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548. FOSSIL SPORES AND POLLEN GRAINS FROM THE NEOGENE DEPOSITS IN NOTO PENINSULA, CENTRAL JAPAN—I A PALYNOLOGICAL STUDY OF THE LATE MIOCENE WAKURA MEMBER*

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能登半島新第三系産化石胞子・花粉—I；中新世後期和倉層の花粉学的研究： 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1報として，能登半島中央部に発達する中新世後期の和倉含珪藻泥岩層の 16 層準について，各層準毎に，化石群集の構成・変化を明らかにし，併せて，和倉層堆積時の古気候・古地理的環境，和倉層の時代について，くわしい考察を行った。 藤　則　雄

Introduction

Some diatomaceous deposits occur at different stratigraphical horizons in the Tertiary (Neogene) System distributed in the northern and central parts of Noto Peninsula, Ishikawa Prefecture, Central Japan.

The diatomaceous deposits of Noto Peninsula are classified into four horizons, ranging from the Middle to Late Miocene in age. These four horizons differ from one another in their environmental conditions, namely, one is non-marine in origin, whereas the other three are marine. The most conspicuous horizon is represented by the marine diatomaceous mudstone of the Late Miocene age. The diatomaceous deposits in Noto Peninsula are distributed in main three areas of Nanao-Nakajima, Suzu, Wajima areas.

The present writer has been studying the fossil pollen grains and spores found from the diatomaceous deposits of Neogene age in the Hokuriku region since 1960. The present article is the first report on the palynological researches of the diatomaceous deposits and treats the pollen grains and spores collected from the Late Miocene Wakura Member near Nanao City in the central part of Noto Peninsula.

The scope of the investigation based on the microfossils is the systematic determination of the microfossils, the palaeoclimatic condition and palaeogeographical environment under which the Wakura Member was deposited in the Late Miocene. Further, correlation and comparison of the conditions and environment of the Wakura Member with the Hijirikawa, Tsukada and I'izuka diatomaceous Members distributed in the central and northern parts of Noto Peninsula are also undertaken.

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Outline of the Geology

Many diatomaceous mudstones of Neogenes age are distributed widely in the central and northern parts of Noto Peninsula. They are mainly composed of homogeneous silty mudstone characterized with the dominance of fossil microorganisms. In the central part of the peninsula, the diatomaceous deposits are distributed locally, and their rock-facies are variable, especially around Mt. Sekidô-san near Nanao City. In the northern part of Nanao the Neogene deposits which overlie the Anamizu Andesite Group with unconformity are classified into six members in ascending order as follows: the Akaura sandstone, Nanao calcareous sandstone, glauconitic sandstone, Wakura diatomaceous mudstone and Kojima sandstone Members overlain with unconformity by Pleistocene deposits.

These strata are distributed in and around Wakura and in the adjacent areas of Nanao City in the central part of Noto Peninsula. Each stratigraphic units is below, in ascending order.

The Anamizu Formation: This formation is distributed locally along the western coast near Wakura and also in the area south of Okuhara. It is generally classified into two parts, namely, one is of pyroxyne andesite or hornblende pyroxyne andesite, and the other consists of andesitic pyroclastic rocks intercalated with dacitic tuff layers. This formation may be Early Miocene in geological age.

--- unconformity ---

The Akaura sandstone Member: In areas of Nanao, Takahama and Mt. Bijô-zan, an arkose sandstone derived from granite, which may be correlated with the Hida metamorphic complex, is distributed widely. It is named the Akaura sandstone Member near Nanao City. This member consists of a yellowish gray coarse-grained sandstone with granule sandstone showing remarkable cross lamination structures. The member has yielded a fossil mollusc as *Patinopecten kagamianus permirus*. The thickness of this member is about 200 meters.

—— interfigering with the upper part of the Akaura Member ——

The Nanao calcareous sandstone Member: The upper part of the Akaura Member interfigers with the calcareous sandstone, which is named the Nanao calcareous sandstone Member. This member occurs locally at Iwaya, Hosoguchi and Ôsugi-zaki in the limits of

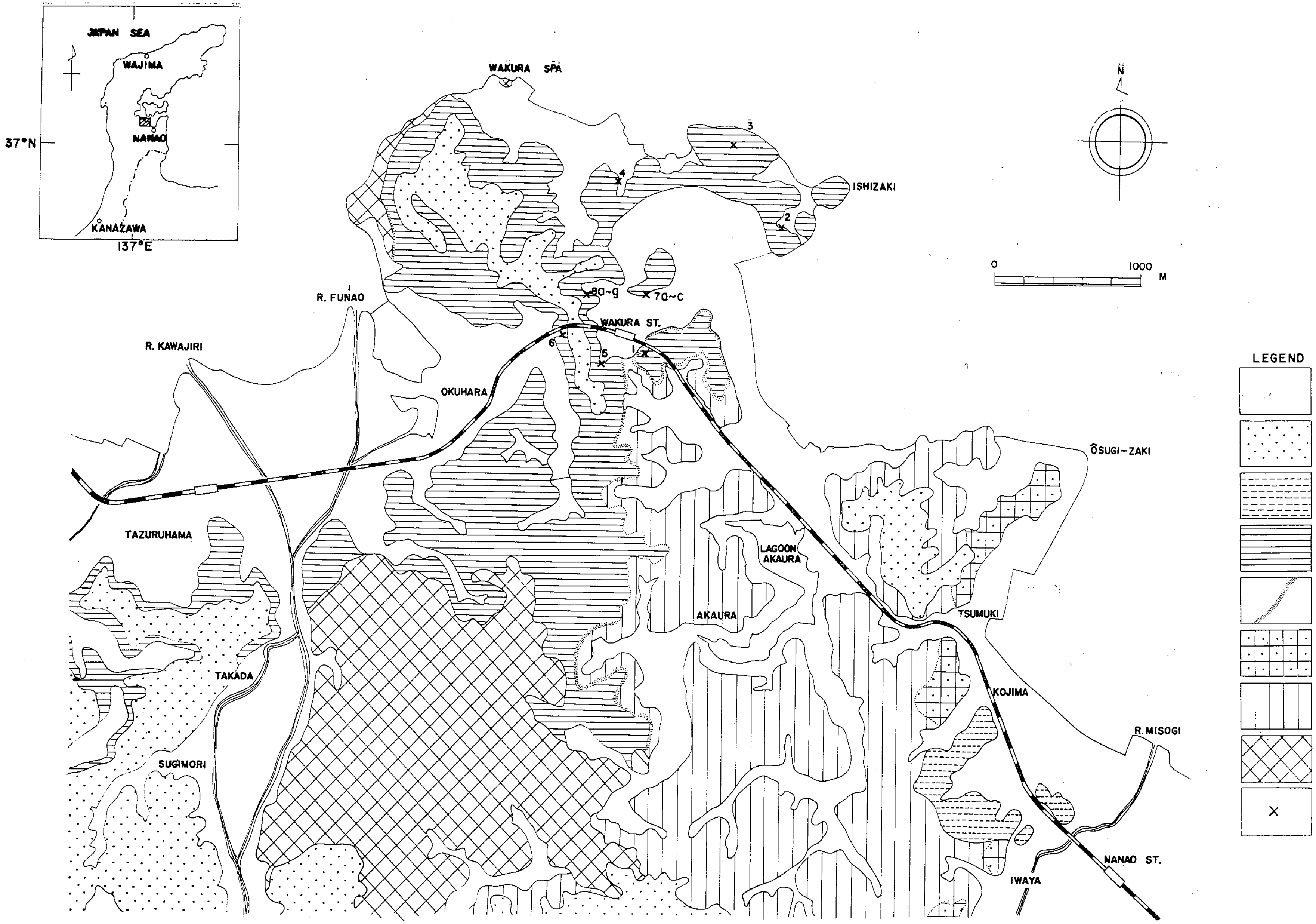

Fig. 1. Geological map of the Nanao area, central part of Noto Peninsula, Japan (Compiled by Y. KASENO, 1963; after N. FUJI, T. AOKI, Y. KITAMURA and HOKURIKU QUATERNARY RESEARCH GROUP). 1: Holocene deposits, 2: Pleistocene deposits, 3: Kojima siltstone Member, 4: Wakura diatomaceous mudstone Member, 5: glauconitic sandstone, 6: Nanao calcareous sandstone Member, 7: Akaura sandstone Member, 8: Andesite and andesitic pyroclastic rocks, 9: sampling localities.

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

Geological Age	Standard stratigraphic division of the oilfields in North Japan	Standard stratigraphic division in Hokuriku Region	Hijirikawa area	Nakajima area	Wakura — Notojima area	Suzu area
Pliocene	Shibikawa	Hanyu				
Pliocene	Wakimoto	Himi	Ogijima Oginoya		Kojima	
Late Miocene	Kitaura	Otogawa	"Hijirikawa"		Akasaki	
Late Miocene	Funakawa	Otogawa	"Hijirikawa" Hara	"Kasashio"	"Wakura" glauconite	"Iizuka" glauconite
Middle Miocene	Onnagawa	Higashibessho	Tonokuma Akage Shingu	Hamada	Nanao calcareous sandst. Akaura	"Iida diatomaceous mudstone member" "Hojuji diat. mst. m." Higashi-Innai
Middle Miocene	Nishikurosawa	Kurosedani	Shingu	Araya / Kusaki / "Yamatoda"	Nanahara	Higashi-Innai Yanagida
Early Miocene	Daijima	Iwaine		Anamizu	Anamizu	Anamizu

Nanao City. Most of the sandstone member consists of granule and coarse-grained sandstone. Fossils are very abundant, namely, sponge spicules, bryozoa, smaller foraminifers as *Nonion pompilioides, Angulogerina hughesi, Cassidulina margareta, Cibicides* sp., *Fissulina* sp., *Lagena apiopleura, Nonion nicobarense, Rotalia* sp., *Uvigerina* sp. etc., molluscs as *Patinopecten kagamianus permirus, Miyagipecten matsumoriensis, Nanaochlamys notoensis, Chlamys crassivenia,* brachiopods as *Terebratella coreanica, T. gouldi, Terebratulina japonica, T. crossei, T. peculiaris, Terebratella nipponensis, Laqueus rubellus, Coptothyris grayi,* and *Hemithyris psittacea* etc. are known to occur.

