen described by KRASSILOV (1967, Pl. 52, fig. 1) from Ussuriland as *C. yokoyamae* is rather smaller in size and is similar in pinna form to ours, but it differs from ours in more or less decurrent basiscopic margins.

Conspicuously decurrent nerves at their bases are another characteristic feature of our species. Such feature is also seen in *C. reedi* and some of pinnae of *C. kaneharai*, but the former is easily distinguishable from ours in having long and narrow pinnae. As there are no other recorded species which show a closer resemblance any more, a new species is instituted here to accommodate our fronds and the name *Ctenis nipponica* is proposed.

*Occurrence:* Common.

*Reg. Nos.:* KM-57101 (Holotype), KM-61327 and KM-61328 (Paratype), KM-61329, KM-61337.

### *Ctenis kaneharai* YOKOYAMA

1906. *Ctenis kaneharai*: YOKOYAMA, p. 29, Pl. 9, figs. 1, 1a.
1933. *Ctenis kaneharai*: YABE & OISHI, p. 32.
1940. *Ctenis kaneharai*: OISHI, p. 296, Pl. 24, fig. 1.
1950. *Ctenis kaneharai* HARRIS: p. 1001, Text-figs. 1-3, 4B.
1961. *Ctenis kaneharai* KIMURA: p. 29, Pl. 6, fig. 1 (non fig. 2)

1964. *Ctenis kaneharai*: HARRIS, p. 112, Text-figs. 48, 49.

*Remarks:* As formerly mentioned, YAKOYAMA's original specimen from the plant bed considered to be Upper Jurassic at Nien-tsu-kou, Sai-ma-chi, Shen-ching-Sheng, Northeastern China, is imperfect one with several pinnae lacking the apical portion.

Many fragments of *Ctenis* frond have been collected from the present locality, most of which have clearly been distinguished from *C. kaneharai* in representing pinna apices which are abruptly tapering. We named them *Ctenis nipponica.*

The rest lacking apical portion of pinna are so close in general appearance to the original one and also OISHI's one from Kuwashima that we'd like to keep them under the name of *C. kaneharai*, together with one specimen formerly described (KIMURA, 1961, Pl. 6, fig. 1) until further evidence will be in hand.

HARRIS' specimens from Yorkshire have pinnae with tapering apices meeting at 15-20 degrees. He gave *C. kaneharai* an emended diagnosis based upon his good preserved material. Were the apical portion of pinna lacking in his material, they would closely agree with the ones from China and Japan.

It seems to be quite questionable whether the Japanese pinnae described under the name of *C. kaneharai* have apices like those of Yorkshire pinnae, or not.

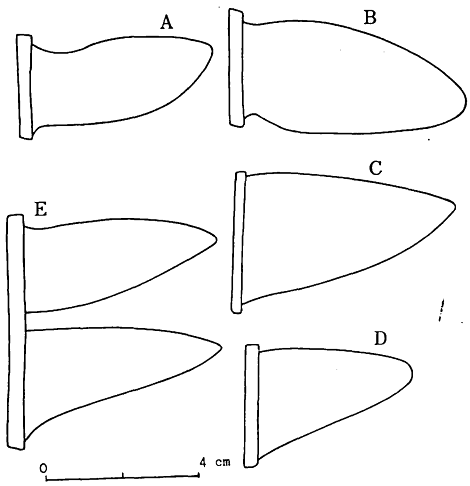
*Occurrence:* Not rare.

*Reg. Nos.:* KM-59101, KM-61325, KM-61326.

## *Ctenis* sp. (n. sp.?)

Pl. 44, fig. 3; Pl. 45, fig. 3; Text-fig. 2E

*Description of specimen:* Pl. 44, fig. 3 shows a part of frond of a single specimen examined. Frond pinnate with fairly thick rachis, 5 mm across measured on impression, sending off subopposite pinnae perpendicularly from its upper lateral sides. Pinnae narrowly spaced, long-triangular in shape about 5 cm long, with the acutely pointed apex meeting at angle of 50 degrees and with more or less contracted both margins or decurrent basiscopic margin, about 2 cm wide at the base. Nerves delicate, numerous, 8 per cm in density at the base, radiating towards the entire margin except most of the median part, often forking dichotomously forming meshes elongated in the longitudinal direction as shown in Pl. 45, fig. 3.




Text-fig. 2. Pinna outline of *Ctenis* sp. (n. sp.?) and those of allied species, A; *Ctenis burejensis* PRYNADA f. *typica* PRYNADA copied from SAMYLINA, 1963, Pl. 11, fig. 1. B; *Ctenis burejensis* PRYNADA from VAKHRAMEEV & DOLUDENKO, 1961, Text-fig. 26. C; *Ctenis auriculata* FONTAINE from WARD, 1905, Pl. 29, fig. 1. D; *Ctenis uwatokoi* TOYAMA & OISHI from SZE & HSÜ, 1954, Pl. 49, fig. 2. E; *Ctenis* sp. (n. sp.?) KIMURA & SEKIDO from KM-61450.

*Remarks:* judging from long-triangular pinnae, fairly thick rachis and delicate nerves being not decurrent at their bases, it can not be considered that this specimen is within the variation of *Ctenis nipponica* newly described here.

The known species which should be compared with the present specimen, might be *Ctenis auriculata* and *C. burejensis* and its forma *typica*, but they differ in having fairly coarser nervation from the present one. *Ctenis uwatokoi* originally described by TOYAMA & OISHI (1935) from Northeastern China and Mongolia, is another allied species but it differs from the present one in that most of pinnae have broadly rounded apices.

