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

## A PALYNOLOGICAL STUDY OF THE PLIOCENE OGINOYA AND LATE MIOCENE HIJIRIKAWA MEMBERS*

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能登半島新第三系産化石胞子・花粉―Ⅲ；鮮新世荻谷層と中新世後期聖川（ひじりかわ）層の花粉学的研究：能登半島に広く分布する新第三系に含まれている化石胞子・花粉について研究を行った。今回はその第Ⅲ報として，能登半島南部に分布する中新世後期の聖川層と鮮新世初頭の荻谷層の一部について，6 層準からの 6 試料について，各層準毎に，化石群集の構成・変化を明らかにし，既報の中新世後期の和倉層・中新世中期の山戸田層からの化石胞子・花粉群集と比較検討し，併せて，聖川層・荻谷層の堆積時の古気候・古地理学的環境，および地質時代についての考察を行った。 藤 則雄

## Introduction

The writer has been studying the fossil pollen grains and spores found from the diatomaceous deposits of Neogene age in the Hokuriku region.

The present article is the third report on the palynological researches of the diatomaceous muddy deposits and treats the spores and pollen grains collected from the Late Miocene Hijirikawa Member distributed in and around Hijirikawa and Kuwanoin, Shio Town, in the central part of the Noto Peninsula.

The scope of the research on the microfossils is the systematic determination of the fossil pollen grains and spores and the reconstruction of the palaeoclimatic condition and palaeoecological environment under which the Hijirikawa Member was deposited, and to make correlation and comparison of the conditions and environment of the Hijirikawa Member with the Wakura, Tsukada, I'izuka and Entsunagi diatomaceous mudstone Members distributed in the northern and central parts of Noto Peninsula.

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Deep gratitude is expressed to Mr. Kôichi NAKAGAWA of the Institute of Earth Sciences, Faculty of Science, Kanazawa University, Kanazawa City, for his advice on the Miocene and Pliocene tectonic movement in the area studied. Sincere thanks are expressed to Emeritus Professor Dr. Wataru ICHIKAWA and Professor Yoshio KASENO both of the Institute of Earth Sciences, Faculty of Science, Kanazawa University, for their valuable suggestions on the diatoms and informations on the biostratigraphy of the area studied.

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## Outline of the Geology

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

In the area north of Mt. Hôdatsu the Neogene deposits which overlie the Hida gneiss complex with unconformity are divisible into seven members in ascending order as follows: the Tsuboike alternation, Shingû conglomeratic sandstone, Tônokuma alternation, Hara sandstone, Hijirikawa mudstone, Oginoya siltstone and Oginoshima sandstone. These members are conformable with one another as shown in the correlation table (Table 1). Each stratigraphical unit is described below, in ascending order.

Table 1. Correlation table of the Neogene diatomaceous deposits distributed in Noto Peninsula, Central Japan. "——": diatomaceous deposits.

| Geological Age | Oil Field in Japan | Hokuriku Region | Hijirikawa – Area | Nakajima – Area | Wakura–Notojima Area | Suzu Area |
|---|---|---|---|---|---|---|
| Pliocene | Shibikawa | Hanyu | | | | |
| | Wakimoto | Himi | Oginoshima<br>Oginoya | | Kojima | |
| Late Miocene | Kitaura | Otokawa | "Hijirikawa" | | Akasaki | |
| | Funakawa | | | "Kasashio" | "Wakura" | "I'izuka" |
| | | | Hara | | glauconite | glauconite |
| Middle Miocene | Onnagawa | Higashibessho | Tonokuma | Hamada | Nanao | "I'ida" |
| | | | Akage | | Akaura | "Hojuji" |
| | | | Shingu | | | Higashiinnai |
| | Nishikurosawa | Kurosedani | | Araya / Kusaki / Yamatoda | Nanahara | |
| | | | | | | Yanagida |
| Early Miocene | Daijima | Iwaine | | Anamizu | Anamizu | Anamizu |

*The Hida gneiss complex:* This gneiss forms the basement the area southwest of Mt. Hôdatsu, and is distributed locally. The rock-facies is mainly biotite hornblende gneiss intercalated with layers of thin crystalline limestone. In the southeastern part of the area studied some light green fluorite veins, which are N25°E in strike, are distributed locally. The gneiss and Neogene deposits are in unconformable or fault contact and generally have a E–W strike.

………… unconformity or fault …………

*The Tsuboike fine-grained sandstone and mudstone alternation Member:* The type locality of this member is the outcrop at Tsuboike in Himi City, Toyama Prefecture. The member consists generally of an alternation of sandstone and mudstone. The sandstone is fine-grained and has yielded the large foraminifer *Myogypsina* sp. This member overlies the Hida Gneiss Group with unconformity and is overlain conformably by the Shingu conglomerate and sandstone Member.

———— conformity ————

*The Shingu conglomerate and sandstone Member:* This unit is distributed in the northern and southern parts of the surveyed area. It is overlain with conformity by the Tônokuma sandstone and mudstone alternation Member. The Shingu Member consists of conglomerate and sandstone, and the conglomerate is composed of angular and/or subangular pebbles derived from the Hida Metamorphic Group distributed in and around Mt. Hôdatsu. The sandstone is a very coarse-grained quartzose sandstone intercalated with many carbonaceous layers.

The upper part of the member generally shows typical graded bedding, and one unit of a graded bed is generally composed of granule and/or pebbles at the base and of mudstone at the top.

The thickness is about 600 meters in the southern part of the area of distribution.

The stratigraphical relation between this member and the basement rocks is a fault, and a conformity with the Tsuboike or Tônokuma Members. The member interfingers with the Tsuchikura sandstone, Shoshigahara sandstone and mudstone alternation and Akage hard shale Members.

…… interfingering with the Shingu Member ……

*The Akage hard shale Member:* This member consists of a black or dark gray very hard tuffaceous (?) shale, alternating with a coarse-grained sandstone and hard shale in the lower part; remarkable banded structure is seen in part.

———— conformity ————

*The Tonokuma alternation Member:* This member is distributed at Tonokuma, Shoshigahara and Oitani, Shio Town, Hakui-gun. The lower part of the member is an alternation of bluish grayish green tuffaceous fine-grained sandstone and mudstone, showing graded bedding in a part; two or three layers of pumiceous tuff are contained in the middle part which consists of sandstone, and the upper part is an alternation of greenish gray fine-grained sandstone and hard mudstone.

The member yielded many marine molluscan fossils as *Acila divaricats* (HINDS), *Cardium* sp., *Clinocardium* sp., *Chlamys crassivenia* (YOKOYAMA), *Cuspidaria* sp., *Dentalium yokoyamai* (MAKIYAMA), *Diplodonta* sp., *Lucinoma annulata* (REEVE), *Macoma* sp., *Natica* sp., *Venericardia* sp., *Volsella* sp. (found from the upper part of the member), and plant fossils as *Fagus* sp., *Ficus* sp., *Salix* sp. (from the lower part).

The member is about 450 meters in thickness at Shoshigahara in the eastern part of the surveyed area and 40 to 70 meters at Hijirikawa, the western part.

———— conformity ————

*The Hara sandstone Member:* This member has been studied by M. MISAWA (1960), and is distributed at Hara, Shingu, Hiradoko, Ebisaka, Ichinoshima and Iwabuchi of Shio Town. The rock-facies is a light green or bluish gray fine- to medium-grained sandstone intercalated with some thin carbonaceous layers which bear bodly preserved plant remains.

The member is about 130 meters in thickness at Shoshigahara in the eastern part, 60 meters at Hijirikawa in the western part, and thins out in the northern part of the area studied.

———— conformity ————

*The Hijirikawa mudstone Member:* The member is distributed widely on the western and eastern sides of the boundary between Toyama and Ishikawa prefectures. Its lower part is a fissile mudstone and upper part consists of a massive diatomaceous mudstone, and there is a very thin medium- to fine-grained tuff layer (ca. 20 cm.) in the middle horizon. The member is characterized in the western area of the prefectural boundary by its northern part being of a massive mudstone whereas the southern part is an alternation of bluish green coarse- to medium-grained sandstone and mudstone. The megafossils are rare in the member, that is, the shaly mudstone of lower horizon of the member yielded only *Lucinoma concentrica* HIRAYAMA. Microfossils such as diatoms, sponge spicules, smaller foraminifers (*Martinottiella communis* and *Textularia* spp.) are common. The member is about 700 meters thick.

——— conformity ———

*The Oginoya siltstone Member:* The member is distributed locally in the northern part of the area drawn in the geological map. The maximum thickness is about 150 meters. The rock-facies is a homogeneous bluish gray very fine-grained sandstone and siltstone. Below the lower limit of the member, there is an intercalation of fine-grained tuff of 20 cm or more in thickness. The member has yielded many foraminiferal fossils as *Elphidium advenum*, *Eponides* spp., and also molluscs, diatoms and sponge spicules.