—— conformity ——

The glauconitic sandstone Member: This member is distributed in the Sakiyama, Nanao and Noto-jima areas. It represents the earlist phase of the Otokawa stage of which age is considered to be the Middle Miocene generally consists of a glauconitic sandstone, in which flinty shale is intercalated and this suggests an interruption of sedimentation or a diastem. These glauconitic sandstones or shales are thought to have been deposited on a shallow sea bottom and they have yielded abundant remains of a silicisponge such as *Aphrocallistes* sp. and a mollusc called *Chlamys crassivenia.*

—— conformity ——

The Wakura diatomaceous mudstone Member: This member has been studied by Takuji OGAWA (1908), Yanosuke OTUKA (1935) and Yoshio KASENO (1963) from the viewpoint of stratigraphy. The Wakura Member is distributed locally in the areas of Wakura, Okuhara and Ishizaki in the northern part of Nanao City. The Entsunagi mudstone Member, which is distributed at Han'no-ura, Suso, Sanami and Kôda of Noto-jima Island near Nanao City, coresponds to this member. The rock-facies is generally a homogeneous yellowish brown on a weathered surface and a bluish gray on a fresh surface diatomaceous mudstone. The fossils from the member are diatoms as *Actinocyclus flos, Actinoptychus senarius, Arachnoidiscus ehrenbergii, Coscinodiscus subtilis, C. lineatus, C. marginatus,* and *Stephanopyxis turris,* sponge spicules and pollen grains. This member is about 80 meters in thickness.

The member developed in the Wakura area forms a small basin structure.

- - - unconformity - - -

The Kojima sandstone Member: The member is developed locally in the mapped area, that is, it is distributed from near Kojima and Iwaya to the northwest of the Nanao Station. This sandstone member overlies with unconformity the Akaura sandstone and Nanao calcareous sandstone Members, and is a light bluish gray or grayish yellow silty sandstone containing abundant remains. Fossil molluscs from the member are such as *Turritella saishuensis motidukii, Neptunea* sp., *Epitonium angulatosimile, Dentalium* sp., *Pecten* spp., *Astarte hakodatensis, Cardium,* sp., and foraminifers as *Angulogerina hugesi.* This member attains about 100 meters in thickness.

- - - unconformity - - -

The Quaternary deposits of this district are classified into five units, namely, the Takashina, Okuhara, Nishiminato, Tokuda gravel Members and Holocene deposits in ascending order.

The Takashina Member which yielded such marine molluscs as *Cerilbideopsilla cingulata, C. djadjariensis* and *Tegillarca granosa* var. in its middle horizon may be correlated with the Kamitako Member (Middle Pleistocene) in the Himi district of Toyama Prefecture. It is noteworthy that the marine environment during the Middle Pleistocene along the Japan Sea coast is well represented in the Takashina Member.

The Okuhara Member including the Wakura-eki shell bed is classified into two members, that is, the lower or mud submember and the upper or sand submember. Marine molluscs as *Scapharca satowi*, *Dosinella penicillata* and *Paphia undulata*, and marine diatoms such as *Coscinodiscus* were found from the lower submember. A study of the deposits reveals that there occurred one major marine transgression which attained a maximum rise of 50 meters above the present sealevel during the Late Pleistocene, probably due to the glacial eustatic movement called the Hiradoko phase in the Hokuriku region. This phase can be correlated with the Shimosueyoshi phase of the Kwanto region, Central Japan.

The Nishiminato Member is divided into two submembers: the lower or mud and upper or sand submembers. The lower part of the mud submember preserves wood stumps and plant remains as *Trapa macropoda*, *Alnus japonica* and *Juglans mandshurica*, which indicate a marsh environment. Molluscs and diatoms of marine origin are found in the upper part of the mud submember, which may be correlated with the lower part of the Okuhara Member.

The Tokuda gravel Member is a nonmarine deposit, the age of which is judged to be the Latest Pleistocene (Würm glacial age).

Palynological Research

(1) Foreword

As already stated different kinds of diatomaceous deposits occur in the Noto Peninsula, and there have yielded abundant microfossils as diatoms, flagellates, foraminiferes, pollen grains and spores. Although several papers have been published on the deposits, there 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 diatomaceous mudstone members, and previous works have been summarized (FUJI, 1964, 1966 & 1968) on the Early Miocene Yamatoda, Middle Miocene Hojuji and I'ida, and Late Miocene Hijirikawa, I'izuka and Nakayama-toge Members.

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 Wakura Member, mainly in terms of palaeoclimatic condition and palaeogeographical environment. These records, which are thought to reflect, in a relative manner in general, the fluctuation of atomospheric temperature in the southern part of Noto Peninsula during the Late Miocene to Pliocene, is based on the criteria gained by the writer during his about ten years palynological researches.

The samples taken by the writer in collaboration with NOHARA and KITAMURA, serve as an example for the application of the criteria for the pollen grains analysis of the samples from Central Japan.

(2) Sampling, Preparation of Materials and Method of Study

Among the samples analysed six (Sample nos. 1–6) were collected by the writer, KITAMURA and NOHARA in the summer season of 1961. The other samples (7a–7c and 8a–8g, ten samples in total) were obtained from two wells drilled for the research of the diatom earth distributed

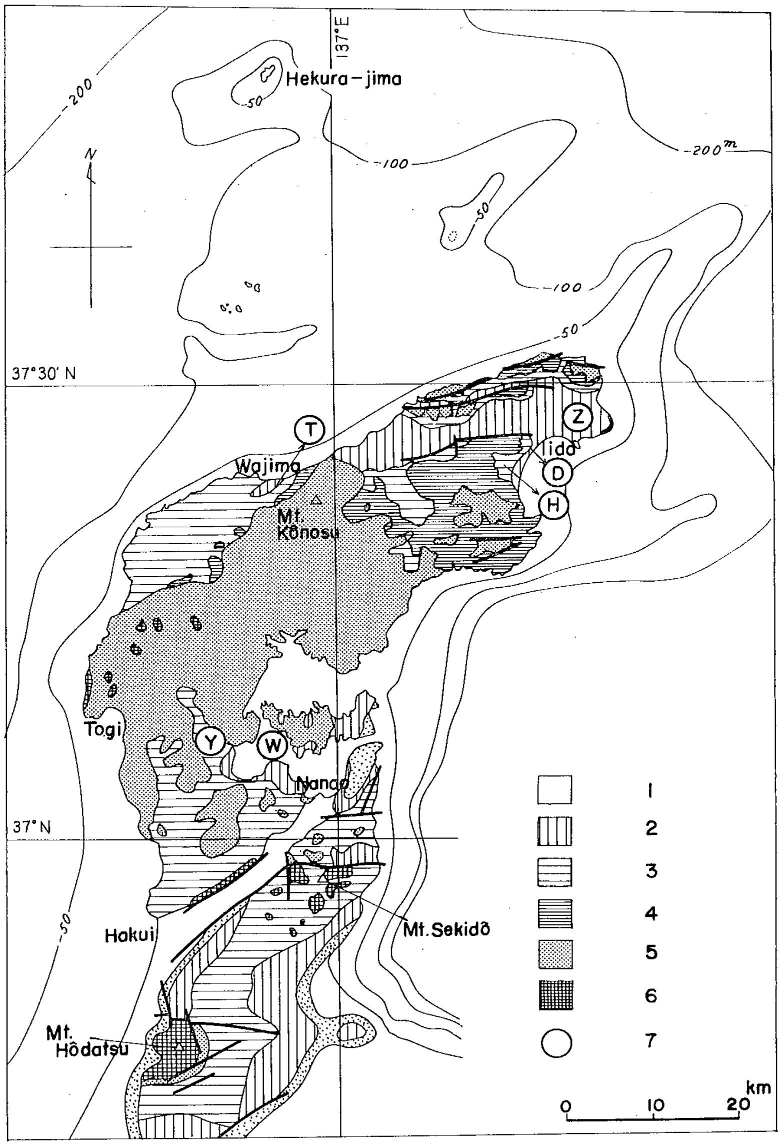

Fig. 2. Geological outline of Noto Peninsula and distribution of diatomaceous deposits (After W. ICHIKAWA & Y. KASENO, 1963). 1 : (denoted by a few spot) Pliocene series, 2 : Upper Miocene series, 3 : Middle Miocene series (sedimentary rocks), 4 : Middle Miocene series (pyroclastic rocks), 5 : Lower Miocene series, 6 : Pre-Tertiary system (granite & gneiss), 7 : diatomaceous deposits : Z : I'izuka Member, T : Tsukada Member, W : Wakura Member, D : I'ida Member, H : Hojuji Member, Y : Yamatoda Member.

widely in Noto Peninsula. The sampling localities and stratigraphical horizons in the Wakura Member are shown in Figs. 1 and 3.