Then finally the present specimen seems to be scientifically new, but the reason for making our hesitation for instituting the second now species here, is because of only a single and unsatisfactory specimen now in hand.

Text-fig. 2 shows two pinnae of the present frond together with those of allied species mentioned above.

*Occurrence:* Rare.

*Reg. No.:* KM-61450.

## References


BELL, W. A. (1956) : Lower Cretaceous floras of Western Canada. *Geol. Surv. Canada, Mem.* 285, pp. 1-153+10, pls. 1-85.

BRONGNIART, A. (1828-1838) : Histoire des végétaux fossiles, ou recherches botaniques et geologiques sur les végétaux renfermes dans les divers couches du globe. *Paris*, 1 (1828-1837), pp. 1-488+12, pls. 1-171; 2 (1837-1838), pp. 1-72, pls. 1-28.

DOLUDENKO, M. P. & TS. I. SVANIDZE (1969) : The late Jurassic flora of Georgia. *Geol. Inst. Sci. USSR. Trans.* 178, pp. 1-116, pls. 1-81 (in Russian).

FLORIN, R. (1933) : Studien üeber die cycadales des mesozoicums nebst erörterungen üeber die spaltöffnungsapparate der bennettitales. *K. svenska Vetensk Acad., Handle., Stockholm*, 12(5), pp. 1-134, pls. 1-16.

FONTAINE, W. N. (1889) : The Potomac or younger Mesozoic flora. *US Geol. Surv. Mon., Washington*, 15, pp. 1-377, pls. 1-180.

GENKINA, R. Z. (1963) : Fossil flora from the Middle Jurassic coaly formations in the Eastern Ural coal-field. *Acad. Sci., USSR, Moscow*, pp. 1-115, pls. 1-51 (in Russian)

HARRIS, T. M. (1932) : The fossil flora of Scoresby Sound, East Greenland. Pt. 2. *Medd. Greenland, Kjobenhavn*, 85(3), pp. 1-112, pls. 1-9.

—— (1946) : Notes on the Jurassic flora of Yorkshire, 34-36. *Ann. Mag. Nat. Hist., Ser. 11*, 13, pp. 649-662, 1-5 figs.

—— (1950) : Ditto., 46-48. *Ibid., Ser. 12*, 3, pp. 1002-1030, figs. 1-9.

—— (1964) : The Yorkshire Jurassic flora. II. *London*, pp. 1-191, 1-7 pls.

HERBST, R. (1965) : La flora fosil de la formacion Roca Blanca, provincia Santa Cruz, Patagonia con consideracion geológicas y estratigráficas. *Univ. Nac. Tucuman*, 12, pp. 7-101, 4 pls.

JACOB, K. & B. N. SHUKLA (1955) : Jurassic plants from the Saighan series of Northern Afghanistan and their palaeo-climatological and palaeo-geographical signi-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Explanation of Plate 44

Fig. 1. *Ctenis nipponica* KIMURA & SEKIDO sp. nov.: Paratype, KM-61327, showing the middle portion of a frond, natural size.

Fig. 2. *Ctenis nipponica* KIMURA & SEKIDO sp. nov.: Holotype, KM-57101, showing the nervation, enlarged from the holotype, ×3

Fig. 3. *Ctenis* sp. (n. sp.?): KM-61450, showing a part of a frond, in natural size.

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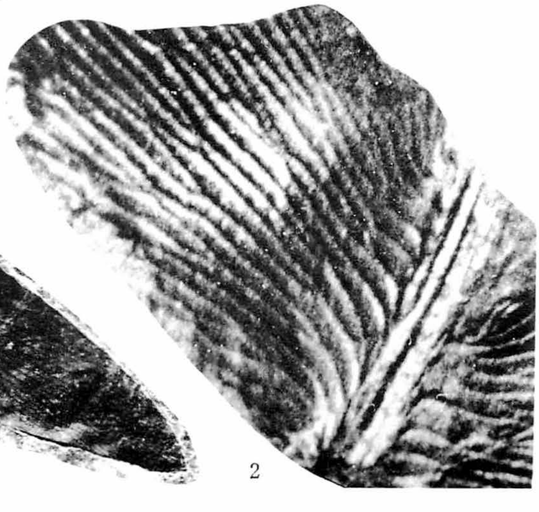

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ficance. *Mem. Geol. Surv. India*, NS, Vol. 33, No. 2, pp. 1-64, pls. 1-13.

JONES, O. A. & N. J. DE JERSEY (1947) : The flora of the Ipswich coal measures-morphology and floral succession. *Univ. Queensland, Geol.*, Vol. 3, Nos. 3, 4, pp. 1-88, pls. 1-10.

KAWASAKI, S. (1925) : Some older Mesozoic plants in Korea. *Geol. Surv. Korea*, Vol. 4, No. 1, pp. 1-71, 47 pls.

—— (1926) : Addition to the older Mesozoic plants in Korea. *Ibid.*, No. 2, pp. 1-35, pls. 1-11.

KIMURA, T. (1961) : Mesozoic plants from the Itoshiro sub-group, the Tetori group, Central Honshu, Japan, Pt. 2. *Trans. Proc. Palaeont. Soc. Japan, N. S.*, No. 41, pp. 22-32, pls. 4-6.