——— conformity ———

*The Oginoshima sandstone Member:* This member is distributed in the northwestern side of the foot of the hilly mountains in the area studied. The rock-facies is a yellowish brown fine- to medium-grained sandstone in part. The member is 60 to 75 meters in thickness.

The area studied is characterized by many parallel faults extending east to west in general. Consequently, the Neogene members of this area are displaced and partly overturned as verified by the graded bedding. The fault zone developed through successive stages of the upheaval movement of the Hôdatsu mountain block. Intimately related therewith is the development of the Tsuboike and Shingu dome structures. MISAWA (1960) pointed out that during this stage, named the Oginoya-Oginoshima stage, when the members were deposited a remarkable change in the environmental conditions took place, and this probably indicated a new phase of transgression. NAKAGAWA (1968) studied the minor faults in the Miocene members exposed in this area and concluded that they were developed either during or immediately after the deposition of the Shingu Member.

## Palynological Research

### (1) Foreword

As already stated different kinds of diatomaceous deposits occur in Noto Peninsula, and they have yielded abundant microfossils as diatoms, flagellates, pollen grains and spores. The several papers published on the deposits were concentrated to stratigraphical investigations, and no literature has appeared concerning the fossil pollen grains and spores until comparatively recently. The writer has been studying the Neogene system, especially the diatomaceous deposits, and the two previous works (FUJI, 1969a and 1969b) have summarized the palynology of the Miocene Wakura and Yamatoda Members, and the present paper is the third report.

The purpose of the present study is to interpret the significance of the pollen grains and spores from the samples collected from the Late Miocene Hijirikawa Member, mainly in terms of palaeoclimatic condition and palaeogeographical environment. These records are based on the reconstructions gained by the writer during his about ten years palynological researches.

### (2) Sampling

The samples analysed in the investigation were collected by the writer and

Mr. Mineo MISAWA, a student of our University, in the summer season of 1959 and 1960. The sampling localities and stratigraphical horizons of the samples are shown respectively in Figs. 1 and 2. These samples are from the upper part of the Hijirikawa and the lower part of the Oginoya Members and the western slope of the Shingu dome on the northern side of Mt. Hôdatsu.

(3) Preparation of Materials and Method of Study

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

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 City, Japan.

(4) Description of the Pollen Grain and Spore Assemblages

(a) General Statement

A living flora is composed of the species which are adapted to the physical condition and biological phenomena which constitute the environment. But the fossil assemblage of any locality

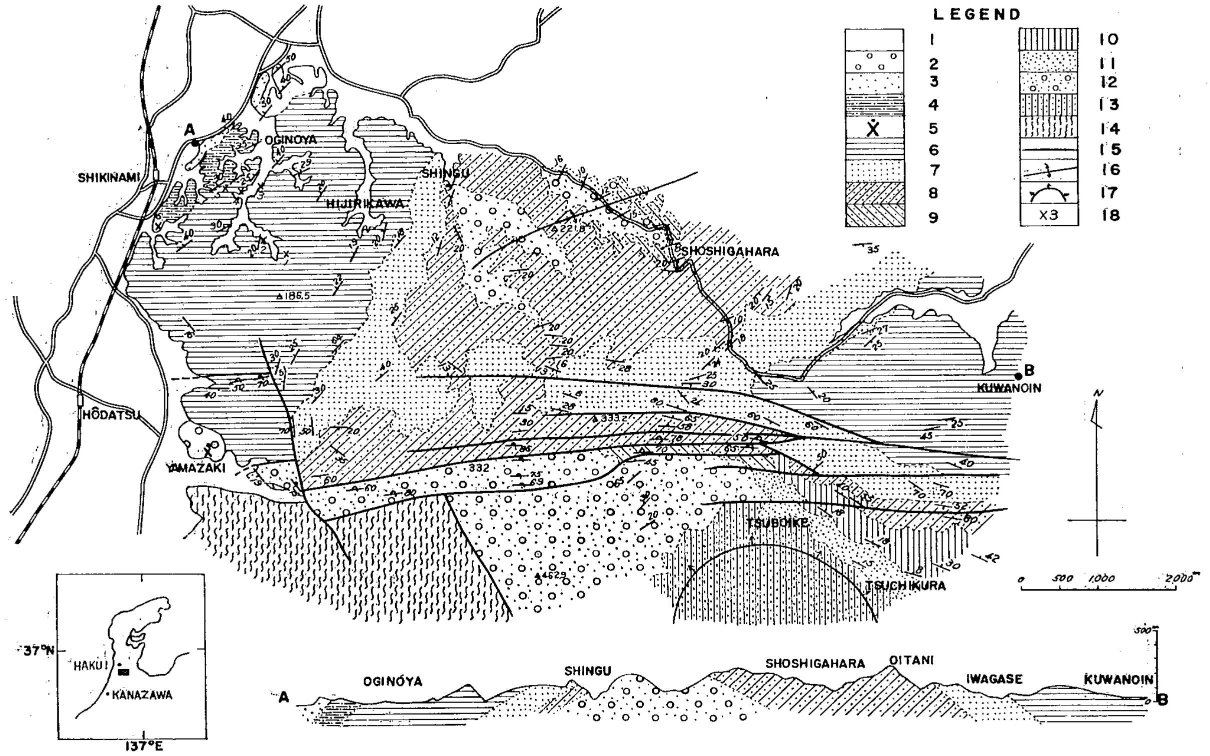


Fig. 1. Geological map of the Hijirikawa area, the southern part of Noto Peninsula, Central Japan (Compiled by N. FUJI, 1968; after M. MISAWA, 1960 MS; N. FUJI, 1963 MS; K. NAKAGAWA, 1968 MS). 1: Holocene deposits, 2: Pleistocene deposits, 3: Oginoshima Member, 4: Oginoya M., 5: Yamazaki mollusc-bearing bed, 6: Hijirikawa M., 7: Hara M., 8: Tônokuma M., 9: Shoshigahara M., 10: Akage M., 11: Tsuchikura M., 12: Shingu M., 13: Tsuboike M., 14: Hida Gneiss Group, 15: fault, 16: anticline, 17: dome structure, 18: sampling localities.

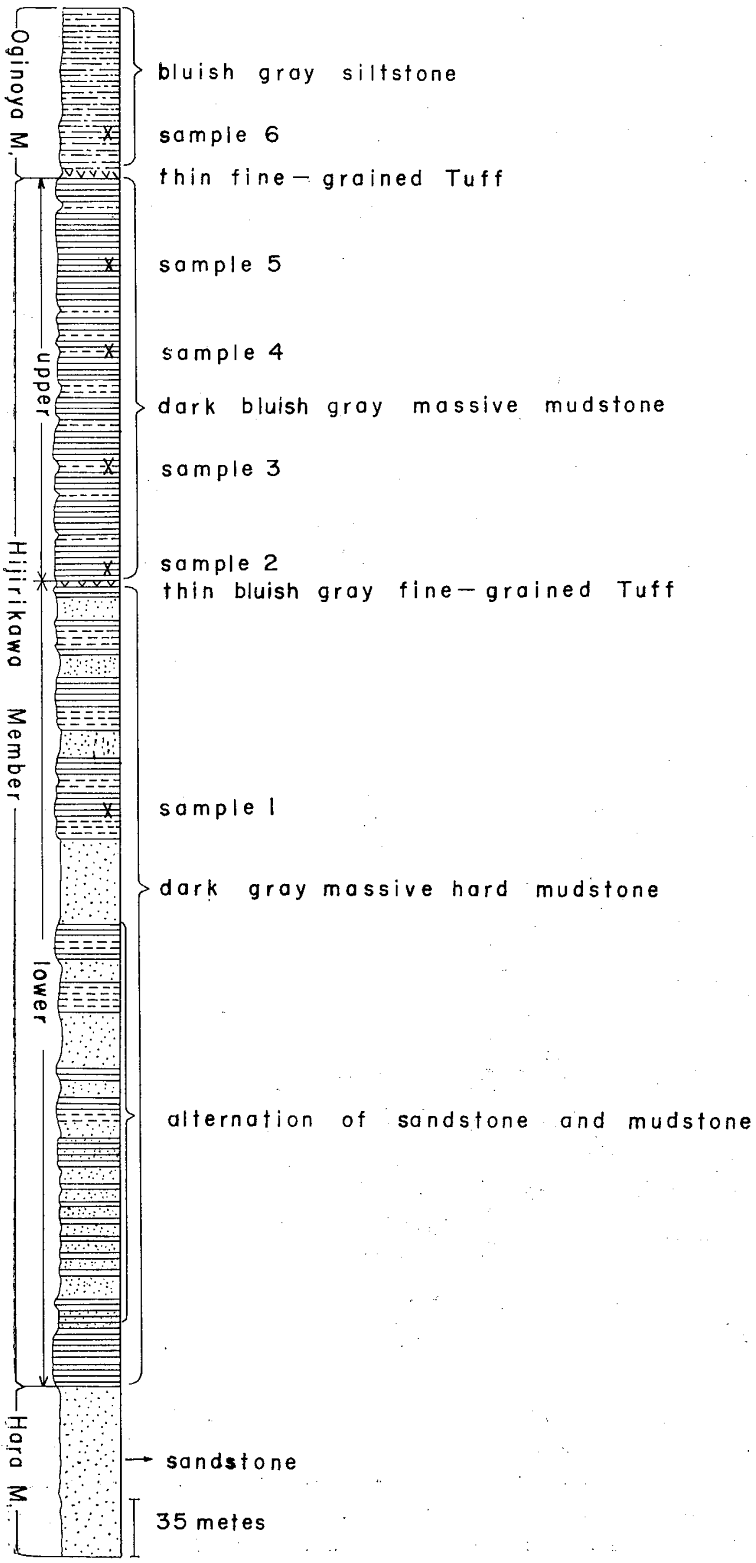


Fig. 2. Columnar section showing the horizons of the samples.