Of the sample collected from 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. These rock pieces were mixed together to form a composite sample, which is taken here to represent the

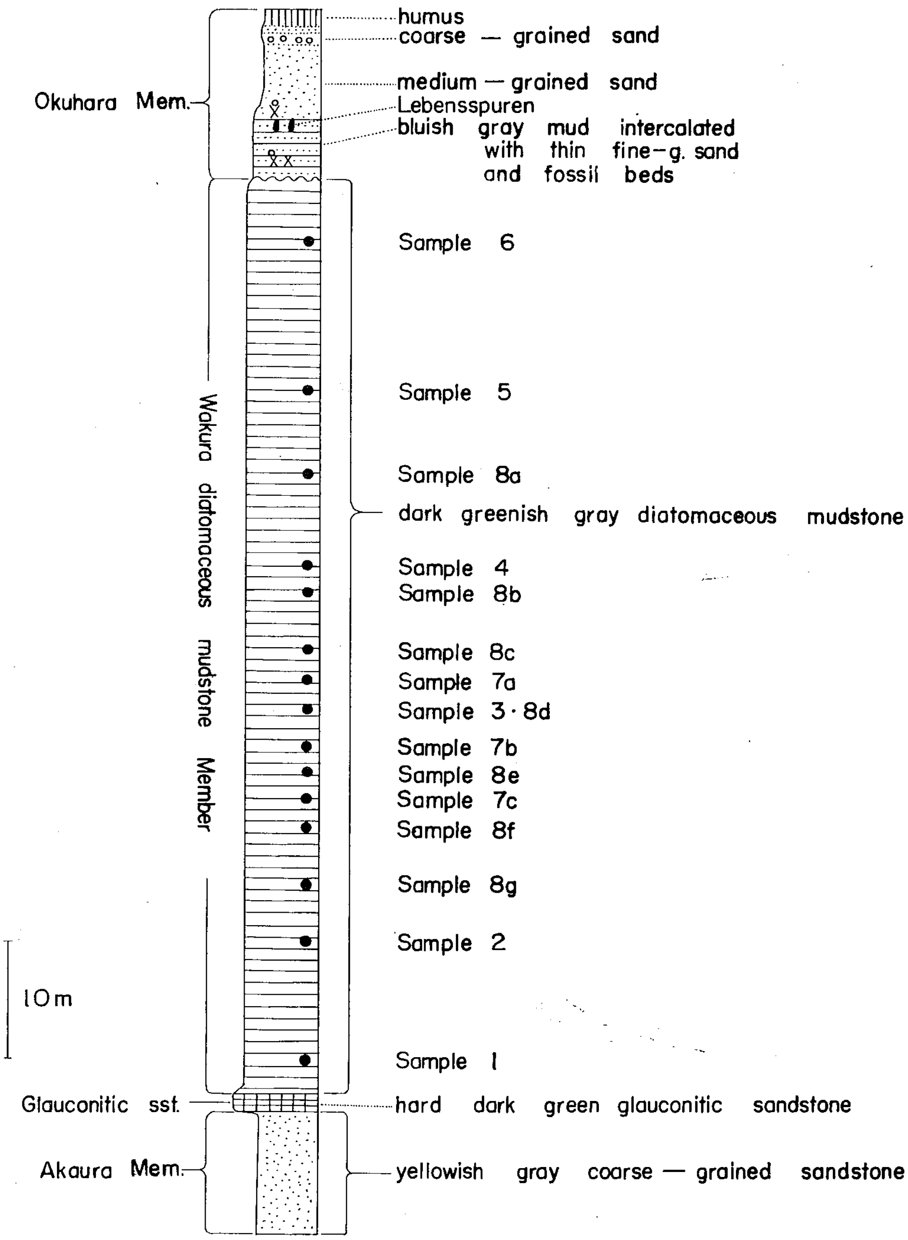

Fig. 3. Columnar section showing the sampling horizons of the Wakura diatomaceous mudstone Member.

outcrop. The present study is based on the composite samples. Many rock samples and separate specimens for reference at the writer's disposal, materially facilitated the present work in checking the distribution and confirming the identification of the pollen grains and spores.

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

To record the position of a specimen in the slide for taxonomical and biostratigraphical studies, Maltwood's finder or England finder were used to register the necessary specimens in this investigation.

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

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

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

(3) Description of the Pollen and Spore Assemblages

(a) General Statement

The present flora is composed of the species which are adapted to the physical phenomena which constitute the environment. But the fossil assemblage of any locality may be the total accumulation composed of a biocoenosis and/or a thanatocoenosis. Therefore, to interpret the geological and palaeoecological significances of the fossil assemblage it is necessary to make an analysis of the fossil composition from the viewpoint of the presence or absence, 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 widely distributed in the present field and the depths from the surface in the wells drilled may be correlated to the exposures on the surface. They can be illustrated as a columnar section and for the sake of convenience are called horizons in this work. 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 work can be classified into 13 horizons shown as the columnarl section (Fig. 3).

(c) Description of Assemblages

The assemblage of the fossil pollen grains and spores found from the analysed 16 samples is shown in Figs. 4-8, and is explained as follows in ascending order.

Sample 1: This sample which belongs to the lowermost horizon of the Wakura Member. It yielded, Gymnosperm-four genera and one family; Dicotyledon-12 genera and two subgenera; Monocotyledon-two families and one genus; and 4 genera of spores. Among them, *Pinus* and Gramineae are abundant, 11% in frequency, being the highest concentration in this composite sample. *Quercus* (evergreen), this genus includes two types, one is of large size and the other of small size based on the diameter of grain, the latter belongs to the evergreen

6%. Gymnosperm appers with a high rate of 23%, and Dicotyledon, Monocotyledon and Pteridophyta are respectively type, and attains 6%. *Juglans* and *Myriophyllum* are common, both being about 46%, 14% and 29%. *Metasequoia*, *Cunninghamia*, *Glyptostrobus*, *Taiwania*, the evergreen *Quercus* and *Liquidambar* are the representative plants of a warm temperate and subtropical region and

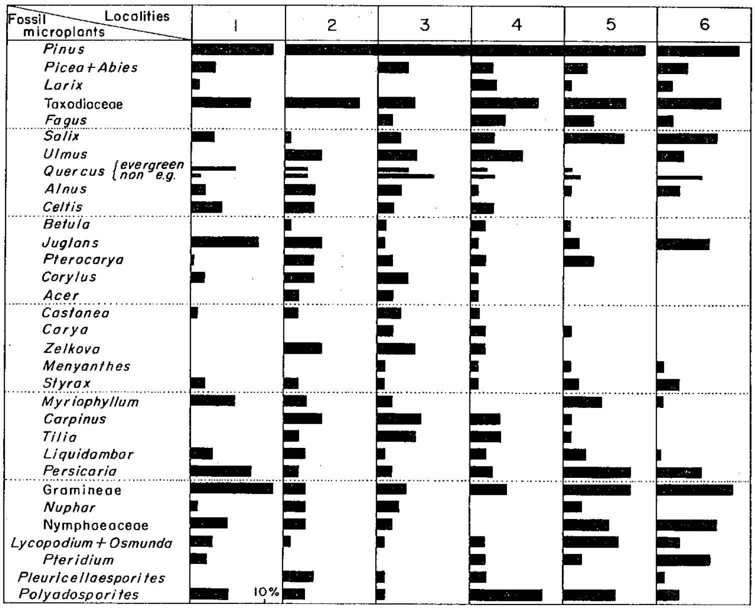

Fig. 4. Pollen diagram (1) of the Wakura diatomaceous mudstone Member. Numbers refer to Figs. 1 and 3.

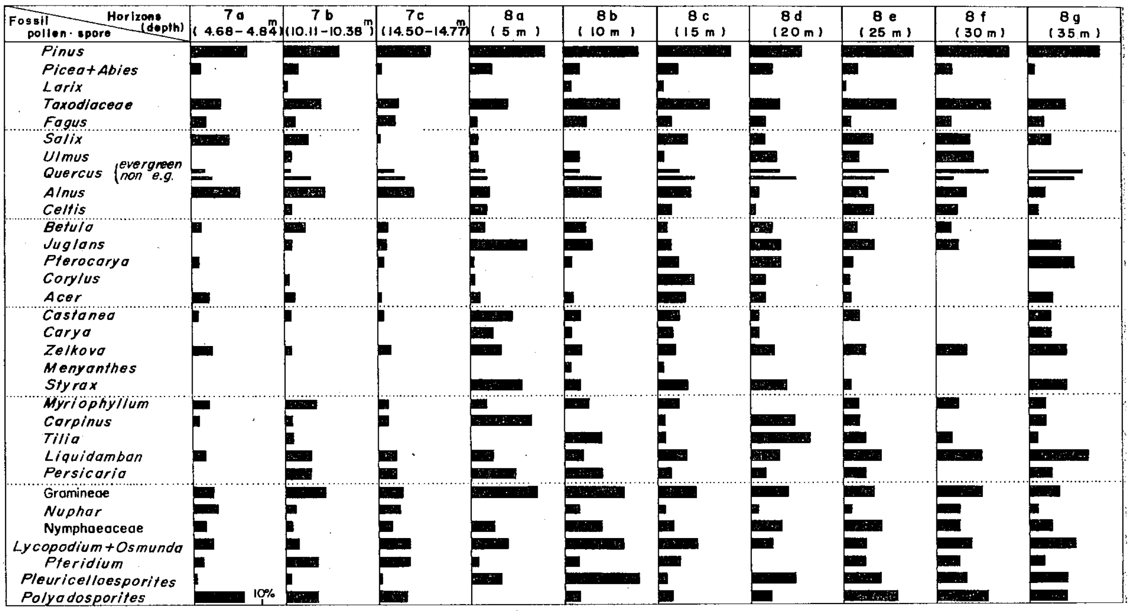

Fig. 5. Pollen diagram (2) of the Wakura diatomaceous mudstone Member. Numbers refer to Figs. 1 and 3.

are denoted by "B" in Fig. 6. *Pinus*, *Tsuga*, Taxodiaceae without the warm elements mentioned above, the deciduous *Quercus*, *Zelkova*, *Fagus*, *Salix*, *Juglans*, *Castanea*, *Tilia* and *Ilex* are the representative plants of the temperate to cool temperate regions analogous with the Hokuriku region (indicated by "C" in Fig. 6). Also admixed in the composite sample are *Abies*, *Picea*, *Fagus*, *Betula* etc., the representative plants of the cooler to cold regions (indicated by "A" in Fig. 6). According to the result, "A" appeared with a very low frequency of 7% in total. On the contrary, the plants of the warmer type denoted as "B" and the cool temperate type "C" are respectively 16% and 77% in frequency. The frequency of the spore which certainly belongs to Pteridophyta is as high as that of an originary marine deposit, being 10%. The frequency of the plants of the warm temperate and subtropical regions gives the highest ratio in the treated sample. The phenomena seem in the composite sample will be explained in later pages on the discussion on the palaeoclimatic condition and palaeogeographical environment.

To facilitate considerations on the ecological environments under which some ancient plants lived, the modern equivalents of the fossil species are grouped into four habitats, namely upland, mixed-slope, stream-side or riparian, and lake or marshy elements. From the viewpoint of the above mentioned significant statistics the fossil pollen grains and spores from this composite sample can be classified into upland, mixed-slope and stream-side elements, occupying respectively 18%, 38% and 44% of the total.