KHAN, A. M. (1969) : *Senia reticulata*, a new plant fossil from the Raniganj rocks of the Talchir coal-field, Orissa, India. *J. Sen Mem. Vol., Calcutta*, pp. 335-337, 1 pl.

KRASSILOV, V. A. (1967) : Lower Cretaceous flora of Southern Primorie and its stratigraphical significance. *Moscow*, pp. 1-364, pls. 1-93 (in Russian)

KRYSHTOFOVICH, A. N. (1933) : Baikal formation of the Angara group. *Trans. Geol. Prosp. Serv. USSR. Moscow* 326, pp. 1-136, pls. 1-17 (reprint, in Russian)

—— & V. PRYNADA (1932) : Contribution to the Mesozoic flora of the Ussuriland. *Bull. U. Geol. Prosp. Serv. USSR*, 51(22), pp. 363-374, 2 pls. (reprint, in Russian)

OISHI, S. (1931) : On *Fraxinopsis* Wieland and *Yabeiella* OISHI gen. nov. *Japan, Jour. Geol. Geogr.*, Vol. 8, No. 4, pp. 259-267, 1 pl.

—— (1932) : The Rhaetic plants from the Nariwa district, Okayama Pref., Japan. *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, Vol. 2, Nos. 3, 4, pp. 257-379, pls. 19-53.

—— (1940) : The Mesozoic floras of Japan. *Ibid.*, Vol. 5, Nos. 3, 4, pp. 123-480, pls. 1-48.

—— (1951) : Illustrated catalogue of East-Asiatic fossil plants. *Kyoto*, pp. 1-235, pls. 1-53. (in Japanese)

—— & E. TAKAHASHI (1936) : The Rhaetic plants from Province Nagato. A supplement. *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, Vol. 3, No. 2, pp. 113-133, 1 pl.

SAMYLINA, V. A. (1963) : The Mesozoic flora of the lower course of the Aldan river. *Paleobotanika, Moscow*, 4, pp. 59-139, pls. 1-37. (in Russian with English summary)

SEWARD, A. C. (1917) : Fossil plants. III. *Cambridge*, pp. 1-656+18, figs. 377-629.

SRIVASTAVA, P. N. (1954) : Studies in the *Glossopteris* flora of India : 1. Some new fossil plants from the Lower Gondwanas of the Raniganj coal-field, India. *Palaeobotanist*, No. 3, pp. 70-77, 3 pls.

SZE, H. (1931) : Beiträge zur liasischen flora von China. *Mem. Nat. Res. Inst. Geol. Nanking*, Vol. 12, pp. 1-85, pls. 1-10.

—— & R. HSÜ (1954) : Typical fossil plants in China. *Peking*, pp. 1-99, pls. 1-69.

TESLENKO, JU. V. (1970) : Jurassic stratigraphy and flora of Western and Southern Siberia and Tuba. *Inst. Sib. Nat. Sci. USSR, Ser. Paleont. & Stratigr.*, 42, pp. pp. 1-213, pls. 1-52 (in Russian)

TOYAMA, S. & S. OISHI (1935) : Notes on some Jurassic plants from Chalai-nor, Prov. Hsingan, Manchoukuo. *Jour. Fac. Sci., Hokkaido Imp. Univ., Ser. 4*, Vol. 3, No. 1, pp. 61-77.

TSAO, C. (1965) : Fossil plants from the Siaoping series in Kaoming, Kwangtung. *Acta Palaeont. Sin.*, Vol. 13, No. 3, pp. 510-528, pls. 1-6. (in Chinese with English description)

VAKHRAMEEV, V. A. & E. V. BLINOVA (1971) : New early Cretaceous flora from the Stanovoy Range. *Jour. Palaeont., Moscow*, 71-1, pp. 88-94, 2 figs. 1 pl. (in Russian)

—— & M. P. DOLUDENKO (1961) : Upper Jurassic and Lower Cretaceous floras of the Bureja Basin. *Trud. Geol. Inst. Acad. Nauk USSR. Moscow*, 54, pp. 1-136, pls. 1-60. (in Russian)

WARD, L. (1905) : Status of the Mesozoic floras of the United States. *Mon. U. S. Geol. Surv., Washington*, 48, pp. 1-616, pls. 1-45.

YABE, H. & S. OISHI (1933) : Mesozoic

plants from Manchuria. *Sci. Rept. Tohoku Imp. Univ., 2nd. Ser. (Geol.)*, Vol. 12, No. 2B, pp. 195-238, pls. 30-35.

YOKOYAMA, M. (1906): Mesozoic plants from China. *Jour. Coll. Sci., Imp. Univ. Tokyo*, Vol. 21, Art. 9, pp. 1-39, pls. 1-12.

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|---|---|---|---|
| Ishikawa | 石川 | Nariwa | 成羽 |
| Itoshiro | 石徹白 | Oguchi-mura | 尾口村 |
| Kuwashima | 桑島 | Ozo | 尾添 |
| Mekkodani | 目付谷 | Tetori | 手取 |

## Explanation of Plate 45

Fig. 1. *Ctenis nipponica* KIMURA & SEKIDO sp. nov.: Paratype, KM-61328, showing the middle portion of a frond, natural size.

Fig. 2. *Ctenis nipponica* KIMURA & SEKIDO sp. nov.: Holotype, KM-57101, showing the pinna apices, enlarged from the holotype (KIMURA, 1961, Pl. 6, fig. 2), ×1.5

Fig. 3. *Ctenis* sp. (n. sp.?): showing the nervation, enlarged from KM-61450, ×2

All specimens here described are deposited in the Komatsu City Museum, Ishikawa Prefecture.