may be the total accumulation composed of a biocoenosis and/or a thanatocoenosis. Therefore, it is necessary to make an analysis of the fossil composition from the viewpoint of the presence or absence, abundancy and distribution of every climatic element to know the palaeoclimatic condition and palaeogeographical environment at the time of deposition.

(b) Stratigraphical Relations of the Samples

The localities of the samples studied are distributed in the present field. The stratigraphical position of these samples can be illustrated as a columnar section and for the sake of convenience are called horizons in this study. Here, the term horizon is used to denote the same or nearly same stratigraphic position or level within the stratigraphic unit.

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

(c) Description of the assemblages

The assemblages of the fossil spores and pollen grains found from the six samples are shown in Figs. 3, 4, 5 and 6.

*Sample* 1 :

The mixed sample is from an outcrop of Locality No. 1 (Fig. 1), where is situated at about 2,000 meters southeast of the Shikinami Station of

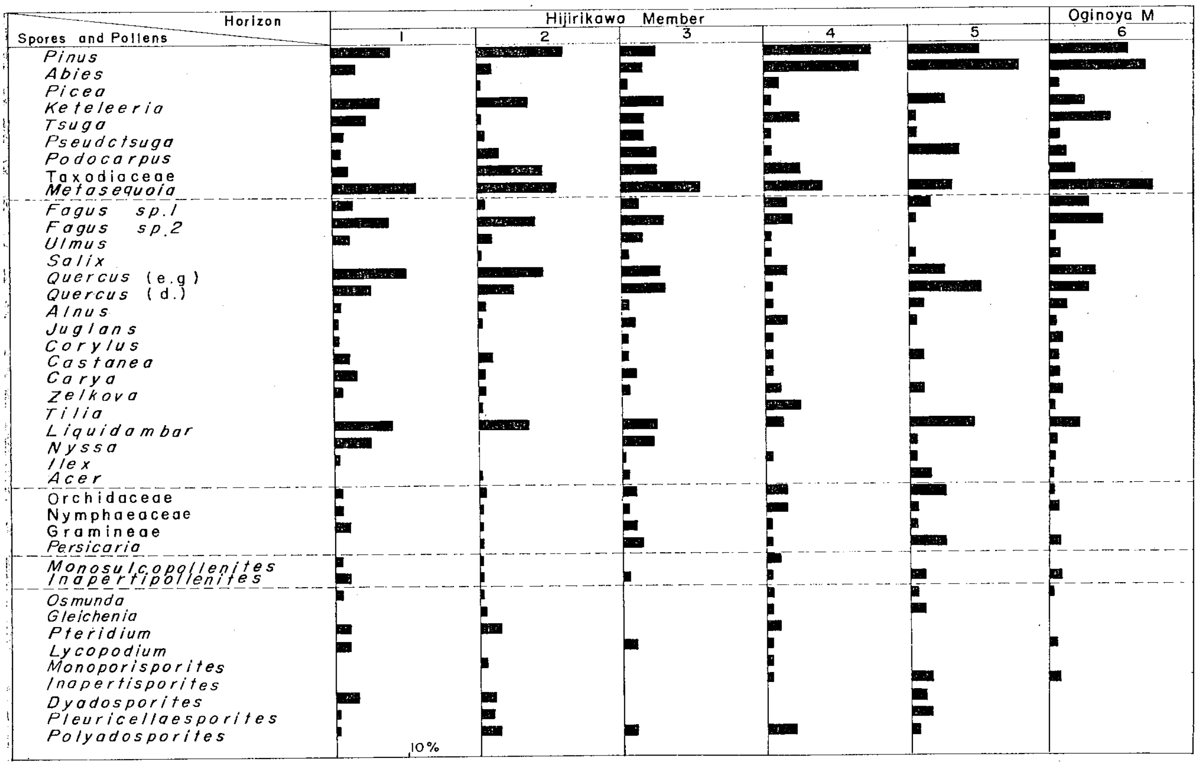


Fig. 3. Pollen diagram (1) of the Hijirikawa and Oginoya Members. Numbers refer to Figs. 1 and 2.

the Japanese National Nanao Railway and about 1,250 meters southwest of Hijirikawa. It belongs to the upper horizon of the lower part of the Hijirikawa Member.

This sample yielded; Gymnosperm-eight genera; Dicotyledon-ten genera and four subgenera; Monocotyledon—three families and one genus; two indeterminable pollen grains, and spores-six genera. Among them, *Metasequoia* is abundant, showing the highest concentration (11.5 per cent) in this composite sample. The Genus *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. *Pinus* and *Liquidambar* are frequent, amounting to more than about 7 per cent. Deciduous *Quercus*, *Nyssa* and *Tsuga* are common, ranging from 4 to 6 per cent. Gymnosperm total 36 per cent, Dicotyledon, Monocotyledon and Pteridophyta are 48 per cent, 4 per cent and 8 per cent respectively.

As shown in some text-figures and tables, plants having different havitats are distinguished among the treated composite sample.

The plants which are distributed in the cold climatic region are denoted by "A" in Fig. 4, and are *Larix*, *Abies*, *Fagus* and *Betula*. *Keteleeria*, *Pseudotsuga*, *Metasequoia*, *Cunninghamia*, *Glyptostrobus*, and *Taiwania*, the evergreen *Quercus* and *Liquidambar* are the representative plants of a warm temperate and subtropical region as denoted by "B" in Fig. 4. *Pinus*, *Tsuga*, and Taxodiaceae without the warm elements above-mentioned, and the deciduous

*Quercus, Zelkova, Ulmus, Salix, Acer, Juglans, Castanea, Tilia,* and *Ilex* are the representative plants of the temperate to cool temperate region as for example the Hokuriku region. They are denoted by "C" in Fig. 4. According to the present analysis, the plants belonging to the element "A" appear with a very low frequency of 6 per cent of the total. On the contrary, the plants of the warmer type denoted by "B" and the cool temperate type "C" are respectively 38 per cent and 56 per cent. The frequency of the spores which certainly belongs to Pteridophyta is as high as that of a ordinary marine deposit, ranging from 8 per cent to 10 per cent. The frequency of the plants distributed widely in the warm temperate and subtropical region and found in the