Sample 2: The composite sample yielded one genus and one family of the Gymnosperm (23%), 17 genera and two subgenera of the Dicotyledon (60%), one genus and two families of the Monocotyledon (9%), three genera of the Pteridophyta and two genera of the other groups (1% and 7% respectively). Among them, *Pinus* and Taxodiaceae are abundant (13% and 10% respectively). *Ulmus*, *Juglans*, *Zelkova* and *Carpinus* are common (5% to 6%). The other genera and families are rare in frequency. The boreal elements attain 5%, the temperate ones 87% and the others indicated by "B" in Fig. 6 about 8%.

The fossil pollen grains and spores found from the composite sample are divided into three groups based on the habitat as follows;

upland element..................20%
mixed-slope element 52%
stream-side and/or riparian
element 28%

Sample 8g: The sample was taken from the well drilled at Locality No. 8 situated about 150 meters northwest of the Wakura Station. A depth of the sample is about 35 meters below the present ground surface. The analysed sample contains three genera and one family of the Gymnosperm (16%), 17 genera and two subgenera of the Dicotyledon (66%), two genera and one family of the Monocotyledon (8%), and three genera of the Pteridophyta and two genera of plants lower than Pteridophyta (respectively 8% and 10%).

Among the pollen grains and spores found from the sample, *Pinus* is abundant (10%). It is noteworthy that *Liquidambar* and evergreen *Quercus* as the representative plants of warm elements are 8% and 7% respectively in frequency. The other genera and families are few, ranging from 1% to 6%. The boreal (indicated by "A"), warm (indicated by

"B") and temperate (indicated by "C") elements are respectively 4%, 21% and 75%. As the mentioned previous in the description, the relative frequency of the warm climatic elements obtained from this sample is higher than those from Samples 1 and 2. On the other hand, the upland, mixed-slope, and stream-side and/or riparian elements are 17%, 38% and 45% respectively.

Sample 8f: Although the locality of this sample is similar to that of Sample 8g, its depth is about 30 meters below the present ground surface. This sample yielded three genera and one family of Gymnosperm (16%), 12 genera and two subgenera of the Monocotyledon (12%), and three genera of the Pteridophyta and two genera belonging to another group (8% and 13% respectively). *Pinus*, Taxodiaceae and evergreen *Quercus* are abundant (respectively 10%, 8% and 7.5%). *Liquidambar* is the representative plant of warm element (7%). For this sample the relative frequency of warm components is higher than those from some higher horizons. Namely, the boreal, warm and cooler temperate elements are 9%, 19% and 72% respectively. The upland, mixed-slope and stream-side elements are 21%, 42% and 37% respectively.

Sample 7c: This sample is from the well drilled at Locality No. 7 situated about 100 meters north of the Wakura Station. The depth of the sample is 14.50-14.77 meters below the present ground surface. The sample yielded three genera and one family of Gymnosperm (15%), 13 genera and two subgenera of Dicotyledon (38%), two genera and one family of Monocotyledon (12%), three genera of Pteridophyta and two genera belonging to the plants lower than Pteridophyta which shows 12% and 6% respectively. Among them, *Pinus* is abundant (10%). *Alnus*, *Liquidambar* and *Osmunda* are common, being 6% in every genus. The other genera and families are rare (1% to 4%). *Liquidambar* is the representative plant of warm component but amounts to 3%. The cold or subalpine, warm and temperate elements are respectively 13%, 13% and 74%. The upland, mixed-slope and stream-side and/or riparian elements are 23%, 54% and 23% respectively.

Sample 8e: The sample is from the well drilled at Locality No. 8, and its depth is 25 meters below the present ground surface. The sample yielded four genera and one family to the Gymnosperm (20%), 18 genera and two subgenera of Dicotyledon (54%), two genera and one family of Monocotyledon (10%), three genera of Pteridophyta and two genera belonging to the plants lower than Pteridophyta, attaining respectively 6% and 10%.

The relative frequency of *Pinus*, Taxodiaceae and *Polyadosporites* are 10%, 7% and 6.5% respectively. Evergreen *Quercus*, Gramineae, Nympaceae, *Lycopodium* and *Osmunda* are common (5% to 6%).

The boreal, warm and temperate elements are respectively 9%, 16% and 75%. In connection with the palaeogeographical environment the stream-side and/or riparian, upland and mixed-slope elements are 34%, 52% and 14% respectively.

Sample 7b: From this sample, of which the locality is similar to Lolality No. 7, *Pinus* is abundant, being 10%.

The genera of common frequency are Taxodiaceae, *Alnus*, Gramineae, *Pteridium* and *Polyadosporites*, being about 6% to

7%. *Picea, Abies, Fagus, Salix,* deciduous *Quercus, Betula, Acer, Liquidambar, Persicaria, Nuphar, Lycopodium* and *Osmunda* are of rare frequency, and the other genera are very few. Gymnosperm includes *Pinus, Picea, Abies, Larix* and Taxodiaceae (about 20%). Dicotyledon containing mainly *Alnus, Myriophyllum* and *Liquidambar* etc., Monocotyledon and Pteridophyta respectively 44%, 10% and 8%. The boreal, temperate and warm elements are respectively 16%, 8% and 76%.

The upland, mixed-slope and stream-side components are 18%, 50% and 32% respectively.

It is noteworthy that the relative frequency of the warm climatic elements such as *Liquidambar* and evergreen *Quercus* which occurred from the horizons higher than that of Sample 7b is lower than that of the other horizons. In the horizon lower than that Sample 7b the warm climatic elements show frequency higher than that of the cold and/or cooler climatic elements.

Sample 3: The composite sample is from Locality No. 3, situated at about 500 meters northerneast of the Wakure Station.

Pinus and deciduous *Quercus* are abundant (10% to 12.5%). Taxodiaceae, *Ulmus, Zelkova, Carpinus* and *Tilia* are of common (5%) without *Carpinus* which is about 6% in frequency. The other genera and families are rare (less than 3%).

The cold, temperate and warm climatic elements are 11.7% and 82% respectively. The upland, mixed-slope and riparian and/or stream-side components are respectively 17%, 55% and 28%.

Sample 8d: The stratigraphical horizon of this sample is similar probably to that of Sample 3.

Tilia, Pinus, deciduous *Quercus, Carpinus* and *Pleuricelloesporites* are abundant in relative frequency. The boreal, temperate and warm climatic elements are 11%, 11% and 78% in relative frequency.

In the connection with the palaeoecological environment the stream-side and/or riparian, upland and mixed-slope components are 35%, 10% and 55% respectively.

Sample 7a: This sample, of which the locality is similar to Locality No. 7, yielded: *Pinus* is abundant (10%). The other genera showing a high frequency except for *Pinus* are *Alnus* and *Polyadosporites* (9%). All of the Taxodiaceae, *Salix* and *Nuphar* are common (4% to 6%). *Liquidambar* (2%) represents a warm climate together with the evergreen *Quercus.* All of *Picea, Abies, Fagus* and *Betula,* which grow under a climate cooler than that of the present day Hokuriku region, are 2% in relative frequency. Gymnosperm contains three genera and one family (17%), Monocotyledon has one genus and two families (11%), Dicotyledon comprises 11 genera and two subgenera (57%), Pteridophyta and five other genera, amount to about 15%. The warm, temperate and cold climatic elements are respectively 7%, 83% and 10%. In respect to the palaeoecological environment, the upland, mixed-slope and stream-side components are 21%, 51% and 28% respectively.

Sample 8c: With respect to the assemblage of specimens found from this sample which is from about 15 meters below the present ground surface in Locality No. 8, the Gymnosperm containing four genera and one family (20%); the Dicotyledon 20 genera and two subgenera (61%), the Monocotyledon one genera and two families (8%), and the Pteridophyta and the others amount to 11%.

The warm, temperate and cold climatic components are 9%, 81% and 10% respectively, and the upland, stream-side and/or riparian and mixed-slope elements respectively 14%, 32% and 54%.

Sample 8b: This sample yielded twenty two genera, two subgenera and three families; namely, four genera and one family of Gymnosperm (20%); Monocotyledon one genera and two families (15%); Dicotyledon 16 genera and two subgenera (43%); Pteridophyta three genera (10%) and the other group gave a frequency of 12%. The boreal climatic plants such as *Picea*, *Abies*, *Larix* and *Betula* amounted to 16%, the plants which grow in the temperate climatic region 76% and the warm climatic elements 8%. With respect to the palaeoecological environment the upland, mixed-slope and stream-side or riparian elements are respectively 17%, 58% and 25%.

Sample 4: The mixed sample from Locality No. 4, where situated about 1 km north of the Wakura Station, belongs to the middle horizon of the Wakura Member.

This sample yielded four genera and one family of the Gymnosperm (27% in total frequency), 19 genera and two subgenera of Dicotyledon (46%), one genus of Monocotyledon (5%), three genera of Pteridophyta (4%) and two genera of the other lower plants.

Among the pollen grains and spores from the sample, *Pinus* is abundant (13%), deciduous *Quercus* and *Carpinus* are common (7% and 6% respectively), and the others are rare or few (1% to 5%).

The boreal (A), warm (B) and temperate (C) climatic elements are respectively 24%, 7% and 69%. And also, the upland, mixed-slope and stream-side components are respectively 19%, 55% and 26%.

Sample 8a: The sample is from the well drilled at Locality No. 8 situated northwest of the Wakura Station. The depth of the sample is some 5 meters below the present ground surface.

Among the pollen grains and spores found from the sample, Gymnosperm attains 18%, Monocotyledon 12%, Dicotyledon 54%, Pteridophyta 12% and the others 4%. *Pinus*, Gramineae and *Carpinus* are abundant (8% to 10%); *Juglans*, *Castanea*, *Stylax* and *Persicaria* are common (6% to 8%); the boreal, warm and temperate elements are respectively 8%, 7% and 85%, and the stream-side and/or riparian, mixed-slope and upland elements are 44%, 42% and 14%. It is noteworthy that the stream-side and/or riparian components such as *Salix*, *Celtis*, *Juglans*, *Pterocarya*, *Styrax* and *Liquidambar* etc. are more common than the mixed-slope and upland elements.