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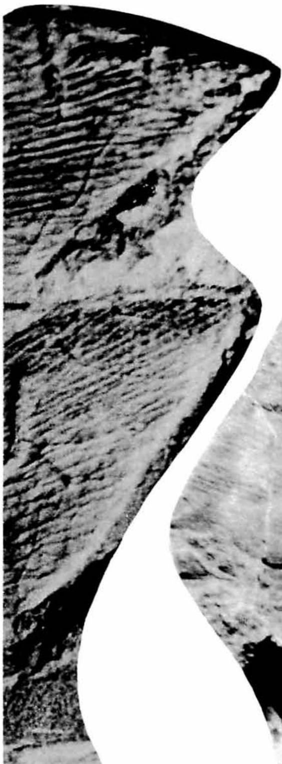

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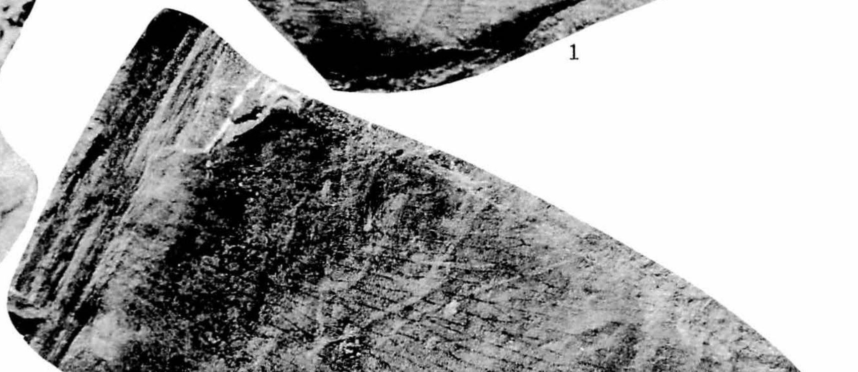

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Trans. Proc. Palaeont, Soc. Japan, N. S., No. 86, pp. 369-374, pl. 46, June 30, 1972

# 600. *COLANIA DOUVILLEI* (OZAWA), A FUSULINID FORAMINIFERA FROM THE NORTHERN KITAKAMI MOUNTAINS, N. E. JAPAN

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北部北上山地より産した紡錘虫化石 *Colania douvillei* (OZAWA) について：北部北上山地よりは紡錘虫の産出報告は極めて少なく，Neoschwogerinids に関しては，*Neoschwogerina* sp. 及び *Yabeina* sp. が数ケ所から知られているのみである。筆者が下閉伊郡花輪村北川目付近にて化石採集中 *Colania douvillei* (OZAWA) を採集したのでここに記載をする。北部北上山地産の紡錘虫としては最初の記載である。*Colania douvillei* (OZAWA) は，中部ペルム系上部を指示するよい標準化石となっている。日本で知られる限りでは，Neoschwagerinids としては，岩手県北部の大平沢鉱山 (*Neoschwagerina craticulifera*? を産する）と共に最北端の産地の一つである。また，南北両北上山地が，*Cancellina-Minoella-Colania-Lepidolina* bioseries で特徴づけられる紡錘虫生物区に属する事がいっそう明らかになった。

崔　東　龍

Although the Palaeozoic deposits developed in the northern part of the Kitakami Mountains are seemingly to be Permian in age from the lithologic nature, at least so far as their major parts are concerned, fossils are very few. These deposits have been accordingly stratigraphically little investigated up to the present.

In this short note new occurrence of fusulinid foraminifera, *Colania douvillei* (OZAWA) will be presented, which was actually discovered by the present author with *Parafusulina* sp. and coral fragments from a lenticular limestone, dark gray in colour, cropping out at a left bank of a river, about 700 m east of the Kitagawame primary school, when he recently made an excursion along the river Nagasawa, in the vicinity of Hanawa-mura (village), Shimohei-gun (county), Iwate prefecture, the central part of the Northern Kitakami Mountains. Geology of the area is composed of the alternation of chert and slate. The limestone from which the fossils were found out is about 7 m in thickness, is observed to be intercalated in the thickly bedded black slate formation.