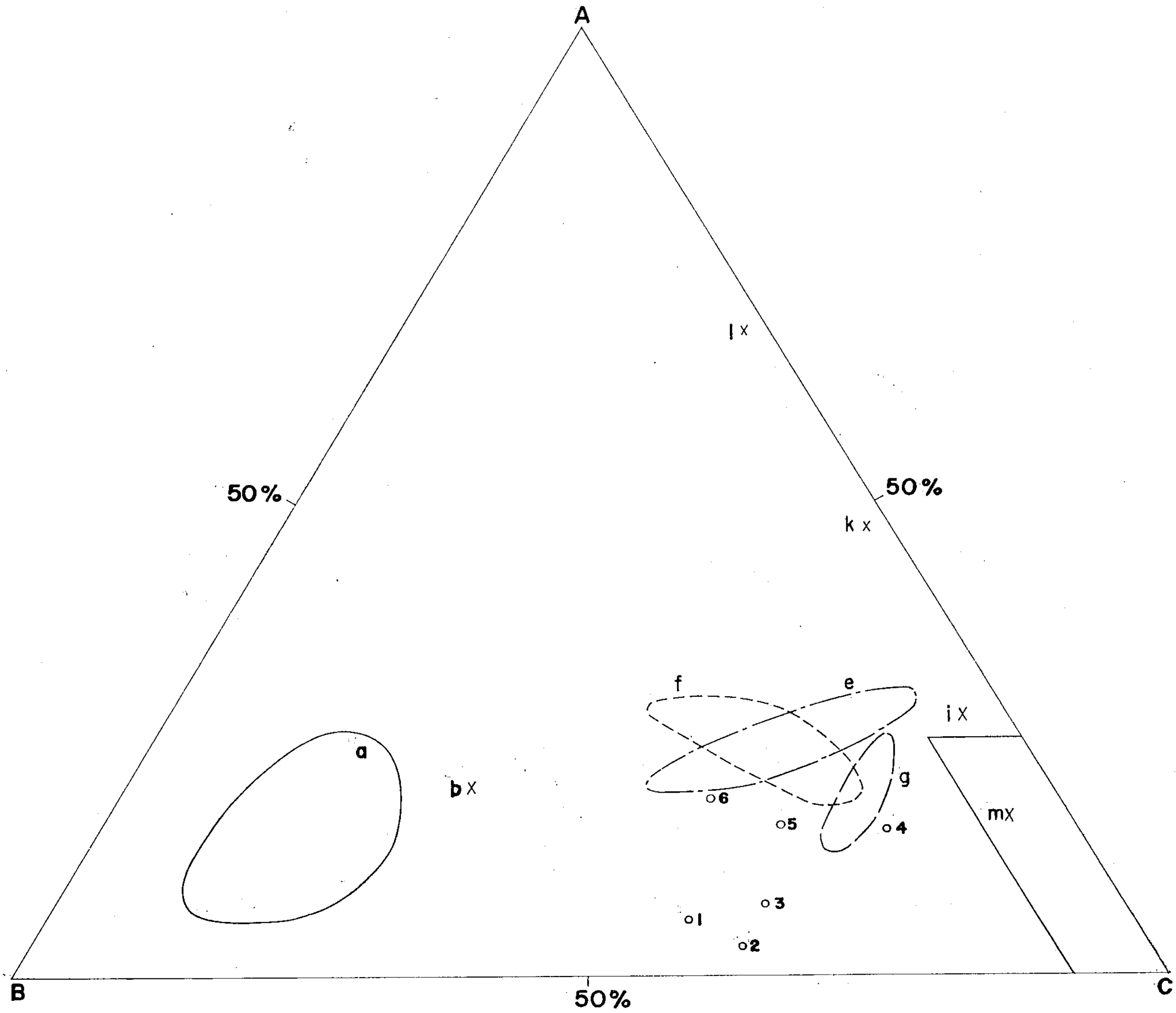


Fig. 4. Pollen diagram (2): Triangular diagram showing the relationship between cold and cool climatic, temperate climatic and warm climatic elements found from several samples of the Hijirikawa and Oginoya Members. Numbers refer to Figs. 1 and 2. a: Yamatoda Member, b: Sunagozaka M., e: Hojuji M., f: I'ida M., g: Wakura M., i: Nakayama-toge M., k: Takakubo M., l: Omma M., 1–5: Hijirikawa M., 6: Oginoya M., m: the present deposits of Hôjozu-gata Lagoon, Toyama Prefecture.

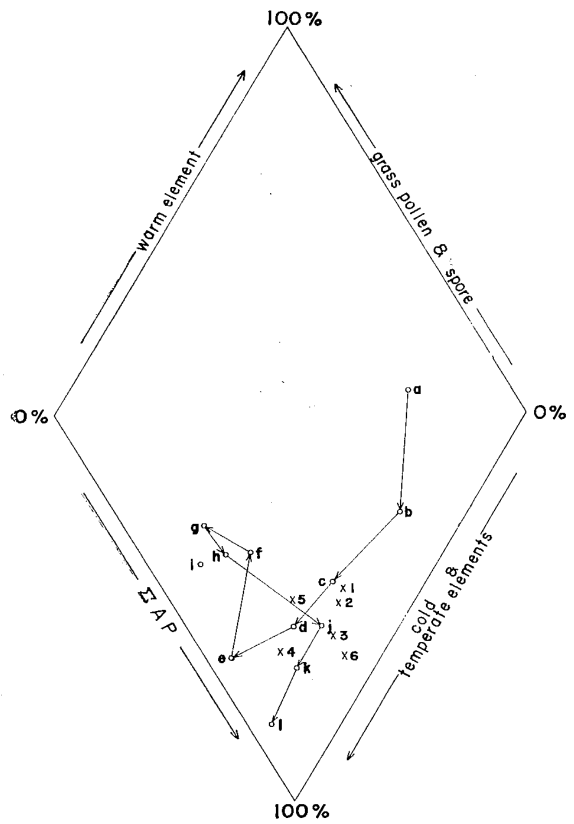


Fig. 5. Pollen diagram (3): Quadrilateral diagram showing the palaeoclimatic condition and palaeogeographical environment during the sedimentation of the Hijirikawa and Oginoya Members. a: Yamatoda Member, b: Sunagozaka M., c: Higashi-'in'nai M., d: Najimi M., e: Hojuji M., f: I'ida M., g: Wakura M., h: I'izuka M., i: Nakayama-toge M., j: Hijirikawa M., k: Takakubo M., l: Omma M., 1–5: Hijirikawa M., 6: Oginoya M.

fossil flora shows the highest ratio among the treated samples, and this is a characteristic feature of the flora.

To facilitate considerations on the ecological environments under which some ancient plants lived, their modern equivalents are grouped into four habitats, namely, upland, mixed-slope, stream-side or riparian, and lake or marshy elements. From the viewpoint of the significant statistics mentioned above the fossil pollen grains and spores can be classified into upland, mixed-slope and stream-side elements, occupying 16 per cent and 27 per cent, respectively.

*Sample* 2:

The composite sample from Locality No. 2, situated at about 1,500 meters southwest of Hijirikawa, was examined for the present study. Locality No. 2 belongs to the lowermost horizon of the upper part of the Hijirikawa Member. The composite sample yielded, Gymnosperm-nine genera (45 per cent); Dicotyledon-ten genera and four subgenera (37.5 per cent); Monocotyledon-three families and one genus (2.5 per cent); spore-nine genera (13 per cent). Among these taxa, *Pinus* is abundant and amounts to 12 per cent of the total frequency, being the highest in the sample. The fossil pollen grain of *Metasequoia* totals 11 per cent. Evergreen *Quercus*, *Keteleeria* and *Liquidambar* are frequent, being respectively 9 per cent, 7 per cent and 7 per cent of the total frequency. All of these genera which are representative plants of a warmer temperate and subtropical regions, are denoted by the component "B", amounting to 35 per cent. The cooler temperate plants denoted by "C" reach 62 per cent of the total. Whereas the other elements amount to only 3 per cent. Deciduous *Quercus* is common, reaching 5 per cent of the total.

On the other hand, with respect to the palaeoecological environment, the upland, mixed-slope and stream-side elements are respectively 15 per cent, 60 per cent and 25 per cent of the total frequency.

*Sample* 3:

This sample is from an outcrop of

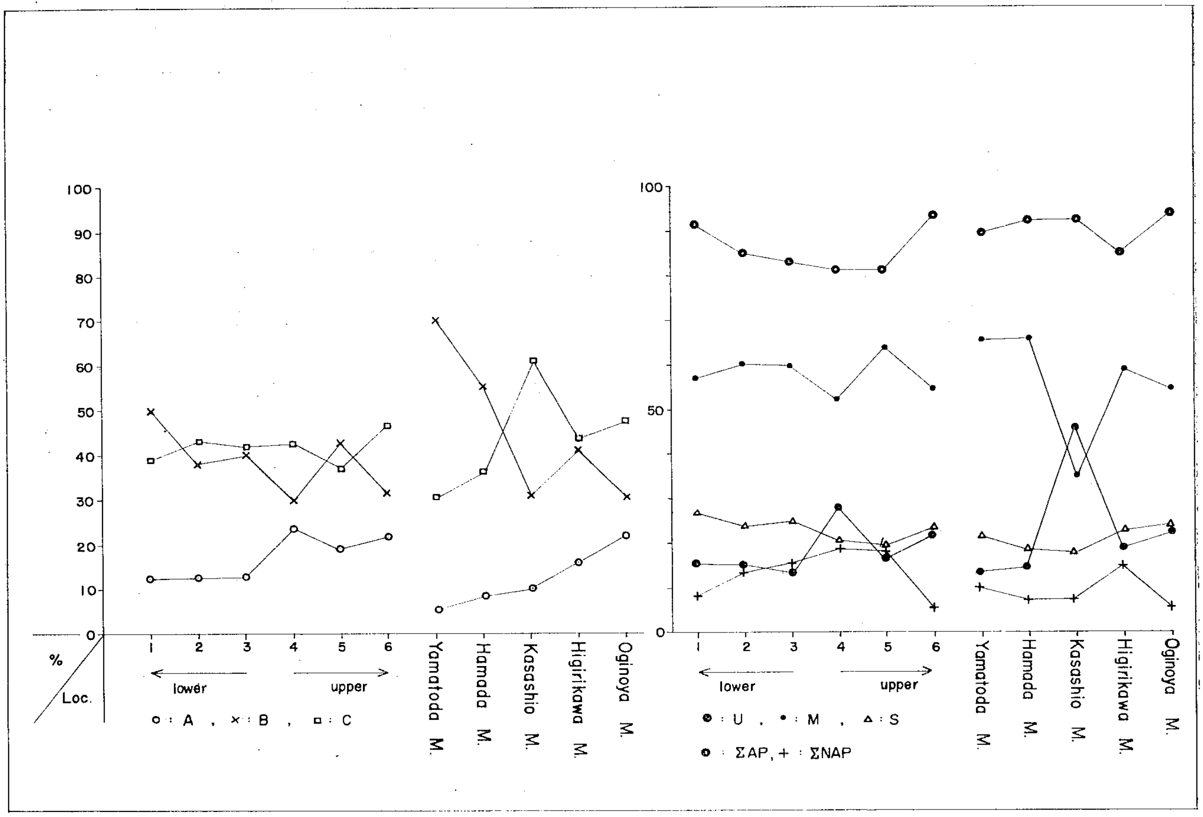


Fig. 6. Pollen diagram (4) showing the relationship between cold and cool climatic, temperate climatic, warm climatic, upland, mixed-slope and riparian elements found from several samples of the Hijirikawa and Oginoya Members.