Sample 5: The mixed sample is collected from Locality No. 5 at about 200 metres south of the Wakura Station. This sample belongs to the middle part of the upper horizon of the Wakura Member.

The upland, mixed-slope andstre amside elements are respectively 20%, 35% and 45%. The cold, warm and temperate climatic elements contain 18%, 7% and 75% respectively.

The Gymnosperm including *Pinus*, *Picea*, *Abies* and *Larix* (23% in relative frequency), Monocotyledon (18%), Dicotyledon (42%), Pteridophyta (10%) and others (7%) are found. *Pinus*, Taxodiaceae, *Salix*, *Persicaria* and Gramineae represent the pollen-flora of Sample 5.

Sample 6: The mixed sample from Locality No. 6, where situated at about 500 meters west of the Wakura Station, belongs to the uppermost horizon of the Wakura Member. At this locality the Pleistocene Okuhara Member overlies with unconformity the Wakura diatomaceous mudstone Member and was analysed for a palynological research. The Wakura-eki shell bed (NI'INO & YAMADA, 1946) occupies the lower part (mudstone in rock-facies) of the Okuhara Member. The horizon of this Sample 6 is just under to the unconformity separating member mention ed above.

The pollen-flora of Sample 6 is represented by *Pinus*, Gramineae, Taxodiaceae and *Salix* (11%, 10%, 8.5% and 8% re-

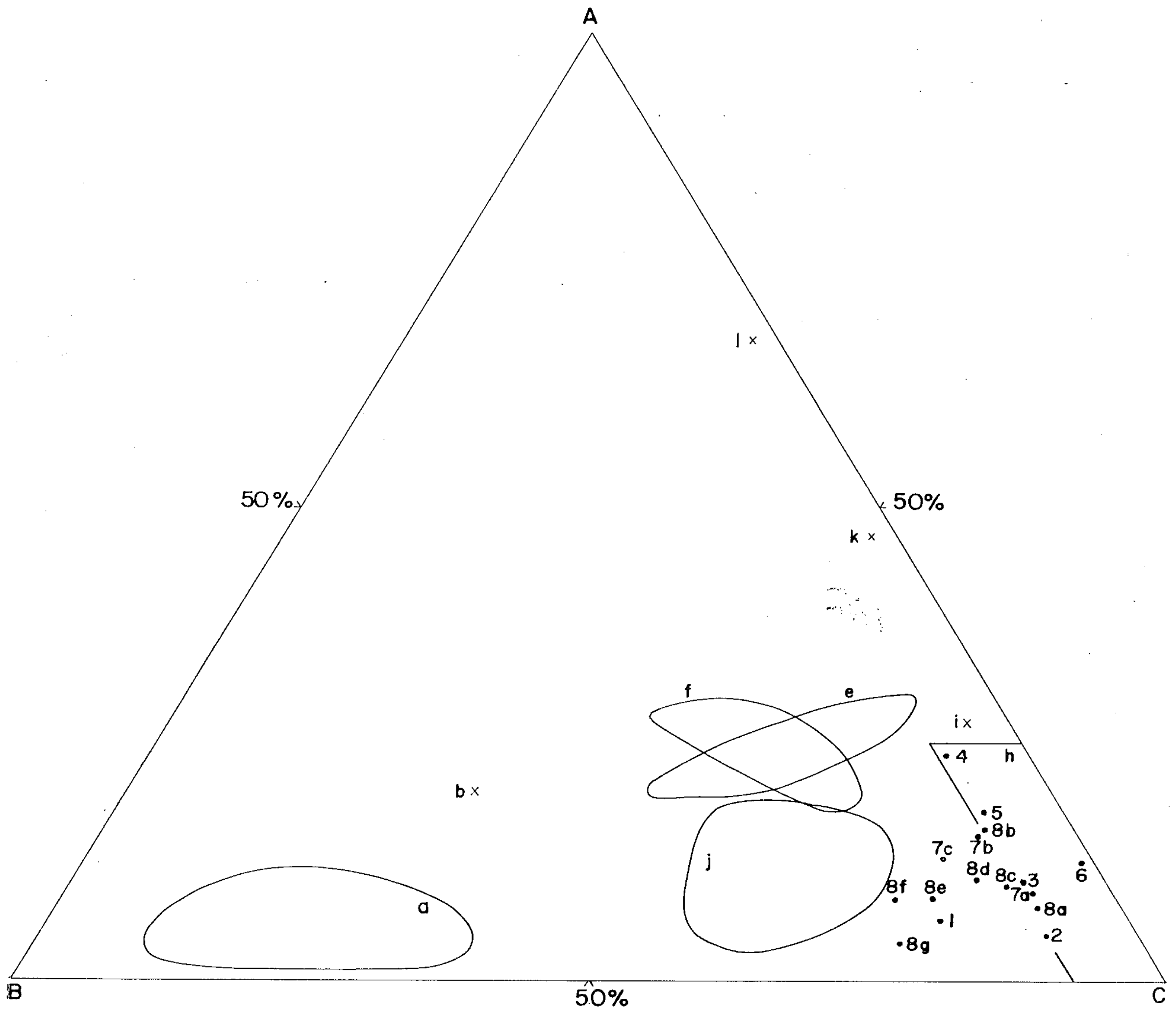

Fig. 6. Pollen diagram (3): Triangular diagram showing the relationship between cold & cool climatic, temperate climatic and warm climatic elements found from several samples of the Wakura diatomaceous mudstone Member. Numbers refer to Figs. 1 and 3. a: Yamatoda Member, b: Sunagozaka Member, e: Hojuji Member, f: I'ida Member, h: present deposit of Lagoon Hojozu-gata, i: Nakayama-toge Member, j: Hijirikawa Member, k: Takakubo Member, l: Omma Member. A: cold & cool climatic element, B: warm climatic element, C: temperate climatic element.

spectively). The Gymnosperm (one family and four genera in this sample) attains 24.5%, Monocotyledon (two families 18%, Dicotyledon (ten genera and one family) 43.5%, Pteridophyta (three genera) 10% and the other (two genera) 4%.

In respect to the palaeoecological environment, the upland, mixed-slope and stream-side and/or riparian elements are respectively 18%, 42% and 40% in relative frequency.

(4) Discussion

From analysis of the pollen grains and spores a general interpretation can be made of the physical conditions prevailing during growth of the sedimentary basin in which they were found. In this section, the writer will discuss on the palaeoclimatic condition, palaeographical environment and geological age of the stratigraphical units based upon the microfossils.

(a) Palaeoclimatic Condition

The pollen grain and spore assemblages have been analysed and from the results the general characters of the palaeoclimatic condition can be presented. The methods for analysing assemblages for palaeoclimatic interpretation have been developed by ERDTMAN, FAEGRI and IVERSEN, besides palynologists, and the writer has used another method for palaeoclimatic analysis of his palynological researches on the Neogene Tertiary and Holocene deposits developed along the coastal region of Japan Sea, and reported that the results agreed well with the climatic indications deduced by the other methods (FUJI, 1964 & 1966). The methods used by the present writer are classified into a warmth index, triangular and/or quadrilateral diagrams.

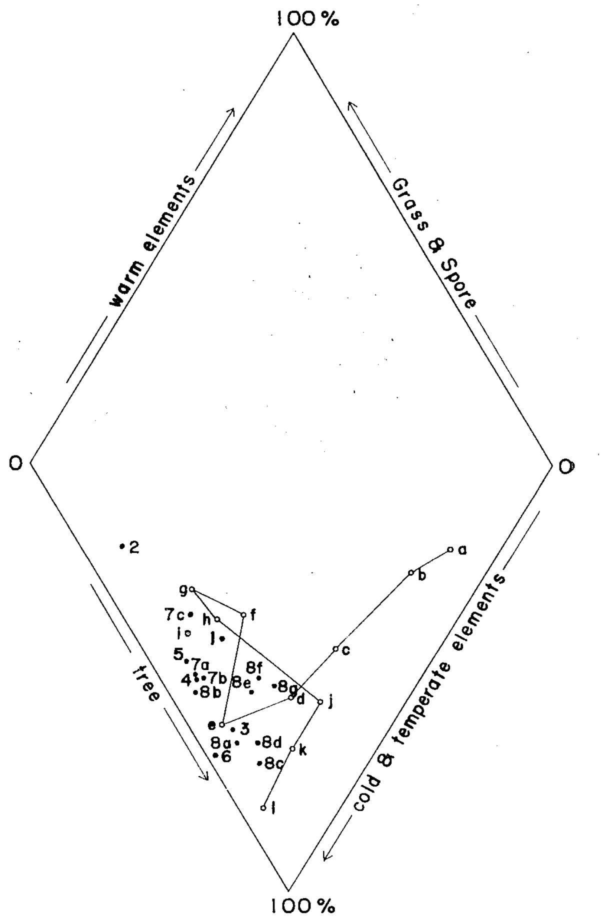

Fig. 7. Pollen diagram (4): Quadrilateral diagram showing the palaeoclimatic condition and palaeoecological environment during the sedimentation of the Wakura diatomaceous mudstone Member. Numbers refer to Figs. 1 and 3. a: Yamatoda Member, b: Sunagozaka Member, c: Higashi-in'nai Member, d: Najimi Member, e: Hojuji Member, f: I'ida Member, g: Wakura Member, h: I'izuka Member, i: Nakayamatoge Member, j: Hijirikawa Member, k: Takakubo Member, l: Omma Member.

According to the writer's investigation, as shown in the triangular diagram (Fig. 6), the warm and subtropical plants such as *Liquidambar* and *Metasequoia* from the Wakura Member is far less in number of specimens than from the Yamatoda and Sunagozaka Members which correspond to the Daijima stage, namely, the latter yielded 61% to 85% in average for the total specimens, and the former 8% to 16%. The present result is closely similar to the analytical results on the pollen and spore assemblages from the Hojuji and I'ida Members studied previously (FUJI, 1966). With respect to the relative frequency of warm and subtropical elements found throughout this member, the higher the horizon is, the less the frequency becomes. However, on the contrary in respect to the cool and cold elements, the higher the horizon is, the more the frequency becomes. The relationship between the temperate, warm and cold elements is illustrated in Fig. 9.