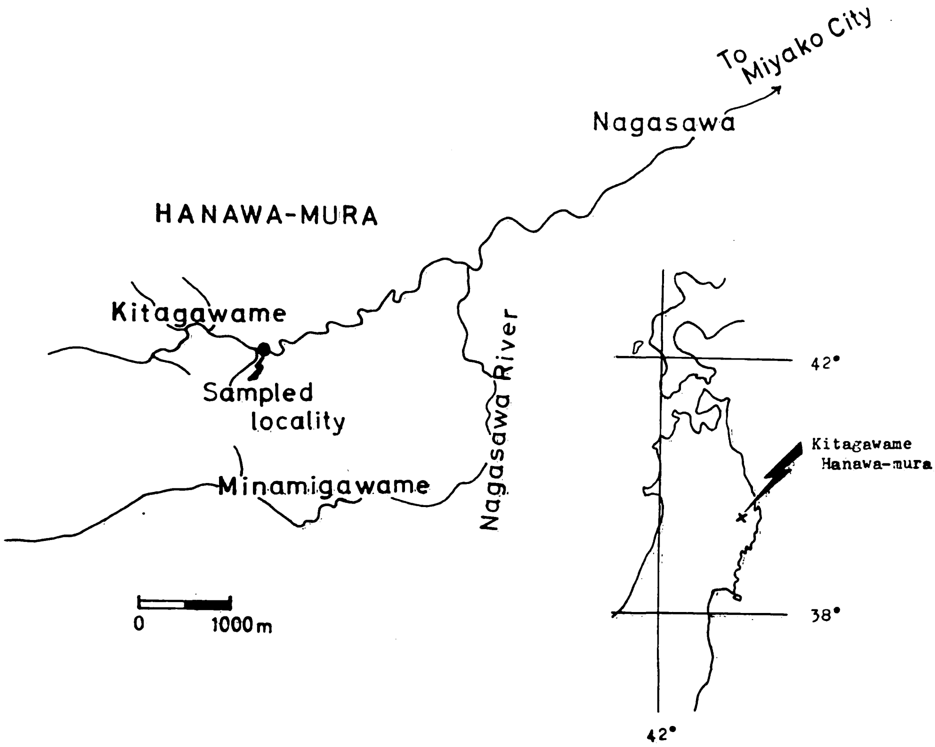
As a matter of fact, the discovery of fusulinid foraminifera in this area above stated, is not new, since Y. ONUKI and H. KUDO (1954) have already reported the occurrence of *Neoschwagerina* sp. and *Parafusulina* sp. from the same area, although the present author is not quite sure, whether or not the locality mentioned by them is same as the one by the author. Further, Y. ONUKI (1969) described the presence of *Neoschwagerina* sp. at Fukushi, Toyomane-cho (town), and *Yabeina* sp. from Wainai, Niizato-mura (village), Shimohei-gun

* Received Jan. 20, 1972; read Nov. 22, 1970 at Hiroshima.

(county) of the same prefecture.

However, all these fossils were merely listed up by those authors, and details of the fossils are unknown for us at the present. The present note will be eventually the first report on description of fusulinid fossils from the northern part of the Kitakami Mountains. The finding of such neoschwagerinid may be somewhat interesting, since this is one of the recorded northern limit of distribution in respect to such younger neoschwagerinid in Japan.

*Colania douvillei* (OZAWA) is widely discovered in the upper Permian throughout Japan, and has been regarded to be one of the remarkable fusulinid elements of the Eastern Tethys Sea region. Nevertheless, two bioseries seem to have been distinguished in Japan amongst Neoschwagerininae. One of which is represented by such genera as *Cancellina-Minoella-Colania-Lepidolina*, while the other one is by *Maklaya-Neoschwagerina*, especially *Neoschwagerina craticulifera* type-*Yabeina*, especially *Yabeina globosa* type series. Such two types of bioseries are also traced in Japan in somewhat different geographical province. By the finding of *Colania douvillei* (OZAWA) from the Northern Kitakami Mountains, it has become more obvious that the Kitakami Mountains belong to the district characterized by the former bioseries. It is also worthy of note that none of species belonging to the latter bioseries which is typically found in the central Japan, as Akasaka




Text-fig. 1. Map showing the sampled locality.

district, is found until present in the Kitakami Mountains.

Before going into description, the author wishes to express his sincere thanks to Professor M. MINATO and Professor M. KATO for their kindness in reading manuscript and valuable suggestions.

## Description of species

### Family Verbeekinidae STAFF & WEDEKIND, 1910

### Subfamily Neoschwagerininae DUNBER & CONDRA, 1928

### Genus *Colania* LEE, 1934, emend. OZAWA, 1970

### *Colania douvillei* (OZAWA)

Pl. 46, figs. 1-6

1906. *Neoschwagerina globosa* DOUVILLE, pl. 17, pl. 18, figs. 1 & 2.
1912. *Neoschwagerina globosa*: DEPRAT, p. 51, pl. IV, figs. 1-4.
1925. *Neoschwagerina douvillei*: OZAWA, pl. 3, fig. 6; art. 6, pp. 55-57, pl. 11, figs. 5 & 6.
1935. *Neoschwagerina douvillei*: GUBLER, pp. 111-113, pl. 6, fig. 2; pl. 8 figs. 6 & 10 (non pl. 7, figs. 7, 8, 10 & 11).
1936. *Neoschwagerina douvillei*: HUZIMOTO, pp. 114-115, pl. 23, figs. 1-5.
1947. *Neoschwagerina douvillei*: TORIYAMA, pp. 78-79, pl. 17, fig. 8.
1956. *Neoschwagerina douvillei*: CHEN, pp. 58-59, pl. 13, figs. 3-7; pl. 14, fig. 7.
1958. *Neoschwagerina douvillei*: TORIYAMA, pp. 223-227, pl. 41, figs. 9-13; pl. 42, figs. 1-6.
1958. *Neoschwagerina douvillei*: SAKAGAMI, pp. 92-93, pl. 4, figs. 7-10.
1959. *Neoschwagerina douvillei*: NOGAMI, pp. 74-75, pl. 1, figs. 18-20.
1959. *Gifuella douvillei*: MINATO & HONJO, table 3, no. 14; pp. 309 & 313.
1960. *Neoschwagerina douvillei*: KANUMA, pp. 70-71, pl. 13, figs. 5, 6 & 7.
1961. *Neoschwagerina douvillei*: NOGAMI, pp. 180-183, pl. 5, figs. 1-5.
1961. *Neoschwagerina douvillei*: SADA, pp. 123-125, pl. 12, figs. 1-8.
1963. *Neoschwagerina douvillei*: HANZAWA & MURATA, pl. 17, figs. 1-10.
1963. *Neoschwagerina douvillei*: SHENG, pp. 102 & 235-236, pl. 33, figs. 1-7.
1970. *Colania* sp. sp. nov., OZAWA, pl. 1, figs. 2, 6-7; pl. 7, figs. 5-7.
1970. *Colania douvillei*: OZAWA, pp. 36-38, pls. 3-6.