Locality No. 3 (Fig. 1), situated at about 1,300 meters south of Oginoya. From sample 3, which occupies stratigraphically the lower horizon of the upper part of the Hijirikawa Member, *Metasequoia* is found in 11 per cent of the total frequency. *Keteleeria*, deciduous *Quercus*, *Fagus* sp. 2, evergreen *Quercus*, *Pinus*, *Liquidambar* and *Nyssa* are common, ranging from 4 per cent to 6 per cent. The element "A" amounts to 8.5 per cent, element "B" to 31 per cent, and element "C" to 60.5 per cent.

This sample yielded, Gymnosperm-nine genera (43 per cent of the total); Dicotyledon-14 genera and four subgenera (44 per cent); Monocotyledon-three families and one genus (8 per cent); spore-only two genera, namely, *Lycoposium* and *Polyadosporites* (4 per cent).

And from the viewpoint of the palaeoecological environment, the upland, mixed-slope and stream-side elements amount to 13 per cent, 60 per cent and 27 per cent respectively.

*Sample* 4:

Sample 4 belongs stratigraphically to the middle horizon of the upper part of the Hijirikawa Member, and was collected from an outcrop of Locality No. 4, situated at about 1,300 meters east of the Shikinami Station of the Japanese National Nanao Railway. From this composite sample, *Pinus*, *Abies* and *Metasequoia* belonging to the Gymnosperm (eight genera and one family) were found, they amount about 48 per cent; Dicotyledon-11 genera and four subgenera (30.5 per cent); Monocotyledon-three genera (4 per cent); and two indeterminable pollen grains. Among them, *Pinus* is very abundant, reaching 15 per cent of the total frequency. Its frequency shows the highest concentration in this mixed sample. *Abies* belonging to one of the plants of a cooler or cold region, is abundant, amounting to 13 per cent of the total frequency. *Metaequoia* is frequent, being 8 per cent. *Tsuga*, Taxodiaceae without warm elements, *Fagus* sp. 2, *Tilia* and *Pleuricellaesporites* are common, ranging from, 4 per cent to 6 per cent. The component "A", "B" and "C" are respectively 14 per cent, 13 per cent and 73 per cent of the total. The plants denoted by "C" which are distributed widely in the present cool temperate zone gradually increase in comparison to others as shown in Fig. 3, and on the other hand the warm elements denoted by "B" gradually decrease.

The plants growing in the upland environment amount to 28 per cent of the total frequency, and the mixed-slope and stream-side elements are 51 per cent and 21 per cent respectively.

*Sample* 5:

The composite sample from Locality No. 5, situated at about 1,500 meters south of Oginoshima, occupies stratigraphically the uppermost horizon of the Hijirikawa Member. In the sample, *Abies* is a very abundant, its frequency being 16 per cent. *Pinus* and deciduous *Quercus* are abundant, and *Liquidambar* and *Podocarpus* are frequent, and the other genera are common. Gymnosperm, Dicotyledon, Monocotyledon and spores are respectively 38 per cent, 38.5 per cent, 10 per cent and 11.5 per cent. The A, B and C elements amount to 13 per cent, 25 per cent and 62 per cent respectively. The upland, mixed-slope and riparian plants are respectively 16 per cent, 64 per cent and 20 per cent of the total frequency.

*Sample* 6:

As shown in Fig. 1, the mixed sample was collected from Locality No. 6, at about 1,300 meters east of the Shikinami Station. The sample belongs to the lowermost horizon of the Early Pliocene Oginoya Member. From the composite sample, *Metasequoia*, *Abies* and *Pinus* are abundant in frequency, amounting to 13 per cent, 12 per cent and 11 per cent respectively, namely, the pollen flora of this horizon is represented. By *Metasequoia* and *Abies*. *Tsuga* and *Fagus* sp. 2 are frequent, and the others are common. Gymnosperm, Dicotyledon, Monocotyledon and spores are 52.5 per cent, 37.3 per cent and 7.5 per cent respectively. The A, B and C components amount to 19 per cent, 30 per cent and 51 per cent respectively.

It is noteworthy that the pollen grains of *Liquidambar* are found from this horizon of the Early Pliocene Oginoya Member.

The upland, mixed-slope and stream-side elements are respectively 21 per cent, 55 per cent and 24 per cent.

(5) Discussion

A general interpretation is made of the physical conditions prevailing during the growth of the sedimentary basin in which the flora was found on the basis of an analysis of the fossil spores and pollen grains. In this section, the writer will be given a discussions on the palaeoclimatic condition, palaeogeographical environment and geological age of the stratigraphical units based upon the palynological and field researches.

(a) Palaeoclimatic Condition

From the analysis of the pollen grain and spore assemblages, that is to say, on the basis of the association of their dominant genera and/or species the general characters of the palaeoclimatic condition can be presented. The methods for analysing the assemblages for palaeoclimatic interpretation have been proposed by ERDTMAN (1954), FAEGRI and IVERSEN (1963) and the writer (FUJI, 1969a and 1969b).

According to the writer's investigation, as shown in the triangular diagram (Fig. 4), quadrilateral diagram (Fig. 5), the warm and subtropical plants denoted by "B" in Fig. 4 such as *Liquidambar* and *Metasequoia* found from the Hijirikawa and Oginoya Members are much less than those from the Yamatoda and Sunagozaka Members which corresponded to the Daijima age of the Middle Miocene Epoch in number of specimens, namely the latter contains from 61 per cent to 85 per cent of the total frequency, and the former only 30 per cent to 50 per cent. This result is closely similar to the analytical result on the fossil pollen assemblage from the Hojuji and I'ida diatomaceous mudstone Members (FUJI, 1966) which are situated in the northern part of Noto Peninsula. However, with respect to the cool and cold elements found in the pollen-floras as the Wakura and Yamatoda floras, the elements from the Hijirikawa Member amount to 10 per cent to 24 per cent of the total frequency, though the elements found in the Oginoya Member is 20 per cent of the total frequency.

With respect to the relative frequency of the warm temperate and subtropical climatic elements found throughout the Hijirikawa Member, it can be said that higher the horizon is, the lower the frequency becomes. On the other hand, it is important and interesting that the higher the horizon is, the higher the frequency of the cool and/or cold elements becomes.

Comparison between the fossil plants and the living equivalents whose climatic requirements are known is frequently used for climatic analysis of a fossil flora. Where the modern relationships are known definitely, this method is probably useful for accurate information. The 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. And exotic genera are sometimes common in the fossil flora. The exotic coniferous genera as *Metasequoia*,

Table 2. Modern equivalents of the fossil microplants from the Hijirikawa and Oginoya Members and their modern distribution.

Modern Distribution

1: Saghalien and Kurile Is., 2: Hokkaido, 3: Northern Honshû, 4: Central Honshû, 5: Southwestern Honshû, 6: Kyûshû and Shikoku, 7: Formosa and Loochoo Is., 8: Korea, 9: North China, 10: Central China, 11: Southeastern China, 12: Southwestern China, 13: Manchuria and Primorskaya Prov.