Comparison between the fossil plants and similar living equivalents whose climatic requirements are known is frequently used for climatic analysis of a fossil flora. Where the modern relationships are known definitely, this method is probably useful for accurate information. The Neogene Tertiary species are comparatively modernized in morphological features, so it is not difficult to compare them with living equivalents with some exceptions. The genera comprising the Neogene flora in Japan are mostly distributed now in East Asia, and nearly all of the temperate Dicotyledonous genera in the fossil flora are now growing in Japanese Islands. However, exotic genera are sometimes commonly contained in the fossil flora. The exotic coniferous genera such as *Metasequoia*, *Glyptostrobus*, *Sequoia*, *Pseudolarix* and *Keteleeria* are found throughout the Neogene flora of Japan, and they are mostly living now in China, and some of them are known in the western part of North America. The nearest living equivalents of the pollen floras from thd Wakura Member and their modern distribution in East Asia are shown in Table 2. According to this table, the Wakura pollen flora consists mainly of temperate genera, with warm climatic elements commonly associated. The dominant genera among the temperate ones are *Alnus*, *Fagus*, *Castanea*, *Quercus*, *Ulmus*, *Zelkova*, *Acer* and *Tilia*. The modern species equivalent to them, according to TANAI (1961), are mostly distributed in Japan proper, especially from Central Japan to Kyûshû. However, some of them are rather luxuriantly distributed in Northern Honshû and Hokkaido. Further, the pollen flora sometimes contains many exotic conifers such as *Cunninghamia*, *Taiwania*, *Metasequoia*, *Glyptostrobus* and *Liquidambar* of the Dicotyledons, though they are not abundant in number of specimens and are rather relicts which survived from the previous Yamatoda and Sunagozaka pollen floras. Such presumption regardingthe climatic conditions is supported by the fact that the pollen flora frequently contains the warm climatic elements.

Thus, according to the writer's researches, the pollen flora of the Wakura Member comprises temperate and warm climatic elements mingled 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 by TANAI (1961) the Wakura pollen flora is related to the present temperate or somewhat temperate forest in Central and Southern Japan, 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 Daijima stage.

(b) Palaeogeographical Environment

To facilitate the considerations on the

Table 2. Modern equivalents of the fossil microplants from the Wakura diatomaceous mudstone Member.

Fossil microplants	Near fossil macroplants	Modern equivalent macroplants	1	Japan					7	8	China					Habitat
				2	3	4	5	6			9	10	11	12	13	
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
Larix																U
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 (evergre.)	*Q. protosalicina*	*Q. salicina*		×	×	×	×		×							M
Quercus (non e.g.)	*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*	×	×	×	×	×	×								U
Celtis	*C. nathorsti*	*C. jessoensis*	×	×	×	×	×		×							M
	C. nordenskiöldii	*C. occidentalis*														M
Betula	*B. miomaximowicziana*	*B. maximowicziana*	×	×	×											M~U
	B. onbaraensis	*B. grossa*		×	×	×	×									M
	B. protoermanni	*B. ermanni*	×	×	×				×							M~U
	B. protoglobispica	*B. globispica*		×	×											M

	B. protojaponica	*B. japonica*	×	×	×										M
Pterocarya	*P. nipponica*	*P. rhoifolia*		×	×	×	×	×			×				M~R
	P. asymmetrosa	*P. paliurus*										×	×	×	R
	P. protostenoptera	*P. stenoptera*								×	×	×	×	×	R
Corylus															M
Acer	*A. nordenskiöldi*	*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. svbpictum	*A. mono*		×	×	×	×	×		×	×			×	×	M
Castanea	*C. miocrnata*	*C. crenata*	×	×	×	×	×									M
Carya	*C. miocathayensis*	*C. cathayensis*										×	×			M
Zelkova	*Z. ungeri*	*Z. serrata*		×	×	×	×		×			×	×			M
Menyanthes																R
Styrax	*S. protoobassia*	*S. obassia*		×	×	×	×	×		×	×				×	M
	S. japonica	*S. japonica*		×	×	×	×	×		×	×	×				M
Carpinus	*C. miocenica*	*C. laxiflora*	×	×	×	×	×		×							M
	C. nipponica	*C. lanceolata*										×	×			M
	C. stenophylla	*C. carpinoides*		×	×	×	×									M
	C. subcordata	*C. cordata*	×	×	×	×	×		×	×	×	×			×	M~R
	C. subyedoensis	*C. tchonoskii*		×	×	×	×		×			×				M~R
Tilia	*T. distans*	*T. amuraensis*								×	×	×				M
	T. miohenryana	*T. henryana*										×	×			M
	T. protojaponica	*T. japonica*		×	×	×	×	×							×	M
Liquidambar	*L. mioformosana*	*L. formosana*						×				×	×	×		R

Member 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

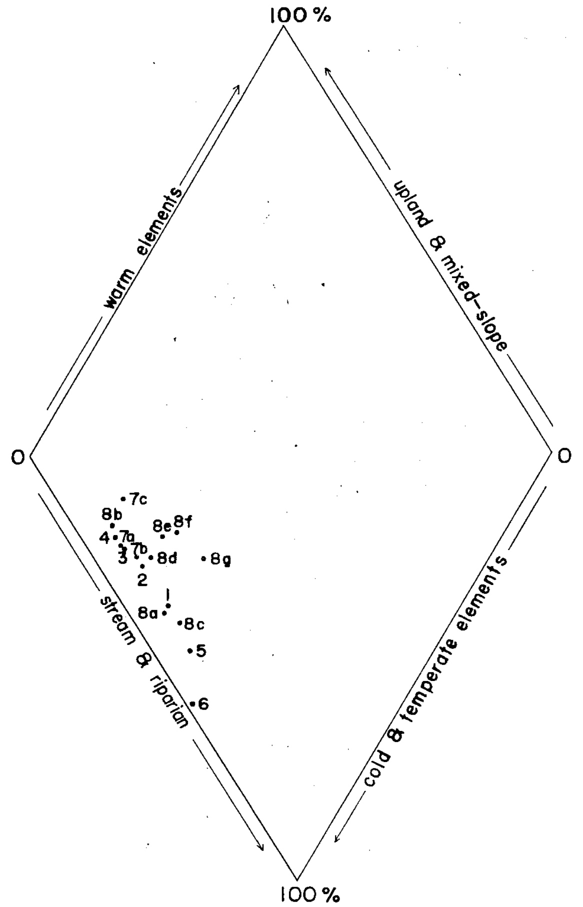

Fig. 8. Pollen diagram (5): Quadrilateral diagram showing the relationship between cold & temperate climatic and warm climatic elements, stream & riparian and upland & mixed-slope elements found from several samples of the Wakura diatomaceous mudstone Member. Numbers refer to Figs. 1 and 3.

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

The Wakura pollen flora is mainly comprised of mixed-slope or mixed-slope—riparian plants in number of specimens, and also contains upland—mixed-slope plants. Namely, this flora seems to represent a mixed-slope to riparian forest. For instance, the mixed-slope plants amount to 44% in frequency on average, stream-side and riparian plants 30% and the remainder of upland plants. On the other hand, judging from the lithofacies, poor contents of planktonic foraminifers, fossil diatom assemblages and diversity in the thickness of the deposits, the sea under which the Wakura Member was deposited during the Neogene Tertiary seems to have been a more or less closed embayment in the Wakura area of central part of Noto Peninsula, though the sea in southern part of Noto Peninsula widened during the Late Miocene age. The spread of this semi-opened sea is shown in Fig. 10.

The friquency of grass-pollen grains and spores have been generally accepted 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 ranges from 36% to 50% in the Wakura Member, though from 26% in the Hijirikawa to 46% in the I'izuka Members.

(c) Geological Age

In the Japanese Islands the correlation and age determination of the Tertiary floras have been frequently made by the use of several characteristic fossils and assemblages. The Neogene flora of Japan has been described by YABE and ENDO, SUZUKI, TANAI and many other authors, and consequently the floristic composition of each flora is comparatively well known at present. On the basis of these researches, TANAI (1961) classified the Neogene floras of Japan into six types, considering the floristic composition and components, along with the geological ages indicated by them.