*Material:* UHR 19350-UHR 19385. Deposited in the Department of Geology and Mineralogy, Faculty of Science, Hokkaido University.

*Lectotype:* R. TORIYAMA (1958) selected the lectotype of this species as DOUVILLE's *Neoschwagerina globosa* illustrated as fig. 1, on pl. 18 in 1906.

*Description:* Shell is large, fusiform with bluntly rounded poles and weakly convex mid-portion. Mature shell may possess more than 17 volutions. On account of ill-orientation of thin sections and result of erosion out of the volutions of the specimens at hand, exact size of shell is unknown. Still, illustrated specimen (fig. 3) shows to possess probably 15 to 16 volutions and estimated about 10. 4 mm in length and 5.2 mm in width. The shell expands uniformly and tightly throughout the growth of the shell. Height of volution in the outer volutions is 100 to 150 microns.

Size of proloculus is not correctly measured, since no well oriented sections are available for study, although it may be larger than 60 microns at least in diameter.

Spirotheca is composed of tectum and keriotheca. Keriothecal structure is not well observable in certain part of spirotheca but is distinct in other part of it.

The spirotheca gradually increases in thickness; 10 to 15 microns in the inner volutions, and 40 to 45 microns in the outer volutions.

Transverse septula are slender and regularly spaced throughout the shell. The distal margin of them reaches the top of the parachomata. Incipient secondary transverse septula appear from the middle to the outer volutions.

Septa are numerous. Initial axial septula begin to appear from the fifth to the sixth volution. So-called *1* type of them from the nineth, and *21*, *21+s*, are observable in the outermost few volutions.

*Remarks:* The present form is included in the genus *Colania* by its large, slightly inflated fusiformed shell with regularly spaced slender transverse septula, ill-developed secondary transverse septula.

In application of the classification of Neoschwagerininae proposed by M. MINATO & S. HONJO (1959 & 1966), upon the basis of the axial septula, the present form shows to possess similar axial septula as *Colania douvillei* (OZAWA), collected from the "*Gifuella*" zone at Akasaka. Compared to the previously described *Neoschwagerina douvillei* by many authors, the present form represents relatively primitive natures especially in development of axial septula, relatively thick spirotheca and small proloculus inspite of having larger shell than any other forms hitherto described.

*Neoschwagerina okuboi* described by R. MORIKAWA and Y. SUZUKI (1961) from Akasaka may be highly probable to be synonymous with *Colania douvillei*.

*Colania kotsuboensis* CHOI, from the southern Kitakami Mountains provides well developed axial and transverse septula than *Colania douvillei*. In this point these two forms are safely discriminated.

The present form is readily distinguishable from *Colania gifuensis* and *C. amicula* in possessing larger shell with well developed natures of axial and transverse septula.

*Colania douvillei* (OZAWA) has never been found out up to date in the Southern Kitakami Mountains, although fusulinid fauna there has thoroughly examined by many workers.

## References cited


CHEN, S. (1956): Fusulinidae of South China part 2. *Palaeont. Sinica, new ser. B*, no. 6, pp. 17–71, pls. 1–14.

DEPRAT, J. (1912): Etude des Fusulinidés de China et d'Indochine et classification des calcaires á fusulines. *Indochine Service Geol., Mem.*, vol. I, fasc. 3, pp. 1–76, pls. 1–9.

DOUVILLE, H. (1906): Les calcaires á fusulines de l'Indochine. *Soc. Géol. France, Bull., Ser. 4*, tome 6, pp. 576–587, pls. 17 & 18.

GUBLER, T. (1935): Les Fusulinidés du permien de l'Indochine, leur structure et leur classification. *Soc. Géol. France, Mém., new sér.*, tome 11, fasc. 4, no. 26, pp. 1–173, pls. 1–8.

HANZAWA, S. & MURATA, M. (1963): The paleontologic and stratigraphic considerations on the Neoschwagerininae and Verbeekininae, with the description of some fusulinid foraminifera from the Kitakami Massif, Japan. *Sci. Rept. Tohoku Univ. Sendai, 2nd Ser.* (Geol.), vol. 35, no. 1, pp. 1–31, pls. 1–20.

HUZIMOTO, H. (1936): Stratigraphical and palaeontological studies of the Titibu system of the Kwanto-Mountainland, part 2, palaeontology. *Sci. Rept. Tokyo Bunrika Daigaku, Sec. C*, vol. 1, no. 2, pp. 29–125, pls. 1–26.

KANUMA, M. (1960): Stratigraphical and paleontological studies of the Southern part of the Hida Plateau and the northeastern part of the Mino Mountainland, central Japan. part 2, paleontology, no. 4. *Bull. Tokyo Gakugei Univ.*, vol. 11, pp. 55–83, pls. 10–13.

MINATO, M. & HONJO, S. (1959) : The axial septula of some Japanese Neoschwagerininae with special reference of the phylogeny of the subfamily Neoschwagerininae DUNBER & CONDRA, 1928. *Jour. Fac. Sci. Hokkaido Univ., Ser. 4, Geol. & Mineral.*, vol. 10, pp. 305–336, pls. 1–6.