Habitat

U: upland, M: mixed-slope, R: riparian and stream-side

Table 2.

| Fossil microplants | Near fossil macroplants | Modern equivalent macroplants | 1 | Japan 2 | Japan 3 | Japan 4 | Japan 5 | Japan 6 | 7 | 8 | China 9 | China 10 | China 11 | China 12 | 13 | 14 | Habitat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Pinus* | *P. palaeopentaphylla* | *P. parviflora* | | × | × | × | | | | | | | | | | | U |
| *Abies* | *A. protofirma* | *A. firma* | | | × | × | × | × | | | | | | | | | M |
| *Picea* | *P. kaneharai* | *P. polita* | | | | × | × | × | | | | | | | | | U |
| | *P. jessoensis* | *P. jessoensis* | × | × | | | | | | × | | | | | × | | M |
| | *P. koribai* | *P. excelsa* | | | | | | | | | | | | | | × | M |
| *Keteleeria* | *K. ezoana* | *K. davidiana* | | | | | | | × | | | × | × | × | | | M |
| *Tsuga* | *T. aburaensis* | *T. diversifolia* | | | × | × | × | × | | | | | | | | | U |
| | *T. miocenica* | *T. longibracteata* | | | | | | | | | | | | × | | | M |
| *Pseudotsuga* | *P. ezoana* | *P. japonica* | | | | | | | | | | | | | | | U |
| *Podocarpus* | | | | | | | | | | | | | | | | | |
| Taxodiaceae | *Cun. protokonishii* | *C. konishii* | | | | | | | × | | | | | | | | U |
| | *Gly. europaeus* | *G. pensilis* | | | | | | | | | | | × | | | | R |
| | *Met. occidentalis* | *M. glyptostroboides* | | | | | | | | | | × | | | | | M |
| | *Seq. affinis* | *S. sempervirens* | | | | | | | | | | | | | | × | M |
| | *Tai. japonica* | *T. cryptomeroides* | | | | | | | × | | | | × | × | | | U |
| | *Tax. dubium* | *T. distichum* | | | | | | | | | | | | | | × | R |
| *Fagus* | *F. palaeocrenata* | *F. crenata* | × | × | × | × | × | | | | | | | | | | M~U |
| | *F. protojaponica* | *F. serrata* | | × | × | × | × | | | | | | | | | | M |
| *Ulmus* | *U. protojaponica* | *U. japonica* | × | × | × | × | | | × | × | × | | | | × | | R |
| | *U. protolaciniata* | *U. laciniata* | × | × | × | × | | | × | × | × | | | | | | M |
| | *U. subparvifolia* | *U. parvifolia* | | | | | × | × | | | | × | × | | | | M |
| *Salix* | *S. k-suzukii* | *S. jessoensis* | | × | × | × | | | | | | | | | | | R |
| *Quercus* (evergreen) | *Q. protosalicina* | *Q. salicina* | | × | × | × | × | | × | | | | | | | | M |
| *Quercus* (deciduous) | *Q. miocrispula* | *Q. crispula* | × | × | × | × | × | | | × | × | × | | | × | | M |
| | *Q. protodentata* | *Q. dentata* | × | × | × | × | × | | × | × | × | × | | × | × | | M |
| | *Q. protoserrata* | *Q. serrata* | × | × | × | × | × | | | × | × | × | × | × | | | M~R |
| *Alnus* | *A. miojaponica* | *A. japonica* | × | × | × | × | × | | | | | | × | | × | | R |
| | *A. protohirsuta* | *A. hirsuta* | × | × | × | × | × | | | | | | | | × | | M~R |
| | *A. protomaximowicziana* | *A. maximowicziana* | × | × | × | | | | × | | | | | | × | | U |
| *Juglans* | *J. nipponica* | *J. ailanthifolia* | × | × | × | × | × | × | | | | | | | | | R |
| *Corylus* | | | | | | | | | | | | | | | | | |
| *Castanea* | *C. miocrenata* | *C. crenata* | × | × | × | × | × | | | | | | | | | | M |
| *Carya* | *C. miocathayensis* | *C. cathayensis* | | | | | | | | | | × | × | | | | M |
| *Zelkova* | *Z. ungeri* | *Z. serrata* | | × | × | × | × | | × | | | × | × | | | | M |
| *Tilia* | *T. distans* | *T. amuraensis* | | | | | | | | × | × | × | | | | | M |
| | *T. miohenryana* | *T. henryana* | | | | | | | | | | × | × | | | | M |
| | *T. protojaponica* | *T. japonica* | | × | × | × | × | × | | | | | | | × | | M |
| *Liquidambar* | *L. mioformosana* | *L. formosana* | | | | | | × | | | | × | × | × | | | R |
| *Nyssa* | | | | | | | | | | | | | | | | | |
| *Ilex* | *I. cornuta* | *I. cornuta* | | | | | | | | | | × | × | | | | M~R |
| *Acer* | *A. nordenski ldi* | *A. palmatum* | | | × | × | × | × | | | | × | × | | | | M |
| | *A. palaeodiabolicum* | *A. diabolicum* | | | × | × | × | × | | | | | | | | | M |
| | *A. palaeorufinerve* | *A. rufinerve* | | | × | × | × | × | | | | | | | | | M |
| | *A. protojaponicum* | *A. japonicum* | | × | × | × | × | × | | | | | | | | | M |
| | *A. protosieboldianum* | *A. sieboldianum* | | × | × | × | × | × | | | | | | | | | M |
| | *A. prototrifidium* | *A. trifidium* | | | | | | | | | | × | × | | | | M |
| | *A. pseudocarpinifolium* | *A. carpinifolium* | | | × | × | × | × | | | | | | | | | M |
| | *A. submayri* | *A. mono* | | × | × | × | × | × | | × | × | | | × | × | | M |
| | *A. subpictum* | *A. mono* | | × | × | × | × | × | | × | × | | | × | × | | M |

*Glyptostrobus*, *Sequoia*, *Pseudolarix* and *Keteleeria* 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 nearest living equivalents of the pollen-floras from the Hijirikawa Member and their modern distribution in East Asia are shown in Table 2.

According to this table, the Hijirikawa and Oginoya pollen-floras consist mainly of the temperate genera with some warm climatic elements. The dominant genera among the temperate flora are *Alnus*, *Fagus*, *Castanea*, *Quercus*, *Ulmus*, *Zelkova*, *Acer* and *Tilia*. Their modern equivalent species are mostly distributed in the Japanese Islands proper, especially in the northern part of Honshû and Hokkaidô. Further, the pollen-floras from the Hijirikawa and Oginoya Members sometimes contain many exotic conifers such as *Metasequoia* (or *Cunninghamia*, *Taiwania*, *Glyptostrobus*) and *Liquidambar* of the Dicotyledons, though the exotic conifers are not abundant in number of specimens and are rather relicts which survived from the previous Middle Miocene Epoch. Thus, according to the writer's research, the pollen floras from the Hijirikawa and Oginoya Members are composed of mixed temperate and warm elements in floristic composition as already described in the previous part of this work.

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 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.

The Oginoya 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, Early Pliocene, varies by the localities, so that the climate at that time shows local difference. The predominance of beech, deciduous oak, elm, birch found from this flora, provide a basis for concluding that the climate during the Early Pliocene was temperate or rather cooler temperate in most regions of the Noto Peninsula. Furthermore, this pollen-flora has comparatively abundant coniferous trees, and the fact probably indicates that the climatic conditions were rather humid and the temperature not so high during the summer season. On the other hand, several warm climate elements as *Liquidambar*, *Cinnamomum* and *Metasequoia* are considered to have been able to overwinter in the lowland area.

Thus, from the Yamatoda or Sunagozaka (FUJI, 1969b) to the Oginoya pollen-flora the Neogene pollen-floras of the Hokuriku region seem to have gradually changed in their vegetation being first represented by lowland elements that changed to a flora represented by mountain elements without any considerable change of generic association. This may not be due to the elevation of the depositional site, but rather to the increased cooling and aridity of the climatic condition. In consequence of the lowering of the temperature during the Hijirikawa stage, the warm temperate or subtropical plants had gradually migrated to the lowland southern region of

East Asia, whereas, on the other hand, the mountain cool temperate elements seem to have become dominant throughout the Japanese Islands during the Pliocene Epoch according to the present writer's and the other palaeobotanist's studies.

(b) Palaeogeographical Environment

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

The Hijirikawa and Oginoya pollen-floras are in number of specimens mainly composed of mixed-slope or mixed-slope—riparian plants, and also contain upland—mixed-slope plants abundantly. That is, these floras seem to represent a mixed-slope to riparian forest. For instance, in the assemblage from the Hijirikawa Member the mixed-slope plants amount to 60 per cent of the total frequency, the stream-side and/or riparian elements 23 per cent and the remainder belong to the upland elements, and with respect to the Oginoya Member they are respectively 56 per cent, 34 per cent and 10 per cent.

On the other hand, judging from the palynological results, the lithofacies, poor contents of planktonic foraminifers, fossil diatom assemblages and diversity in the thickness of the deposits, the sea under which the Hijirikawa Member was deposited during the Late Miocene seems to have been a strait in the Hakui-Hijirikawa area in the southern part of the Noto Peninsula, though the palaeogeographical environment in the Wakura-Notojima area of the central part of Noto Peninsula was a closed embayment probably connected with the lagoon during that age. The palaeogeographical environment during the Late Miocene Epoch is shown in the palaeogeographical map in Fig. 7.