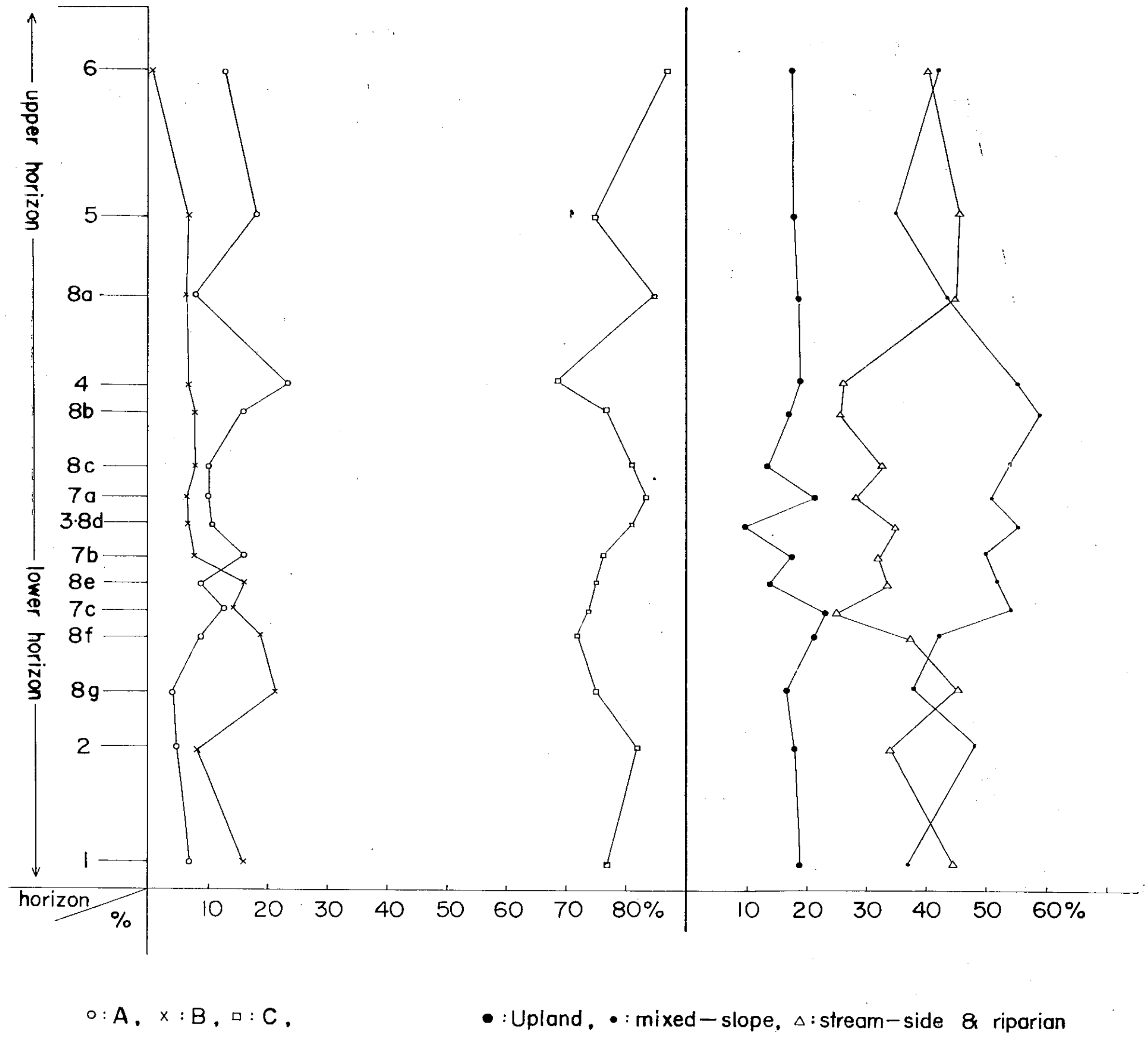

Fig. 9. Pollen diagram (6): Figure showing the relationship between cold & cool climatic, temperate climatic, warm climatic, upland, mixed-slope and riparian elements found from several samples of the Wakura diatomaceous mudstone Member. Numbers refer to Figs. 1 and 3.

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 Wakura pollen flora is very similar in generic composition to the Mitoku-type flora. It contains a few exotic elements which are found abundantly in the Noroshi and Yamatoda floras. It is commonly found in the Late Miocene floras of Europe and in the western part of the United States where the modernized plants are dominant. Thus, in comparison with various floras of the Neogene in Japan and from the viewpoint of its stratigraphical evidences the Wakura pollen flora can be nearly correlated with the Mitoku-type flora, and the geochronological position of the Wakura Member seems to be Late Miocene.

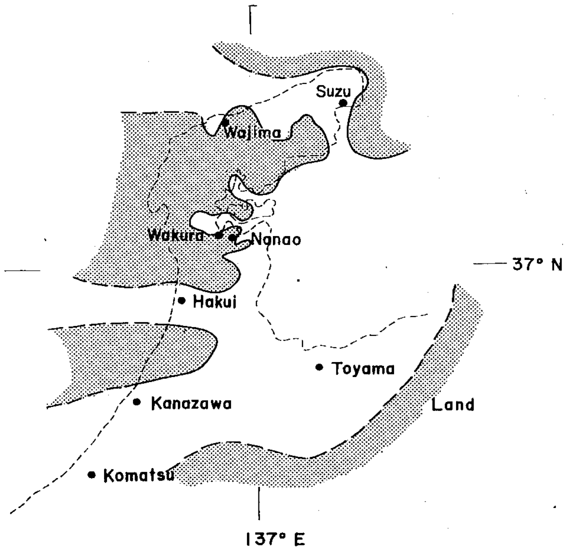

Fig. 10. The Palaeogeographical map during the sedimentation of the Wakura diatomaceous mudstone Member (the Otogawa stage of Late Miocene age) (After Y. KASENO, 1963).

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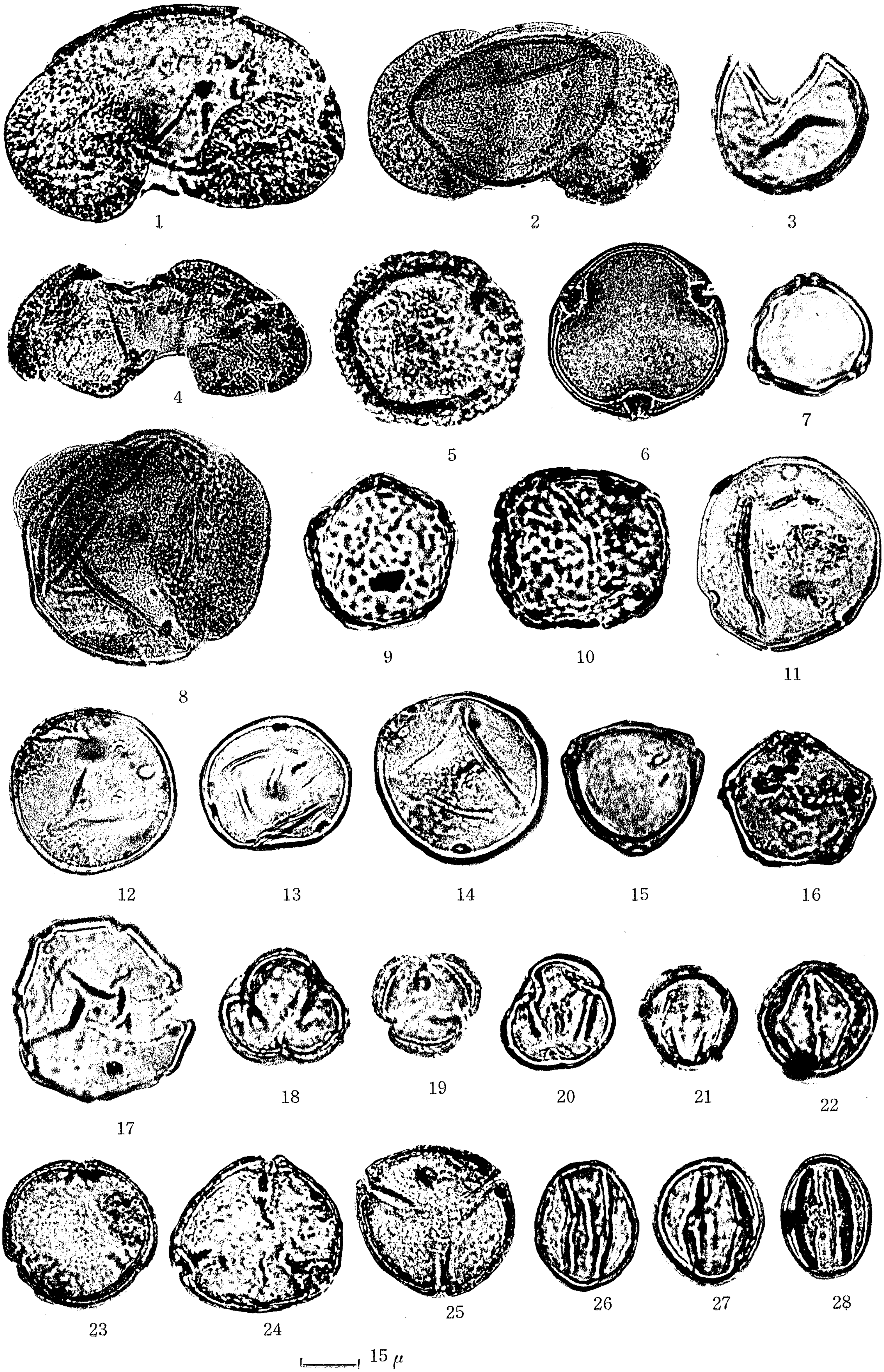
Explanation of Plate 1