—— & —— (1966) : Филогения Подсемейства Neoschwagerininae. *Вопросы Микропалеонтологии*, vol. 10, pp. 109–124, pls. 1–3.

MORIKAWA, R. & SUZUKI, Y. (1961) : Fusulinids from the Akasaka limestone (part 2). *Sci. Rept. Saitama Univ., Ser. B*, vol. 4, no. 1, pp. 43–74, pls. 4–22.

NOGAMI, Y. (1959) : Fusulinides from the Maizuru Zone, Southwest Japan. Part 2. Derived Fusulinides. *Mem. Coll. Sci., Univ. Kyoto, Ser. B*, vol. 26, no. 2, art. 1, pp. 67–82, pl. 1.

—— (1961) : Permische Fusuliniden aus dem Atetsu-Plateau Südwestjapan. Teil 1, *Ibid., Ser. B*, vol. 27, no. 3, art. 1, pp. 159–232, pls. 1–7.

ONUKI, Y. (1969) : Geology of the Kitakami Massif, Northeast Japan. *Contr. Inst. Geol. & Paleont. Tohoku Univ.*, no. 69, pp. 1–239 (in Japanese).

—— & KUDO, H. (1954) : Identification of Permian system in the northern Kitakami Mountains. *Jour. Geol. Soc. Japan*, vol. 60, pp. 361–362 (in Japanese).

OZAWA, T. (1970a) : Notes on the phylogeny and classification of the superfamily Verbeekinoidea. *Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol.*, vol. 20, no. 1, pp. pp. 17–58, pls. 1–9.

—— (1970b) : Variation and relative growth of *Colania douvillei* (OZAWA) from the Rat Buri limestone. *Contr. Geol. & Paleont. Southeast Asia*, 79, vol. 8, pp. 19–42, pls. 3–6.

OZAWA, Y. (1925) : Palaeontological and stratigraphical studies on the Permo-Carboniferous limestone of Nagato. Part II, Palaeontology. *Jour. Coll. Sci., Imp. Univ. Tokyo*, vol. 45, art 6, pp. 1–90, pls. 1–14.

SADA, K. (1961) : Neoschwagerines from the Yukawa group in the Atetsu Limestone Plateau. *Jour. Sci., Hiroshima Univ., Ser. C*, vol. 4, no. 1, pp. 117–129, pls. 11–14.

SAKAGAMI, S. (1958) : Fusulinids from the upper Permian conglomerate of the northern part of Itsukaichi, Tokyo-to, Japan. *Jour. Hokkaido Gakugei Univ.*, vol. 9, no. 2, pp. 72–97, pls. 1–4.

SHENG, J. C. (1963) : Permian fusulinids of Kwangsi, Kueichow and Szechuan. *Palaeont. Sinica, New Ser.* 10, pp. 1–119, 120–247, pls. 1–36.

TORIYAMA, R. (1947) : On some fusulinids from Tosayama, Koti-Ken, Shikoku, with a note on the stratigraphical range of *Neoschwagerina*. *Japan Jour. Geol. Geogr.*, vol. 20, nos. 2–4, pp. 63–82, pls. 16 & 17.

—— (1958) : Geology of Akiyoshi. *Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol.*, vol. 7, pp. 1–264, pls. 1–48.

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|---|---|---|---|
| Fukushi | 福　士 | Niizato-mura | 新里村 |
| Hanawa-mura | 花輪村 | Shimohei-gun | 下閉伊郡 |
| Kitagawame | 北川目 | Toyomane-cho | 豊間根町 |
| Nagasawa | 長　沢 | Wainai | 和井内 |

## Explanation of plate 46

*Colania douvillei* (OZAWA)

Fig. 1. Slightly parallel sagittal section. ×10, UHR 19360.

Fig. 2. Deep parallel section, revealing the development of the axial septula. ×10, UHR 19379.

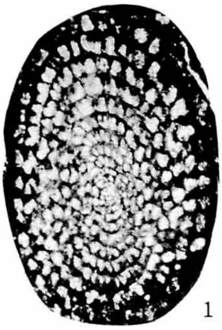
Fig. 3. Tangential section. Note the secondary transverse septula in the outer volutions. ×10, UHR 19356a.

Fig. 4. Enlarged photograph of a parallel section, which shows the especially well developed keriotheca in the wall. ×100, UHR 19356b.

Fig. 5. Enlarged photograph of fig. 3, showing the nature of primary and secondary transverse septula. ×100.

Fig. 6. Parallel section. ×10, UHR 19384.

Locality: Kitagawame, Hanawa-mura, Shimohei-gun, Iwate prefecture, Northern Kitakami Mountains.