The frequency of grass-pollen grains and spores, which are denoted by $\Sigma$ NAP in Fig. 6, has been generally concluded to be related to the geographical environments. Accordingly, such presumption on the marine terrain is supported by that the frequency of the grass-pollen grains and spores is about 15 per cent in the Hijirikawa Member and 6 per cent in the Oginoya Member, though the non-arboreal pollen grains and spores found from the Wakura and I'izuka Members range from 36 per cent to 50 per cent and from 46 per cent to 52 per cent respectively. Namely, as shown in the palynological data mentioned above, these data suggest that the sedimentary basin where the non-arboreal pollen grains and spores are abundant in a relative frequency was situated near a land and also was a more or less closed embayment.

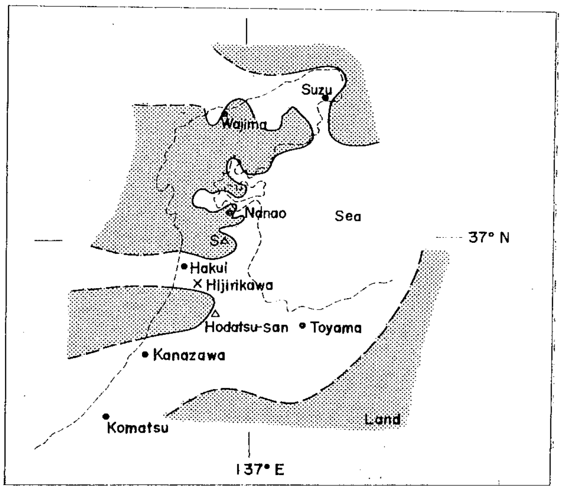


Fig. 7. The palaeogeographical map during the sedimentation of the Hijirikawa Member (the Otokawa stage of Late Miocene age) (After Y. KASENO, 1963).

(c) Geological Age

The correlation and age determination of the Neogene floras have been frequently done by the use of several characteristic fossils and assemblages in the Japanese Islands. On the basis of the researches which have been done by H. YABE, E. KON'NO, S. ENDO, S. OISHI, K. HUZIOKA, H. MATSUO, K. SUZUKI, T. TANAI, and many other palaeobotanists, TANAI classified the Neogene floras of Japan into six types, considering the floristic composition and components, and with the geological ages indicated by them. These types are in ascending order the Ainoura (Earliest Miocene), Aniai (Early Miocene), Daijima (Middle Miocene), Mitoku (Late Miocene to Mio-Pliocene), Shinjô (Early Pliocene) and Akashi (Late Pliocene) types.

The Hijirikawa and Oginoya pollen-floras are very similar in generic composition to the Mitoku-type flora. They contain some exotic elements which are found abundantly in the Middle Miocene Noroshi and Yamatoda floras. These exotic elements are commonly found in the Late Miocene floras of Europe and in the western part of the United States of America, where modernized plants are dominant. Thus, in comparison with various floras of the Neogene in the Japanese Islands and from the viewpoint of the stratigraphical evidences of these two members, the Hijirikawa and Oginoya pollen-floras can be nearly correlated with the Mitoku-type flora.

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## Explanation of Plate 21

Fig. 1. *Picea*, lateral view, 84 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20145.

Fig. 2. *Abies*, oblique lateral view, 104 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20146.

Fig. 3. *Pinus*, oblique polar view, 64 $\mu$; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20147.

Fig. 4. *Pinus*, polar view, a surface pattern structure of grain, 48 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20148.

Fig. 5. *Pinus*, polar view, a surface pattern structure of air-sack, 48 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20148.

Fig. 6. *Pinus*, polar view, 64 $\mu$; Locality No. 3, Oginoya, Shio Town; the lower horizon of upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20149.

Fig. 7. *Metasequoia*, lateral view, 26 $\mu$; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20150.

Fig. 8. *Tsuga*, polar view, 62 $\mu$; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20151.

Fig. 9. *Tsuga*, polar view, 70 $\mu$; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20152.

Fig. 10. *Inapertipollenites* sp., 54 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20153.

Fig. 11. Taxodiaceae, lateral view, 36 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20154.

Fig. 12. *Pleuricellaesporites* sp. a, lateral view; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20155.

Fig. 13. *Pleuricellaesporites* sp. b, lateral view; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20156.

Fig. 14. *Pleuricellaesporites* sp. c, lateral view; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20157.

Fig. 15. *Pleuricellaesporites* sp. d, lateral view, 36 $\mu$; Locality No. 4, Oginoya, Shio Town; the middle horizon of the Hijirikawa Member; EKZJ coll. cat. no. 20158.

Fig. 16. *Pseudotsuga*, lateral view, 92 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20159.

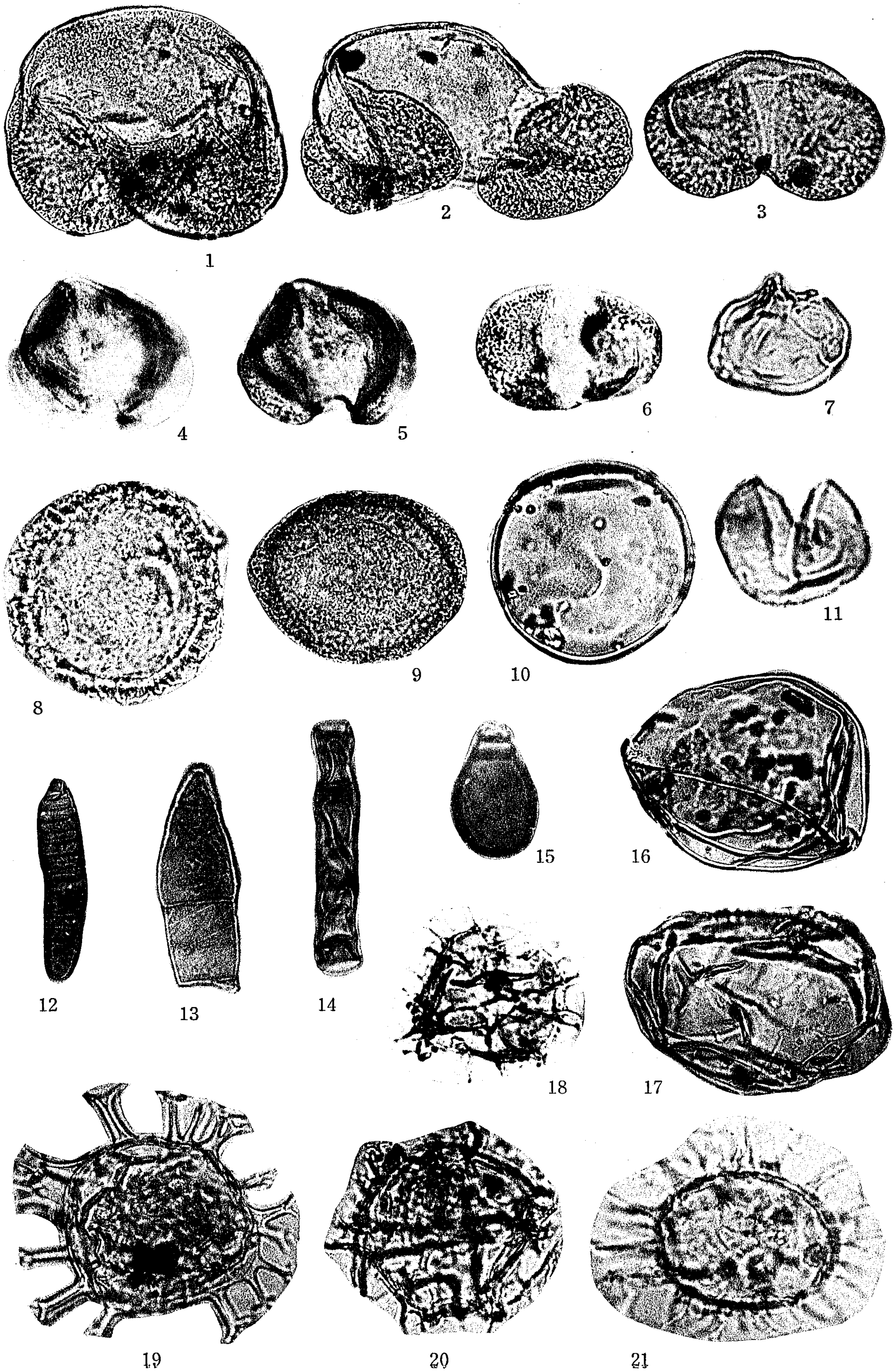
Fig. 17. *Pseudotsuga*, lateral view, 100 $\mu$; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20160.

Fig. 18. *Hysterichosphaeridium* sp., lateral view, 42 $\mu$; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20161.

Fig. 19. *Hysterichosphaeridium* sp., lateral view, 64 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20162.