Fig. 1: *Picea;* Locality 3; EKZJ coll. cat. no. 20019.
Fig. 2: *Abies;* Locality 8, Horizon b; EKZJ coll. cat. no. 20020.
Fig. 3: Taxodiaceae; Locality 7, Horizon a; EKZJ coll. cat. no. 20021.
Fig. 4: *Podocarpus;* Locality 7, Horizon d; EKZJ coll. cat. no. 20022.
Fig. 5: *Tsuga;* Locality 6; EKZJ coll. cat. no. 20023.
Fig. 6: *Tilia;* Locality 8, Horizon d; EKZJ coll. cat. no. 20024
Fig. 7: *Betula;* Locality 4; EKZJ coll. cat. no. 20025.
Fig. 8: *Podocarpus;* Locality 6; EKZJ coll. cat. no. 20026.
Fig. 9: *Zelkova;* Locality 8, Horizon c; EKZJ coll. cat. no. 20027.
Fig. 10: Cfr. *Zelkova;* Locality 7, Horizon b; EKZJ coll. cat. no. 20028.
Fig. 11: *Carya;* Locality 8, Horizon g; EKZJ coll. cat. no. 20029.
Fig. 12: *Carya;* Locality 8, Horizon d; EKZJ coll. cat. no. 20030.
Fig. 13: Aff. *Carya;* Locality 3; EKZJ coll. cat. no. 20031.
Fig. 14: *Carya;* Locality 3; EKZJ coll. cat. no. 20032.
Fig. 15: *Carya;* Locality 4; EKZJ coll. cat. no. 20033.
Fig. 16: *Alnus;* Locality 1; EKZJ coll. cat. no. 20034.
Fig. 17: *Pterocarya;* Locality 5; EKZJ coll. cat. no. 20035.
Fig. 18: *Salix;* Locality 8, Horizon c; EKZJ coll. cat. no. 20036.
Fig. 19: *Salix;* Locality 7, Horizon b; EKZJ coll. cat. no. 20037.
Fig. 20: *Salix;* Locality 8, Horizon g; EKZJ coll. cat. no. 20038.
Fig. 21: *Castanea;* Locality 7, Horizon a; EKZJ coll. cat. no. 20039.
Fig. 22: *Quercus* (small), evergreen *Quercus;* Locality 4; EKZJ coll. cat. no. 20040.
Fig. 23: *Fagus;* Locality 7, Horizon a; EKZJ coll. cat. no. 20041.
Fig. 24: *Nyssa;* Locality 2; EKZJ coll. cat. no. 20042.
Fig. 25: *Nyssa;* Locality 4; EKZJ coll. cat. no. 20043.
Fig. 26: *Quercus* (large), deciduous *Quercus;* Locality 6; EKZJ coll. cat. no. 20044.
Fig. 27: *Quercus* (large), deciduous *Quercus;* Locality 6; EKZJ coll. cat. no. 20045.
Fig. 28: *Quercus* (large), deciduous *Quercus;* Locality 5; EKZJ coll. cat. no. 20046.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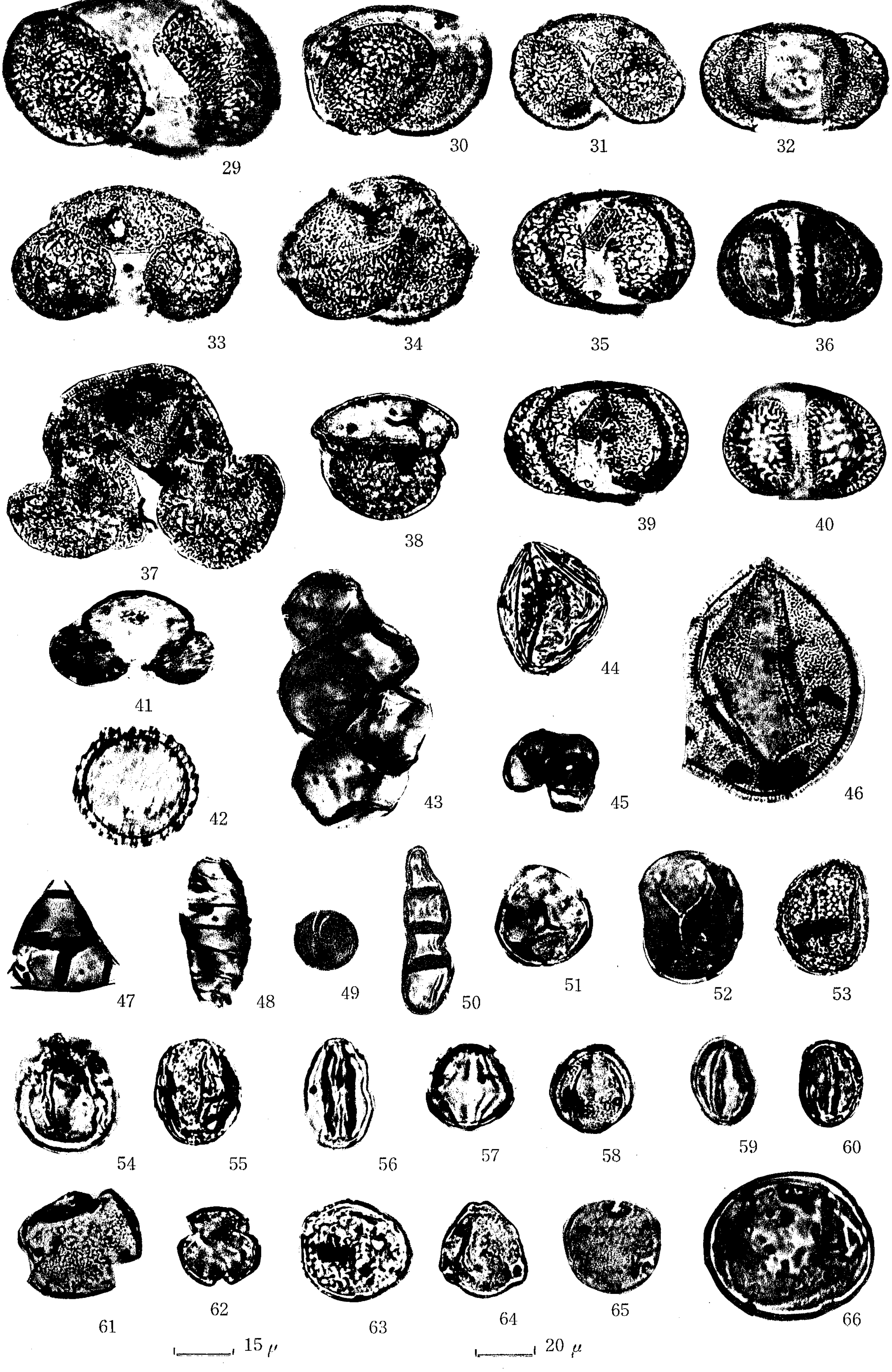
Ainoura	相　浦	Himi	氷　見
Akashi	明　石	Hiradoko	平　床
Akaura	赤　浦	Hojuji	法住寺
Anamizu	穴　水	Hosoguchi	細　口
Aniai	阿仁合	I'izuka	飯　塚
Daijima	台　島	Ishizaki	石　崎
Hijirikawa	聖　川	Iwaya	岩　屋

Kamitako	上田子	Mt. Sekidô-san	石動山
Kôda	向田	Nakayama-toge	中山峠
Kojima	小島	Nanao	七尾
Mitoku	三徳	Nishiminato	西湊
Mt. Bijô-zan	眉丈山	Noto	能登

Explanation of Plate 2

Fig. 29: *Pinus*; Locality 6; EKZJ coll. cat. no. 20047.
Fig. 30: *Pinus*; Locality 8; Horizon b; EKZJ coll. cat. no. 20048.
Fig. 31: *Pinus*; Locality 2; EKZJ coll. cat. no. 20049.
Fig. 32: *Pinus*; Locality 7, Horizon c; EKZJ coll. cat. no. 20050.
Fig. 33: *Pinus*; Locality 8, Horizon e; EKZJ coll. cat. no. 20051.
Fig. 34: *Pinus*; Locality 4; EKZJ coll. cat. no. 20052.
Fig. 35: *Pinus*; Locality 7, Horizon c; EKZJ coll. cat. no. 20053.
Fig. 36: *Pinus*; Locality 2; EKZJ coll. cat. no. 20054.
Fig. 37: *Abies*; Locality 3; EKZJ coll. cat. no. 20055.
Fig. 38: *Pinus*; Locality 8, Horizon d; EKZJ coll. cat. no. 20056.
Fig. 39: *Pinus*; Locality 7, Horizon c; EKZJ coll. cat. no. 20053.
Fig. 40: *Pinus*; Locality 2; EKZJ coll. cat. no. 20054.
Fig. 41: *Pinus*; Locality 7, Horizon a; EKZJ coll. cat. no. 20057.
Fig. 42: *Persicaria*; Locality 4; EKZJ coll. cat. no. 20058.
Fig. 43: Spore, gen. indet.; Locality 4; EKZJ coll. cat. no. 20059.
Fig. 44: *Monosulcopollenites*; Locality 4; EKZJ coll. cat. no. 20060.
Fig. 45: *Pleuricellaesporites*; Locality 7, Horizon c; EKZJ coll. cat. no. 20061.
Fig. 46: *Monosulcopollenites*; Locality 5; EKZJ coll. cat. no. 20062.
Fig. 47: *Triadosporites*; Locality 8, Horizon c; EKZJ coll. cat. no. 20063.
Fig. 48: *Pleuricellaesporites*; Locality 5; EKZJ coll. cat. no. 20064.
Fig. 49: *Inapertisporites*; Locality 3; EKZJ coll. cat. no. 20065.
Fig. 50: *Pleuricellaesporites*; Locality 6; EKZJ coll. cat. no. 20066.
Fig. 51: Trilate type spore, gen. indet.; Locality 6; EKZJ coll. cat. no. 20067.
Fig. 52: Trilate type spore, gen. indet.; Locolity 5; EKZJ coll. cat. no. 20068.
Fig. 53: *Lycopodium*; Locality 3; EKZJ coll. cat. no. 20069.
Fig. 54: *Tricolporopollenites*; Locality 8, Horizon d; EKZJ coll. cat. no. 20070.
Fig. 55: *Tricolporopollenites*; Locality 7, Horizon c; EKZJ coll. cat. no. 20071.
Fig. 56: *Tricolporopollenites*; Locality 8, Horizon d; EKZJ coll. cat. no. 20072.
Fig. 57: *Castanea*; Locality 4; EKZJ coll. cat. no. 20073.
Fig. 58: *Tricolporopollenites*; Locality 1; EKZJ coll. cat. no. 20074.
Fig. 59: *Tricolporopollenites*; Locality 4; EKZJ coll. cat. no. 20075.
Fig. 60: *Tricolporopollenites*; Locality 8, Horizon d; EKZJ coll. cat. no. 20076.
Fig. 61: *Acer*; Locality 7, Horizon e; EKZJ coll. can. no. 20077.
Fig. 62: *Castanea*; Locality 6; EKZJ coll. cat. no. 20078.
Fig. 63: Pollen grain (?); Locality 8, Horizon c; EKZJ coll. cat. no. 20079.
Fig. 64: *Corylus*; Locality 6; EKZJ coll. cat. no. 20080.
Fig. 65: *Tilia*; Locality 8, Horizon a; EKZJ coll. cat. no. 20081.
Fig. 66: *Carya*; Locality 6; EKZJ coll. cat. no. 20082.

(Figs. 30–32, 37–38, 41–44, 47, 49, 51–53, 64–65 are measured by a right scale, 20 μ, and the other figs. by a left scale, 15 μ. All specimens illustrated are kept in the Institute of Earth Science, Kanazawa University)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15 μ
20 μ

Noto-jima	能 登 島
Okuhara	奥 原
Ôsugi-zaki	大 杉 崎
Otogawa	音 川
Sakiyama	崎 山
Sanami	佐 波
Shinjô	新 庄
Sunagozaka	砂 子 坂
Suso	須 曾
Takashina	高 階
Tokuda	徳 田
Tsukada	塚 田
Wakura	和 倉
Wakura-eki	和 倉 駅
Yamatoda	山 戸 田