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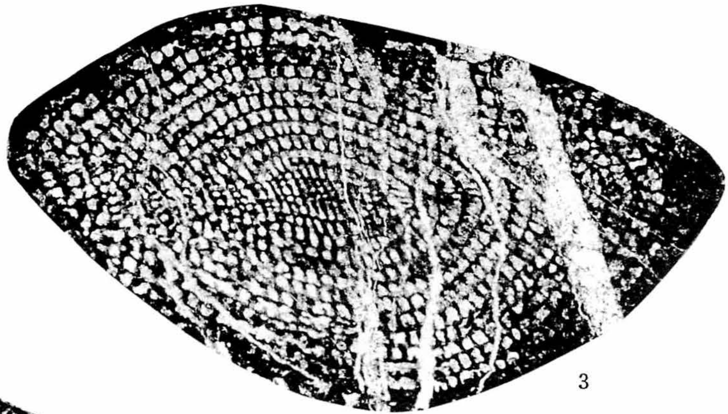

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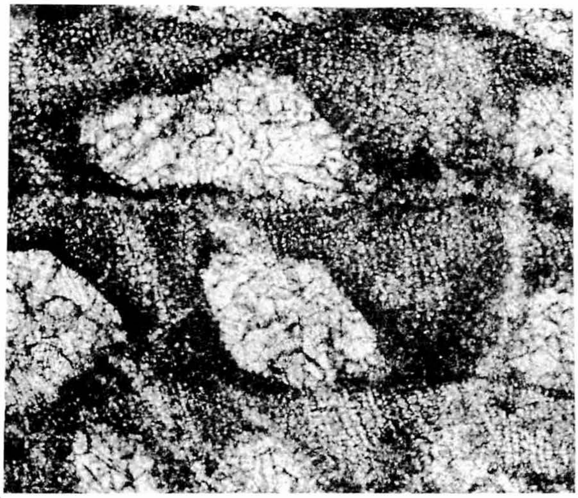

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**Palaeontological Society of Japan Special Papers No. 16—Tertiary Molluscan Fauna from the Yakataga District and Adjacent Areas of Southern Alaska**

By Saburo KANNO. Issued December 25, 1971, 154 pp., 20 text-figs, 18 plates.

Price (postage and handling included) for non-members......................U. S. $ 15.00
for members ..........................U. S. $ 12.00

The paper contains systematic descriptions of 64 genera and 104 species, of which 9 species are new. On the basis of the molluscan fauna the author gives remarks on the geological age, correlation and paleoecology of the faunas. The intimate faunal relationships between southern Alaska and northern Japan-Kamchatka and also Washington-Oregon are stressed.

The special papers are on sale at the Society. Orders must be accompanied by remittance, made payable to Dr. Tatsuro MATSUMOTO, Editor of the Special Papers, Palaeontological Society of Japan, c/o Department of Geology, Faculty of Science, Kyushu University, Fukuoka (Hakata) 812, Japan.

The following backnumbers are on sale at the Society and also purchasable through the University of Tokyo Press, Hongo, Tokyo 113, Japan.

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会　　場：愛媛大学理学部 301，302 号講義室
日　　時：昭和47年10月28日（土） 9時—17時　講演会
17時30分—18時30分　懇親会
10月29日（日） 8時30分—16時30分（国鉄松山駅前解散）野外巡検

〔野外巡検〕
参加人員：申込先着順40名（案内 永井浩三）
目　　的：中央構造線，久万層群（始新統）模式地の検討と二名層化石採集

野外巡検および懇親会（1000円程度）は，準備の都合上**9月末日**までに下記宛申込むこと。

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愛媛大学教育学部地学教室気付
日本古生物学会準備会

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例会当日は同大学において，他の学会なども開催が予定されているため，宿泊申込みはできるだけ早目に，下記の各宿泊所宛に**直接**申込むこと。

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〔以上の他詳細については後日，例会プログラムに付してお知らせします。行事係〕

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**訂正**　報告・紀事第85号294頁のお知らせで，特別号 No. 16 の定価中，郵送・梱包料を300円としてあるのを**200円**と訂正します。

## 例 会 通 知

| | 開催地 | 開催日 | 講演申込締切日 |
|---|---|---|---|
| 110回例会 | 愛媛大学 | 1972年10月28·29日 | 1972年9月20日 |
| 1973年総会·年会 | 東北大学 | 1973年1月19·20日(予定) | 1972年12月10日 |
| 111回例会 | 新潟大学(予定) | 1973年6月下旬 | 1973年5月20日 |

## 国 際 会 議

First International Congress of Systematic and Evolutionary Biology (略称 ICSEB) の開催が予定されている。行事の大略は下記の通りであるが，サーキュラーの送付希望者は HURD 博士宛に直接申込まれたい。

1973年8月4日～12日（巡検は13日にも行われる）
University of Colorado, Boulder, Colorado
Program

1. Symposia
   Species diversity as related to habitat; Ecological substructure of natural communities; Evolutionary biology of populations; Coevolution of animals and plants; Continental drift and its evolutionary consequences; Evolutionary development of form and symmetry; Evolutionary significance of proteins; Computer revolution in systematics; Phylogeny of Protista; Origin and evolution of eucaryotic cells; Ultrastructure, biochemistry, and genetics of Fungi; Numerical taxonomy; Evolution of pheromonal mechanisms.
2. Special interest groups
3. Environmental symposium
   a. Alpine biota, b. desert biota, c. grasslands biota, d. marine biota, e. tropical biota.
4. Contributed papers
   表題および要旨（タイプ用紙1頁以内）の提出は1972年末まで。

Field trips

1973年8月6日から13日まで7班に分けて行われる予定。Boulder 山岳公園や Florissant Fossil Beds などが候補にあげられている。

Dr. Paul D. HURD, Jr., Co-Chairman
Program Committee, ICSEB
Department of Entomology
National Museum of Natural History
Smithonian Institution
Washington, D.C. 20560, U.S.A.

なおセカンドサーキュラーは今秋発行の予定となっている。

◎ 本会誌の出版費の一部は文部省研究成果刊行費による。

1972年6月25日 印刷
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### CONTENTS

TRANSACTIONS