Fig. 20. *Hysterichosphaeridium* sp., lateral view, 50 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20163.

Fig. 21. *Hysterichosphaeridium* sp., lateral view, 58 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20164.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| Ainoura | 相ノ浦 |
| Akage | 赤毛 |
| Akashi | 明石 |
| Aniai | 阿仁合 |
| Daijima | 台島 |
| Ebisaka | 海老坂 |
| Entsunagi | 縁繋 |
| Hakui | 羽咋 |
| Hara | 原 |
| Hida | 飛騨 |
| Hijirikawa | 聖川 |
| Hiradoko | 平床 |
| Hôdatsu-san | 宝達山 |
| Hojuji | 法住寺 |
| Hokkaidô | 北海道 |
| Hokuriku | 北陸 |
| Honshû | 本州 |
| Ichinoshima | 一ノ島 |
| I'izuka | 飯塚 |
| Ishikawa | 石川 |
| Iwabuchi | 岩渕 |
| Kanazawa | 金沢 |
| Kuwanoin | 桑ノ院 |
| Mitoku | 三徳 |
| Nanao | 七尾 |
| Noto | 能登 |
| Noto-jima | 能登島 |
| Oginoshima | 荻ノ島 |
| Oginoya | 荻ノ谷 |
| Oitani | 老谷 |
| Sakuragaoka | 桜ケ丘 |
| Shikinami | 敷波 |
| Shingu | 新宮 |
| Shinjô | 新庄 |
| Shio | 志雄 |
| Shoshigahara | 所司ケ原 |
| Sunagozaka | 砂子坂 |
| Tônokuma | 当ノ熊 |
| Toyama | 富山 |
| Tsuboike | 坪池 |
| Tsuchikura | 土倉 |
| Tsukada | 塚田 |
| Wakura | 和倉 |
| Yamatoda | 山戸田 |

## Explanation of Plate 22

Fig. 22. *Zelkova*, polar view, 38 $\mu$; Locality No. 1, Hijirikawa, Shio Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20165.

Fig. 23. *Alnus*, polar view, 30 $\mu$; Locality No. 3, Oginoya, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20166.

Fig. 24. *Myriophyllum*, polar view, 37 $\mu$; Locality No. 1, Hijirikawa, Shio Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20167.

Fig. 25. *Carya*, polar view, 48 $\mu$; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20168.

Fig. 26. *Betula*, polar view, 40 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20169.

Fig. 27. *Carya*, polar view, 42 $\mu$; Locality No. 1, Hijirikawa, Shio Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20170.

Fig. 28. *Tilia*, polar view, 27 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20171.

Fig. 29. Cf. *Tilia*, polar view, 31 $\mu$; Locality No. 3, Oginoya, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20172.

Fig. 30. *Liquidambar*, lateral view, 30 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower horizon of the Oginoya Member; EKZJ coll. cat. no. 20173.

Fig. 31. *Alnus*, polar view, 24 $\mu$; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20174.

Fig. 32. *Juglans*, lateral view, 40 $\mu$; Locality No. 2, near Mt. Suemoriyama, Oshimizu Town; the lowermost horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20175.

Fig. 33. Cf. *Juglans*, lateral view, 42 $\mu$; Locality No. 3, Oginoya, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20176.

Fig. 34. *Corylus*, lateral view, 28 $\mu$; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20177.

Fig. 35. *Nyssa*, polar view, 35 $\mu$; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20178.

Fig. 36. *Fagus*, equatorial view, 32 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20179.

Fig. 37. *Fagus*, equatorial view, 30 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20180.

Fig. 38. *Fagus*, oblique polar view, 46 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20181.

Fig. 39. *Fagus*, oblique polar view, 40 $\mu$; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20182.

Fig. 40. *Fagus*, oblique equatorial view, 32 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20183.

Fig. 41. *Fagus*, oblique equatorial view, 42 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20184.

Fig. 42. *Fagus*, oblique polar view, 40 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20185.

Fig. 43. *Quercus* (deciduous), oblique equatorial view, 42 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20186.

Fig. 44. *Quercus* (deciduous), equatorial view, 36 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20187.

Fig. 45. *Quercus* (evergreen), equatorial view, 23 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20188.

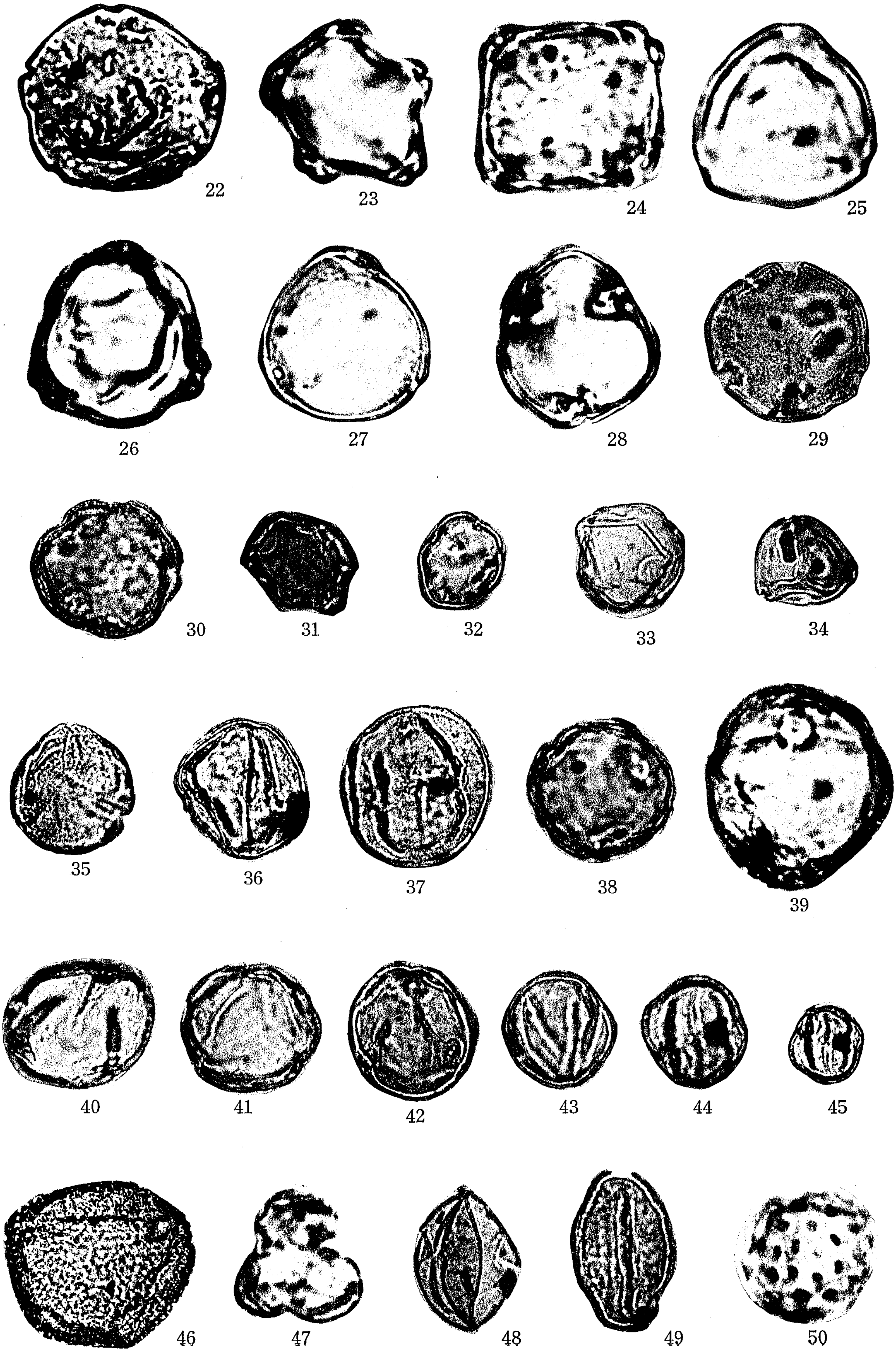
Fig. 46. ? *Tricolporopollenites* sp., polar view, 32 $\mu$; Locality No. 6, Syuku, Oshimizu Town; the lower part of the Oginoya Member; EKZJ coll. cat. no. 20189.

Fig. 47. *Salix*, polar view, 28 $\mu$; Locality No. 4, Oginoya, Shio Town; the middle horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20190.

Fig. 48. *Monoletepollenites* sp., equatorial view, 36 $\mu$; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20191.

Fig. 49. Cf. *Monoletepollenites* sp., equatorial view, 33 $\mu$; Locality No. 5, Shikinami, Shio Town; the upper horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20192.

Fig. 50. *Chenopodium*, equatorial view, 34 $\mu$; Locality No. 1, Hijirikawa, Shio Town; the lower horizon of the upper part of the Hijirikawa Member; EKZJ coll. cat. no. 20193.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